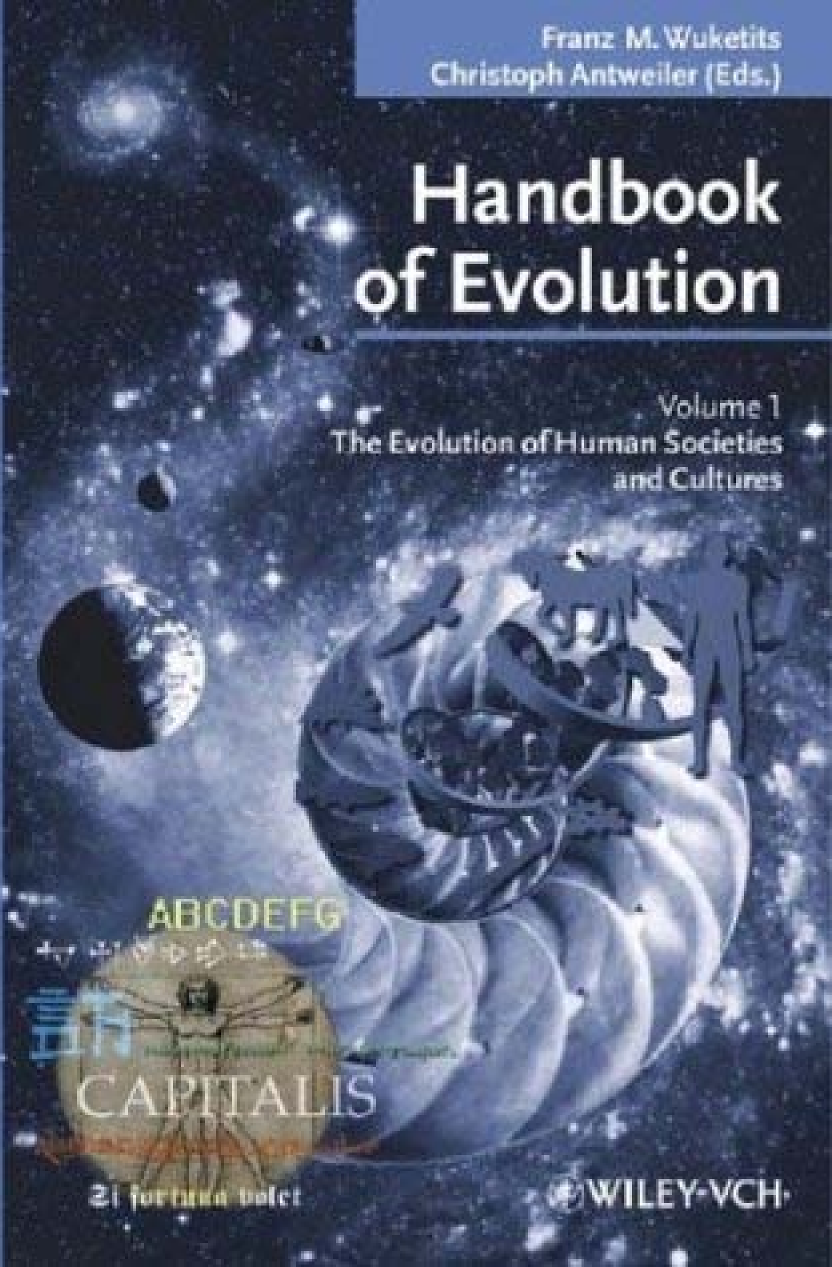
Franz M. Wuketits
Christoph Antweiler (Eds.)

Handbook of Evolution

Volume 1
The Evolution of Human Societies and Cultures



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Edited by
Franz M. Wuketits
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and Cultures

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Preface

„Nothing in biology makes sense except in the light of evolution." This famous statement by Theodosius Dobzhansky (1900–1975) is not only true in biology but applies – at least to a certain extent – also to other disciplines. In search for an understanding of human societies and cultures, including their particular expressions in moral systems and languages, we cannot dispense with evolutionary thinking. A proper treatment of these phenomena requires some lessons from evolutionary theory. However specific their cultural activities may be, humans are deeply rooted in the animal kingdom, and their capacity for culture has been formed and constrained in the course of evolution by means of natural selection.

The editors and authors of this *Handbook* claim that evolution in the broadest sense of the word is a universal principle. They try to reveal its specific meaning at different levels of the organization of our world. Therefore, this work is to be understood as an interdisciplinary treatment of evolution: The meaning of evolution is discussed from the point of view of cosmology, physics, chemistry, geology, biology, anthropology, social and political sciences, economics, linguistics, and philosophy of science. Also, the impact of evolutionary thinking on (philosophical) disciplines that are not traditionally connected with – and do not refer to – evolution (particularly epistemology and moral philosophy or ethics) is elaborated.

The aim of the *Handbook* is, first, to inform about the state of affairs, i. e., the current theories, problems, and results of evolutionary thinking in different disciplines, and, second, to show some close connections and interrelations between the disciplines *sub specie evolutionis*. Hence, the *Handbook* can serve as a reference work, but should also be seen as an attempt to yield an evolutionary synthesis. Its very purpose is to meet the urgent need of various scientific and philosophical disciplines for a comprehensive up-to-date treatise of our knowledge about evolution and its many facets. We hasten to say that we do not want to give the impression that evolutionary theory is a „finished case". Of course, it is not. As can be learned from different contributions to this work, evolutionary thinking is still in flux, so to speak, and it includes many controversial issues. So, the reader of this *Handbook* may, finally, also get some ideas about unsolved problems and important tasks for the future.

The present volume is devoted to human social and cultural evolution. It includes 8 Chapters, dealing with the basic data, concepts and models of evolutionary thinking in the human sciences and discussing their most important consequences. Chapter 1 explains the human adaptation for culture. Michael Tomasello shows how humans have developed cultural skills in ways that are unique in the animal kingdom. In Chapter 2 Olaf Diettrich presents evolutionary conceptions of (human) cognition and knowledge, and gives an account of what has been discussed, for some decades, under the label of evolutionary epistemology. In Chapter 3 Harald Haarmann extends the evolutionary approach to language and languages, and points out the wealth of cultural resources that are stored in each language. Social evolution is the topic of Chapter 4. Peter Meyer discusses the meaning of evolutionary thinking in the social sciences, connects social evolution with biological evolution and also gives to understand that the former has always led to new and unprecedented characteristics of cultural institutions. Chapter 5, by Camilo J. Cela-Conde and Francisco Ayala, tackles the problem of evolution and morality which recently has been revived in different forms of evolutionary ethics. In Chapter 6, Peter Corning pays tribute to *Homo sapiens* as a political animal and explains evolutionary mechanisms in politics. Chapter 7, by John M. Gowdy, is devoted to evolution of economics and outlines the intricate relations between human biology and economy. Finally, in Chapter 8, Erhard Oeser espouses an evolutionary model of the history and development of scientific method.

The idea for this *Handbook* is mainly due to Dr. Hans-Martin Schmidt (Cologne). With his characteristic enthusiasm for evolutionary theory as an interdisciplinary project, he encouraged us to finalize this work, carefully watched its gestation, and offered financial support from his *Stiftung "Apfelbaum"*. Without him and his *Stiftung "Apfelbaum"* some important preparatory work could not have been done. We acknowledge with gratitude all his efforts. Our thanks also go to the staff of Wiley-VCH (Weinheim) for their patience and competent production of this work. Last, but not least, we have to express our thanks to the authors of the present volume who, in spite of many other obligations, devoted much time and energy to this project and supplied us with excellent contributions.

October 2003

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1 The Human Adaptation for Culture*

Michael Tomasello

Abstract

Human beings are biologically adapted for culture in ways that other primates are not, as evidenced most clearly by the fact that only human cultural traditions accumulate modifications over historical time (the ratchet effect). The key adaptation is one that enables individuals to understand other individuals as intentional agents like the self. This species-unique form of social cognition emerges in human ontogeny at approximately 1 year of age, as infants begin to engage with other persons in various kinds of joint attentional activities involving gaze following, social referencing, and gestural communication. Young children's joint attentional skills then engender some uniquely powerful forms of cultural learning, enabling the acquisition of language, discourse skills, tool-use practices, and other conventional activities. These novel forms of cultural learning allow human beings to, in effect, pool their cognitive resources both contemporaneously and over historical time in ways that are unique in the animal kingdom.

1.1 Introduction

All animal species have unique characteristics and human beings are no exception. Perhaps most important, human beings have some unique cognitive skills The precise nature of these skills is unknown, but they must be such that they enable a number of species-unique and easily observable behavioral practices including the following: (a) the creation and use of conventional symbols, including linguistic symbols and their derivatives, such as written language and mathematical symbols and notations, (b) the creation and use of complex tools and other instrumental technologies, and (c) the creation of and participation in complex

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social organizations and institutions. It is difficult to imagine a more fundamental anthropological question than that of where these complex and species-unique behavioral practices, and the cognitive skills that underlie them, came from.

Recent research on human evolution has provided some important facts that may help us to answer this most basic of questions. First, human beings shared 0 common ancestor with their nearest primate relatives, *Pan troglodytes* and *Pan paniscus*, a mere 6 million years ago – about the same time there existed a common ancestor for horses and zebras, lions and tigers, and rats and mice (King and Wilson, 1975). Second, for almost two thirds of this 6 million years, the human lineage consisted of one or more species of Australopithecine, which in most recent research are characterized as ape-like in both brain size and behavior (Klein, 1989). Third, although controversial, many anthropologists now believe that in the 2 million years of the existence of genus *Homo*, it has only been during the past several hundred thousand years, with the rise of something like modern humans, that the unique aspects of human cognition have come into full bloom (Stringer and McKie, 1996). What these new facts and interpretations establish is the rapidity with which the species-unique aspects of human cognition must have arisen: within the past 6 million years for certain, within the past 2 million years in all likelihood, and within the past half million years according to some respectable theories. The main point is that under none of these scenarios – especially the last-has there been sufficient time for a large number of major cognitive adaptations (contra most of so-called evolutionary psychology) (Tooby and Cosmides, 1989; Pinker, 1997). If we are searching for the origins of uniquely human cognition, therefore, our search must be for some small difference that made a big difference – some adaptation, or small set of adaptations, that changed the process of primate cognitive evolution in fundamental ways.

In my view there is only one candidate for this small difference that made a big difference and that is human culture. Other primates and mammals are certainly social, and some may even have social organizations for which it is useful to apply the term culture (McGrew, 1998). But human social organization is something else again, and this organization was, in my view, an integral part of the process by which human cognition came to have many of its most distinctive characteristics. That is, although the cognition of many mammalian and primate species is influenced in important ways by their social environments, human cognition, at least in its species-unique aspects, is actually socially constituted. In this paper, I attempt to explicate this proposition more fully and to explore some of its most important anthropological implications by systematically comparing the social learning, social cognition, and cultural organization of human beings and their nearest primate relatives.

1.2 Primate and Human Cognition

Human cognition is a species, in the literal meaning of the word, of primate cognition. Tomasello and Call (1997) reviewed all of the most important studies of primate cognition over the past century and established that a vast array of cognitive skills are common to all primates, including humans. Thus, in their cognition of the physical world, all primate species remember 'what' is 'where' in their local environments, take novel detours and shortcuts in navigating through space (cognitive mapping), predict where food will be located in the future based on a number of current cues, follow the visible and invisible displacements of objects (Piaget's object permanence), categorize objects on the basis of perceptual similarities, understand relational categories and perform mental rotations of objects in space, match (and perhaps add) small numerosities of objects independent of spatial cues, and use creative strategies and perhaps insight in problem solving (sometimes in tool use). The major conclusion is that all primates live in basically the same sensory-motor world of permanent objects – and categories and relations of permanent objects – arrayed in a representational space, and they all have some insightful problem-solving skills (in some cases involving the making and using of tools) to affect that sensory-motor world.

There are also many similarities in the way all primate species understand their social worlds. Thus, all primate species recognize individuals in their social groups; form direct relationships with other individuals based on such things as kinship, friendship, and dominance rank; understand the third-party social relationships that hold among other members of their groups – again based on such things as kinship, friendship, and dominance rank, predict the behavior of individuals based on a variety of social and physical cues, and sometimes novel insights; use many types of social and communicative strategies to solve social problems and so to out-compete groupmates for valued resources; cooperate with conspecifics in problem-solving tasks and in forming social coalitions and alliances, and engage in various forms of social learning, in which they learn valuable things from conspecifics. The major conclusion again is that all primates live in basically the same type of social world, in which they individually recognize conspecifics and appreciate both the vertical (dominance) and horizontal (affiliative) relationships that hold among group members. They also have the ability to predict the behavior of conspecifics in many situations based on a variety of cues and insights, and in some cases to affect the behavior of groupmates via various social and communicative strategies.

So what makes human cognition different? What enables human beings to create and use language and other symbols, to create and maintain complex instrumental technologies, and to create and maintain complex social organizations and institutions? The first and most obvious observation is that individual human beings do not do any of these things. These are all collective cognitive products in which human beings have in some way pooled their cognitive resources. If we imagine the forbidden experiment in which a human child grows up on a desert island, miraculously supplied with nutritional and emotional sustenance but in the total absence of contact with other human beings, this child would not invent a language or a complex technology or a complex social institution. Even if there were a group of such abandoned children, it is unlikely that together, in their own lifetime, they could invent anything resembling the range of material and symbolic artifacts that characterizes even the least artifactually complex human society. The reason that no single child or group of children could on their own in their own lifetimes create any version of a modern human culture and its material and symbolic artifacts is that human cultures are historical products built up over many generations. Indeed, the most distinctive characteristic of human cultural evolution as a process is the way that modifications to an artifact or a social practice made by one individual or group of individuals often spread within the group, and then stay in place until some future individual or individuals make further modifications – and these then stay in place until still further modifications are made (Tomasello et al., 1993a; Boesch and Tomasello, 1998). This process of cumulative cultural evolution works because of a kind of 'ratchet effect': individual and group inventions are mastered relatively faithfully by conspecifics, including youngsters, which enables them to remain in their new and improved form within the group until something better comes along.

The major part of the ratchet in the cumulative cultural evolution of human societies takes place during childhood. That is, each new generation of children develops in the 'ontogenetic niche' characteristic of its culture (including in some cases explicitly pedagogical niches), mastering the artifacts and social practices that exist at that time. It is only because human children are so good at social learning (and in some cases adults are so good at teaching) that an artifact or social practice may conserve its form over many generations of stasis, until eventually a modification that group members find worthwhile is made and the cycle starts anew. For this process to work, therefore, human beings not only need to be inventive, they need to be good at preserving those inventions by imitatively learning, and sometimes explicitly teaching, the inventions of others. This process is more complex than it might seem at first glance, however. Imitative learning does not just mean mimicking the surface structure of a poorly understood behavior, the way a parrot mimics human speech, with no understanding of its communicative significance, it also means reproducing an instrumental act understood intentionally, that is reproducing not just the behavioral means but also the intentional end for which the behavioral means was formulated. This requires some specially adapted skills of social cognition.

The main point is that unlike the young of any other primate species, human children grow up in the midst of the accumulated wisdom of their social group, as embodied in its material artifacts, symbolic artifacts, and conventional social practices, and children are specifically adapted to appropriate this wisdom as embodied in these forms. Although we have yet to explore the details, these facts provide a sufficient explanation for the existence of many of the most distinctive cognitive products that human beings produce. But there is more. As a result of participating in social and communicative interactions with other persons understood intentionally, human children also come to cognitively represent the world in some uniquely powerful ways. The most important of these involves the use of linguistic symbols that are both intersubjectively understood and perspectival, in the sense that that a single item or situation may be construed linguistically in many different ways. For example, a single event may be seen as X sold Y to Z or Z bought Y from X; or a single object may be an apple, a fruit, or some food. Intersubjective and perspectival cognitive representations are unique in the animal kingdom, and they enable human beings to deal with their worlds in some uniquely flexible and powerful ways.

To appreciate fully (a) the social cognitive skills necessary for children to participate fully in their cultures and (b) the transforming effect of cultural participation on individual cognition, we must follow out key aspects of the human ontogenetic scenario – and then compare it with the basic scenario of nonhuman primate cognitive ontogeny.

1.3 The Ontogeny of Human Cultural Learning

Human children grow up in the ontogenetic niche of their culture, which, in a sense, exists before they are born. But children also need to have some social cognitive skills if they are to exploit the preexisting cultural resources in a species-typical manner. These skills cannot be simply presupposed, as is often the case in cultural psychology (e.g., Rogoff, 1990; Shweder, 1990). This point is most clearly demonstrated by the unfortunate case of children with autism, the vast majority of whom lack the social cognitive skills necessary to participate fully in or to appropriate the artifacts and social practices characteristic of those around them (Baron-Cohen 1993; Hobson, 1993). For typically developing children, the ontogeny of these social cognitive skills begins at the end of the first year of life.

1.3.1 Joint Attention

Six-month-old infants interact dyadically with objects, grasping and manipulating them, and they interact dyadically with other people, expressing emotions back-and-forth in a turn-taking sequence. But at approximately 9–12 months of age, infants begin to engage in interactions that are triadic in the sense that they involve the referential triangle of child, adult, and some outside entity to which they share attention. Thus, infants at this age begin to flexibly and reliably look where adults are looking (gaze following), use adults as social reference points (social referencing), and act on objects in the way adults are acting on them (imitative learning) – in short, to 'tune in' to the attention and behavior of adults toward outside entities. At this same age, infants also begin to use communicative gestures to direct adult attention and behavior to outside entities in which they are interested – in short, to get the adult to 'tune in' to them. In many cases, several of these behaviors come together as the infant interacts with an adult in a relatively extended bout of joint engagement with an object (Bakeman and Adamson, 1984). Most often the term joint attention has been used to characterize this whole complex of triadic social skills and interactions (Moore and Dunham, 1995), and it represents something of a revolution in the way infants relate to their worlds.

Infants begin to engage in joint attentional interactions when they begin to understand other persons as intentional agents (Tomasello, 1995). Intentional agents are animate beings with the power to control their spontaneous behavior, but they are more than that. Intentional agents also have goals and make active choices among behavioral means for attaining those goals. It is important to note that intentional agents also make active choices about what they pay attention to in pursuing those goals (for the argument that attention is intentional perception, see Gibson and Rader, 1979). All of the specific joint attentional behaviors in which infants follow, direct, or share adult attention and behavior are not separate activities or cognitive domains, they are simply different behavioral manifestations of this same underlying understanding of other persons as intentional agents. Strong support for this view comes from a recent study by Carpenter et al. (1998b), who followed a group of infants longitudinally from 9 to 15 months of age and found that for any individual child these skills emerged together as a group, with some predictable orderings among individual skills.

1.3.2
Imitative Learning

The social-cognitive revolution at 1 year of age sets the stage for infants' second year of life, in which they begin to imitatively learn the use of all kinds of tools, artifacts, and symbols. For example, in a study by Meltzoff (1988), 14-month-old children observed an adult bend at the waist and touch its head to a panel, thus turning on a light. They followed suit. Infants engaged in this somewhat unusual and awkward behavior, even though it would have been easier and more natural for them simply to push the panel with their hand. One interpretation of this behavior is that infants understood that (a) the adult had the goal of illuminating the light and then chose one means for doing so, from among other possible means, and (b) if they had the same goal, they could choose the same means. Cultural learning of this type thus relies fundamentally on infants' tendency to identify with adults, and on their ability to distinguish in the actions of others the underlying goal and the different means that might be used to achieve it. This interpretation is supported by the more recent finding of Meltzoff (1995) that 18-month-old children also imitatively learn actions that adults intend to perform, even if they are unsuccessful in doing so. Similarly, Carpenter et al. (1998a) found that 16-month-old infants will imitatively learn from a complex behavioral sequence only those behaviors that appear intentional, ignoring those that appear accidental. Young children do not just mimic the limb movements of other persons, they attempt to reproduce other persons' intended actions in the world.

Although it is not obvious at first glance, something like this same imitative learning process must happen if children are to learn the symbolic conventions of their native language. Although it is often assumed that young children acquire language as adults stop what they are doing, hold up objects, and name these objects for them, this is empirically not the case. Linguistics lessons such as these are (a) characteristic of only some parents in some cultures and (b) characteristic of no parent in no culture for words other than concrete nouns and some actions, i.e., no one names for children acts of 'giving' or prepositional relationships such as 'on' or 'for'. In general, for the vast majority of words in their language, children must find a way to learn in the ongoing flow of social interaction, sometimes from speech not even addressed to them (Brown, 1999), In some recent experiments, something of this process has been captured, as children learned words in situations in which the adult was not specifically intending that they learn a word, the referent was not perceptually available when the word was said, and there were multiple potential referents in the situation that the child had to choose among based on various kinds of adult social-pragmatic cues.

- In the context of a finding game, an adult announced her intentions to 'find the toma' and then searched in a row of buckets all containing novel objects. Sometimes she found it in the first bucket searched, smiling and handing the child the object. Sometimes, however, she had to search longer, rejecting unwanted objects by scowling at them and replacing them in their buckets until she found the one she wanted (again indicated by a smile and the termination of search). Children learned the new word for the object the adult intended to find regardless of whether or how many objects were rejected during the search process (Tomasello and Barton, 1994).
- Also in the context of a finding game, an adult had the child find four different objects in four different hiding places, one of which was a distinctive toy barn. Once the child had learned which objects went in which places, the adult announced her intention to 'find the gazzer'. She then went to the toy barn, but it turned out to be 'locked'. She thus frowned at the barn and then proceeded to another hiding place, saying 'Let's see what else we can find' (taking out an object with a smile). Later, children demonstrated that they had learned 'gazzer' for the object they knew the experimenter wanted in the barn – even though they never saw the object after they heard the new word, and even though the adult had frowned at the barn and smiled at a distractor object (Akhtar and Tomasello, 1996; Tomasello et al., 1996).
- An adult announced her intention to 'dax Mickey Mouse' and then proceeded to perform one action accidentally and another intentionally (or sometimes in reverse order). Children learned the word for the intentional not the accidental action regardless of which came first in the sequence (Tomasello and Barton, 1994).

Tomasello et al. (1993a) called this kind of imitative learning cultural learning because the child is not just learning things from other persons, she is also learning things through them – in the sense that she must know something of the adult's perspective on a situation to learn the active use of this same intentional act. The adult in the above scenarios is not just moving and picking up objects randomly, she is searching for an object and the child must know this in order to make enough sense of her behavior to connect the new word to the adult's intended referent. The main theoretical point is that an organism can engage in cultural learning of this type only when it understands others as intentional agents, like the self, who have a perspective on the world that can be followed into, directed, and shared. Indeed, a strong argument can be made that children can only understand a symbolic convention in the first place if they understand their communicative partner as an intentional agent with whom one may share attention – since a linguistic symbol is nothing other than a marker for an intersubjectively shared understanding of a situation (Tomasello, 1995, 1998, 1999). As a point of comparison, children with autism do not understand other persons as intentional agents, or they do so to only an imperfect degree, and so they do poorly at imitative learning of intentional actions in general (Smith and Bryson, 1994): only half of them ever learn any language at all, and those who do learn some language do poorly in word-learning situations such as those just described (Baron-Cohen et al., 1997). As we see below, nonhuman primates are not very human-like in these kinds of social-cognitive and cultural learning skills either.

1.3.3
Linguistic Symbols and Cognitive Representation

One of the most interesting things about the process of language acquisition is that the adults from whom the child is learning went through the same process earlier in their lives, and across generations the symbolic artifacts that comprise English or Turkish, or whatever language, accumulate modifications as new linguistic forms are created by grammaticization and other processes of language change (e.g., Traugott and Heine, 1991). Thus, today's child is learning the whole historically derived conglomeration. Consequently, when the child learns the conventional use of these well-traveled symbols, what she is learning is the ways her forbears in the culture found useful for manipulating the attention of others in the past. And because the peoples of a culture, as they move through historical time, evolve many and varied purposes for manipulating the attention of one another (and because they need to do this in many different types of discourse situations), today's child is faced with a whole panoply of different linguistic symbols and constructions that embody many different attentional construals of any given situation. As a sampling, languages embody attentional construals based on the following (for more specifics, see Langacker, 1987): generality–specificity ('thing', 'furniture', 'chair', 'desk chair'); perspective ('chase–flee', 'buy–sell', 'come–go', 'borrow–lend'); function ('father', 'lawyer', 'man', 'American') ('coast', 'shore', 'beach'). There are many more specific perspectives that arise in grammatical combinations of various sorts: "She smashed the vase" versus "The vase was smashed". It is at about 18 months of age that children first begin to predicate multiple things about objects to which they and the adult are jointly attending, for example by saying that this ball is either 'wet' or 'big' or 'mine' – all about one and the same object (Reed, 1995; Tomasello, 1988, 1995).

Consequently, as a young child internalizes a linguistic symbol, as she learns the human perspective embodied in that symbol, she cognitively represents not just perceptual or motoric aspects of a situation but also one way, among other ways of which she is also aware, that the current situation may be attentionally construed by 'us', the users of the symbol. The way that human beings use linguistic symbols thus creates a clear break with straightforward perceptual or sensory-motor cognitive representations. It is true that a prelinguistic child, or a nonhuman primate, may construe situations in more than one way: one time a conspecific is a friend and the next time an enemy, one time a tree is for climbing to avoid predators and the next time it is for making a nest in. In these different interactions with the same entity, the individual is deploying its attention differentially, depending on its goal at that moment. But shifting attention sequentially in this manner as a function of goal is not the same thing as knowing simultaneously a number of different ways in which something might be construed – in effect, imagining at the same time a number of different possible goals and their implications for attention. An individual language user looks at a tree and, before drawing the attention of her interlocutor to that tree, must decide, based on her assessment of the listener's current knowledge and expectations, whether to say "that tree over there", "it", "the oak", "that hundred-year-old oak", "the tree", "the bagswing tree", "that thing in the front yard", "the ornament", "the embarrassment", or any of a number of other expressions. She must decide whether the tree is in, is standing in, is growing in, was placed in, or is flourishing in the front yard. And these decisions are not made on the basis of the speaker's direct goal with respect to the object or activity involved, but rather they are made on the basis of her goal with respect to the listener's interest and attention to that object or activity. This means that the speaker knows that the listener shares with her these same choices for construal – again, all available simultaneously. Indeed, the fact is that while she is speaking, the speaker is constantly monitoring the listener's attentional status (and vice versa), which means that both participants in a conversation are always aware that there are at least their two actual perspectives on a situation, as well as many more that are symbolizable in currently unused symbols and constructions.

The point is not just that linguistic symbols provide handy tags for human concepts, or even that they influence or determine the shape of those concepts, though they do both of these things. The point is that the intersubjectivity of human linguistic symbols – and their perspectival nature as one offshoot of this intersubjectivity – means that linguistic symbols do not represent the world directly, in the manner of perceptual or sensory-motor representations, but rather they are used by people to induce others to construe certain perceptual/conceptual situations – to attend to them – in one way rather than in another. This breaks symbols away from the sensory-motor world of objects in space and puts them instead in the realm of the human ability to view the world in whatever way is convenient for the communicative purpose at hand. The most important point in the current context is that as children participate in these communicative exchanges, they internalize, in something like the way Vygotsky (1978) envisioned the process, the perspectives of other persons. The internalization process is not something mystical or unanalyzable, as it is sometimes characterized, but rather it is just the normal process of imitative learning when linguistic (and perhaps other communicative) conventions are involved. That is, in imitatively learning a linguistic symbol from an adult, the child comprehends that by using a particular symbol she intends for another to pay attention to some specific aspect of their shared experience. When the child attempts to appropriate the use of this communicative convention for her own use, she must reverse roles: If others wish her to focus on this same aspect of reality, they must use that same symbol toward her. This learning process is indeed what creates the communicative convention in the first place, in the sense that it initiates the child into the convention. Because linguistic symbols are perspectival, i.e., used to focus the attention of others on specific aspects of situations as opposed to other aspects, if the child is to use the symbol in its conventionally appropriate manner she must understand something of the adult's perspective. It is in this sense and only in this sense that internalization involves a special form of social learning – cultural learning – in which the child internalizes the perspective of another person.

Some of the effects of operating with symbols of this type are obvious, in terms of flexibility and relative freedom from perception. But some are more far reaching and quite unexpected, in the sense that they give children truly new ways of conceptualizing things, such as treating objects as actions ("he porched the newspaper"), actions as objects ("skiing is fun"), and all kinds of metaphorical construals of things ("love is a journey") (Lakoff and Johnson, 1980; Johnson, 1987; Lakoff, 1987). These new ways of conceptualizing and thinking result from the accumulated effects of engaging in linguistic communication with other persons for some years during early cognitive development. More extended bouts of discourse interaction with other persons also create opportunities for explicitly exploring and comparing differing verbally expressed perspectives on situations. Perhaps of special importance are discourse interactions in which the communicative partner provides a verbally expressed perspective on the child's previous verbally expressed perspective, since in this case the internalization of the other's perspective helps to create children's ability to self-regulate, self-monitor, and reflect on their own cognition (Vygotsky, 1978).

1.4
Nonhuman Primate Culture

McGrew (1998) claims that nonhuman primates engage in social activities that are best characterized as cultural in that they share all the essential features of human culture. I agree with this (Tomasello, 1990, 1994, 1996a). Nevertheless, at the same time I insist that human culture has, in addition, some unique characteristics (as may the cultures of other primate species). The most important of these, at the macro level, is the fact that many human cultural traditions and artifacts accumulate modifications over time, whereas this does not seem to be the case for nonhuman primate cultural traditions (Tomasello et al., 1993a; Tomasello and Call, 1997). The reason for this difference resides in the micro-level processes by which individuals learn things from and through one another, and as just elaborated, it may be the case that in their early ontogenies, human beings do this in some species-unique ways. To see whether these skills are indeed unique to humans, we should look briefly at nonhuman primate culture, nonhuman primate social learning, and nonhuman primate social cognition.

1.4.1
Japanese Macaque Potato Washing

The most often-cited case of nonhuman primate culture is the case of Japanese macaque potato washing (Kawainura, 1959; Kawai, 1965). In 1953, an 18-month-old female named Imo was observed to take pieces of sweet potato, given to her and the rest of the troop by researchers, and to wash the sand off of them in some nearby water (at first a stream and then the ocean). About 3 months after she began to wash her potatoes, the practice was observed in Imo's mother and two of her playmates (and then their mothers). During the next 2 years, 7 other youngsters also began to wash potatoes, and within 3 years of Imo's first potato washing approximately 40% of the troop was doing the same. It was thought significant that it was Imo's close associates who learned the behavior first, and their associates directly after, in that it suggested that the means of propagation of this behavior was some form of imitation, in which one individual actually copied the behavior of another.

The interpretation of these observations in terms of culture and imitation has two main problems, however. The first is that potato washing is much less unusual a behavior for monkeys than was originally thought. Brushing sand off food turns out to be something that many monkeys do naturally, and indeed this had been observed in the Koshima monkeys prior to the emergence of washing. It is thus not surprising that potato washing was also observed in four other troops of human-provisioned Japanese macaques soon after the Koshima observations (Kawai, 1965), which implies that at least four individuals learned on their own. Also, in captivity, individuals of other monkey species learn quite rapidly on their own to wash their food when provided with sandy fruits and bowls of water (Visalberghi and Fragaszy, 1990), The second problem has to do with the pattern of the spread of potato washing behavior within the group. The spread of the behavior was relatively slow, with an average time of over 2 years for acquisition by all the members of the group who learned it (Galef, 1992). Moreover, the rate of spread did not increase as the number of users increased. If the mechanism of transmission was imitation, an increase in the rate of propagation would be expected as more demonstrators became available for observation over time. In contrast, if processes of individual learning were at work, a slower and steadier rate of spread would be expected – which was in fact observed. The fact that Imo's friends and relatives were first to learn the behavior may be due to the fact that friends and relative stay close to one another, and thus Imo's friends very likely went near the water more often during feeding than other group members, increasing their chances for individual discovery.

1.4.2 Chimpanzee Tool Use

Perhaps the best examples to examine in the current context are humans' closest primate relatives, the chimpanzees – especially with regard to tool use and gestural communication, the two behaviors for which cultural transmission has been most often claimed. First, there are a number of population-specific tool-use traditions that have been documented for different chimpanzee communities, for example termite-fishing, ant-fishing, ant-dipping, nut-cracking, and leaf-sponging (for a review, see McGrew, 1992). Sometimes the 'same' tradition even shows variability between groups. For instance, members of the Kasakela community at Gombe (as well as some other groups elsewhere) fish for termites by probing termite mounds with small, thin sticks, whereas in other parts of Africa there are chimpanzees who perforate termite mounds with large sticks and attempt to scoop up the insects by the handful, One possible explanation is that the chimpanzees in the western parts of Africa are able to destroy termite mounds with large sticks because the mounds are soft from much rain, whereas in the east they cannot use this strategy because the mounds are too hard. Each individual thus reinvents the wheel for itself, with population differences due to the different local ecologies of the different groups – so-called environmental shaping.

Although environmental shaping is likely a part of the explanations for group differences of behavior for all species, experimental studies have demonstrated that more than this is going on in chimpanzee culture (see also Boesch et al., 1994). Tomasello (1996a) reviewed all the experimental evidence on chimpanzee imitative learning of tool use (a total of five studies) and concluded that chimpanzees are good at learning about the dynamic affordances of objects they see being manipulated by others, but they are not skillful at learning from others a new behavioral strategy per se. For example, if a mother rolls over a log and eats the insects underneath, her child will likely follow suit. This is simply because the child learned from the mother's act that there are insects under the log – a fact she did not know and very likely would not have discovered on her own. But she did not learn how to roll over a log or to eat insects, these are things she already knew how to do or could learn how to do on her own. (Thus, the youngster would have learned the same thing if the wind, rather than its mother, had caused the log to roll over and expose the ants.) This is what has been called emulation learning because it is learning that focuses on the environmental events involved – the results or changes of state in the environment that the other produced – rather than on the actions that produced those results (Tomasello, 1990, 1996a).

Emulation learning is a very intelligent and creative learning process that, in some circumstances, is a more adaptive strategy than imitative learning. For example, Nagell et al. (1993) presented chimpanzees and 2-year-old human children with a rake-like tool and an out-of-reach object. The tool was such that it could be used in either of two ways, leading to the same end-result of obtaining the object. For each species, one group of subjects observed a demonstrator employ one method of tool use (less efficient) and another group of subjects observed another method of tool use (more efficient). The result was that whereas human children in general copied the method of the demonstrator in each of the two observation conditions (imitative learning), chimpanzees used the same method or methods to obtain the object no matter which demonstration they observed (emulation learning). The interesting point is that many children insisted on this reproduction of adult behavior even in the case of the less-efficient method, leading to less successful performance than the chimpanzees in this condition. Imitative learning is not a 'higher' or 'more intelligent' learning strategy than emulation learning, it is simply a more social strategy – which, in some circumstances and for some behaviors, has some advantages. This emulation learning explanation also applies to other studies of chimpanzee social learning of tool-use activities, such as those by Russon and Galdikas (1993) and Whiten et al. (1996).

Chimpanzees are intelligent and creative in using tools and understanding changes in the environment brought about by the tool use of others, but they do not seem to understand the instrumental behavior of conspecifics the same way as do humans. For humans, the goal or intention of the demonstrator is a central part of what they perceive, and indeed the goal is understood as something separate from the various behavioral means that may be used to accomplish the goal. An observer's ability to separate goal and means serves to highlight for herself the demonstrator's method or strategy of tool use as an independent entity – the behavior she is using in an attempt to accomplish the goal, given the possibility of other means of accomplishing it. In the absence of this ability to understand goal and behavioral means as separable in the actions of others, chimpanzee observers focus on the changes of state (including changes of spatial position) of the objects involved during the demonstration, with the motions of the demonstrator being, in effect, just other motions. The intentional states of the demonstrator, and thus her behavioral methods as distinct behavioral entities, are simply not a part of their experience.

1.4.3 **Chimpanzee Gestural Communication**

The other well-known case is the gestural communication of chimpanzees, for which there are also some population-specific behaviors (Goodall, 1986; Tomasello, 1990). There is one reasonably well-documented example from the wild. Nishida (1980) reported 'leaf-clipping' in the Mahale K group of chimpanzees – thought to be unique to that group but later observed by Sugiyama (1981) in another group across the continent. The reporting of data for individuals in these studies showed that there were marked individual differences within the groups in how (toward what end) the signal was used, for example for sexual solicitation, aggression toward groupmates, or aggression toward humans. One hypothesis is that after one individual used leaf-clipping to make noise (the tearing of the rigid dead leaves makes a very loud noise), others learned via emulation to make the same noise (i.e., they learned the affordances of the leaf). This had different attention-getting effects on conspecifics in the different groups, however, and these were then learned as contingencies. The fact that leaf-clipping has been observed in more than one group, who have had no opportunity to observe one another, raises the possibility of some such process.

This possibility is also supported by studies with captive chimpanzees. In ongoing studies of the gestural signaling of a captive colony of chimpanzees, Tomasello and colleagues have asked whether youngsters acquire their gestural signals by imitative learning or by a process of ontogenetic ritualization (Tomasello et al., 1985, 1989, 1994, 1997). In ontogenetic ritualization, a communicatory signal is created by two organisms shaping each other's behavior in repeated instances of a social interaction. For example, an infant may initiate nursing by going directly for the mother's nipple, perhaps grabbing and moving her arm in the process. In some future encounter the mother might anticipate the infant's impending behavioral efforts at the first touch of her arm, and so become receptive at that point, leading the infant on some future occasion still to abbreviate its behavior to a touch on the arm while waiting for a response ('arm-touch' as a so-called intention movement). Note that there is no hint here that one individual is seeking to reproduce the behavior of another; there is only reciprocal social interaction over repeated encounters that results eventually in a communicative signal. This is presumably the way that most human infants learn the 'arms-overhead' gesture to request that adults pick them up (Lock, 1978).

All of the available evidence suggests that ontogenetic ritualization, not imitative learning, is responsible for chimpanzees' acquisition of communicative gestures. First, there are a number of idiosyncratic signals that are used by only one individual (see also Goodall, 1986). These signals could not have been learned by imitative processes and so must have been individually invented and ritualized. Second, longitudinal analyses have revealed quite clearly, by both qualitative and quantitative comparisons, that there is much individuality in the use of gestures, with much individual variability both within and across generations, which suggests something other than imitative learning. It is also important that the gestures that are shared by many youngsters are gestures that are also used frequently by captive youngsters raised in peer groups with no opportunity to observe older conspecifics. Finally, in an experimental study, Tomasello et al. (1997) removed an individual from the group and taught her two different arbitrary signals by means of which she obtained desired food from a human. When she was then returned to the group and used these same gestures to obtain food from a human in full view of other group members, there was not one instance of another individual reproducing either of the new gestures.

The clear conclusion is that chimpanzee youngsters acquire the majority, if not the totality, of their gestures by individually ritualizing them with one another. The explanation for this learning process is analogous to the explanation for emulation learning in the case of tool use. Like emulation learning, ontogenetic ritualization does not require individuals to understand the behavior of others as separable into means and goals in the same way as does imitative learning. Imitatively learning an arm-touch as a solicitation for nursing would require that all infant observe another infant using an arm-touch and know what goal it was pursuing (viz. nursing), so that when it had the same goal it could use the same behavioral means (viz. arm-touch). Ritualizing an arm-touch, on the other hand, only requires the infant to anticipate the future behavior of a conspecific in a context in which it (the infant) already has the goal of nursing. Ontogenetic ritualization is thus, like emulation learning, an intelligent and creative social learning process that is important in all social species, including humans. But it is not a learning process by means of which individuals attempt to reproduce the behavioral strategies of others.

1.4.4 Nonhuman Primate Social Learning and Social Cognition

Chimpanzee tool use and gestural communication thus provide us with two very different sources of evidence about nonhuman primate social learning. In the case of tool use, it is likely that chimpanzees acquire the tool use skills they are exposed to by a process of emulation learning. In the case of gestural signals, it is likely that they acquire their communicative gestures through a process of ontogenetic ritualization. Both emulation learning and ontogenetic ritualization require skills of cognition and social learning, each in its own way, but neither requires skills of imitative learning, in which the learner comprehends both the demonstrator's goal and the strategy she is using to pursue that goal – and then in some way aligns this goal and strategy with her own. Indeed, emulation learning and ontogenetic ritualization are precisely the kinds of social learning one would expect of organisms that are intelligent and quick to learn, but that do not understand others as intentional agents with whom they can align themselves.

The other main process involved in cultural transmission as traditionally defined is teaching. Whereas social learning comes from the 'bottom up', as ignorant or unskilled individuals seek to become more knowledgeable or skilled, teaching comes from the 'top down', as knowledgeable or skilled individuals seek to impart knowledge or skills to others. The problem in this case is that there are few systematic studies of teaching in nonhuman primates. The most thorough study is that of Boesch (1991), in which chimpanzee mothers and infants were observed in the context of tool use (nut cracking). Boesch discovered that a mother does a number of things that serve to facilitate the infant's activities with the tool and nuts, such as leaving the tools idle while she goes to gather more nuts (which she would not do if another adult were present). But the interpretation of the mother's intention in such cases is far from straightforward. Moreover, in the category of 'active instruction', in which the mother appears to be actively attempting to instruct her child, Boesch observed only two possible instances (over many years of observation). These two instances are also difficult to interpret, in the sense that the mother may or may not have had the goal of helping the youngster learn to use the tool. On the other hand, although there is much variability across different human societies, adult humans in all cultures actively instruct their young on a regular basis in one way or another (Kruger and Tomasello, 1996). Along with imitative learning, the process of active instruction is likely crucial to the uniquely human pattern of cumulative cultural evolution as well.

It should be acknowledged, of course, that this way of viewing nonhuman primate culture and social learning is not the only way of viewing them, and indeed researchers such as McGrew (1998) and Boesch (1999) would likely disagree with many of the current conclusions. Indeed, there are also a number of widely publicized studies purportedly demonstrating that nonhuman primates have theories of mind, deceive their conspecifics, and engage in many other kinds of 'mindreading' activities (e.g., Byrne, 1995). If these studies represented the true picture of nonhuman primate social cognition, it would be a complete mystery why they did not engage in more powerful forms of cultural learning. However, there are in actuality surprisingly few of these studies, and as in all scientific paradigms, a few studies is not enough to settle opinion. My own interpretation of these studies is that they represent cases in which nonhuman primates have acquired clever strategies to manipulate the behavior, not the mental states, of others (for detailed analyses of all the relevant studies, see Tomasello, 1996b; Tomasello and Call, 1994, 1997). If they are not dealing with mental or intentional states, but only behavior, nonhuman primates will not engage in the kinds of cultural learning, that lead to the ratchet effect – and that thus create human-like cultural niches full of symbolic artifacts and instructional formats for the cognitive ontogeny of their offspring.

With regard to nonhuman primate culture in particular, Boyd and Richerson (1996), in a paper entitled "Why culture is common, but cultural evolution is rare", hypothesize that humans and other animals both engage in the same kinds of social and imitative learning but with a quantitative difference. Thus, chimpanzees may have some imitative learning abilities, but they may display them less consistently or in a narrower range of contexts than do humans – or it may even be that only some individuals have these skills. These authors go on to make a quantitatively based evolutionary argument that this rarity itself can make cultural evolution of the cumulative type impossible. So it might be that a quantitative difference in social learning leads to a qualitative difference in the nature of cultural traditions, and in particular how they change and evolve over time. Although there are currently no easy ways to quantify the frequency of imitative learning in the societies of different species, this hypothesis is intriguing because it posits the existence of the kind of variation that might have characterized the human–chimpanzee common ancestor and with which subsequent evolutionary processes might have worked.

1.4.5
Enculturated Apes

It may be objected that there are a number of convincing observations of chimpanzee imitation in the literature, and indeed there are a few. It is interesting, however, that basically all the clear cases in the exhaustive review of Whiten and Ham (1992) concern chimpanzees that have had extensive amounts of human contact. In many cases, this has taken the form of intentional instruction involving human encouragement of behavior and attention, and even direct reinforcement for imitation for many months [e.g., 7 months of training in the case of Hayes and Hayes (1952) and 4 months of training in the case of Whiten and Custance (1996)]. This raises the possibility that imitative learning skills may be influenced, or even enabled, by certain kinds of social interaction during early ontogeny.

Confirmation for this point of view is provided in a study by Tomasello et al. (1993b). It compared the imitative learning abilities of mother-reared captive chimpanzees, enculturated chimpanzees (raised like human children and exposed to a language-like system of communication), and 2-year-old human children. Each subject was shown 24 different and novel actions on objects, and each subject's behavior on each trial was scored as to whether it successfully reproduced (a) the end result of the demonstrated action and/or (b) the behavioral means used by the demonstrator. The major result was that the mother-reared chimpanzees reproduced both the end and the means of the novel actions (i.e., imitatively learned them) hardly at alt. In contrast, the enculturated chimpanzees and the human children imitatively learned the novel actions much more frequently, and they did not differ from one another in this learning. Interesting corroboration for this latter finding is the fact that earlier in their ontogeny, these same enculturated chimpanzees seemed to learn many of their human-like symbols by means of imitative learning (Savage-Rumbaugh, 1990).

For the issue of chimpanzee culture in the wild, these results raise an important question. Which group of captive chimpanzees is more representative of chimpanzees in their natural habitats: mother-reared or enculturated? Are enculturated chimpanzees simply displaying more species-typical imitative learning skills because their more enriched rearing conditions more closely resemble those of wild chimpanzees than do the impoverished rearing conditions of other captive chimpanzees? Or might it be the case that the human-like socialization process experienced by enculturated chimpanzees differs significantly from the natural state and, in effect, helps to create a set of species-atypical abilities more similar to those of humans?. There can be no definitive answer to these questions at this time, but one possibility is that a human-like sociocultural environment is an essential component in the development of human-like social-cognitive and imitative learning skills, no matter the species. That is, this is true not only for chimpanzees but also for human beings – a human child raised in an environment lacking intentional interactions and other cultural characteristics in all likelihood would also not develop human-like skills of imitative learning.

The hypothesis is thus that the understanding of the intentions of others, necessary for reproducing another's behavioral strategies, develops in, and only in, the context of certain kinds of intentional interactions with others (Tomasello et al., 1993a). More specifically, to come to understand others in terms of their intentions requires that the learner him- or herself be treated as an intentional agent in which another organism encourages attention to and specific behaviors toward some object of mutual interest – often reinforcing in some manner the learner's successful attempts in this direction (Call and Tomasello, 1994, 1996). Such interactions are not sufficient, of course, as many animals are subjected to all kinds of human interaction, and even direct instruction, without developing human-like skills of imitative learning (and the same is true of human children with autism). The important point for current purposes is that in terms of these dimensions of social interaction, captive chimpanzees raised by conspecifics are a better model for wild chimpanzees than are chimpanzees raised in human-like cultural environments – since wild chimpanzees receive little in the way of direct instruction from conspecifics.

A corollary hypothesis is thus that the learning skills that chimpanzees develop in the wild in the absence of human interaction (i.e., skills involving individual learning supplemented by emulation learning and ritualization) are sufficient to create and maintain their species-typical cultural activities, but they are not sufficient to create and maintain human-like cultural activities displaying the ratchet effect and cumulative cultural evolution. The fact that chimpanzees and other great apes raised from an early age and for many years in human-like cultural environments may develop some aspects of human social cognition and cultural learning demonstrates the power of cultural processes in ontogeny in a particularly dramatic way. The effect of cultural environments on nonhuman primate cognitive development is thus a question that deserves more empirical investigation.

1.5 Conclusions

It is easy to observe a human behavior and posit a specific gene for that behavior with no research into the genetics of the situation. Many scholars and popularists of biological and social sciences make their living doing just that. But when we have behaviors that are unique to a species, we have serious time constraints on such hypotheses, and so the positing of a large number of significant genetic events becomes highly implausible. In the case of humans, the time frame for the emergence of their unique cognitive skills is almost certainly in the range of 2 to 0.3 million years ago with my own theoretical bias being toward the smaller of those figures. But the genetic event that happened at that time was not an everyday genetic event. It was not an everyday genetic event because it did not just change one relatively isolated characteristic, it changed the nature of primate social cognition, which changed the social-cultural transmission process characteristic of primates, which led to a series of cascading sociological and psychological events in historical time. The new form of social cognition that started the entire process involved understanding other persons as intentional agents like the self, and the new process of social-cultural transmission involved several forms of cultural learning, the first and most important being imitative learning. These new forms of cultural learning created the possibility of a kind of ratchet effect in which human beings not only pooled their cognitive resources contemporaneously, they also built on one another's cognitive inventions over time. This new form of cultural evolution thus created artifacts and social practices with a history, so that each new generation of children grew up in something like the accumulated wisdom of their entire social group, past and present.

And so, while not denying that a significant genetic event happened in human cognitive evolution, probably fairly recently, I would deny that this event specified the detailed outcomes we see in adult humans today. In my view, that genetic event merely opened the way for some new social and cultural processes that then, with no further genetic events, created many, if not all, of the most interesting and distinctive characteristics of human cognition. Perhaps of special importance was a new form of perspectively based cognitive representation that emerged when children began to learn and use linguistic symbols, evolved over historical time for inducing others to construe certain situations in certain ways, which necessitated an internalization and representation of the different perspectives of other persons. *This* story is not as simple as the 'genes create all novelties' story, but it accords better with data from both anthropological and developmental psychological investigations. Modern human adult cognition is a result not just of processes of biological evolution, but also of other processes that human biological evolution made possible in both cultural historical time and individual ontogenetic time.

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2
Cognitive Evolution

Olaf Diettrich

2.1
Introduction

One may ask what kind of rationale can justify a handbook on evolution in so many different areas. We might answer that there is a sort of unity to evolution, saying that the various evolutions have more in common than just the fact that something evolves. In some cases this is easy to show, in others not, and in still others we believe that there is no commonalty at all. I think we should focus our attention on whether the various areas are inherently linked to each other, and on why and how, rather than writing independent essays on the state of the art in the various areas. As to cognitive evolution, this means that we accept – tacitly or explicitly – the premise that cognitive evolution is the continuation of organic evolution by equal or (perhaps) other means. Cognitive capabilities contribute to survival as much as organic tools do. There seems to be no a priori reason why cognitive evolution should 'use' different strategies than organic evolution. This applies at least to the cognitive 'hardware', i.e., the various sense organs. It seems, indeed, reasonable to believe that sense organs evolved according to (neo)Darwinian principles to increase their sensitivity for physical input data.

But does it hold also for the 'software' concerned, i.e., for the mental interpretation of sensorial input (i.e., our perceptions) which we use to come to useful decisions? Does it hold also for the regularities we find in our perceptions, which we condense to what we call the laws of nature? Does it hold also for the higher, scientific, interpretation of what we experience, which we use to construct our scientific world picture?

How relevant is the fact that we can transfer knowledge not only genetically but also culturally? That is, do the evolution of science and culture follow the same principles as organic evolution? Or do we have to follow Gould (1979), Hayek (1983) and Medawar (1988) in saying that organic evolution is Darwinian whereas cultural evolution is Lamarckian?

What about epistemology in its quality as physical metatheory: can we follow Campbell (1974a) who speaks of a natural selection epistemology? If so, what sort

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of metaphysical commitment, such as realism, do we have to make before we can allow nature to select the way we see it? And if selection really does come into play: to what extent does it act on the mental mechanisms that transform sensorial input into knowledge, or does it act primarily on what is brought about by these mechanisms, i.e., on the resultant theories? In other words, what is the relationship between the so-called literal and analogical versions of evolutionary epistemology? The literal version emphasizes that cognitive mechanisms evolved biologically and thus affect what kind of innate knowledge can be acquired. This is described by Bradie (1986) in his evolution of cognitive mechanisms program (EEM) and Ruse (1986). The analogical version emphasizes the aspect that human knowledge (by analogy to organic evolution) is governed by natural selection processes. This is represented by Campbell's (1974a, b) natural selection epistemology as well as by Bradie's (1986) evolution of theories program and the Spencerian approach of Ruse (1986). I will return to this point when discussing more generally how action and perception may be linked to each other.

And what about the teleological question? According to general understanding, epistemic evolution progresses towards a goal (truth). So does scientific evolution which is said to be teleological in character, in so far as it will converge (though in sometimes rather roundabout ways) toward the hoped-for end that physicists call the *theory of everything* (Barrow, 1990). In contrast, organic evolution obviously has no specific focus towards which all species will converge, the *pride of creation* so to say (Campbell, 1974a).

Another discrepancy, already emphasized by Piaget (1974), is that we see organic evolution in terms of autonomous internal modifications (mutation, recombination, etc.), to which the external world reacts by means of selection mechanisms. However, in cognitive evolution we speak in terms of an autonomously existing and changing world to which intelligent beings react by forming theories and learning. So, the attribution of action and reaction is opposite in the theories we use to describe organic and cognitive evolution.

Here is another difference: in the organic area we can modify our environment by means of inborn or technologically acquired tools (assimilation) with a view to modifying the selection pressure so as to cope more easily by our adaptive efforts. (This is a rather successful tool in all instances where we have no time to wait for evolution to increase our adaptive competence.) In the cognitive area the selection pressure is given by the laws of nature (a theory is 'true' and thus successful if it reflects the laws of nature). So far as these laws are seen to be ontologically objective (and invariant in time), cognitive evolution, as opposed to organic evolution, has no chance to modify its selection pressure. If so, cognitive evolution would be the better playground for adaptationists, because there are clearly defined objects of adaptation, whereas organic evolution contributes considerably to constructing its own adaptive boundary conditions.

In addition to the mechanisms and the 'software' in the narrow sense that we use to improve our knowledge, we have to deal with the more general strategies applied. This is, first of all, induction. Next to induction, rationality enjoys the highest credibility of the various cognitive strategies. To improve and strengthen the methods of rational thinking is indeed seen to be of general utility, not only in science but also in the world of day-to-day living. From what we understand as the success of rationality, it is often derived that it must be based on the constitution of the world we live in, and, consequently, that the world's order can be decoded only by means of rational methods. From this assumption, then, we conclude that even when a consciously applied rationality can be excluded (as in the workings of the subconscious or the behavior of animals), the success of organs is guaranteed only insofar as they meet rational criteria, i.e., insofar as they are ratiomorphic (Brunswik, 1955). This means that strategies and construction principles (concerning both the physical and the cognitive contexts) have to consider all relevant facts in the same manner as an accordingly informed analyst would do.

The question here is: are there alternatives to rational thinking that are nevertheless useful in the human context?

We see that there are discrepancies between the various theorists advocating the discussion of cognitive evolution within the wider context of general evolution and those attributing a strategic autonomy to cognitive evolution. This would be of minor relevance insofar as we can describe both evolutions by means of similar notions and categories, such as natural selection. But it becomes problematic if we would find out that notions such as the Darwinian/Lamarckian dichotomy cannot be applied equally well in the cognitive area or in the area of induction, which obviously cannot be translated into a sort of organic analogue.

I cannot deal here with all the previous approaches to solve one or the other of these problems. Those who are interested in this can find ample information in the Blackwell Companions to Philosophy, particularly *A Companion to Epistemology* (Dancy and Sosa, 1992) and *A Companion to the Philosophy of Mind* (Guttenplann, 1994). Rather, I will concentrate on approaches that, in my opinion, throw some light on the contradictions involved, hoping that this will provide us with new evidence for the concept of the unity of evolution.

2.2 The Equivalence Postulate

At the beginning of all efforts to see the development of cognition in biological terms, i.e., as cognitive evolution, was the idea that there is a certain equivalence between elements of organic and cognitive evolution. In particular, some have postulated that adaptational processes in the organic area correspond to the acquisition of knowledge in the cognitive area (equivalence postulate, see Wagner, 1984). This led to comparing the organic and cognitive devices concerned.

Phylogenetically acquired cognitive devices, i.e. learning programs have been compared with organic instruments such as homeostatic mechanisms, antlers, or limbs. Lorenz (1971, pp. 231–262) and Popper (1973, p. 164) classed theories and organic devices under the common concept of survival tools and considered both to be theories in a broad sense (defined below). This suggests that we need to distinguish two kinds of theories:

- *Theories in the structural sense* are considered to be a picture, an image, or a mapping of a given or created object. This understanding of a theory is mainly found in the natural sciences and in mathematics. Such theories are considered true insofar as they are isomorphic with the structures they describe. Structural theories require that the objects concerned have an independent if not ontological character.
- *Theories in the functional sense*: Lorenz (ibid.) and Popper (ibid.) suggested expanding the notion of theory to include all kinds of problem-solving instruments. This concept of theory would include physical theories insofar as they help us to master technical problems and to control physical nature, the inborn categories of space and time we use to interpret perceptions and to coordinate mechanical activities, limbs as instruments for locomotion, biological species as an instrument to meet the particular requirements of a special biotope, and social communication and social entities as tools to meet the requirements of the broad social environment.

I call all these various kinds of theories 'theories in the broader sense', as opposed to rationally generated theories in the usual sense, such as physical theories. The latter can include both structural theories (if they claim to depict structures of the world) and functional theories (if they provide us with correct predictions).

The alleged equivalence between organic devices, which have to meet functional requirements, and cognitive tools, which have to provide us with true statements on the world, is here reduced to an equivalence between functional and structural theories.

Functional theories are better the more they meet the given requirements. Structural theories, however, are better the more isomorphic they are with the structures they have to depict. These statements are equivalent, in the sense that a structural theory that is isomorphic with the structures of reality (Popper, 1982) speaks in terms of truth and verisimilitude) also has functional qualities. In other words, structurally true theories are considered to be functionally helpful theories. The opposite is not necessarily true. A theory that is seen to be structurally false may nevertheless provide us with useful forecasting power. For example, Galileo found many of the regularities of the paths of the planets. But lacking the concept of Newtonian gravitation, he came to a false conclusion in explaining the paths of the planets as circular inertial orbits around the sun.

The alleged equivalence of structure and function or of truth and efficiency is the main legitimization of all empirical science. Although we often start from functional experiences that we try to explain a posteriori by means of structural theories, the general strategy for mastering nature, particularly in the basic sciences, is to search for the structures of nature. This is considered as a heuristic imperative. Hence it follows that an independently existing nature as summed up in the notion of reality is the only possible source of competent criteria for evaluating any empirical theory.

Theories in the usual sense must be teleological in character. Their progress is said to be guided by the structure of reality or, more precisely, by boundary conditions that reflect these structures, rather than being the result of autonomous, independent development. Scientific evolution, therefore, must converge – not necessarily monotonously but at least asymptotically – toward a final state that will constitute the definitive, correct description of nature. Davies (1990b) sees this view as follows:

> Let me express this point in a somewhat novel way. Hawking (1979) has claimed that 'the end of theoretical physics may be in sight'. He refers to the promising progress made in unification and the possibility that a 'theory of everything' might be around the corner. Although many physicists flatly reject this, it may nevertheless be correct. As Feynman (1965) has remarked, we can't go on making discoveries in physics at the present rate forever. Either the subject will bog down in seemingly limitless complexity and/or difficulty, or it will be completed.

What has been said here can be summarized as follows: The alleged relationship between structure and function means not only (1) that a theory's structure determines its functional qualities, but also (2) that the structure of what we call nature determines the theories we have to apply in order to cope functionally with this nature.

The first allegation says that the functional success of a theory may depend on its structure. But from its success we cannot conclude that a theory is true, as long as the only criterion is nothing but its success – unless we agree that 'true' and 'successful' are synonymous. (Similar reasoning applies to fitness which could be considered the organic analog of truth: If fitness is defined by nothing but its contribution to survival, it is synonymous with survival and cannot be an independent category, i.e., we are led to the well known tautology of the 'survival of the fittest'.)

The second allegation is based on the suggestion that a problem determines the methods needed for its solution, i.e., that functional adaptation determines the structures and procedures by means of which adaptation will be achieved. This is obviously not true. Horses and snakes, for example, although they may have developed in exactly the same physical environment, have entirely different organs of locomotion, which have no structural element in common. So, the hooves of horses cannot be considered, as suggested by Lorenz (1966), to be a kind of image of the steppes on which they live (see Wuketits, 1990, 1998).

2.3
Our Inborn World View

To the cognitive tools (as included in what Riedl (1980) called the cognitive apparatus) belong what we usually view as metatheories, i.e., the categorical reference frame we use to describe the world. Metatheories are neither universal metalanguages by means of which we can portray all we like, nor do they determine the theories brought into existence under their authority. They rather constitute important boundary conditions. A metatheory stating that the world is made of particles having independent identity and moving around in three-dimensional (3D) space cannot deal with subatomic processes. In the same sense, cells can be seen as metatheories for metazoa. Cells of course do not determine a certain phenotype, but they constitute boundary conditions. For example, because cells do not know about remote interaction, plants and animals must be physically compact entities.

Before discussing how metatheories come into being and whether selection mechanisms are involved, we have to take a more detailed look at what metatheories are. Describing something, whether by means of language, a theory, or mathematical formulae, means a notional mapping within a notional reference frame, i.e., within a metalanguage, metaphysics, metamathematics, or more generally, within a metatheory. (The theories that themselves do the mapping within a metatheory are called object-theories.) Such a reference frame is a prerequisite for any description, in the same way as spatial localization requires a geometrical reference frame. However, it is not always necessary to be explicitly aware of the metatheory concerned. Particularly in ordinary languages, all people make unconscious, but more or less correct, use of the same (or nearly the same) metalanguage. Otherwise no meaningful communication would be possible. For a long time, philosophers (particularly analytical philosophers) generally felt that the imperfection of our philosophical speaking is mainly due to the lack of an objective metalanguage, or at least to the fact that people do not use exactly the same metalanguage. Accordingly, striving for an objective metalanguage was seen to be the good approach to finishing epistemology. It was a bitter experience when Gödel (1931) showed that a definitive, objective metalanguage for mathematics in the form of objective axioms is impossible and that similar conclusions would apply to any descriptive tool, including language in general. I will derive here, from a constructivist evolutionary epistemology (CEE, Diettrich, 1991), a conclusion that physics also cannot be based on a definitive set of objective laws of nature (the axioms of physics, so to speak). Then we will be able to say that neither is there an objective metalanguage from which we can derive all true statements, nor are there axioms from which we can derive everything in mathematics, nor are there objective laws of nature (and therefore, no theory of everything) from which we can derive everything that physically can happen in nature. Or, in other words: there is no definitive world view. Neither is there an absolute reference frame in space (as we know from Einstein), nor are there absolute notional reference frames whether in language, mathematics, or physics.

2.3.1 Induction

The most enigmatic element of metaphysics is that unexperienced experiences can be derived and predicted from experienced experiences by means of induction. Thinking in terms of induction is the most elementary and the most frequently used strategy for organizing our lives. Whether in day-to-day life where we have to make our usual decisions on the basis of incomplete data or unconfirmed hypotheses, in science where we have to conceive theories on how to extrapolate empirical data, or in philosophy of science where we try to find a basis for teleology or determinism – inductive thinking dominates all we do and is the most successful of all the mental concepts people apply.

The obvious and uncontested success of induction is one of the greatest fascinosa that the philosophy of science was ever confronted with (Stegmüller, 1971). Despite all philosophical efforts, we are more or less still in the same position as that described by Hume 250 years ago: universal laws can be justified only by induction, which he understood to be unjustifiable, although natural. Chalmers said (1982, p. 19):

> Faced with the problem of induction and related problems, inductivists have run into one difficulty after another in their attempts to construe science as a set of statements that can be established as true or probably true in the light of given evidence. Each maneuver in their rearguard action has taken them further away from intuitive notions about that existing enterprise referred to as science. Their technical program has led to interesting advances within probability theory, but it has not yielded new insights into the nature of science. Their program has degenerated.

Nearly the only progress achieved until now is in clarifying and specifying the problem itself.

The key notion in this context is what Wigner (1960) called "the unreasonable effectiveness of mathematics in the natural sciences", meaning that it is difficult to understand why so much of the complexity of the world can be described by such relatively simple mathematical formulas. Davies (1990a) had a similar idea in mind when, following an idea of Solomonoff (1964), he said:

> All science is really an exercise in algorithmic compression. What one means by a successful scientific theory is a procedure for compressing a lot of empirical information about the world into a relatively compact algorithm, having a substantially smaller information content. The familiar practice of employing Occam's razor to decide between competing theories is then seen as an example of choosing the most algorithmically compact encoding of the data. Using this language, we may ask: Why is the universe algorithmically compressible? and why are the relevant algorithms so simple for us to discover?

Another version of the same question is "how can we know anything without knowing everything?" and, more generally, "why is the universe knowable?" (Davies, 1990a). The most typical examples are the correct prediction by means of linear extrapolation. Here, again, the development of certain systems can be compressed into the most simple (i.e., linear) relationship.

However, Popper (1982, p. 4) goes further in criticizing the notion of induction: despite all the practical successes of inductive thinking, according to him natural science should dispense with induction completely, because it cannot be justified. His argument is that a general principle of induction can be neither analytic nor synthetic. Were it analytic it could not contribute to the growth of knowledge and therefore would not be inductive. Were it synthetic it would have to be justified by another inductive principle of a higher order which would lead to an endless regression.

2.3.2 Reality

The above and many other positions concerning induction have one thing in common: they arise from our intuitive conviction that there is some reality that exists independently of us, which we have to recognize without having any a priori idea of what it may look like. In other words: all these positions arise from the claim to organize our lives according to an independent reality that is to be described in terms of its structure. With Popper (1973), our way of coping with reality is comprised in the term 'growth of knowledge', to which induction must contribute, and which can be defined only in the context of some reality about which we may accumulate knowledge.

Davies takes a more explicit stand (1990a):

> There exists a real external world which contains certain regularities. These regularities can be understood, at least in part, by a process of rational enquiry called scientific method. Science is not merely a game or charade. Its results capture, however imperfectly, some aspect of reality. Thus these regularities are *real* properties of the physical universe and not just human inventions or delusions. ... Unless one accepts that the regularities are in some sense objectively real, one might as well stop doing science.

The nearly generally agreed view that the problem of induction can and must be solved only within the framework of an ontological reality is the most influential metaphysical element in all sciences. Even more: induction would not be a problem at all if it were not expected to expand our knowledge about a real world. This argument, however, becomes problematic when carried on within the so-called evolutionary epistemology (EE), even though EE was developed with the particular view of acquiring a better understanding of the human categories of perception and thinking, i.e., of our physical metatheory. The classical version (as I call it) of EE (Vollmer, 1975) declares that these categories, such as space, time, object, reality, causality, etc., result from evolution in the same way as organic elements and features do. This, in classical parlance, means that in the same way as organic evolution is guided by adaptive forces, cognitive evolution is the result of adaptation to the independent structures of an ontological reality. Campbell (1973) speaks in terms of a 'natural-selection epistemology'.

The general argument goes as follows: the theories we have designed to describe the structures of reality are surely incomplete or may have other strong deficiencies – reality itself, however, has been developed as a category of human thinking just because of the ontological character of outside reality. The fact that we think and act in terms of reality is taken as a proof that a sort of reality must exist. What I try to do here is to explain the formation of the category of reality by means of reference to its own content, i.e., to the existence of an ontological reality. In addition to the fact that such reasoning would lead to circular inference is an even stronger objection: the existence of an ontological reality may, of course, have been a good reason for mental evolution to emulate it by creating a corresponding category of thinking. This argument, however, cannot be reversed. That is, we cannot say that human mental phylogeny never would have come up with the category of reality if there were no such thing as an ontological reality, so long as other reasons can be found that are functionally conceivable and phylogenetically plausible even though they do not refer to an ontological reality (see Section 2.4).

Most people, upon hearing that reality may not be really real, would argue that ignoring the existence of tables, trees, traffic lights, or whatever we find in our environment is unacceptable. Of course – but these are objects or facts that we can, at least in principle, alter or displace according to what we intend. Let me call this 'actuality' (Wirklichkeit). In contrast, I speak of 'reality' (Realität) as something that can neither be ignored nor be modified by anything we do. According to classical thinking, this notion applies in a strict sense only to the laws of nature. Indeed, we are fully subject to the laws of nature: it is not advisable to ignore them, nor can we modify them. So, disputing the ontological character of reality is reduced here to saying that there can be no definitive or objective laws of nature. (It is evident that this view has no solipsistic consequences, which people sometimes see when realism is disputed in general.) I discuss this in detail in Section 2.4 on the cognitive operator theory: what we call the laws (or the properties) of nature depends on our cognitive apparatus in the same way as in physics the properties of objects depend on how we measure them.

2.3.3
The Conservation of Identity

Another a priori concept (also from classical physics) is that identity is conserved in time. That is, we do not consider the thought that something can loose its identity and then be 'reborn' later. We rather say that an object was invisible for a while, or that two equal (but not identical) objects appeared. Identity cannot be interrupted without the object's losing its character.

2.3.4
The 3D Structure of Visual Perception

Seeing the world in 3D allows us to distinguish between a (visible) reduction in size due to physical compression and one due to distance. But we cannot say that our space for visual perception is 3D because the world itself is 3D in character, or that apes that could not see the world in 3D were unable to jump from tree to tree and therefore could not survive to become our ancestors (Lorenz, 1983). It is easy to show that appropriate, successful survival strategies could well be based on 2D or 4D perception spaces, independent of how many degrees of freedom are actually available.

With 2D perception, we would not know the phenomenon of perspective. Things are small or things are big, but they do not seem to be small because they are more distant and they do not seem to be big because they are nearer, because distance to the observer belongs to the third dimension that is excluded here. But objects, nevertheless, would shrink if we moved backwards and would enlarge if we went forward. So, with 2D perception we would develop a world view according to which, not only our hands and mechanical tools can modify objects, but also our movement. With such a perception, an ape may well be able to jump from branch to branch. The only thing he has to learn is that he has to grasp the branch seen just when its size and position meet certain typical values. If the perceived size of a branch doubles after three steps, the ape must know that he will arrive at it after another three steps and then has to grasp it. If he has learnt to do so, an external observer would find no difference between the movement strategies of such an ape and those based on 3D perception. (It is evident that physical theories based on an inborn world view according to which objects can be 'deformed' not only by means of our hands but also by means of our walking or jumping would have no similarities with the theories we are used to apply.)

We can explain this by another example: let us imagine locally fixed plants that have eyes, can see, and may have acquired a 2D perception. They would tell you that they have smaller and larger companions. For us this would be due to different distances, but not for these plants. As soon, however, as they learn to communicate and tell each other what they see, they would find out that what is small to one observer may well be large to another one. After some perplexity they may construct a theory of relativity of size, saying that size is not absolute but depends on the relative position of observers – something difficult to understand for someone who is used to living in a 2D perceptional space. Exactly the same thing happened to physicists when empirical evidence forced them to construct the theory of special relativity, which states that time intervals are not absolute but depend on the relative motion of the observer – difficult to understand for someone who is used to living in a Newtonian world. (This analogy can even be extended: the (relativistic) limit to speed in the 3D world ($v \leq c$) corresponds to the limit to length in the 2D world, because length can be defined only by means of an aperture $\alpha \leq 180°$).

The question of whether modifications of visual perceptions should be interpreted geometrically or physically is well known from another example in physics: the orbits of planets cam be considered as the effect of explicit gravitational forces (the physical interpretation) or as geodetic lines within a 4D space (the geometrical interpretation according to the theory of general relativity). Because these are merely different interpretations of the same observations we cannot decide between them on empirical grounds, nor was adaptation or selection relevant when the cognitive evolution of primates had to 'decide' whether to see the visual world in 2D or 3D. In other words: perceptional spaces and systems of categories are purely descriptive systems that may tell us something about how we see the world but nothing about the world itself. So they cannot be the outcome of adaptation to the world. *From this it follows that our epistemology cannot be a natural selection epistemology,* because adaptation values cannot be attributed to single characters (Curio, 1973; Bock, 1980). Some obviously counterproductive characters can nevertheless survive, so long as other characters compensate for its weakness. What counts is the fitness of the organism as a whole. So, the fact that we are surviving quite well with a 3D perception space cannot be taken as an argument that this is due to adaptation.

2.4
The Cognitive Operator Theory

That our natural epistemology cannot be a natural selection epistemology in Campbell's sense does not dispense with the need for explaining why the evolution of our natural epistemology went just this way and not another. In particular, it does not exclude the suggestive idea that organic and cognitive evolution must be linked to each other, or even more, that organic evolution has brought about cognitive evolution, i.e., that cognitive evolution may well be considered the continuation of organic evolution by other means. From this one may suggest that a good theory of evolution is required to describe both organic and cognitive evolution in a strictly coherent way.

To understand cognitive evolution from an organic point of view, I start here from a constructivist extension (CEE, Diettrich, 1991) of classical evolutionary epistemology (EE). The particularity of the CEE is based on a methodological element used mainly in physics, the so-called operational definition of physical terms. The usual dilemma regarding evolutionary and constructivist approaches to epistemology is that physicists in particular have difficulty in getting used to these ideas. The epistemological approach used here goes just the opposite way: physics transfers one of its most important modern elements (i.e., operational definition) to cognitive considerations rather than constructivism imposing its ideas on physics.

What does an operational definition mean? As is well known, classical physics failed to accommodate the phenomena of quantum mechanics and special relativity.

In our everyday life this epistemological refinement is not necessary. We have a clear understanding of what the length or the weight of a body means, and we do not need confirmation by a tape measure or a scale to carry on with our lives. However, the situation is different with microscopic distances that are smaller than atoms. Here, first of all, we have to decide what kind of experimental facility we will use to define length or momentum. Physicists say that properties are defined as invariants of measurement devices. This even applies to the order in time of events which, under normal conditions, can easily be defined and detected. At very high speeds, however, the topology of events may depend on relative motions, as we know from the theory of relativity.

Since this kind of experience can be repeated again and again, it suggests a generalization that can be summarized as follows: properties of whatever kind and of whatever subject have no ontological quality. Instead they are defined by the fact that they are the invariants of certain measurement operators. This contrasts with classical thinking, in which properties are used for the objective characterization of objects. Usually, and most importantly, we assume that properties are independent entities in an antological sense. In everyday life this is incontestable. The length of a body and its color exist independent of each other and can be measured separately. This does not necessarily apply in subatomic regions, as we know. The position and momentum of submicroscopic particles cannot be measured independently of one another. Physicists learned from this that theoretical terms have to be defined operationally, i.e., they have to describe nature by means of theories in which terms are accepted only if they can be defined by certain experimental facilities, rather than by means of theories in which categories and notions are defined by protophysical common sense.

The crucial step of CEE is to suggest that not only theoretical terms have to be defined operationally, but also observational terms, as well as mathematical and logical terms.

Theoretical terms are defined as invariants of operations represented by physical measurement devices.

Observational terms, comprising both visually perceived regularities (patterns) and those we condense into theories and into what we call laws of nature, are considered to be invariants of phylogenetically evolved mental cognitive operators. These operators are physiologically implemented somewhere in our brains and can be considered a kind of cognitive measurement device: measurement objects are the sensory inputs and measurement results are perceptions, i.e., views, and, within these views, certain regularities, structures, or patterns, rather than numbers or pointer positions. Therefore, the entire system of laws of nature we have derived from these regularities cannot be objective entities but only mental constructs.

In this context, the often-discussed dichotomy of observational and theoretical terms is reduced to a rather secondary difference: observational terms have developed phylogenetically in the unconscious parts of the human brain, whereas theoretical terms are the outcome of conscious, rational efforts. Nevertheless, observational terms remain privileged as the basic elements of any higher theories. We can modify theories according to observational data, but we cannot modify the genetically fixed mental operators and their invariants according to the requirements of special situations.

It is useful to realize that organizing our perceiving and thinking in terms of invariants is not only a view suggested here by physics. As shown by Piaget (1967) it might well be an old inborn tendency in human cognition. According to him, cognitive functions construct invariants in all areas where this is necessary for their operating. Even when this is not directly suggested by actual experiences, invariants are attributed to objects and the outside world rather than seen as the outcome of cognitive functions. When dealing with the physical theory of Hamilton–Jacobi (see below), we will see that this is not the only instance in which something invented by physicists acquires a deeper meaning when seen from the side of cognitive science.

2.5 The Operational Definitions of Space, Time, and Causality

2.5.1 Space

The most crucial consequence of what has been said above is that space, time, and causality, which, according to Kant, are the necessary categories on which all external appearance is based, are not the only possible (and therefore necessary) categories. They are rather the phylogenetically evolved features of human perception and interpretation, defined operationally as invariants of certain actions and transformations. Let us look at this in more detail.

Following Piaget (1974), the *spatial metric* of our perceptional space (and therefore its topology) is operationally defined by means of motion. The identity of extended subjects, therefore, is defined as an invariant of locomotion (Uexküll, 1921: "A body is what moves together as a unit"). This definition is probably the main reason for the major difference between what we call space and what we call time. Time is said to flow in an irreversible way; no one can retrieve any part of the past. We cannot move back and forth between two points in time. But we can do so quite well between two points in space. If we say we travel from point *A* to point *B* and than back again to *A*, we mean that the *A* where we started before arriving at *B*, and the *A* to which we arrived after leaving *B*, are not only equal but identical. To say this is, however, possible only if we can distinguish between 'equal' and 'identical' and if what we call identical is not influenced by our travel. This means that identity is defined as the invariant of motion. And exactly this is the point. Only on grounds of such a definition can we call a change in spatial positions reversible, or more precisely: only on the basis of such a definition can we distinguish between the repeated return to the same *A* and travel along a sequence of equal *A*'s, i.e., between periodicity in time and space.

In a similar way, locomotion can change the visually perceived environment. We can transform the perception we call 'forest' by walking into the perception we call 'city'. But this is not what we are accustomed to saying. It is more common to speak in terms of an environment which, a priori, is multidimensional in character, i.e., comprising at the same time several structures that differ, first of all, in what we call their spatial positions. What we achieve, then, by means of walking, is not a modification of our respective environment. We just 'go' to places consisting of different structures and therefore experience different perceptions. What we call the multiplicity of the world, thus, is defined as invariant to changing our position in that world. From the functional (and CEE) point of view, mentally generated spatial views belong to the most elementary theories we have at our disposal, by means of which we can forecast perceptions when walking – in the same way as the temporal structures stored in our memory inform us about what we can expect when repeating certain actions. So, both the formation of visual patterns and the formation of memory are first of all modes of extending life competence.

2.5.2 The Arrow of Time

Within the context of our day to day experiences we have a very clear understanding of what past and future are. Past is what embodies all the events we have experienced; past is the source of all knowledge we have acquired. Future is the subject of our expectations; future embodies events that may happen and for which we have to wait to see if they really will happen. How can we express this by means of physical theories? Or, more precisely and according to the operationalization concept: are there devices or processes that can operationalize the terms 'past' and 'future', i.e., the arrow of time?

Many efforts have been made in this direction (Zeh, 1984). The result is short and disappointing: in all cases where it is said that the arrow of time has been operationalized it can be shown that the direction of time was already contained implicitly in the preconditions of the experiment. A typical example is the following: shaking a box containing black and white balls placed in order according to their color always leads to disorder and never again to order. In physical terms: entropy increases in time and never decreases. Entropy therefore seems to operationalize the arrow of time. But in this instance, the result depends on what we do first, separating the balls or shaking them. Shaking before separating leads to order. Shaking after separating leads to disorder. So we already have to know what the terms 'before' and 'after' mean before we can do the experiment that is to tell us what 'before' and 'after' mean. Another example: a hot physical body left in a cooler environment always cools down. But this applies only if the collisions between the atoms involved are endothermic, i.e., if the kinetic energy of the colliding partners is higher before the collision than after. However, if we have exothermal processes, which are characterized by the fact that the kinetic energy of the particles involved is higher after the collision, then the body heats up rather than cooling down. Here again we have to know what 'before' and 'after' mean in order to define the collision process that will define the result of the experiment that is to define the arrow of time.

These are particular examples. Prigogine (1979, p. 220) has showed in a more general way that irreversible processes in thermodynamics cannot help us to operationalize the arrow of time: the existence of the so called Ljapunow function – which is closely related to macroscopic entropy – is a prerequisite for the distinction between past and future also in microscopic systems. Unfortunately, the Ljapunow function is ambiguous with respect to the arrow of time. It can be constructed in a way such that equilibrium is achieved in the future, in accord with classical thermodynamics, but it can also be constructed so that equilibrium is 'achieved' in the past.

From all this, one can make the hypothesis that, in principle, the arrow of time cannot be operationalized objectively, i.e., it cannot be derived from what we call nature. What 'past' and 'future' mean, then, can be described only by means of a sort of mental operationalization. The following definition, for example, may be suitable: from two perceived events *A* and *B*, *A* is said to be before *B* if we can remember *A* when *B* happens but not *B* when *A* happens. Of course, past is what we can remember but we cannot remember the future. This 'mentalization' of past, present, and future, I think, is very close to what Einstein (published 1972) may have had in mind when he wrote to his friend Bosso "that these categories are sheer illusions".

2.5.3 Causality

To define causality we must be able to identify patterns of events. If several events, say *A*, *B*, *C*, and *D* follow one another always at typical intervals independent of when the first event occurs (i.e., if the pattern is an invariant of translation in time), then we say that there must be a causal relationship between the events concerned (see Wuketits, 1981). Otherwise, the perceived regularity could not be explained. Causal relations, then, are defined as invariant patterns of time (Reichenbach, 1924). This, however, requires more than just having a topology of events as provided by our memory. We also must be able to distinguish between shorter and longer intervals of time, i.e., we need a time metric defined by a mental metric-generator implemented physiologically somewhere in our brain. For example, the fact that we say lightning is the cause of thunder but not the contrary is based on the fact that the time between lightning and the next thunderclap is usually much shorter and varies less than the time between thunder and the following lightning strike. But the length of time intervals can be defined only by means of a time metric. If our time metric-generator were such that it would be accelerated after a flash of light and retarded after an acoustic event, we might well come to the conclusion that thunder is the cause of lightning. *The mental time metric-generator is therefore responsible for the causal order established and for the prognostic capability derived from it.*

The specificity of the metric-generator has direct effects on the laws of conservation that we record in physics (energy, momentum, etc.). These laws can be derived from the invariance properties of the equation of motion: invariance under a translation in time (i.e., physics is the same yesterday and today) implies conservation of energy; invariance under a translation in space (i.e., physics is the same in America and Europe) implies conservation of momentum; invariance under spatial rotations implies conservation of angular momentum. In other words: the conservation of momentum follows from the homogeneity of space, and the conservation of energy follows from the homogeneity of time. What 'homogeneity' means, however, is exclusively a matter of the mental metric-generator concerned. This applies also to the other conservation laws which, therefore, are human specifics rather than objective properties of nature. As seen below, the conservation laws constitute what one can call the cognitive reference frame we use to describe actions and what those actions will bring about. Other conservation laws, based on other cognitive operators, would effect a different cognitive phenotype, but this would not mean that the methods and life strategies based on other operators would be less consistent or efficient. What is excluded, however, is communication between representatives of different cognitive phenotypes such as (possibly) between terrestrial and extraterrestrial beings.

2.6
Induction and the Compressibility of Observational and Theoretical Terms

Perceptions (and observations) are related to each other according to what we call the regularities perceived. These regularities, as we have seen, are the outcome of special mental operators. A (scientific) theory on the relation between observations, therefore, can be 'true' (i.e., it can extrapolate the data observed correctly) only if it would emulate the generating mechanisms. But how can we emulate these mechanisms if we do not have access to the brain where they are implemented and if we have no means of analyzing them otherwise? What we have is nothing but mathematical methods which – astonishingly enough as Wigner (1960) said – work very effectively in helping us to extrapolate observational data. Then, the conclusion is near at hand that there is a certain homology between the mechanisms generating mathematical, logical, and other theoretical terms and those generating observational teams. This would explain, of course, why observational extrapolation (i.e., waiting for the observations expected or doing the experiments required) may lead to the same result as mathematical extrapolation from observed data does. A helpful contribution to solving the problem of induction, therefore, are plausible hypotheses on a common metatheory of mathematics and observational terms.

The stated equivalence of observational and theoretical terms requires that we approach mathematics and logic under the same constructivist aspect as we do the empirical world. There is already a certain tradition of constructivist approaches (Lorenzen, 1975) having in mind mainly a better foundation for mathematics: only if we know how things have developed can we understand why they are as they are. Unfortunately, it is not enough to find a 'generative mathematics' that generates all the mathematical rules or regularities we know, because there is no guarantee that it would also generate those we may yet find in the future. The only guarantee for generally succeeding is that we find a solution that emulates the actually implemented mental mechanisms. This generative mathematics, however, as well as Chomsky's generative grammar, is inaccessibly located in the subconscious parts of cognition. All we know and all we have access to are their results. From them, unfortunately and as a matter of principle, we cannot conclude the generating mechanisms. This is why it is so difficult to concretize a generative grammar producing more than just one or two grammatical regularities or rules.

To deal with the compressibility of mathematical terms means to pose the questions: Why can we describe the results of rather complex mathematical operations by relatively simple expressions? How can we extrapolate ordered sequences of mathematical operations by explicit formulas, i.e., why does the principle of mathematical induction work? That this is a serious problem is known – at least in principle. Mathematicians generally acknowledge that Peano, by means of his five axioms has contributed considerably to understanding the world of natural numbers – in particular, the fifth axiom ("If the natural number 0 has some property P, and if further, whenever n has P then so does $n + 1$, then all natural numbers have P") is the basis of mathematical induction, which is one of the most important procedures in practical algebra. However, Hofstaedter (1979) has rightly remarked that this does not provide a criterion to distinguish true from false statements about natural numbers. He asked (ibid., p. 229):

> How do we know that this mental model we have of some abstract entities called 'natural numbers' is actually a coherent construct? Perhaps our own thought processes, those informal processes which we have tried to capture in the formal rules of the system, are themselves inconsistent!

Well, at least in the constructivist context, they are not inconsistent. But the possibility remains that the formal rules we have established do not correctly or completely emulate the informal thought processes (i.e., what we called mental operators). The ongoing success of mathematical sciences, however, makes it rather probable that mathematics is a fairly good theory of what the mental operators can bring about. It may even be a correct or true theory if the mental operators, in the course of cognitive evolution, contributed implicitly to their own conscious formalization, i.e., to the development of mathematical and logical thinking. In other words: mathematics succeeds by means of compressing theoretical terms (e.g., by means of mathematical induction) because the mechanisms of generating theoretical terms and of compressing them are closely related to each other, due to a special cognitive coevolution having the effect that compressed and uncompressed terms behave alike and therefore are interchangeable.

The fact that large amounts of empirical information can be described by a relatively simple mathematical formula, by a simple view or regularity, or by just a few words (i.e., by a theory in general), we explain by their compressibility. On the other hand, we can consider these formulas (etc.) to generate the data in question in the sense that we can derive the data from the generating theory. Within the framework of constructivism, however, there is nothing that is not generated, whether by a physical or biological process, by a theory in the proper sense, or by a mental operator generating what we perceive as regularities or laws. Compressibility, therefore, is not a special feature of some data or entities we have to investigate or to wonder about. It is rather the central characteristic of constructivism. The generating mechanisms (and only they) can tell us how we have to extrapolate given data or what we can conclude from certain observations, i.e., how we can apply mathematical or empirical induction. Without generating mechanisms, both extrapolation and induction are merely arbitrary – and therefore useless and meaningless.

The difficulty of classical approaches to the problem of induction follows from the idea that the operators generating the regularities of our perceptions are seen exclusively as nonmental external mechanisms. We say: regularities (such as symmetries) are in the outside nature and not in the way we see it. According to this, it is generally understood that we have to extrapolate data concerning celestial mechanics according to the effects of gravitational force as contained in Newton's laws. But we find it strange to understand why we usually succeed in extrapolating much sensory data perceived according to a regularity identified by means of nothing but the data themselves – as if the regularity of the past and future data were caused by the same reason. But exactly this is true. There is of course a causal reason generating these regularities, but it is not an external reason, as gravitation is said to be. It is rather the internal mental operators that generate the regularities. This is the very legitimization of empirical induction. Because this applies for any kind of regularity, so also the laws of classical mechanics as described by Newton are nothing but emulations of mental operators by means of what we call explicit external forces. What still has to be explained, however, is how to deal with the regularities we find in areas such as elementary particle physics, etc., which can hardly be expected to be 'inborn', as are the regularities of classical mechanics.

2.7
Communication, Meaning, and the Compressibility of Semantic Terms

If all structures we perceive are only human-specific artifacts that can be defined only as invariants of cognitive operators, then this concept must apply also to the perception (or interpretation) of language structures, i.e., as a physical object cannot have objective properties that can be used for an objective description, neither can verbal texts have an objective interpretation. Then the question arises as to whether a text can carry an autonomous message, and if not, what the notion of communication means.

According to common understanding, 'communication' means that certain structures, for example texts, are transferred from the sender to the recipient, where they actuate text-specific reactions. The text enables the recipient to draw conclusions insofar as he has understood (i.e., analyzed) what we call the meaning of the text. Meaning, then, is something encoded in the text. For the recipient, therefore, meaning is an externally defined structure. A similar view is held by Hofstadter (1979), who believes in the general possibility of deciphering context-free messages. For him (Hofstadter, 1979, p. 165), "meaning is part of an object (or a text) to the extent that it acts upon intelligence in a predictable way".

This implies conceding to 'meaning' the status of an objective property in the sense of realism. Further to this, within the framework of the CEE, the notion of analyzing a structure to identify the structure's inherent meaning is not explicable. Structures can be generated but not analyzed. What we usually call an analysis refers to other structures that are generated by the same operation and that we, just because of this, perceive as 'similar'.

Both theories and their meaning (in their quality as invariants of cognitive operators) are mental artifacts. Their effect is that they connect data or statements with each other – and here they have a monopoly: there is no other possibility of connecting data and statements except within the framework of a theory or a known meaning. From one sole observation we cannot derive a second observation except by means of a theory that is able to do this. From the fact, for example, that one has seen until now only white swans says nothing about the existence of black swans, unless there were a theory saying something on this matter. (Diettrich, 1989, p. 78). Nor is it possible to derive from an isolated statement a second statement, without having knowledge of the context of meaning. If we nevertheless sometimes try to derive statements from each other, then this is only on the basis of tacit assumptions concerning the context.

Under these circumstances, to 'perceive' a text or any other structure can only mean to reproduce it through the recipient's own generative means. If these means are insufficient, they have to be modified accordingly by the recipient himself. This is what we call learning, and the text that has effected this is called a piece of information. Information is something the recipient did not know before, i.e., what he or she could not reproduce by their own means. To understand a text means that the recipient is not only able to reproduce the text but also to draw the same (or similar) conclusions from it or to infer the same texts as the sender. But what does it mean to make inferences, and especially inductive inferences, within the context of constructivism? In common thinking, all things that can be derived from one another by extrapolation or by inductive inference represent certain relations. Under constructivist aspects, however, relations of any kind can be defined only through common generative mechanisms (operator, theory, etc.).

We can now say that a recipient understands a text in the sense intended by the sender if he or she not only reproduces the text but does so by the same (or similar) mechanisms as used by the sender. Only under these circumstances does the recipient, further to the text in question, also have all the other texts at his disposal to which the sender could refer, i.e., they can both draw the same 'conclusions'. Strictly speaking, this does not require that the generating mechanisms are structurally equal. But because they produce the same output, more or less, we can assume that this is due to their phylogenetically acquired common metatheory. In this case they, i.e. sender and recipient, would not only be functional but also structural homologs.

Let us summarize: to say that the recipient has understood the meaning of a text means that the recipient has interpreted the text within the same theory that the sender has used to generate the text, or, in other words, that the recipient has decoded the text in the same way as it was encoded by the sender.

A prerequisite for communication is that those concerned have the same (or at least a similar) cognitive phenotype. Only then could they think in terms of the same categories and deal with the same things and phenomena, about which they can inform and talk to each other by pointing to the object in question or by means of interpreters. In other words, the perceived worlds of those who want to communicate with each other must be largely isomorphic. This occurs when Chinese and Europeans speak with each other – however different their languages are in detail. If this condition is not met, no communication is possible. If one of them deals with objects having an identity defined as invariant of motion within a (3+1)-dimensional space–time continuum (as we do), but the other one describes objects as being the eigenvector of certain operators in Hilbert space (as may happen with certain extraterrestrials), i.e., if the partners in communication use different defining operators, nothing could be compared. Here, the perceived worlds are not only furnished with different objects but also are syntactically structured in different ways.

Some years ago, on a NASA rocket launched into space was mounted a copper plate engraved with some elementary information about humans and the terrestrial environment. This endeavor was based on the assumption that the same laws of physics would apply everywhere in the universe and that extraterrestrials, however else they might be structured, had to adapt to these laws and, therefore must have developed equivalent cognitive structures in the course of their evolution. But since the laws of nature, as we have seen, characterize our cognitive and empirical phenotype rather than the world we live in, humans will identify the same laws of nature wherever they are in the universe. From the human point of view, the laws of nature are indeed universal because humans carry, so to speak, their own laws with them wherever they go. The same would apply to extraterrestrials. They as well would identify laws of nature which, from their point of view, would be as universal as ours but which would not necessarily be the same. Even when visiting the earth, there would be no reason for them to modify their world view and the laws included in it towards our laws of nature. By this reasoning, the prerequisite for the success of the NASA experiment is not met, because extraterrestrials, if any, cannot adapt themselves to laws which are not their own.

This does not mean that we could not come to a kind of working arrangement with extraterrestrials if we met them. After a period of cohabitation we might learn how they behave in given situations. This might lead to a modus vivendi. But we cannot understand them, i.e., we cannot extrapolate their behavior to new and unknown situations. Understanding is possible only on the ground of similarity, but not necessarily cognitive similarities. If such beings were physically closed and of more or less fragile structure and not fixed in the ground like plants but rather could walk or fly around, they would have to avoid collisions with other objects, as we do. Then we could understand their habits of moving, at least to a certain extent.

The question of the compressibility of the world (i.e., why observational data can be successfully extrapolated and, therefore, why induction works) can be transferred to the linguistic area (Diettrich, 1997). We can speak of the compressibility of language and we can ask why we can extrapolate texts semantically, i.e., why we can draw correct conclusions from a text. The problem of induction, then (how can we successfully generalize physical data transmitted from nature?), corresponds to the problem of communication (how can we successfully generalize verbal data transmitted from other persons?).

We see here a parallel between sensory and linguistic perception. Both result from mental operators acting on sensory or linguistic stimuli, respectively. The invariants of both operators present themselves as structures. In sensory perception, we perceive this structure as regularities that allow us to complete observations, or, as we would say in most instances, to extrapolate perceived data. In linguistic perception, we perceive the structure produced as meaning which allows us to draw the 'correct' conclusion from the text given or, as one could say, to extrapolate the text semantically. Regularities and meaning, or extrapolation and logical inference, respectively, are analogous categories in the sensory and linguistic areas.

2.8 Extensions

2.8.1 Physical Extensions of Perceptions and the Notion of Reality

Typical of most empirical sciences is the use of instruments and measurement devices (measurement operators) by means of which we extend the range of natural perception in ways similar to those we use to extend our inborn physical capabilities by means of tools and engines. Here we have to distinguish between two important types of extensions (Diettrich, 1994a).

We speak of *quantitative extensions* if the inborn perception operators and the measurement operators commute in the sense of operator algebra. Here, both operators have a spectrum of invariants (i.e., eigenvectors) that can represent each other. This means that the results of the measurement operations can be presented in terms of invariants of the inborn cognitive operators, i.e., in terms of our classical world view.

We speak of *qualitative extensions* if perception operators and measurement operators do not commute. Here, the results cannot be presented in a classical manner and require new, nonclassical theories. Because the set of possible measurement devices is, in principle, unlimited, it can never be excluded that qualitative extensions of previously established operators will bring about modifications of the previously established world view and of the theories associated with it. So there will never be a definitive world view and there will never be a definitive theory of everything. No objective laws of nature will ever be formulated. Those laws that we have, we have constructed in a human-specific way in the course of human evolution; they will never converge toward a definitive set of laws except within the context of a limited set of operators, i.e., if we desist from further experimental research that would go beyond these limitations. What we actually do when we do science is construct a world that we believe we analyze by doing science. In other words, 'analytical', in the sense of deepening our knowledge, is characteristic of science only within quantitative extensions.

The notion of a theory of everything is equivalent to the notion of reality. Reality, to our understanding, is independent of whatever we do or can do. So it must be characterized by objective laws of nature. We have seen that there are no objective laws of nature. But further to this, the notion of reality cannot even be defined operationally (and this is what we require of all meaningful scientific notions). To require of reality structures that are independent of all human action, i.e., structures that are invariant under all possible operators, would deprive reality of just the specificity necessary for being a nontrivial notation. The operator that is to define reality must be resistant against anything humans can do, i.e., it must commute with all other operators. Unfortunately, only the trivial unity operator meets this requirement. A nontrivial reality can thus result only by being invariant under particular operations, such as all the operations applied until now (rather than all possible operations). In this situation, reality would reflect all the perceptions and experiences mankind has ever had or made. This is exactly what we have in mind when we speak in ontological terms about a reality that – according to our current knowledge – has this or that structure. Reality in this sense represents the sum total of our actual knowledge. Therefore let us call it actual reality. That reality can be defined only as actual reality, i.e., with reference to what we experienced in the past, does not mean that there is a well defined remainder that we will come to know some time in the future. What we will experience in the future that we can use to bring reality up to date depends on what qualitative extensions we may bring about – and this is an entirely open set. There is not even a guarantee that our knowledge-based competence will increase on and on. If we are forced to emigrate into a new, unknown biotope, it may well happen that our acquired competence is useless and that new tools and means have to be developed.

If we base empirical theories on observations, as we actually do, and if observations are theories as well, then the evolution of science is an entirely internal matter between theories. Whatever we call the structures of reality, it must be comprised in the more elementary theories upon which we base higher theories. Reality, so to say, is the outcome of its own history. This view will allow us to see the realist's main argument in another light: the basic experience of all humans is that our perception contains regularities that we cannot influence. So, they must be objective, the realist infers, and hence it is legitimate to try to condense them into the laws of an objective world. Here, we concede that we have indeed no means of influencing the regularities perceived nor can we alter what we call the (classical) laws of nature – but only so far as the present is concerned. In the past, as we have seen, we intervened well through the phylogenetic decision on the development of the mental operators and by this on the regularities we perceive. The biological development of these operators can indeed be considered finished. What is not finished, however, is the development of possible physical extensions in the form of novel experimental facilities with novel invariants forming novel laws.

Sometimes it is argued that the absence of objective laws of nature would open the door for sheer arbitrariness. This is not true. That a different time metric generator in our brain might replace the 10 variables for which we identified conservation laws (energy, momentum, angular momentum, etc.) with another set of conservation variables does not mean that we would have fewer problems (such as with energy provision). We would just have different ones. The laws we actually find and the categories we actually apply constitute, so to speak, the categorical reference frame we use to describe and to master our real-life problems. The fact that the evolution of our cognitive phenotype might well have brought about another cognitive phenotype with another cognitive reference frame (i.e., the fact that our reference frame and the laws of nature concerned are not objective) does not allow the conclusion that cognitive reference frames are per se irrelevant and therefore can be ignored. Similar reasoning applies for our organic phenotype.

That we have just two legs rather than one or three is not due to an objective law of nature. It rather is a specification of human evolution. But this does not mean that we can ignore the number of our legs when walking.

From the functional point of view, realism implies the idea that theories and the instances of their evaluation can strictly be separated from each other so that independent evaluation criteria can be found. This view is also the basis for the logicians' notion of truth. In the same way as proximity to reality is seen as the criterion for the success of theories in natural sciences, truth is seen as the criterion for the success of linguistic behavior in its contribution to overall behavior. Accordingly, the aim of natural sciences is seen to be to identify the (independent) structures of reality, and the aim of semantics, to identify universal conditions of truth. Yet this concept cannot be realized. We cannot even identify what we call current reality. The genetically and historically acquired knowledge that constitutes current reality has no doubt a crucial role in the evaluation of theories – but not an absolute role, because it may well happen that a theory may modify existing views and thus also the authority for its own evaluation. In other words: the genetic, cognitive, and historical burdens constitute severe constraints, particularly when implemented in phylogenetically older parts of our cognitive apparatus. However, more recently established constraints can sometimes be ignored, at least to a certain degree. A typical example is the revision of previous interpretations of experimental facts and data in the light of new experiences and insights. So, even what we call current reality fails to meet the minimum demand of common language practice on reality.

From this it becomes evident that what we call reality does not just mean adaption to an independently extant or ontological reality. Under these circumstances we may well ask why then did cognitive evolution bring about the category of reality? A possible answer to this question is that we have to immunize our perceptions against doubts and distrust, particularly in situations where quick reactions are required. This is exactly what the notion of reality does. Within our day-to-day realism we consider our perceptions as representations of what is real rather than as the outcome of deliberate cognitive interpretation. In this way, time-consuming (and therefore potentially dangerous) considerations as to whether these interpretations can be improved on do not arise. Careful reflections on how to interpret the results of physical measurements are no doubt useful. So, reality in its quality as the sum total of all we have derived from past experiences has to be taken seriously and objectively, and whenever it is required; this is a very meaningful outcome of cognitive evolution. Thinking in terms of reality can be regarded as a kind of cognitive burden incorporated during the course of cognitive evolution. That is, in whatever direction our cognitive evolution may proceed, reality remains an irreversible category.

Empirical evidence may suggest to changing a theory and, sometimes, even its metatheory. But this is not an exclusive effect of empirical findings. Sometimes a metatheoretical change can be caused by purely theoretical considerations. The evolution of theories and knowledge is generally not predictable, because new results do not determine their theoretical interpretation, nor do open theoretical questions determine the experimental measures needed to answer them. New developmental lines have been created very often in the history of physical theories. Fresnel's interpretation of light refraction phenomena by means of a wave theory (1816) led to the idea of the ether and thence to the Michelson–Morley experiment, from there to the theory of general relativity, to the mass–energy equivalence, and finally directly to modern elementary particle physics and nuclear energy. Fresnel's decision, however, was not a logical 'must'. Quantum mechanics has shown that neither the corpuscular nor the wave aspect of light has an ontological quality. Rather, they are purely theoretical concepts. Refraction phenomena do not require a wave theory. They can be derived directly from the quantum mechanical uncertainty principle: an atom beam of given momentum passing through a slit diaphragm does not follow the geometrical path, because this would mean that both momentum and future location are precisely defined – contradicting the uncertainty principle. Instead, the beam is refracted to an extent exactly predictable by both wave theory and quantum mechanics. This idea could have been derived in principle from the work of Hamilton who embedded classical mechanics formally into a kind of wave mechanics. Nobody can say where we would be today if Fresnel had not embarked on wave theory. Perhaps we would have neither particle physics nor nuclear energy.

2.8.2 Algorithmic Extensions of Mathematical Thinking

As already mentioned, CEE requires that not only do the regularities we find in sensory perceptions have to be seen as invariants of certain mental operators, but also the regularities we find in logical and mathematical thinking. Indeed, the elementary logical structures and procedures that we find and apply in language are phylogenetically based human specifications, just like the perceptional structures upon which we apply them to generate higher theories. In particular, the laws of logic cannot be explained as universals (in the sense of Leibniz) that, on grounds of their truthfulness, hold in any possible world. This view is implicitly held, for example, by Hösle (1988) when he writes "the statement S 'there is no synthetic a priori' is obviously itself an a priori statement. So S contradicts itself and its negation, therefore, must be true".

Of course, categories exist that, for phylogenetic reasons, are used by all humans. Logic deals with the structures that can be constructed on this phylogenetically established basis, which we later on furnished with empirical and other theories. Lorenz (1941) speaks of our 'forms of intuition' (Anschauungsformen), which cannot be derived from any individual experience and are therefore *ontogenetic a prioris*, but which, however, are the outcome of evolution and so are also *phylogenetic a posterioris*. What we call a synthetic a priori reflects nothing but the inborn human-specific ways of thinking which, outside this framework, cannot even be articulated. What is more, no statement at all can be articulated independent of and outside the framework of human categories. So it is impossible to find statements that can be accepted by any sufficiently complex intelligence, irrespective of its phylogenetic background and which, therefore, can be called universal. Even the question of whether a certain statement expressed by an intelligence *A* would mean the same as what another intelligence *B* has formulated can be answered only if the categories of thinking of *A* and *B* can mapped onto each other, which is possible only on the ground of a transformation that necessarily is human-specific as well. In other words, the notion of universal synthetic a prioris cannot be logically explained. Statements dealing with the existence of universal synthetic a prioris, as advocated by Hösle (1988), are neither false nor true. They are empty. This is in accordance with the views of Kant, insofar as there are forms of intuition prior to any experience – but only prior to any individual experience, not prior to any phylogenetic experience. The phylogenetically accumulated experience, as represented in our picture of the world, and the categories of our thinking and perceiving are the result of a permanent coevolution between inner images and outer world. The idea that what is a priori for an individual is a posteriori for the species has been articulated by Lorenz (1941), Spencer (1872), and Haeckel (1902) and summarized by Oeser (1984) and Wuketits (1984, 1990).

If the cognitive operators generating our perception are phylogenetically related to those generating mathematical thinking, then their respective results, i.e., perceived and mathematical structures, must show certain similarities. This would explain why we can simulate the extrapolation of perceptions (i.e., make predictions) by means of mathematical extrapolations and why the mathematics we use is so well suited to the description of what we call nature. In this context, Davies (1990a) speaks of the "algorithmical compressibility of the world" and Wigner (1960) of the "the unreasonable effectiveness of mathematics in the natural sciences". From the classical point of view (i.e., within the theory of reality), however, the algorithmic compressibility of the world cannot be explained, and neither, on the same basis, can the success of induction.

If there is really a relationship between mathematics and perception as postulated here, then the phenomenon of qualitative extensions must occur also in mathematics (Diettrich, 1994b). This sounds strange, but there is some plausibility to this idea. Similar to the operators generating sensory perception, which can be extended by physical facilities, the mental operators generating our elementary mathematical conceptions can also be extended via higher and more complex mathematical calculi. This is what mathematics does as science. Insofar as higher mathematics is based on appropriate axioms, i.e. (in CEE parlance), on axioms that emulate correctly the relevant cognitive operators, there is no reason, from the classical point of view, to believe that this will lead to 'nonclassical' statements, i.e., to statements that cannot be formulated within the syntax constituted by the axioms concerned. This view substantiates the confidence in Hilbert's program of the complete axiomatization of mathematics – or, in the terms used here, the confidence that mathematics can extend itself only quantitatively.

From Gödel (summarized by Nagel, 1958), however, we know that there are mathematical procedures that, although entirely constructed by means of well proven classical methods, lead to statements representing a truth that can no longer be derived from the axioms concerned. Mathematics has turned out to be as incomplete as classical physics. Nothing but the application of well-tested, sound methods and procedures can lead to results that cannot be extracted from the foundations of these methods and procedures. We must therefore conclude that we cannot be sure that there will be no surprises of a similar kind in the future. Indeed, just as experimental operators, although constructed entirely according to the rules of classical physics, may lead to results that cannot be described in classical terms, there are also mathematical calculi which, as shown by Gödel, although based entirely on well-tested axioms, can lead to statements that cannot be proven within the context of these axioms – and this can happen again and again. So we have qualitative extensions in physics as well as in mathematics and we can make some definitions accordingly:

We speak of *quantitative extensions* if the truth value of the terms achieved can be derived from the axioms used.

We speak of *qualitative extensions* if the truth value of the terms achieved cannot be derived from the axioms concerned even though the calculi used are completely based on these axioms. When this occurs, the axioms themselves have to be extended to make the truth value in question derivable.

Qualitative extensions, whether in physics or mathematics, are purely emergent phenomena that cannot be predicted, because, by definition, they cannot be derived from previous knowledge. The blueprints of quantum mechanical devices are entirely classical in character and nothing provoked the idea that the results they may bring about could no longer be interpreted within classical theories. The same applies to mathematics. There is no general criterion telling us if a given calculus will exceed its own axiomatic basis.

With this, the existence of nonclassical theories in physics and the incompleteness theorem of Gödel are homologous cognitive phenomena. Neither is there a definitive set of physical theories (i.e., a theory of everything) explaining and describing all (also future) physical problems nor is there a definitive set of mathematical axioms determining the truth value of all possible mathematical statements.

As to qualitative extensions, the only difference between the physical and the mathematical situations is that we already have in physics two nonclassical theories (quantum mechanics and special relativity) and that we can say precisely under what conditions we have to apply them, namely (simply spoken) in subatomic areas and at very high speeds. In mathematics we only know from Gödel's theory that there must be nonclassical phenomena, but we do not know what they are, and, more specifically, we cannot say which operations will bring us out of the classical domain. Is it the notion of cardinal and ordinal numbers, or the notion of set or of infinity, or is it the combined application of these notions that will constitute the cause of nonclassical mathematical phenomena? Will logic turn out to be as incomplete as physics or mathematics? And what will happen if we deal with more and more powerful computers? Up to now, we do not know. But when we do, we will have modern, nonclassical mathematics as well as physics.

The astonishment of mathematicians with respect to Gödel's proof continues unbroken. The literature is full of responses to Gödel. Among others, an explanation was proposed that the brain's action cannot be entirely algorithmic (Lucas, 1961; Penrose, 1989). Besides the fact that it is not quite clear what in a neural network such as the brain could be nonalgorithmic, this kind of reasoning is not necessary. What follows from Gödel's proof is only that what certain mathematical calculi can bring about is not necessarily the same as what a combination of them could generate. Similar reasoning applies to physics: instruments, although constructed entirely according to the laws of classical physics, would not necessarily reproduce the laws of classical physics, as seen in quantum mechanics (e.g., scattering experiments with atomic rays). But no physicist would draw from this the conclusion that something in our natural sciences is not natural.

In contrast to the physicists, who suggested as an explanation for their respective experiences that they had happened upon domains of nature where other and unpredictable laws rule, mathematicians hesitated to admit the idea that mathematical research is empirical in the sense that it can lead to really new discoveries which could in no way have been expected, even not a posteriori. If mathematics had its own specificity, as included in the notion of Plato's reality, then, according to general mathematical understanding, this must be something that is included in the very rudiments of mathematics and therefore determines all possible consequences. In other words, if there is such a thing as Plato's reality it must reveal itself by the fact that a consistent mathematics can be based only on particular, well defined axioms (the analogy to the laws of physical reality, so to speak). Once these axioms have been found they would settle once and for all the 'phenotype' of all future mathematics. Mathematics, then, would be nothing but a kind of craft filling up the possibilities opened by the axioms identified – similar to physics which, according to prevailing understanding, can do nothing but look for applications of the theory of everything once it has been found.

In the beginning it was hoped that extending or modifying the axioms in view of the unprovable statements concerned could solve the problem. Unfortunately, the new axioms would be in no better a situation, because for any set of axioms, unprovable statements may be found. This applies also to physics. Of course, we can modify theories according to 'unprovable' phenomena, i.e., new phenomena that cannot be formulated within the existing theories or metatheories, and physicists did so when establishing quantum mechanics – but this provides no guarantee that similar things will not happen again. So, neither in physics nor in mathematics can a tool for everything be found, by means of which all relevant problems, present and future, can be solved in a purely technical or formalistic manner.

The relationship between physics and mathematics as suggested by CEE constitutes a certain heuristic balance. Experimental physics is no longer privileged in providing information from the outside world, while mathematics sets it into theories. Instead, hopes are reasonable that a possibly successful study of nonclassical mathematical phenomena may be a key to better understanding nonclassical phenomena in physics also – and vice versa. In a way, physics and mathematics can see each other as very general theories. So, mathematics could outgrow its role as an auxiliary science, which it has held from the outset of empirical science, and come into the role of a heuristic partner of equal rights. Strictly speaking, this has already happened. Of course, that we consider the world to be algorithmically compressible reflects nothing but the suitability of mathematics for prognostic purposes in physics. This is what physicists call the unreasonable effectiveness of mathematics in the natural sciences which, in the light of CEE, might well be reasonable.

But what, then, are the specifics that mathematics and the world of our perceptions have in common so that the two areas can consider each other to be their successful theories? This is difficult to say, because we have to abstract from just these specifics, which is possible only if they themselves do not belong to the most primitive elements of our thinking. The following might be a clue: the fact that we use the same kind of division to separate ourselves from the outside world as we use to divide the outside world itself into single subjects, to each of which we attribute an independent identity, belongs to the very beginning of our inborn ways of thinking. However, quantum mechanics shows how the entire (physical) universe can be seen as a unity that can be described by a single wave function. Each division of the universe into subsystems is a matter of the categories applied and is therefore arbitrary, because phylogenetically acquired categories are not determined. Our inborn category of identity allows us to separate systems into discernible entities. It is therefore constitutive for the notion of plural (and, therefore, for the notion of set), as well as for the notion of cardinal numbers.

A second clue concerns the relationship between the metrics of space and numbers. According to what Piaget (1970, p. 58) found with children, it is not the category of space that allows us to define motion as mapping a line in space to the scale of time. It is rather motion that generates the category of spatial structure. The most primitive intuition, as Piaget called it, is not space but motion. Just as it is impossible to come from one number to another without a counting (or equivalent) operator, we cannot distinguish points in space except by attributing to them a path of motion. Counting and moving are analogous terms within the genesis of homologous algebraic and geometric structures. This homology allows us to extrapolate the observations of motional phenomena in an empirically verifiable manner. The continuity of any physical motion, for example, is a cognitive phenomenon, i.e., it is part of our metaphysics, and is not the consequence of an independent law of nature. Formulating discontinuous motions would require a spatial metric which, on the other hand, is only defined by means of the category of motion itself. Discontinuous motions, therefore, cannot be realized within the human cognitive apparatus, i.e., within our metaphysics. This competition drastically reduces the degrees of freedom of actual motions. The same applies to the compactness of numbers we use to establish metric spaces and (regular) analytical functions in metric spaces. Discontinuity of a set of numbers is defined only within the context of a previously defined metric. So, numbers generated by a metric defining (counting) operator are per se compact. Analytical functions in metric spaces are, therefore, natural candidates for describing the phenomena of mechanics. This strengthens the assumption that what Davies (1990 a, b) called the algorithmic compressibility of the world is essentially based on functional homologies between the mental roots of perceptual and mathematical procedures.

The close relationship between spatial perception and mathematics can also be seen from another example: spatial coding of mathematical notions from areas outside geometry is probably the very beginning of mathematical heuristics. This includes the visualization of sets as a closed figures with points inside representing the set's elements, as well as seeing ordered sets as spatial chains. Similar reasoning applies to the basic notions of topology, such as exterior, boundary, interior, isolated points, etc. Even the notion of cardinality of sets comprises a certain geometrical coding. The cardinality of sets cannot be defined operationally, because the process of counting or mapping in pairs requires that the elements concerned differ in at least one property defining their identity (e.g., in their position with respect to the counting device). You cannot pick out an element that does not have a well defined geometrical position. Similar reasoning applies to the notion of plurality. That something exists in several separate but equal copies is plausible only if these copies differ in their spatial positions. But we cannot replace position as an element defining identity by, say, color; that is, we cannot say that several objects have all properties in common – including position – but not color.

2.9 Action, Perception, and the Role of 'Cyclic Variables' in Cognitive Evolution

The task of perception is to allow the formation of theories by means of which we can predict the effects of action. Because the effects of action can be presented only in terms of perceptions, we can say: by means of perceptions we discover how perceptions can change under the influence of action. In other words, actions are operators that act on perceptions.

Within classical realism, we say that the effects of our acting are determined by the laws of nature, and by means of our (natural and experimental) perceiving we acquire knowledge about these laws. Thus, scientific decoding of nature is seen as the crucial prerequisite for mastering nature. This is the legitimization for all natural sciences insofar as they aim at the exploration of natural laws.

Searching for the laws of nature was useful when it was done for the purpose of mastering nature. Because there are, however, no objective laws (as we have seen), this way despite its success, is not heuristically legitimate. So there must be yet another link between perception and action that does not depend on the mediation of objective laws. If, nevertheless, we continue speaking about the laws of nature, we can expect that those laws will help us predict perceptions and the perceived effects of action but not that they will provide us with objective statements about the world.

According to classical understanding, action and perception are two completely different categories: action refers to the individual's input to the world, and perception refers to the world's input to the individual. With CEE, however, both refer to the same mechanism, with the consequence that there is no essential difference between them. This sounds strange but is easy to illustrate. Visualize a hammer. It is an instrument designed primarily to alter certain objects. But a hammer, in its quality as an operator, also has invariants: objects and properties that would resist hammer strokes of a given strength. The hammer, then, can be used to measure mechanical properties such as the strength of materials. So, both perceiving and acting mean applying the same operator. The only difference is that, in perceiving, we seek the invariants of the operator in question, i.e., we look for what remains unchanged under the application of the operators, whereas in acting we seek what changes under the operator's influence. Our inborn world view (i.e., the inborn interpretation of sensory input) therefore depends on the phylogenetic 'decision' about which operators we use to construct the cognitive reference frame and which operators we use to modify what is described within the reference frame. (We already mentioned one of these phylogenetic decisions: using locomotion to give our perceptual space a third dimension rather than using it to modify the size of structures in a 2D world.) The decision made about our actual cognitive reference frame, however, was not an evolutionary accident. It rather was made according to a relatively simple scheme, as we will see.

The result of performing a physical measurement (which is an action, of course) is, in physical parlance, the invariant of the measuring process. In other words, we use the invariants of a process to describe the effect of that process, i.e., we describe the covariants of an operator by means of its invariants. This can be generalized into the cognitive area. The actions by means of which we explore the world can be considered measurements (i.e., perceptions in the broadest sense). The results of measurements (or, as one could say, the results of our experiences) then are views of the world and theories representing what we call the unchangeable and, therefore, the objective world (i.e., what is invariant under all our doing and acting). If we instead look for the covariants of our action, i.e., what changes under the influence of our actions, we have to refer to what we said about the relationship between the covariants and invariants of measuring processes: the effect of action can be described only in terms of the invariants of action, i.e., in the terms of our world view. *This is exactly the direct relationship between perception and action that we looked for and that does not rely on the concept of a world with objective laws.*

If this is true, then the elementary categories of our perception must be the invariants of our most elementary action operators. But what are the most elementary action operators? They are not, as one might think, our hands and the tools guided by hands. They are, rather, our legs. By means of a few steps, we can change our environment from the room we are in into the environment of a blooming garden. Of course, we could achieve the same also by using our hands if we used them do the necessary reconstruction work. But this is troublesome and time consuming. So, one of the most important specifically human operators is locomotion. Our world view, as a result, must be based on the invariants of this operator – and this is indeed true. The most elementary descriptive category of our world view is the identity of extended objects and spatial structures defined as an invariant of locomotion. This provokes the assumption that, from a phylogenetic point of view, the categories of description can be understood only through their capability to cope with the covariants of certain operators. From this it follows that the cognitive phenotype was fashioned by evolution not to explore the world but, instead, to extend the action possibilities of the organic phenotype.

Spatiality and the spatial metric, as we have seen, are categories that are necessarily defined by the process of motion. On the other hand, motion cannot be explained without the notion of space in which motion takes place. From this, it follows that motion itself must have brought about the mental category of spatial structures necessary for dealing with motion. This is exactly what we maintain: what an operator is doing can be explained only in terms of its invariants.

We encountered a similar problem when we dealt with the operational definition of the arrow of time. An operational definition was impossible, because the notion of operators themselves would require a prior definition of the arrow of time. We therefore proposed referring to the memory and to events stored there. But, from the cognitive point of view, events themselves are already operators transferring the status before the event into the status after the event. So events, just like any operator, require prior definition of the arrow of time. Without a definition of the arrow of time, events and all we store in our memory in order to write history remain undefined. Thus, time turns out to be a mental modus that itself needs to have been brought about by operational means. In the same way as the spatial metric was generated by the process of motion (i.e., motion bringing about the category of space which is necessary for describing motion), the category of time must have been generated by operators (i.e., operators bringing about the category of time which is necessary for describing what operators are).

The approach of describing the covariants of operators by means of their invariants is well known and often used in physics. Within the framework of Hamilton–Jacoby formalism, the variables of a mechanical system are chosen so that conservation laws (invariants) apply for them. With this prerequisite taken care of, the transformations describing the system's development in time can be found easily and explicitly. On the other hand, the conservation laws themselves can be shown to be generated by the transformations considered. So the canonical total momentum (in this paper identified, in a more general way, as 'motion') brings about spatial translation, and the total energy (represented by the Hamiltonian) brings about translations in time. Something very similar applies for quantum mechanics. The system's development in time is generated by the Hamiltonian, and the eigenvectors of the Hamiltonian constitute the reference frame by means of which this is described. This means that our elementary cognitive coordinates are 'cyclical variables', by means of which the motion of force-free bodies can be described simply and linearly in time.

Therefore, the existence of conservation laws and the closely related fact that the development in time of mechanical systems often seems rather simple (i.e., algorithmically compressed, as Davies (1990 a, b) would say) are not based on objective laws of nature and their harmony and simplicity. They are instead related to the permanent coevolution of acting and cognitive instruments that is necessary for predicting the consequences of acting, i.e., for action management. The perceived simplicity of the world is based on the phylogenetic decision to apply those cognitive variables for the description of the effects of elementary acting (such as locomotion) that are cyclic in the sense of the Hamilton–Jacobi theory. Nature appears complex only when we deal with situations in which additional forces with unusual properties depending on various variables constitute a system with respect to which the 3D Cartesian coordinates of our phylogenetically acquired world view are no longer cyclic. To predict how such a system will develop in time (i.e., to find the integration of the equation of motion) therefore depends on whether unspecific system variables can be transformed into system-specific cyclic variables. Such problems are often solved by means of the Hamilton–Jacobi theory.

We can conclude that physical actions, and the cognitive operators we use to describe them, are brought about by the same organic operators (i.e., organic tools). Perceived patterns or regularities, and the instruments of mathematical thinking we use to describe them, are brought about by the same cognitive operators. So mathematical patterns, perceived patterns, and the results of our actions are literally homologous in so far as they have a common ontogenetic root, and this is the very reason why they can 'cooperate' so well with one another – as well as being why the various physiological mechanisms brought about each other in the course of organic evolution.

2.10
Adaptation and Assimilation vs. Action and Perception

According to Piaget (1967, 1970), *assimilation* means modifying or using external data to meet internal needs. *Accommodation* means modifying these internal needs so they can be met more easily. Let us apply the terms assimilation and accommodation to general evolution. According to the synthetic theory, successful evolution means constructing or modifying an organism so that it can meet external requirements. Evolution is thereby understood to precede primarily by means of accommodation, from its early commencement through to human technical and scientific achievements for managing life.

However, what evolves are not only internal needs for meeting external requirements but also the competence for acting, i.e., the capacity for modifying external requirements according to previously defined internal needs. Seen in this way, evolution is both accommodation and assimilation – with an increasing tendency towards assimilation: the more complex and 'higher' organisms are, the more difficult it becomes for them to modify the phylogenetically acquired physiological and other basic strategies, and the more likely is it, therefore, that evolution tends toward assimilating strategies, i.e., towards improving the methods for modifying the environment. Warm-blooded animals, for example, do not react to climatic changes by altering their physiologically defined body temperature. Instead, they conserve their internal climate by better isolation or higher (internal or external) energy investments. Humans, after all, do not react any longer by means of evolutionary accommodation. Especially with humans – whenever a conflict arises between biologically defined human requirements and the environment, the conflict is solved at the environment's expense (Diettrich, 1995).

One of the most popular methods of all animals for changing the environment is locomotion. Paramecia use locomotion for escaping adverse local conditions. That the relevant environment and its selection pressure is an artifact of the various species occupying it, rather than an objective and external issue, was seen already by Waddington (1959, p. 1636):

> Animals are usually surrounded by a much wider range of environmental conditions than they are willing to inhabit. They live in a highly heterogeneous 'ambience', from which they themselves select the particular habitat in which their life will be passed. Thus the animal by its behavior contributes in a most important way to determining the nature and intensity of selective pressures which will be exerted on it. Natural selection is very far from being an external force, as the conventional view might lead us to believe.

Regarded from this aspect, life is a mode of world construction in the sense of Goodmann (1984) rather than a process of exploring the world or of acquiring knowledge about the world as Lorenz (1983) said ("life is a cognition process"). In other words, evolution seems to aim at assimilation rather than accommodation.

Actually, however, this view is as biased as the pure-accommodation view, because the capacity for acting and reacting does not represent a successful assimilation strategy. Strategies, as well as organic features, must accommodate themselves to given external conditions. This is what accommodation strategies aim at – not to explore the environment and modify one's constitution accordingly, but to improve the capability of changing one's environment so as to meet the requirements of one's constitution. These requirements, however, mean first of all making optimal use of existing assimilation techniques. So, accommodation must orient itself to the techniques available rather than to the environment concerned. The most elementary example is the evolutionary extension of homeostasis for adapting to a larger variety of external data rather than finding special solutions for each special case. Accommodation, therefore, aims at extending the set of controllable data independent of what is actually required. Whether a species can profit from this strategy depends on whether new conditions or a new environment can be found in which these new achievements will pay off. (A cultural example would be basic research that provides solutions for problems that do not yet exist and that will find successful application only if appropriate applications or problems can be identified.) So, the interplay characteristic of evolution is not only that between mutation and selection (supply strategy, defined by the supplies and constraints of the environment), but also that between extension of competence and applicability (demand strategy, defined by the requirements and the possibilities of the organism). If we nevertheless want to continue using the notion of environment as the instance that articulates the boundary conditions for physical and evolutionary acting, we have to consider it as a construct in a double sense: (1) by acting in the proper sense we can modify the relevant boundary conditions – for example, by means of external heating we can reduce the demands on internal temperature management; (2) by changing the internal requirements the same environment can come to represent different boundary conditions – for example, by switching from anaerobic to aerobic respiration, the previously irrelevant oxygen content of the atmosphere became the key survival factor. More generally we can say that what counts is the 'distance' between organism and environment, and this can be reduced at both 'ends'.

Here we have an analogue in cognition. We said that the cognitive phenotype is entirely a construct of the organic phenotype, which was brought about to extend the functional possibilities of the phenotype rather than to 'recognize' the world or to explore what Vollmer (1975) called the cognitive niche. Nevertheless, here as well, we can continue using the notion of environment if we consider it (as we did in the organic case) as being constructed in a double sense. (1) We can displace objects, change our position, practice agriculture, or construct streets with traffic lights. By all this we change our environment and, if we do this in the interest of our needs, we practice assimilation. By this we construct what we call actuality (Wirklichkeit). (2) How we see the environment, what regularities we register, and to what 'laws of nature' we condense them is a matter of our cognitive phenotype. The development of the cognitive operators, up to the development of our world view (including the formation of scientific theories), is therefore an act of accommodation to the conditions of actuality brought about by assimilation. Our cognitive environment, thus, is a human-specific construct characterized by the laws of nature as comprised in the notion of reality. Nature does not tell us how we have to see it (for example, as spatial objects moving in a 3D world). Nature is rather the phylogenetically developed mental operators and their invariants that define the regularities we perceive and the laws we derive from them. If we consider that the biological development of these operators is complete, but not the development of their possible physical extensions by means of novel experimental devices with novel invariants that require novel theories, then we can say that we continue more than ever to construct the object of scientific research, i.e., reality. Reality, in so far as it is articulated in terms of laws that physicists formulate and try to explore so as to make predictions possible, is a human-specific artifact. What we see depends both on what we do and on how we interpret the sensory reflection of our doing.

In strict analogy to the organic situation, we can say that actuality and reality are the two ends that characterize the cognitive distance between individual and environment. Actuality is the result of our doing (including locomotion), i.e., of assimilation. Reality is the result of our phylogenetically acquired ways of interpreting of experiences with a view to making predictions. So reality is the result of accommodation. Because we cannot describe actuality without a previously defined interpretation of our sensory input, we cannot speak of assimilation without accommodation. Just as in the organic context, the results of accommodation (i.e., the actual phenotype) define what certain assimilating activities mean for the organism concerned. This applies, as well, in the opposite direction: accommodation is not possible without assimilation. We cannot speak of reality and its purpose for making predictions (accommodation) without reference to the object of those predictions, the actions (assimilation). The same argument holds in the organic situation: action means the accommodation of assimilation strategies. Action and perception cannot be defined independently of one another. More particularly, it does not make sense to speak in terms of perception or recognition of an independent, objective outside world.

2.11
Epistemological Autoreproduction

The difficulty we have in accepting the notional character of our experiences as human-specific constructs differs with space and with time. Regarding the notion of space, it is not doubted (except perhaps by naïve realists) that the spatial patterns we perceive are not objective in the sense of their being considered views of real structures, i.e., the world is not necessarily as what it appears to be. With space, we quite readily attribute a reduced objectivity to our world view. Not so with time: we consider the recorded time topology of events to be real. The past is as it was and not even God can change it a posteriori, we say. Weizsäcker (1985) called this the 'facticity of the past'. Actually, however, events can only be defined as the results of cognitive or scientific interpretations, just as visual patterns can only be defined as invariants of cognitive operators. Events, as such, have less clearly defined outlines than visual patterns have. A modification of the interpretations of events used (for example, in the presence of a novel theory) may well affect the past. But because this has not happened during historical times, the illusion arose of both the facticity of the past and the objectivity of the laws of nature.

The allegation that the historicity of the world is a human-specific artifact is the more problematic because it is based (through CEE) on what is known about biological evolution, which deals explicitly with the historical order of phylogenetic events. Said another way: on the one hand our world view is the construct of our cognitive and experimental apparatus; on the other hand, this world view is exactly what physics and biology refer to, particularly when describing the development of the human brain and the operators established there. So which is the hen and which is the egg? Is it the real world we live in and which developed in the course of organic evolution up to and including the brain's functions, or is it just these brain functions that bring about the view of a real world as a tool for both articulating and solving our problems? Formulated differently: are perceptions brought about by nature, or is nature a category brought about by our cognitive apparatus? This dichotomy is the reason for the frequent accusations that the EE is circular in so far as it interprets not only the categories of space, time, and causality in phylogenetic terms, but also the notion of reality and nature – the latter comprising phylogeny itself. So, phylogeny is interpreted by phylogeny, which is circular.

Actually, however, no real dichotomy exists so long as there is certainty that perceptions and nature condition one another by generating one another. This certainty is provided by the fact that our cognitive phenotype constructs a world picture that permits an understanding of the genesis of this cognitive phenotype by means of evolution within the framework of this world picture. Thus, not only ontogenesis but also cognitive evolution have to be understood as circular, autoreproductive processes.

In the biotic area the following holds: the epigenetic system of an organism is what determines how the genome's structure is to be interpreted and expressed in the phenotype. Identical reproduction is possible, however, only if the epigenetic system brings about a phenotype comprising the epigenetic system itself.

In the cognitive area the following holds: the cognitive apparatus (and all the science based on it) is what decides how the sensory input is to be interpreted and what world view is conveyed. The knowledge acquired in this manner is consistent and reproducible, however, only if the cognitive/scientific apparatus generates a world view that includes the cognitive/scientific apparatus itself.

A genome on its own cannot determine the phenotype in the sense of providing a complete 'blueprint' – it rather represents one of several levels in the process of autoreproduction – nor can sensory input dictate its own interpretation, and, by this, the reactions it causes. This limitation does not contradict the fact that, within the context of a given organic or cognitive phenotype having a given interpretative machinery, a genetic mutation as well as a new perception may lead to reproducible modifications of our physical constitution or of our theories. This means that, so long as the epigenetic system remains unmodified, a given genetic mutation always produces the same phenotypic change; and so long as our cognitive apparatus and our scientific theories also remain unmodified, a given sensorial input always leads to the same reading. What we have to avoid, however, is concluding that what mutations and perceptions initiate is also what they determine. Determinism is possible only within a given scheme of interpretation, i.e., outside qualitative extensions changing the interpretation concerned. The same limitations hold for adaptation. Adaptation makes sense only so long as there are no qualitative extensions, because these modify the requirements to be met, i.e., the selective pressure. The world, seen as the sum total of the boundary conditions of our acting, is subject to a permanent actualization, because acting aims at changing just these conditions that make further and more ample acting feasible. This begins with the organic phenotype, which defines the constraints for evolutionary 'acting', which in turn changes the constraints for further evolution ('evolution' meaning the evolution of its own boundary conditions). And it ends with the cognitive phenotype that defines, through our world view, what kind of scientific acting is possible by which the world view itself may be affected. The world as an object of adaptation can be defined only for the time between two paradigm shifts, i.e., between two qualitative extensions.

Circularity, a devastating objection to any theory within the context of classical realism, becomes (in the sense explained here) a necessary prerequisite for any complete constructivist approach. A world view brought about by a cognitive phenotype is consistent if and only if the world concerned enables the genesis of the cognitive phenotype. The role of circularity constitutes the key difference between realism (of whatever kind) and constructivism as presented here. Realism requires life-mastering methods to be consistent with an independent outside world. A constructivist interpretation of the world as proposed here, however, needs only to reconstruct itself. To avoid conflict with what von Glasersfeld (1995) and others called radical constructivism, I would rather speak in terms of 'complete constructivism' in characterizing CEE. The various epistemologies mentioned here can be explained more clearly when they are classified according to how they meet their functional requirements:

1. The most elementary position taken is that cognitive constructs (perceptions) have to delineate correctly the structures of the environment, because the strategies devised to meet the requirements of the environment are believed to be derivable from those structures. This is the basis for most kinds of *realism*. Physical knowledge is reliable (i.e., it allows verifiable predictions) if and only if it is 'true', i.e., if it is derived from perceptions and their 'true' theoretical interpretations. Both perceptions and true theories are seen to depend on the structure of an external world. Knowledge, when true, is irreversible, additive, and converges towards a complete and definitive set of laws of nature. The progress of knowledge is based on inductive inference. The success of induction cannot be derived rationally. If epistemology is seen as a matter of cognitive evolution it is understood as 'natural selection epistemology'. This was the starting position of *Evolutionary Epistemology* (Lorenz, 1941; Campbell, 1974a; Vollmer, 1975; Riedl, 1980; Oeser, 1984; Wuketits, 1984, 1990).

2. In *functional realism* (Wuketits, 1998), and in *radical constructivism* (Glaserfeld, 1995) as well, cognitive constructs have to contribute to meeting the requirements of the environment, not necessarily by means of delineating environmental structures, but rather functionally. The notion of 'truth' is replaced with 'viability' within the subjects' experiential world. Physical knowledge is reliable (i.e., it allows verifiable predictions) if it is derived from perceptions (or phenomena) that depend on an external world and their interpretation by means of theories, which no longer must be true but viable. The progress of knowledge is based on inductive inference (i.e., what succeeded in the past will also succeed in the future). The success of induction cannot be derived rationally.

3. In *complete constructivism* physical knowledge is reliable (i.e., it allows verifiable predictions) if it is derived from perceptions and their appropriate interpretation, but neither perceptions nor their (viable) interpretations need evaluation by an external world. The most elementary prediction, i.e., prediction by means of linear extrapolation, is possible only if the development in question is linear in time. For this, it is sufficient and necessary that the phylogenetically acquired observational terms are cyclic variables with respect to the elementary operators of human action. This line of thought has resulted in the metatheory of classical physics, i.e., in the mental notions of time, space, spatial identity, locomotion, momentum, etc., and in the 10 conservation laws of classical mechanics. More sophisticated actions (particularly qualitative extensions) require nonclassical views, i.e., a redefinition of our notional reference frame, i.e., of what we consider to be an observation or a phenomenon with a direct effect on what we call the laws of nature. The structure of our perceptional world therefore depends on what humans can do by natural or technical means and it changes according to possible qualitative extensions brought about by novel

experimental developments. Knowledge is irreversible, additive, and convergent only within the times between qualitative extensions. Outside this range, knowledge depends on what nonclassical metatheory we use to respond to the qualitative extension concerned. The progress of knowledge within quantitative extensions is based on inductive inference. Induction succeeds because and as long as we describe the 'world' in terms of cyclical variables. An epistemology comprising the notion of time and development in time is consistent if it can explain its own genesis.

2.12
Is Cultural/Scientific Evolution Really Lamarckian?

There are not many theories that have been as successful as the idea that cultural evolution is Lamarckian in character and opposed to organic, Darwinian, evolution:

> Cultural evolution has progressed at rates that Darwinian processes cannot begin to approach. Darwinian evolution continues in *Homo sapiens*, but at very slow rates. This crux in the Earth's history has been reached because Lamarckian processes have finally been unleashed upon it. Human cultural evolution, in strong opposition to our biological history, is Lamarckian in character. What we learn in one generation, we transmit directly by teaching and writing. Acquired characters are inherited in technology and culture. Lamarckian evolution is rapid and accumulative. It explains the cardinal difference between our past, purely biological mode of change, and our current, maddening acceleration towards something new and liberating – or towards the abyss (Gould, 1979).

> Cultural Lamarckism has a great inherent plausibility, because social evolution is so obviously Lamarckian in character – we learn generation by generation and can propagate our learning to the next generation (Medawar, 1988).

> The development of culture is completely based on the transfer of acquired characters, which modern Darwinism has good reasons to reject for the developmental processes of organisms. If at all to draw a biological parallel, the theory of cultural development must be called Lamarckian (von Hayek 1983).

But what, exactly, does Lamarckian evolution mean? To speak in terms of inheritance of acquired characters is not very enlightening. All characters have once been acquired, either genetically, by genetic mutation, or culturally, by means of learning; and all characters are inherited, either genetically or culturally. So, the inheritance of acquired characters can hardly specify a relevant difference between Lamarckian and Darwinian evolution. What we really have in mind when comparing cultural and organic evolution is something different: knowledge as a particular aspect of cultural evolution is seen as something that is brought about by means of procedures that usually guarantee a certain usefulness, whereas the value of genetic mutations is entirely a matter of chance. Let us try to transfer this into a definition that is general enough to be applicable to the organic/genetic context as well as the cultural:

- An evolution (of anything) is Darwinian if it follows the principle of trial and error, i.e., if it starts from accidental modifications that subsequently are selected (or more generally, evaluated or interpreted) according to independent criteria.
- An evolution is Lamarckian if a calculus is applied by means of which modifications can be produced that will be considerably more successful than purely accidental modifications – a calculus that, for example, makes it possible to meet given (external) requirements in a target-oriented manner, such as a genetic reproduction of 'acquired characters', i.e., of any proven phenotypic modification brought about in a living organism during its own lifetime; or a theory that will allow reasonable planning rather than Darwinian trial and error.

According to these definitions, we have to distinguish clearly between the genesis of modifications, which can be Darwinian or Lamarckian, and their subsequent dissemination, which has nothing to do with Darwin or Lamarck. That "what we learn in one generation, we transmit directly by teaching and writing" as Gould said, does not qualify cultural evolution as Lamarckian. Genetic achievements (i.e., modifications that survived selection) also are transmitted directly to the next generation. A difference, of course, is in speed and in the potential number of individuals involved. In cultural evolution, particularly in the times of telecommunication, it is possible to communicate within seconds with everyone, whereas genetic information can be exchanged only between mates (leaving horizontal gene transfer aside), and to 'inform' the entire population with individual genes takes many generations. So, cultural evolution indeed proceeds very much faster than genetic evolution, but this is because genetic and cultural knowledge use different ways of disseminating their modifications and has nothing to do with the way in which the modifications concerned were brought about.

What then are the differences between the genetic and cultural techniques of generating innovations or changes, and how significant are they? The transformation from the genome to the phenotype is done by what, since Waddington (1957) and Riedl (1975) has been called the epigenetic system, meaning, briefly, the totality of the developmental processes involved (Katz, 1982). The epigenetic system is highly specific. It rejects not only any alien genome but also inappropriate (i.e., lethal) mutations. So, the epigenetic system has two functions: on the one hand, it translates the genotype into the phenotype according to very specific rules, and on the other hand, it selects the purely accidental mutations according to their appropriateness for the various levels of the developmental process – a Darwinian mechanism, as long as the mutations do not change the epigenetic system itself.

Preselection of inappropriate input data is not reserved for organic evolution. In a 'cultural' situation that we cannot master with available tools, many ideas cross our mind. We immediately identify some of them as unrealistic. Others turn out to be inappropriate only after careful comparison with the theories we know. Only a few pass all our checks (and, when relevant, also those of other persons). So we use these to approach the problem. Simon (1983, p. 40) said:

> According to the behavioral theory, rational choice may require a great deal of selective search in order to discover adaptive response. The simplest, most primitive search processes require that possible responses be first generated and then tested for appropriateness. The generator/test mechanism is the direct analogue, in the behavioral theory of rationality, of the variation/selection mechanism of the Darwinian theory. Just as in biological evolution we have variation to produce new organisms, so in the behavioral theory of human rationality we have some kind of generations of alternatives – some kind of combinatorial processes that can take simple ideas and put them together in new ways. And similarly, just as in the biological theory of evolution the mechanism of natural selection weeds out poorly adapted variants, so in human thinking the testing process rejects ideas other than those which contribute to solving the problem that is being addressed.

There are further parallels between genetic and cultural evolution. New ideas or theories that are produced by our own imagination or reasoning correspond to mutated genes in biology. Critical evaluation of these ideas in the light of all we know (consistency test) corresponds to the selecting evaluation by the epigenetic system. Evaluation in the light of experiments made in the outside world corresponds to the usual Darwinian selection by the physical biotope. Evaluation in the light of what other people know or believe means natural selection by the social environment (i.e., competition). The result can be called individual (genetic or cultural) learning. If we adopt, however, foreign ideas, which usually have the advantage of having already been tested by other persons' experiences, and combine them with our own concepts, then this corresponds to the adoption of proven genes within the framework of sexual reproduction, and their subsequent recombination. This we call social (genetic or cultural) learning. So, the term individual or social refers to the source of data (Did I learn it myself, or did I let others learn for me?), whereas the term genetic or cultural refers to the type of data concerned (Is the result stored in my genes or in my 'memes'?). In an exclusively cultural context, social contacts and social learning are always cultural, which has sometimes prompted people to replace the term 'social' by 'cultural' (Callebaut, 1987). If so, however, when drawing parallels to organic evolution, genetic 'learning' by sexual recombination and reproduction has to be called a cultural phenomenon, which would be against all scientific terminology.

All theories, plans, and developmental processes have a certain range of competence, inside which they act in a well planned, predictable, proven manner – Lamarckian processes according to the definition given. Outside this range, however, they can succeed only according the possibilities of Darwinian trial and error. For embryogenesis based on a specific genome, for example, the competence ends with the production of a viable organism. Whether a certain organism, once it has been produced, survives in its physical and social environment is outside the competence of the epigenetic system. Here, the only method that organic evolution can apply is trial and error (whereas the Lamarckist believes that the developmental process can at least partially respond also to external requirements). Something similar applies to culturally acquired theories. Economic and social theories, for example, may tell us what particular budgetary or employment measure may increase inflation, but their competence is not sufficient to fully predict the outcome of more complex measures. The consequence is that policy, despite all scientific efforts, is largely a matter of trial and error. So, whether we have to call a modifying process Lamarckian or Darwinian does not depend so much on the process itself but rather on whether we look at the process from inside or outside its competence. The terms Darwinian and Lamarckian, therefore, describe aspects rather than qualities.

If we look at two different processes, one from inside, the other from outside their competencies, then it is evident that we see different phenomena but these need not reflect possibly existing real differences. It is as if one would compare the physical hardness of two metals, one below and one above the melting point. We have to keep this precaution in mind when comparing genetic and cultural evolution: if we speak in terms of theories and knowledge to be transmitted culturally to the next generation, we mean proven and tested theories, i.e., the results of cultural learning, and not the uncontrolled and unproven products of intuition. We have to compare these proven and tested theories with the results of genetic 'learning', i.e., with the proven genetic modifications that have already shown their ability by producing an organism that can survive and reproduce and which will therefore be transmitted to the next generation. Gould (and others), however, look at cultural evolution from inside its competence and at genetic evolution from outside, i.e., they compare culturally acquired theories that have already passed all checks with spontaneous genetic mutations that still have to pass all testing. If at all, the latter have to be compared with culture, policy, etc., by looking from outside the competence of the theories by means of which we try to guide social development. Then the evolution of culture would be Darwinian, driven by incompetent human action in the same way as organic evolution is driven by 'incompetent' mutations. So, to try to distinguish organic and cultural evolution by means of the terms Darwinian and Lamarckian is a kind of semantic confusion (Diettrich, 1992).

2.13
Physical and Social Problem-Solving in Cognitive Evolution

To this point, I have dealt with cognitive evolution mainly from the point of view of how to manage sensory input or to identify laws of nature, i.e., how to solve the problems of our physical environment. Cognitive capabilities were presented mainly as tools to improve our physical fitness. The more time, however, we spend in social clusters, the more we have to cope with social problems and the more we have to improve our social fitness.

'Fitness' is defined as the quality that contributes to the survival of a species – in the narrow sense if only genetically determined qualities are concerned and in the broad sense if culturally inheritable forms of behavior and capabilities are also considered, including the scientific and organizational skills of *Homo sapiens*. Although not customary, I will apply fitness also to theories or strategies if they succeed for a long time and under a variety of conditions. A sufficient condition for biological survival is a high reproduction rate, but it is not necessary: it is easy to show that under conditions of profitable social cooperation, maximal procreation might be counterproductive and that a restricted and modest reproduction rate can be a better guarantee of long-term survival of the species concerned. Somatic cells in metazoa that would forget this and reproduce maximally like 'free and independent' cells will die as cancer cells. To a certain degree humans (as well as some socially organized animals) have also acquired the status of somatic cells. They still propagate (and, of course, they must do so), but mainly according to certain social criteria and not so as to maximize their genetic output. Indeed, few of us would invest all our biological and social resources in bringing up as many children as possible. We are cultural individuals in so far as we strive for cultural and not only for genetic immortality. We strive for a lasting contribution to the 'culture pool' of our society. Some groups even explicitly resign (via celibacy) from genetic propagation, to be culturally or socially more efficient. They recruit their members by social integration instead of by biological replication.

Yet, fitness is a theoretically fruitful notion only if it is more than just a synonym for the ability to survive, i.e., it must manifest itself also in other qualities from which one could then draw conclusions as to the species' future position. Otherwise, one would run into the well known tautology of 'survival of the fittest'. It would be sufficient, for example, if we could deduce from a species that has survived until now that it must have developed so many survival skills that it will have a good chance of succeeding also in the future. But this is exactly what we cannot do. Special species have developed special skills tailored to the special difficulties of the past, but not necessarily those of the future – and particularly not for those they have brought about themselves by what they tried in the past. The more sophisticated and comprehensive the problem-solving techniques a species has engineered are, the more sophisticated and comprehensive will the problems that will result as an unintended byproduct be, and the more expensive and troublesome the efforts needed for mastering the new problems. Nearly all problems mankind has today result from the success our ancestors had in solving their problems. Under these circumstances it is not at all evident that humans, despite all their problem-solving capabilities, have less reason to worry about their future than many of the eukaryotes. What is more: because the risk of colliding with the boundary conditions of our existence grows with increasing effort and investment, we may become victims of irreversible life-threatening long-term consequences, and we may well find that progress undertaken for the conservation of the species will turn out to be counterproductive. What looked ingenious in its time may have been the first step into a dead-end street.

This process can also be described in somewhat differently. There seems to be something that can be called risk-homeostasis (Wilde, 1982). All successful evolutionary solutions of problems diminish the extinction risk of endangered species. On the other hand, species are tempted to load new risks onto the strategic reserves just acquired. The net security yield, therefore, may be zero, or even negative when overcompensation occurs. Animals, for example, that cannot only walk but also fly should, under otherwise equal conditions, be better adapted then those that can only walk or only fly – but only so long as their greater competence will not entice them to occupy biotopes where both walking and are required for survival, so that the loss of one of these abilities would be fatal. The driver who wastes the security benefits of the additional technical facilities of his automobile, such as ABS brakes, by driving at a correspondingly higher speed (a behavior that is unfortunately very common, as insurance companies confirm) is not much better off.

This principle is very general: the number of potentially fatal problems humans have brought about by merely completely exploiting their various capabilities is not much less than the number of capabilities themselves, because solving any problem implicitly results in the generation of new problems, which are often more complex as they derive from a solution that must have overcome the previous problem. In terms of ecology, the greatest problem of mankind is probably waste management.

Although we saw that neither organic tools nor theories have a definitive or universal value, I firmly believe that there are at least general strategies that are useful and therefore recommendable in any situation, even though their long-term profit may be reduced by the mechanisms of risk-homeostasis – functionally 'true' strategies so to say, similar to structurally true propositions in the real world. Improving and strengthening the methods of rational thinking is of general utility not only in science but also in the world of day-to-day living. From what we understand as the success of rationality, we often conclude that it must be based on the constitution of the world we live in, and, consequently, that the world's order can be decoded only by rational methods. From this notion, we conclude that, even in those cases in which consciously applied rationality seems to be excluded (as in the subconscious or in animal behavior), the success of strategies or the applicability of organs is guaranteed only insofar as they meet rational criteria, i.e., insofar as they are 'ratiomorphic' (Brunswik, 1955). This means that strategies and construction principles (concerning both the physical and the cognitive context) have to consider all relevant facts in the same way as an accordingly informed analyst would.

To derive the 'rational structure' of our world from the success of rationality and to conclude retrogressively that cognitive methods can survive only when being ratiomorph reflects the allegation that rationality results from cognitive adaptation to the real world (Campbell's natural-selection epistemology). Because, however, the notion of an independent reality evaluating the efforts of those dealing with it cannot be explained, as we have seen, the success of rationality can hardly characterize the world as it is but only the class of rationally solvable problems. Thus, the ability of rational thinking cannot represent a value per se based on the particular constitution of the world. Its utility can be defined only in the context of the various applications concerned. Indeed, the high reputation rationality has enjoyed since the Enlightenment, particularly in the context of science and technology, is mainly based on mankind's decision to favor just those values (such as the physical mastery of nature) that can be satisfied only by means of rational methods. The development of these methods, in turn, stimulated technology-based cultural achievements such as telecommunication, which in turn generated incentives for further research in this direction. This statement holds rather generally: there is an inherent coevolution between all means and their applications in general behavior, cognition, and culture, as well as in organic life. It refers to rationality and control of nature (or more particularly to basic research and technological applications), biological limbs and manual skills, visual sense organs and space–time perception, physical theories and experiments, or culinary tools and feeding habits, and so on. None of these tools would make any sense or could be evaluated except in the context of the applications that they had evolved with. In particular, we cannot say that species with rational capabilities would necessarily dominate all other species. With a view to the large number of unsolved human problems based primarily on a lack of social coherence rather than of scientific knowledge, we cannot exclude that societies specialized in intuitive (and therefore irrational) social problem management would, in the long run, be better off than societies with a high scientific standing but without the necessary feeling for what the social consequences of science can be.

From another line of thinking we attain at the same conclusion. For a long time in human history, the world that humans had to cope with was the physical environment, and they had to master physical problems to survive. The fight against cold, hunger, and disease dominated human striving for ages, culminating eventually in modern science and technology, solving nearly all of our classical problems. With respect to the scientific possibilities available, mankind is largely saturated. With increasing social communication, however, the relevant environment is shifting more and more from the physical to the social environment, thus opening up an entirely new set of requirements. Looking at the course of a typical day, it is obvious that we spend the most effort in meeting social boundary conditions, such as in making money or finding acceptable balances with other peoples' interests, rather than in grappling directly with physical needs. Even though scientists deal explicitly with the physical structure of the environment, they do so mainly to survive in the academic rather than in the physical world. In the long term, this may reduce the general curiosity about scientific– technological issues and the perception of the physical environment in favor of a sharper comprehension of societally relevant matters. Under these aspects, the high strategic importance we attribute to scientific and technological capabilities is a relic from times when the mastery of nature was the prevailing requisite for survival. Today, most of the problems we have and even more of those we will have in the future are social in character or can be solved only by social measures. So it may well be possible that the (Western) cultural dominance of the science of nature is a fading episode in man's history, to be replaced by what one could call the societal paradigm.

I would hesitate to see in the present widespread antiscience movement, as manifested particularly in the fields of nuclear energy and biotechnology, a first indication of a paradigm shift in the sense discussed above. On the one hand, these attitudes relate to fears and concerns about fatal applications or otherwise risky consequences due to mismanagement, lack of control, or neglecting the nonrenewable character of many resources, rather than to a general reevaluation of the goals to be achieved by science. On the other hand, however, the fact that science has become an issue on the public agenda makes it clear that science is going to shift from being a pure survival tool, such as agriculture was, toward one of the societal 'enzymes' that constitute the mechanism of social development as described by Luhmann (1990).

For the time being, one of the most severe difficulties mankind has ever been confronted with is environmental pollution, which is no doubt physical in character. However, even pollution is first of all a social problem, because it requires socially reasonable responses to diminish the output rather than scientific effort. Scientific solutions, however ingenious and effective, cannot eliminate the mechanisms of risk-homeostasis, i.e., they cannot prevent a counterproductive increase in detrimental production so that, after a while and despite all the technical environmental protection skills we have, pollution will rise to historical levels again – or even higher. Unfortunately, there are many similar problems in which the often fascinating scientific success in fighting them prevents us from looking at the real, i.e., the societal, solution.

2.14
Summary

I have dealt with two different kind of approaches to cognitive evolution and evolutionary epistemology, referred to as the classical and the nonclassical approaches.

The classical approach is based on the categories of our inborn world view, such as subject/object, space, time, causality, and even reality. That these categories are inborn imparts great inherent plausibility to this approach. Similarly, classical physics is based on the same categories, which is exactly the reason why we can really 'understand' it, whereas quantum mechanics – however well it may do – remains outside its mathematical framework a notionally inexplicable matter. Yet the point is that we do not really need to understand physics so long as it helps to master nature – whereas it is problematic to explain cognitive evolution by means of a notion of reality that has been brought about by cognitive evolution itself. Cognitive evolution may have had good reasons to 'convince' us that it is useful for describing the sum total of past and present experience in terms of what we call the laws of nature. But evolution did not tell us that these laws would converge towards definitive, universal versions. This is an anthropomorphic allegation. Because evolution at the same time 'told' us that everything has to have a cause, we invented 'ontological reality', to comprise among other things the universal laws of nature. This invention (however heuristically dubious it might be) was a paying investment. To believe that what we see is real rather than the output of mental interpretations restrains us from time-consuming reflection on how appropriate our interpretations are, which accelerates many decision-making processes. Realism also legitimizes all scientific efforts to identify and analyze the structure of nature. Any empirical experience can be seen as a lasting contribution to the decoding of nature. Because, from the realistic point of view, the structure of nature is definitive and of finite complexity, realism supports the idea that science is not a matter of endless striving but can be completed – at least in principle (theory of everything). Even epistemologists are made more comfortable by the thought that our inborn epistemology might have been evaluated by selection of a real nature and its laws. But realism is first of all a theory constructed to explain the definitive, objective character of the laws of nature. As a theory, however, realism cannot endow its subject, reality, with ontological authority. In particular, it cannot declare its own subject to be the reason or justification of why it itself came into being. Further to this, realism, defined by objective laws, became more problematic when it turned out that the laws of nature are neither objective nor definitive.

The nonclassical approach tries to explain the well documented links between action and perception and the possibility of prediction without reference to an intermediate independent reality. If the independence of reality is based on the objectivity of laws of nature, we must first of all find a possibility to explain these laws as human-specific artifacts.

Here we can profit from physics: after the experiments physicists made with quantum mechanics, they agreed that the properties of physical objects have no ontological character but are defined as invariants of measurement operators. This must apply also for physical laws, which can be seen as the properties of nature and which are thus defined as invariants of the cognitive apparatus as a whole. I showed this by referring to the cognitive operators contained somewhere in our cognitive apparatus, which transform the physical input of the sense organs into perceptions. The regularities that we perceive and condense into what we call the laws of nature can then be considered to be the invariants of cognitive operators. A typical example: the law of energy conservation can be derived from the homogeneity of time and thus depend on the time metric generator in our brain. Experimental physicists extend our cognitive operators by means of measurement operators. If both operators commute in the sense of operator algebra, the measurement results can be described in terms of the inborn cognitive operators, i.e., in classical terms (quantitative extensions). Otherwise (qualitative extensions), nonclassical theories have to be designed. Because qualitative extensions can never be excluded, physics cannot be completed. Similar reasoning applies in mathematics: because we (according to Gödel, 1931) can never be rule out that the axiomatic system has to be changed, mathematics cannot be completed. The idea that the laws of nature are defined as invariants of the cognitive apparatus and that they cannot be seen as condensations of the experiences we have had with an external world, is very close to what Cruse (1999) had in mind when he wrote in a paper on the external and internal views in cognitive sciences: "We do not have the experience, we are the experience."

As to the predictability of the results of our acting, we again can profit from physics. Whether a variable in a physical system evolves linearly in time (and can therefore easily be predicted) depends on the variables used. According to the theory of Hamilton–Jacobi, in many cases transformations can be found that make some of the variables 'cyclic', i.e., they change linearly in time. If cognitive evolution had managed to provide us with perceptional variables that are cyclic with respect to our elementary actions, then it is clear why we can extrapolate or predict the perceptions caused by our actions, such as locomotion. A generalization of this relationship between action and perception leads to what Davies called the algebraic compressibility of the world. That so many and such complex features of our world can be described in rather simple mathematical formulas might well be based on functional homologies between the mental roots of perceptual and mathematical procedures.

The most promising effort of the approach proposed here aims at a coherent description of organic, cognitive, and scientific evolution. However, the price to be paid is high. We have to accept that the laws of nature are phylogenetically acquired human-specific artifacts; that there is no 'natural selection epistemology' (in the sense of Campbell, 1974 a); that there will be no complete set of physical theories (theory of everything), and that there will be no meaningful context-free communication (such as with extraterrestrial beings). On the other hand, I have offered some explanations that could hardly have been expected from outside the cognitive operator approach: the incompleteness of physical theories and the incompleteness of mathematical axioms discerned by Gödel (1931) have the same cognitive roots – the algorithmic compressibility of the world (which is equivalent to the success of induction) is due to the homology of cognitive mechanisms and the mechanisms of mathematical thinking. Of particular interest is the link between organic and cognitive tools: if cognitive tools are to describe the covariants of an operator (i.e., what the operator effects), they have to be designed in terms of the operator's invariants (a principle that has been reinvented by physicists within Hamilton–Jacoby and quantum mechanical formalism). Cognitive evolution (including the epistemology applied here) is therefore brought about by organic evolution (and by the evolution of experimental tools) rather than by trial and error and selection. And, vice versa, organic (and experimental) evolution is guided by the possibilities provided by cognitive tools. In addition to this I have shown that improving our scientific knowledge must not necessarily be the definitive goal of cognitive evolution. To the extent that our environment will be defined more and more by social boundary conditions rather than physical limitations, it may well be possible that in the long term, competence in social problem-solving will be more relevant than scientific skills.

Let me summarize here in a synoptic view how the approach used enables us to describe the major elements of organic and cognitive evolution.

Organic Evolution:

- Organic evolution has to meet the requirements of the environment (adaptation).
- Only appropriate adaptation is retained by natural selection.
- Evolution brings about acting skills and tools to modify the (external) environment according to the requirements of the organism (assimilation).
- Thus, discrepancies between the organism and its environment can be reduced from both ends, by adaptation, (internal solution) and by assimilation (external solution).
- The higher organisms have evolved, the more they use assimilation. (Humans, when confronted with physical problems, rely exclusively on external solutions, rather than waiting for evolution to provide better adaptation).
- As evolving species modify their environment, the selection power is not static. Evolution will therefore not converge towards a definite or optimum state – (no definitive species of universal competence) – the pride of creation so to say (organic evolution will not reach completion).
- An organic phenotype (and the action tools comprised in it) cannot be 'true'; to survive it must reproduce.
- The variety of organisms is subject to the boundary conditions of cells. The variety of cells is subject to the boundary conditions of molecules, etc.
- The success of organs is specific to species.
- Organisms of different species usually cannot communicate genetically, i.e., interbreed.
- Genetic mutations, once they have passed all internal and external selection mechanisms, can be transferred directly to the next generation. Mutations are modifications of approved genotypes and are subject to genomic boundary conditions. So they are in many cases more promising than a stochastically redesigned genome. Regarding Darwinism/Lamarckism, there is a strict balance between organic evolution and the evolution of science.
- Organisms with a novel phenotype are not necessarily obliged to meet the requirements of their actual niches. They can emigrate to more appropriate ones, i.e., they can find a better application for their phenotype.

2.15
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3
Evolution, Language, and the Construction of Culture

Harald Haarmann

3.1
Introduction

The relationship between the basic concepts 'evolution' and 'language' is complex. We can understand it in a way that language is involved in evolution and has experienced changes in the process. We can investigate the role that language has played as a means of communication in the communities of different hominid species. We can try to find out about the origins of speech sound production, about the mental preconditions of this "intricate set of structural and representational mechanisms" (Bickerton, 1994, p. 2881) that we call language, and about how language has functioned throughout the ages as a tool for constructing culture (Arutyunov, 1989; Haarmann, 2000).

This field of study is intriguing because, unlike other domains of language sciences, its pertinent issues have, for the longest time in the history of science, been tabooed or simply marginalized. In 1866, the Linguistic Society of Paris refused to accept any studies dealing with the origins of language. The main argument for barring such studies from the scientific record was that the nature of statements about the origins of language could only be speculative.

For more than a hundred years, linguists remained impressed by the wisdom of the Linguistic Society and, even today, some experts entertain the same idea of the allegedly 'unscientific' nature of the subject. Astonishingly, an unprecedented renaissance of research on evolution and language occurred in the 1990s, and this domain has established itself as an arena of scholarly debate in which even renowned linguists and behavioral scientists do not hesitate to participate. Scholarly activities are accelerating, and more and more efforts are made to reconcile findings from various scientific fields that might enhance progress. This chapter pays special attention to interdisciplinary approaches to the problem area.

Human beings are involved in processes of biological evolution as are other living creatures. A facet of evolution that is common to all primates, to ape species and to humans, is the working of cultural evolution. Research in animal communication has highlighted the existence of networks of interaction in ape communi-

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ties which deserve the label 'culture' (Bekoff and Jamieson, 1996). This insight might come as a surprise to traditionalists who consider culture to be a concept reserved for the realm of interaction among human beings. In fact, the evolution of language as a vehicle of human culture cannot be assigned its proper role when one leaves out the links of human culture in the wider panorama of cultural activities in primate species.

Modern humans (modern *Homo sapiens*) share with other primates the use of nonverbal sign systems such as poses and gestures. Therefore, nonverbal communication has a long tradition in primate evolution. Language, too, is not exclusive to modern humans. There are two other hominid species for which its use can be reasonably asserted, and these are archaic humans (archaic *Homo sapiens* or *Homo neanderthalensis* or Neanderthal man) and *Homo erectus*. These earlier hominid species were capable of producing speech sounds. Archaic man's capability to distinguish qualities of speech sounds was rather limited, as was his capacity to organize meaningful elements in a linear sequence (Section 3.5). The stage of development of language in archaic man was that of a protolanguage that lacked the sophistication of modern human language.

"Human language is an embarrassment for evolutionary theory because it is vastly more powerful than one can account for in terms of selective fitness" (Premack, 1985, p. 283). Indeed, it is an embarrassment when the evolution of language is viewed in the light of traditional ideas of adaptation. In the light of the capabilities of modern humans to devise grammatical structures and communicational strategies, we have to acknowledge the astonishing fact that the faculty of language as an elaborate means of information technology in modern humans cannot be explained by applying traditional categories of evolution theory associated with models of refining skills in the process of adaptation. Modern man's capabilities of verbal communication are due to a qualitative leap in evolution, not a gradual development reflecting the adaptation principle.

Language is the major vehicle for organizing social relations among individuals as members of a group, and it functions in this role also to guarantee successful interaction in larger communities. The faculty of complex language gave modern humans the edge over the other hominid species living contemporaneously, archaic or Neanderthal man. For at least 12 000 years, modern man and archaic man lived in the same areas in southwestern France and in the Iberian Peninsula. Settlements have been found with evidence of cohabitation of both species (Carbonell and Vaquero, 1996). In the process of contact, Neanderthal man's lithic industry was 'modernized', while modern humans, competing with archaic man, were challenged to develop their organizational skills. Some have argued that the disappearance of archaic man might have been due to colonization and suppression by modern man as the superior species. Late remains of archaic man can be identified in Andalucia, dating to about 29 000 BCE (before the common era). After that time there are no traces of that hominid species.

The leap in evolution is also true for other domains of modern humans' cultural activities. Palaeolithic rock art is one such domain. Already in the oldest pictures painted on the walls of caves that were found in Europe and Africa, a refined aesthetic sense is reflected. From the beginnings of documentation, modern man was capable of producing naturalistic pictures as well as using abstract symbols. This can be deduced from the presence, in earliest rock art, of paintings of animals and alignments of dots and strokes or of grid motifs. Although archaic humans had the capacity to produce abstract symbols (e.g., a cross sign scratched on a bone plaque), no specimens of figurative art have come down to us. It is noteworthy that the sense of symmetry is already at work in *Homo erectus*. This is evidenced by bifacial tools in the lithic production of that species (Foster, 1990). Neanderthal man obviously had the capacity to apply the organizing principle of symmetry more systematically. Modern man's sense of symmetry is thus the result of a long process of evolution.

To sum up, the cultural capacities of modern humans reflect a set of skills that are partly the result of long-term evolution and partly the product of a leap:

- Capabilities with a longer tradition of evolution:
  - nonverbal communication (communication by symbolic manipulation of poses and gestures)
  - a sense of symmetry
  - perception of abstract visual symbols as meaningful signs
- Capabilities of modern humans with insignificant representation in other hominid species:
  - verbal communication (the production of a variety of speech sounds and the alignment of meaningful elements in the spoken code)
  - an aesthetic sense (the creation of naturalistic pictures and sculptures, starting in the Upper Palaeolithic period)

3.2
Identification through Language and its Impact on Culture Processes

The evolutionary leap that occurred with the elaboration of language skills in modern humans cannot be explained by the workings of the adaptation mechanism. And yet, there is a mental force in human beings that made such a leap possible, for the simple reason that this force required a sophisticated means in which it can crystallize. This driving force is identity or, to be more precise, the identification process. In the discussion of the grand theme of cultural evolution, identity has been widely neglected. In this chapter, I intend to highlight its significance. Humanity's striving for control of their environment was not based on a plan devised by some individuals in the remote past, which spread and inspired others to follow suit. Rather, it was connected to some inner force that is responsible for man's entire cultural enterprise. Identity is a complex mechanism providing an individual with the capacity of multiple choice in decision-making and role relations. Identity is not a phenomenon that – once achieved – continues unchanged. Rather, identity is a dynamic process that is renewed in everyday interactions and is subject to potential changes (Haarmann, 1996).

A human being may play many social and cultural roles during his or her lifetime, and the values as well as the priorities of cultural activities change from childhood to older ages. This dynamic property of identity – its involvement in the constant mental build-up responding to changing needs – is responsible for the manifold impulses which have led, throughout the cultural history of modern humans, to the elaboration of ever-new sign systems, designed for a great variety of purposes.

The process of identification in its broadest sense is equal to the mental construction of the Self in contrast or relation to the Other(s). This is so elementary as to function as a motor for all kinds of interaction and cultural activities. Identity, that is, the awareness of one's Self in distinction from Others, works in modern man in a way that it did not in other hominid species. Individuality and self-awareness were much less developed in Neanderthal man. Identity enhances intentionality, and this in turn enhances the use of a sophisticated means to crystallize: language (Lyons, 1995). Intentionality is fairly week in primates, although it is present on a rudimentary level. An evolutionary reminiscence of this rudimentary stage of intentionality is still discernible in modern humans, namely in the somehow diffuse, prelinguistic intentionality of early childhood.

Linguists have been impressed by the skills of chimpanzees in learning human language (Savage-Rumbaugh and Lewin 1994). Behavioral experiments with apes nourishes the idea that 'nonhuman animals' have their own representational patterns of cognitive categories of the world (Dupré, 1996). Such insights may be helpful for understanding brain capacities in different species on the evolutionary continuum. However, they provide little assistance for the study of communicational skills and their evolution in modern man.

The crucial issue in cultural evolution is not the mental capacity to perform certain acts but rather the incentive that drives one species to elaborate and use a sophisticated technology such as language, and the others not to. Chimpanzees do not need language in their natural environment. Therefore, they have not activated their brain capacities to this end. On the other hand, modern humans would not be able to construct their cultural environment without verbal skills. Our need of language is intrinsically associated with the challenges of our identification process. The recent discovery of a so-called architect gene that is responsible for cerebral asymmetry and language (Crow, 1996) may contribute to the understanding of the driving force that is inherent in the identification process.

If identity is central to the culture process, then

> the theory of identity has to be regarded as the basic theory of all the humanities, on which the more specialized ethnological and other anthropological disciplines ... would have to be based and elaborated (Müller, 1987, p. 391).

If the identification process and the driving force of intentionality are much stronger in modern humans than in archaic man or other hominid subspecies, then we must also expect that the most important vehicle for articulating intentionality, language, is much more elaborate in modern humans than in their predecessors.

Language – the most efficient natural sign system – has taken over a great deal of the functions that were necessary for the cultural construction of the world. 'Constructing' culture means making the world understandable through symbols. In no other hominid species was symbol-making as essential as it was for modern man, who has been called *Homo symbolicus* for this reason (Deacon, 1997, p. 340 ff.). The cultures of modern humans are much more sophisticated than those of archaic man, and this by all standards, because language is so effective. In the dynamic process of identification, the relationship between the major factors can be specified as follows:

$$\text{identification process} \Rightarrow \text{intentionality} \Leftrightarrow \text{language}$$

From the beginnings of social relations among modern humans, oral tradition was a prominent source for organizing the collective experience of the speech community in the cultural process. Arguably, the oldest text genre to develop was the explanation of the world within the framework of mythical categories (Donald, 1991, p. 267 ff.). In the mythical tradition, motivation for learning from experience and for making plans for the future may crystallize and produce an interpretation of one's position in the world. In a comparative view of oral traditions, the modern observer is amazed at man's imaginative skills to communicate with spirits and other divine beings for different purposes (see Novik, 1989, p. 137 ff. for examples of shamanistic rituals among Siberian peoples).

The most elementary layer of mythical experience that we find in the world's cultures are myths of origin, usually explaining, in ethnocentric terms, how a certain group of people (a clan or kin group) was the focus of the creation process for which spirits or divine beings are held responsible. Spoken language served as a means for perpetuating mythical ideas, and its use was always associated with and related to the items in a given culture's environment. Orality is more than what historians choose as their target when inspecting sources of oral history: verbal narratives. The experience with orality in traditional cultures teaches us that the memorized collective knowledge in a speech community is reiterated, renewed, and/or elaborated in ritualistic performances such as story-telling, ritual chanting and dancing, and competitions of verbal and other performance skills (Hoem, 1995, pp. 31 ff., 104 ff.). Ritual chanting, for example, makes sense only under the condition that the verbal narrative is closely associated with local cultural symbolism.

To exemplify this, I draw the readers's attention to oral tradition among the Navajo Indians, which is closely associated with their sand pictures. When a Westerner looks at Navajo sand pictures in ethnographic studies or in popular publications on ethnic styles in art – that is, without their embedding in their original cultural context – he or she perceives them as items of 'art' (Westerners speak of 'sand paintings') or 'design'. When viewing such 'designs' in their proper cultural context, one understands that sand pictures are a ritualistic tool, that their figural and abstract motifs are heavily imbued with mythical symbolism, that the selection of items in a picture is canonical, and that they always function in association with ritual performances, specifically ritual chanting (Griffin-Pierce, 1992, p. 98 ff.). Once the verbal performance has come to an end, the sand pictures are destroyed, because their visual retention beyond the ritual would be a sacrilege. Therefore, the simple fact of technically reproducing sand pictures in photographs is a violation of ritual constraints that are valid in traditional Navajo culture.

Since ancient times, verbalized memories have been associated with visual items and/or auditory experiences (e.g., ritual chanting) of a given regional culture. It is from this crucial interplay of verbalized and audio-visualized elements – the bricks for the construction of culture – that the impulses sprang for devising notational systems. The term 'notational system' is subsumed, as a subcategory, under the overall category of 'sign system', which denotes an orderly organized set of symbols. The processes of developing notational systems follow two mainstreams, one is the visualization of language, the other is the visualization of ideas excluding language. Since language, humanity's most effective sign system, is of ancient origin, one would be inclined to assume that the visualization of language-oriented information would have been the older of the two notational processes. However, this is not so. Among the language-based notational technologies, writing is the most specialized and – at the same time – the most recent achievement in cultural history. The oldest known writing system that emerged from the milieu of the Danube civilization dates back to around 5500 BCE (Haarmann, 2002b, p. 19 ff.).

Those notational systems that operate without the participation of language, such as numerical notation, have the longest record. Modern humans colonized Europe in the Upper Palaeolithic Age, and from that period stems the oldest documentation of numerical notation. Among the items of mobile art in the caves that were frequented by humans are so-called 'commando sticks', deer antlers or mammoth ivory that often bear alignments of abstract signs (i.e., strokes, lines, dots). Certain sign ensembles have been interpreted as an early approach to fixate information about phases of the moon. Such notational systems have been highlighted as "one of the most complex cultural developments of a hunter–gatherer society in the record of anatomically modern man" (Marshack, 1990, p. 481 f.).

3.3
Variation and Variability: The Organizational Principle Par Excellence in Processes of Evolution

In processes of evolution, there is a major arbitrator, and this is the working of the principle of variation. If variation works in the evolution of the living world, then variability is its intimate ingredient. From the very beginning of biological evolution, life forms proliferate into ever-more-individual species. The reason for the proliferation of life forms is obvious. Every new species had the chance to better adapt to differing environmental conditions and to develop more sophisticated strategies of adaptation. The panorama of various life forms provided a solid guarantee of the persistence of life on earth. The more variation between species, the greater the chance for life to persist.

The validity of this life-assuring principle proved itself in several disasters that were caused by the impacts of meteorites into the earth crust at different times during earth's history. One of the most devastating collisions with a meteorite occurred about 60 million years ago. This catastrophe resulted in the loss of more than 80% of the then-living species, including most of the dinosaur species. The only dinosaurs to survive were those from which birds evolved. It has been estimated that only those animal species survived that weighed less than 10 kg.

The principle of variation is discernible in the evolution of primate species. Modern man is one among several variations of hominid species. With the exception of Neanderthal man, who, in the late period of his existence, was contemporary with modern humans, other hominid species are predecessors whose links to us can be demonstrated in terms of genomic structures and biological descent. Although still a matter of dispute, the links to Neanderthal man seem to be the closest that can be identified for modern man.

Variation is also the major arbitrator in the evolution of cultural patterns. *Homo habilis* deserves the name, judging from their capability to use certain objects in the environment, such as stones or sticks as tools, although they would have done this only occasionally. *Homo habilis* did not yet produce tools for specific functions. This organizational skill was developed in *Homo erectus*, the first of the hominid species to control fire, although its actual mastery may have taken a long time of experimenting. With *Homo erectus* we find the beginnings of symbolic ability, that is, an ability to use visual symbols. Evidence for this comes from a region that had been, since the earliest presence of hominids, a contact area where influences from different directions were felt.

In one of the caves in the mountainous region of Karabakh (western Aserbaijan), the Azykh cave, the skull of a bear with man-made notches was found. The cultural strata of this particular find dates back to the lower Acheulian period, to about 430 000 BP (before present). "All the notches are made by dented tools with bifacial edges. The notches seem to be related to some religious ideas of the Azykh people" (Guseynov, 1985, p. 68).

Obviously, the presence of abstract signs on the skull (whose lower jaw was deliberately removed) near the hearth is noteworthy, as is the assembling of two lower jaws from bear skulls in the form of a cross. Judging from circumstantial evidence, one can assert some magical purpose in connection with the cult of the cave bear (Haarmann, 1992, p. 55 f.).

The concept of evolution is intrinsically associated with time. Evolutionary stages of life forms can be pinpointed in relation to absolute chronology. This enables the observer to understand the processes of specialization and proliferation in the horizon of time. Variation in cultural patterns evolves in a spatiotemporal continuum, which means that culture varies in space and time. The working of spatiotemporal variation leads us far back into the history of hominid species. The time depth is the greatest in Africa, where the early primates and all the hominid species are documented. *Homo erectus* spread into Asia and Europe, as did Neanderthal man. However, Australia and the Americas have no fossil remains of earlier hominid species. Australia was peopled by modern humans before 60 000 BP, but North America, no earlier than 15 000 BCE.

At an early stage, spatial variation is observable in the evolution of cultural abilities. This is related to the cultural horizon of archaic man. Pilbeam (1988, p. 134) stated that "by 150–200 thousand years ago, European populations begin to diverge from archaic sapiens populations elsewhere".

The anthropological properties of Neanderthal man are best evidenced from finds in Europe and west Asia. Most of the archaeological evidence for symbolic activity, that is, for the use of visual symbols, "comes from the Mousterian period and the Eurasian area of Neanderthal habitation" (Marshack, 1990, p. 459).

This, however, cannot be interpreted as a lack of symbolic activity in archaic man outside Eurasia. Rather, it is indicative of a more flexible adaptation of archaic man in the Eurasian environment.

Neanderthal man's artistic skills are evidenced from early European sites, for instance, a carved mammoth tooth plaque (c. 100 000 years old at Tata, Hungary) or pendant beads with bored holes (c. 110 000 years old at Bocksteinschmiede, Germany). Although still a matter of scholarly dispute, evidence may exist of archaic man's skill in sculpture, for instance, bear figurines made of flint. Among the inventions of Neanderthal man in Europe are objects with various functions made of bone, such as needles, flutes, and drums. The use of red ochre is evident in Europe since the late Acheulian (c. 120 000 years BP) for archaic man (Marshack, 1981); in other parts of the world, however, only for modern man (Boshier and Beaumont, 1972 for the Mesolithic in Swaziland). As an example of archaic man's sense of abstraction and symmetry, I mention the fossil nummulite from Tata (Hungary), on which a cross sign is engraved.

With the appearance of modern man, the impetus for symbol-making becomes more dynamic. Still in the Upper Palaeolithic, the evidence for symbolic production comes predominantly from Eurasia. Among the outstanding genres of artistic activities are sculpture and painting. From the very beginning, the tradition of sculpture in Europe shows variety in style and motif. Human figurines depicting males are rare compared with the abundance of female statuary. The female sculptures are of two different physical types. Generally speaking, the voluminous type of statuette with protruding breasts and buttocks is characteristic of European sites, whereas in Siberia, the female images are more slender and their attributes less prominent (Abramova, 1995).

Cave painting is another well-documented domain in which modern man has demonstrated his skills. European cave painting especially shows great variety in motif, style, and complexity of pictorial composition. Early cave art is distinguished in two ways. One is the compositional technique of combining two categories of symbols, namely naturalistic or subnaturalistic motifs with abstract symbols, linear and stylized. If humans' general capacity of using symbols is the key to culture, then the capacity of distinguishing between iconicity and abstractness as two cognitive procedures is a practical approach to constructing culture. In the early cave paintings, the two techniques are applied in compositions from the beginning. The other outstanding characteristic is that this duality in visual techniques exhibits a parallel manifestation in "the appearance of both representational and nonfigurative mobile art" (Straus, 1990, p. 293). Evidence for this is found in the caves of Levantine and Vasco-Cantabrian Spain as well as in southwestern France (Anati, 1995).

3.4 Variation 1: Language and the Evolution of Communicational Skills

In the horizon of time one can observe that the number of sign systems that humans have devised multiplies with a stronger drive of intentionality and with an increase of communicational needs in higher stages of cultural development. Sign systems, of which language is but one, have served in constructing culture in all parts of the world, and their great variety can be categorized according to various parameters.

Sign systems are distinguished according to their relatedness to the most basic cultural institution, language (i.e., nonverbal sign systems versus language-related systems), their relatedness to various stages of cultural evolution (i.e., traditional culture versus high culture), and their varying degrees of functional specialization (i.e., elementary versus specialized functions). In Figure 3.1, sign systems are positioned according to their primary properties. Sign systems may be complex, that is, they may be characterized by primary as well as secondary properties. In a complex system, one can observe the working of symbolic techniques that are themselves manifestations of differing principles.

For example, the system of traffic signs and signals is categorized as a specialized system in the section of nonverbal sign systems, because its basic signal functions rely on the forms and colors of mostly abstract symbols. The nonverbal component is the primary property of this system. As a secondary property, traffic signs may also be language-related, as in written signs such as 'STOP', '3 KM', 'ONE WAY', 'THRU TRAFFIC', 'ROAD UNDER CONSTRUCTION', and the many place names that are written on plaques and boards. So, the system of traffic signs has a secondary property, for which it also ranges in the section of specialized language-related systems.

In Figure 3.1, two sign systems are positioned at the very bottom stage of cultural evolution: mimicry in the section of nonverbal sign systems, and language in the other section. These sign systems differ from most others in that their functions are most elementary and in that the means for their use are provided by nature (i.e., the brain, the vocal cords, muscular activity for producing poses and postures, limbs such as arms and fingers for creating gestures). From the standpoint of cultural evolution, mimicry and language are closely interrelated. Judging from the importance of gestural and tactile interaction among primates, human language "clearly evolved in a matrix of extensive non-verbal communication" (Tanner and Zihlman, 1976, p. 474). As we all know from experience, interaction by means of language and mimicry still functions in modern society. In this synchrony of communicational means we find considerable cultural variation. People in Scandinavia are

Cultural stages	Non-verbal sign systems: Elementary systems	Non-verbal sign systems: Specialized systems	Language and language-related sign systems: Elementary systems	Language and language-related sign systems: Specialized systems
Traditional cultures	— Gestures and poses (mimicry)		— Language (signs of verbal behavior)	
		— Symbolism in ceremonial and ritual dances		
	— Magic and religious symbolism			
		— System of gesture signs and symbols (used as a means of interethnic communication among the North American Plains Indians) — Drum language — System of smoke signals — Whistle language (e.g., among Mexican Indians in Tlaxcala) — Symbolism of pictorial literacy		
	— Symbolism in games (e.g., board games)			
Traditional cultures / High cultures and industrialized society	— Identification symbolism (e.g., marks of ownership, trade marks) — Heraldry (e.g., symbols of authority, seals) — Numeric notation — Weights, measures, and the monetary system			
High cultures and industrialized society		— Pictographic writing — Notation of music — Sign systems in professional fields using logographic symbols (e.g., mathematics, astronomy) — Traffic signs and signals — Sign language for deaf people (gestural code)	— Phonographic writing systems (syllabic, alphabetic)	Systems related to alphabetic writing: — Flag signalling — Morse system — Sign systems in professional fields (e.g., chemistry) — Sign language for deaf people (finger spelling)
	— Digital processing of information			

Figure 3.1 Sign systems in a cultural framework (adapted from Haarmann, 1997).

known for their 'weak' body talk, but in Mediterranean and Arab countries gesticulating as a reinforcement of verbal messages is much more vivid.

According to popular prejudice, mimic signs are universal means for expressing emotions and emotion-oriented attitudes. However, mimic signs function in culturally specific systems (Bremmer and Roodenburg, 1993). Even simple gestures may express very different things according to local cultural conventions. As an example of a multifunctional range of an elementary gesture, I mention the sudden opening of the eye as a sign indicating attention, with the movement of the eyebrow as an epiphenomenon (Figure 3.2). Among the various functions of expressing positive or negative attitudes in the cultures of the world are some special usages. As a sign of agreement this gesture expresses a substantial yes (e.g., in Samoan society), but as a sign of rejection it expresses an arrogant attitude (e.g., in

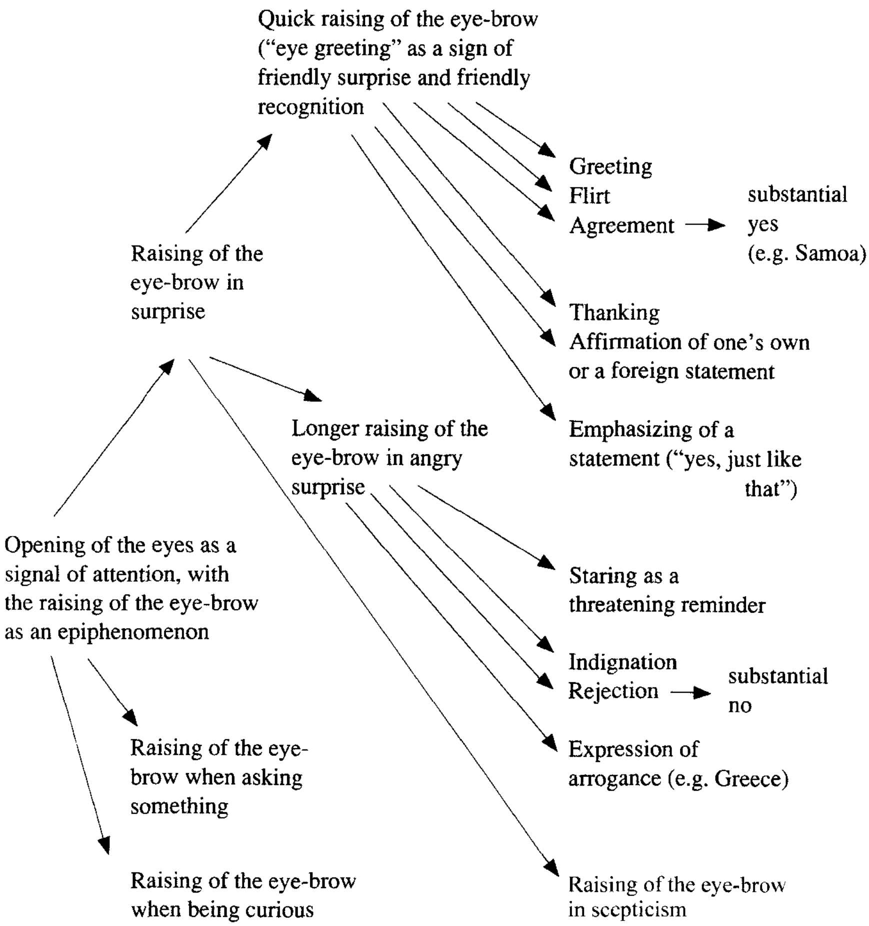


Figure 3.2 The cultural overforming of a gesture (adapted from Eibl-Eibesfeldt, 1972; with additions).

Greek society). This element of 'body language' may be considered a universal symbol of nonverbal communication from the standpoint of biological anthropology. And yet, from the viewpoint of a cultural anthropologist, emphasis lies in the observation of the gesture's cultural overforming.

In Figure 3.1, two sign systems are positioned at the very top of all the stages of cultural evolution: the gestural code (nonverbal systems) and finger spelling (language-related systems). For these systems it is also true that the means of their use are provided by nature. In great contrast to elementary sign systems such as mimicry and language, these two systems for communication among deaf people are among the most specialized of human sign systems. In addition, these insider systems are restricted in range to physically handicapped people and to those who have learned to communicate with them.

Digital processing differs fundamentally from all other sign systems. According to its quantitative capacity of processing information it is the most effective of all sign systems, and according to the stage of its technological development it is the most complex. Although the principle of digital processing is simple (i.e., using combinations of 0 and 1 digits for individual data), the human brain cannot process longer sequences of digits without overstraining the memory. Humans need to translate digital processing into their most effective natural sign system, language.

3.5
Variation 2: Language and the Evolution of Linguistic Structures

The emergence of linguistic structures is a preferred field of study among linguists, anthropologists, and paleontologists. Here, variation is at work in the ways linguistic structures function in a synchronic perspective (Yartseva et al., 1990), and it is recognizable in how complex language evolves in the horizon of time. In particular, the evolutionary transition in communicational skills from the stage of Neanderthal man to that of modern humans has been investigated with great scrutiny. Basically, there are two opposite approaches to how linguistic structures might have developed in the transition process. One is based on the assumption that the complex language of modern man evolved out of a pre-stage of a protolanguage with simple, if not simplistic structures. The other approach advocates a gradual evolvement of linguistic structures – resulting from "the co-evolution of language and the human brain" (Deacon, 1997) – without the intermediate stage of a protolanguage. The assumption of a step-by-step development stands against the concept of an evolutionary leap.

The idea of a protolanguage emerged out of a milieu of the study of Pidgin and Creole languages. In processes of pidginization and creolization, an indigenous language fuses with a colonial language, and the structures of the involved languages usually simplify to form a new set of phonetic sounds, new grammatical and syntactic rules, and a reduced vocabulary. Since the 1970s, the study of such processes has produced many insights into how languages function with simplified linguistic structures. Such insights have inspired some scholars to assume the emergence of a protolanguage in earlier hominid species such as Neanderthal man and *Homo erectus* (Bickerton, 1995; Noble and Davidson, 1996; Mellars, 1998).

The basic capacity of using language would have been present in early man, although its full-fledged evolution would be related exclusively to modern humans. Although the findings from studies on Creoles may help understand the construct of a simple language, there are, nevertheless, still quandaries with the qualitative progress of linguistic development in reaching the level of complex language. The structures of most Pidgins and Creole languages are much simpler than the structures of those languages out of whose fusion a given Pidgin or Creole language emerged. And yet, the level of simplification in Creole languages is relative to the evolutionary stage of language in modern man and far above any capacity of communicational skills that might be assumed for earlier hominid species. The constructs of a protolanguage that have been favored so far still lack the necessary explanatory potential to perceive the transition process to the stage of complex language.

The approach of a gradual evolution of the structures of complex language sheds light on the evolutionary leap in a way as to break up the sudden process into discrete steps. What is tricky about the elaboration in a scaling scheme of internal linguistic changes that ultimately led to the emergence of complex language is the synchronicity of developments. In some simplistic attempts to grade evolutionary steps, the individual steps indicate developments in separate domains of linguistic structures, in phonetics, grammar, syntax, or the lexicon. However, the steps are not coordinated and their consequences for the clustering of linguistic abilities are not revealed. The most recent of such eclectic approaches has been put forward by Jackendoff (2002, p. 424) who claims: "Each of the major components of linguistic structure – phonology, syntax, and semantic/conceptual structure – is the product of an independent generative system, and each is further subdivided into independent tiers".

In all pertinent approaches to a gradation of the evolutionary process toward complex language, individual steps have been reconstructed on the basis of observations of language acquisition in children (Burling, 2002). It is generally agreed among linguists that, in the development of language skills by a child, processes are repeated during individual socialization that originally took many thousands of years to evolve in different hominid species.

In the following, a novel approach is presented, with evolutionary steps ranging from the most elementary to the most sophisticated linguistic structures. What is different here in comparison with other similar approaches is the attention paid to the dynamics of a synchronous evolution of phonetic, grammatical, syntactical, and lexical structures. Each step illustrates a certain stage in the evolutionary process.

1. Communicating with signals and interjections: This activity culminates in a process of embedding certain sounds or sound groups that are produced by the vocal cords in an interactional network, that is, by assigning them pragmatic communicational quality. Elements of language of this early stage still function in complex language (e.g., 'shh' as a signal to 'be quiet!', 'hi' as a greeting, or 'wow!' for expressing astonishment).

The amount of individual signals may have been small in the beginning (e.g., in the repertoire of *Homo erectus*), but their number gradually increased and the inventory of signals for more and more purposes was enlarged.

2. 'Wording' the environment: A precondition for this step is a representational capacity that enables the human being to distinguish individual objects in his perception and to assign them different 'words', that is, individual sound groups with a representational meaning. Even today, there is much uncertainty about how precisely the representational dimension of cognition relates to verbal utterances. Arguably, the following statement still holds true:

> Nobody really has the least idea what is physically going on in the head when we reason, but I agree that whatever goes on is likely to relate in a fairly abstract way to the words of spoken utterances, which are adapted to the necessary linearity of speech and to the fact that speaker and hearer are working with separate models of reality (Sampson, 1997, p. 100).

- The phonetic aspect: The simplest process of 'wording' the environment is the deliberate imitation of sounds or acoustic and visual effects typical of certain animals in order to individualize them as species, of the sounds and noises produced by natural forces such as the wind, the waves of the sea, the water running in a river, the noise of thunder, of a burning fire, etc.
  I must emphasize that archaic man, for whom this stage of protolanguage may be postulated, had a rather limited capability for producing speech sounds (Korhonen, 1993, p. 257 ff.). In all probability, archaic man could produce only two vowel qualities (like e and a) and perhaps eight consonants (i.e., p, b, t, d, s, h, m, n). In addition, archaic man was anatomically capable of producing a glottal stop, a sound that is still present in languages such as German, Danish, and Finnish.
  This stage (2) of language evolution is still visible in complex language. This means that the linguistic technique of producing onomatopoeic words is still functioning today. Every historical and recent language includes onomatopoeic (sound-imitating) expressions. The amount of onomatopoeic elements in the lexicon of a complex language varies considerably. Some languages, such as Finnish and Japanese, have a high proportion of onomatopoeic elements.
  In complex languages, onomatopoeic expressions are embedded in the phonetic, grammatical, and lexical system just like other words. Nevertheless, their structures may differ from other words in certain properties. For example, in Lithuanian, "most onomatopoeic words are monosyllabic (they may comprise only consonants) ..." (Ambrazas, 1997, p. 441).

- The grammatical aspect: At this stage of development one cannot yet expect a clear distinction of word classes or grammatical elements.

- The syntactic aspect: Individual words are used in the function of phrases. This stage, with no syntactic organization, has been termed 'asyntactic' (Carstairs-McCarthy, 1999, p. 15 f.). This stage is still observable in the process of language acquisition. A small child who knows the expression 'cat' might use this single word so that, in differing contexts, it assumes the meaning of whole sentences, such as 'where is the cat?', 'look at the cat!', or 'I would like to take the cat'.

- The lexical aspect: The vocabulary is gradually enlarged to contain signals and onomatopoeic expressions.

3. Talking about things: Talking about things requires more than the capacity to represent objects by linguistic signs. It requires the capacity to reflect about things, to identify interrelations between things and living beings and to verbalize such interrelations, and to speak about happenings and actions and about relationships among human beings. Thus, the preconditions include capacities of cognitive representation on a broader scale than at stage 2 and the ability to process elementary linguistic techniques.

   - The phonetic aspect: This stage produces systematic patterns of binary features in the system of sounds (i.e., voiced versus voiceless consonants, open versus closed vowels). Communication on this level requires a steady increase of new expressions. A precondition of this lexical process is the patterning of sound combinations. This stage of phonetic evolution enhances experiments with syllable combinations to create new expressions. Words now consist of more than one syllable, which in turn allows a wider range of combinations of different syllable types.
     In statistical terms, every complex language has its own proportions of syllable types and combinations of vowels and consonants. In some languages, such as Finnish, consonant clusters are rare and usually found only in loanwords. In other languages such as Ubykh, a North Caucasian language, single consonants are rare and consonant clusters the rule. In retrospect, certain syllable types were preferred in one local speech community, other types in other communities.

   - The grammatical aspect: Basic word classes are distinguished, such as nominal elements (nouns, adjectives), expressions for verbal action, and numbers (up to five; enhancing counting with fingers and hands). A rudimentary system of relational expressions is formed, by which relations such as horizontal and vertical distance and direction, as well as inside and outside locations, can be verbalized. One elementary technique for expressing these relations is the use of prepositions (in association with a noun), e.g., outside the house, from behind a rock, into the wood.
     At this stage of development, basic patterns of the deictic system (personal and possessive pronouns, demonstrative pronouns) emerge. A basic distinction between present and past time relations, as reflected in the tense system of the verb, can be assumed. It is probable that this stage also sees the emergence of nominal classes (that is, the categorization of counted objects according to relevant properties). The distinction between tense and aspect relations is uncertain.

- The syntactic aspect: On a rudimentary level of syntactic structures, lexical elements are connected in protosentences. When using words according to stage 2, there is only one word in an utterance. The meaning of such an utterance is diffuse and attains some precision only in an unambiguous context. However, in situations where it was necessary to indicate the relationship between an agent and an object, more than a single word was needed to express the relationship. The combination of two words, for example, a person's name (Suvi) and the denomination for a fruit (apple), makes it possible to establish different relationships such as 'Suvi holds the apple', 'Suvi eats the apple', or 'Suvi goes into the garden to pick an apple from a tree', according to differing contexts.
  The distinction of word classes is a precondition for the identification of the agent (nominal phrase) and the action (verbal phrase) in the sentence. Main arbitrators of syntactic structures are the subject (agent) and the verbal action. However, this stage of evolution does not yet produce distinctive patterns of word order. Syntactic structures lack complex patterns. This means that the types of main and dependent clauses are not yet distinguished.

- The lexical aspect: The vocabulary increases by adding expressions with two syllables to the basic stock of monosyllabic words. The number of combinations increases considerably so as to produce enough lexical material for this level of communicational needs.

4. Interacting verbally in communities of modern humans: This stage is documented in the recent languages of the world and in the stages that have been reconstructed for protolanguages (the Proto-Indoeuropean language, the Proto-Uralic language, etc.). No existing language represents stage 3 or the earlier stages described above. This means that, in the living languages of the world, there is no developmental stage that would be evidence of 'primitive' linguistic structures.

   - The phonetic aspect: At this stage, the whole panorama of speech sounds that are found in the languages of the world, has evolved (Ladefoged and Maddieson, 1996). The living languages show a vast variety of sounds. For example, in Tahitian, a Polynesian language, only 9 consonantal sound qualities are distinguished (Peltzer, 1996). The language with the most consonants in the world is !Xóõ (/Hua-Owani), a Khoisan language, for which no fewer than 117 consonant phonemes have been identified (Traill, 1985).

   - The grammatical aspect: All word classes are distinguished. This includes the class of conjunctions to link main clauses or main and subordinate clauses. Gender and number relations are fully developed in the system of grammatical categories.
     This stage sees the emergence of full-fledged case systems (with maximum distinctions of 15 cases in Finnish or 23 in Hungarian), of complex verbal

systems (distinction between simple and complex tense categories, fully developed aspect correlations as in Slavic or Semitic languages), and of complex pronominal systems.

- The syntactic aspect: Word order is fully developed, with the elements S (subject), V (verb), and O (object) in different configurations. In the languages of the world, different patterns of word order dominate. Most frequent are those orders with subject-initial position (i.e., SVO as in most European languages, SOV as in Altaic and most Semitic languages). Verb-initial word order is found in Celtic, Berber, and Polynesian languages. Object-initial word order is rare. Languages with an OVS order are Gupapuyngu (Arnhem Land, Australia) and Barasana (Columbia). One finds OSV order in Apos (Papua-New Guinea) (Haarmann, 2001b, p. 255 f.).
  All sentence types are developed, including complex sequences of main clauses or main and subordinate clauses.
- The lexical aspect: The lexicon in complex languages is multilayered. There is abundant lexical material to construct the cultural environment of human beings in their relationships to the natural surroundings. The lexical items in a given local language reflect the focus of socioeconomic and cultural activities in a speech community. Thus, in Saamic or Evenki, we find a highly specialized terminology relating to reindeer breeding. The Somali vocabulary, for obvious reasons, has no terminology relating to reindeer breeding, but this language possesses a special lexicon abounding with terms for camel breeding.
  The processes of division of labor and of specialization of handicrafts in ancient societies enhanced the elaboration of specialized sections of vocabulary. In the industrial era and with the emergence of modern science, the pressure to create new terminologies increased. The world's cultures now face the transition to a network society, which requires the elaboration of a sophisticated vocabulary to cope with modernization and to serve the manifold purposes of electronic communication.

The evolutionary stage (1), representing a simple protolanguage, may be postulated for *Homo erectus*, who possessed capacities for this communicational system. This stage may also have dominated verbal communication of Neanderthal man who, in a later period of his existence, may well have reached stage 2, that of a more elaborate protolanguage. However, stages 3 and 4 are reserved for modern humans. Stage 3 can be assumed for the early phase of the existence of modern humans, that is for the period of about 100 000–70 000 BP.

Stage 4 must have had emerged already before modern humans peopled Sahul (the land mass comprising Australia and New Guinea) ca. 60 000 BP and before they colonized Europe (ca. 55 000 BP). The identification of the period of ca. 60 000 BP as a terminus ante quem is crucial because the languages of Australia and the Papuan languages of New Guinea have no exceptional features that would point to a seclusive development of language skills there. It is clear from the time-horizon of mankind's inhabitation of the Americas that complex, stage-4 languages were introduced. Modern humans entered the North American plains no earlier than ca. 15 000 BCE.

In southwestern Europe, modern humans encountered Neanderthal man. During a time span of at least 12 000 years, moderns and Neanderthals lived in the same areas, either near one another or in cohabitats. Such settlements have been investigated, in which there is evidence for the contemporaneous presence of both archaic and modern humans. Modern humans who colonized Europe used a complex, stage-4 language. Neanderthal man's communicational skills had remained at stage 1. Perhaps their skills were in transition to stage 2. It seems likely that the transition to stage 2 in Neanderthals was enhanced by contact with modern humans. This can be conjectured from the evidence of archaic man's lithic industry, which became more refined in the cohabitats with modern humans.

Even when the evolutionary steps from protolanguage to complex language are individualized, there still remains the clear impression of a qualitative leap that separates stages 1 and 2 from stages 3 and 4. The four-step scaling of the evolution of language that is presented here must be considered provisional. Most probably, future research will shed more light on the transitions from one stage to the next, which might lead to a refinement of the scaling.

The emergence of language types is associated with stage 4. At stage 3 in the evolution, too many linguistic techniques that define a type were still missing. Language typology deals with issues of typological resemblances in languages, not with genealogical kinship, as does historical linguistics. The techniques of one and the same type may work in languages that are historically unrelated. For example, linguistic structures of Chinese are governed by techniques of the isolating type. The same techniques have shaped the structures of modern English, which has retained only a few morphological elements from its stage of development as an inflectional language (i.e., the grammar of Old English).

Despite the fact that issues of typology have been on the agenda of language studies for more than 200 years, no inventory of language types has yet been elaborated that enjoys general consensus among scholars (see Song, 2001, p. 298 ff. for a historical outline). The concept of 'type' itself is much debated. Among the most successful approaches to distinguishing individual types of languages are those that conceive types as theoretical constructs, the features of which do not systematically or totally govern the structure of a language (Haarmann, 2001b, p. 248 ff.).

Empirical research has provided much insight into the cooperative working of typological techniques. This means that, as a rule, a given historical language operates with techniques of different types. No language of the world operates with the techniques of only a single type. The languages of the world can be categorized according to the dominance of one of the following types:

a) The inflectional (flexive) type: The name indicates the significance of inflection. Case relations as well as phases of verbal action are expressed with the help of grammatical morphemes. What distinguishes the inflectional type clearly from the agglutinative type (b) is the fact that also the word stems may change in the process of inflection; e.g., a change in vocalism as in German Baum 'tree, sg.' versus Bäume 'trees, pl.', a change in consonantism as in Russian drug 'friend' versus druzhba 'friendship'. Most of the Indo-European languages are predominantly inflectional.

b) The agglutinative type: Relations are expressed by means of fixing (agglutinating) formative elements to the word stem. The phonetic structure of the stem does not change in this process. Predominantly agglutinative are Altaic and most of the Uralic languages (e.g., Turkic, Tatar, Mongolian, Komi, Mansi, Yurak).

c) The isolating type: The techniques of this type exclude grammatical morphemes. Relations in the nominal and verbal complex are expressed by syntactic means, that is, through the positioning of lexical items in the syntactic continuum. Chinese is a typical isolating language. Isolating techniques are best represented in ancient Chinese. There is no inflection of the monosyllabic word, in neither the noun nor the verb system. In modern Chinese, some agglutination is present (e.g., as reflected in the existence of two-syllable compound words).

d) The incorporating type: Grammatical relations are expressed by a multitude of formative elements which are suffixed, prefixed, and/or infixed. The word stem can be enlarged by adding suffixes or prefixes, and objectival elements expressing dative or accusative objects (pronominal and nominal) are usually incorporated into the conglomerate of the stem and its extension. Generally, words in incorporating languages are longer than those in languages of other types, because of the multitude of elements that are incorporated.
The linguistic techniques of the incorporating type operate most extensively in the indigenous languages of North America (Mithun, 1999). A high degree of incorporation is categorized as polysynthetism. This is typical of the structures of languages such as Chipewyan, Seneca, and Oneida. In the Inuit languages of Canada and Greenland, polysynthetic constructions are most elaborate; e.g., Greenlandic aawlisa-ut-isshaR-siwu-nga 'I try to get something which is suitable for making a fishing tackle' (lit. 'fishing tool-suitable-obtaining-my').

The concept of types (a–d) is based on morphological categories. Although phonetic and certain syntactic features also readily associate with one or the other of these types, priority is given to morphology. Typological research has also produced constructs of language types whose properties are more comprehensive. This is true for the construct that was called 'active type' by the scholar who first investigated it (Klimov, 1977). The constituent features of the active type are found in the lexicon, syntax, and morphology of certain languages. Among those features are:

- Lexical properties: The binary division of nouns into active (animate) versus inactive (inanimate); the binary division of verbs into active (verbs of action) versus inactive (verbs of state); the inclusive/exclusive distinction of pronouns in the first person; the etymological identity of many body-part and plant-part terms (e.g., 'ear' = 'leaf'); etc.

- Syntactic properties: Verb domination of the sentence; preferred word order SOV; incorporation of the direct object into the verb; etc.
- Morphological properties: A richer inflection of the verb as compared to that of the noun; two series of personal affixes on the verb (active and inactive); the category of number is absent or weakly developed; postpositions are rarely used or altogether absent; etc.

The languages that represent the active type are mostly found in North America (Na-Dene, Siouan, Muscogee, to a lesser degree also Iroquoian–Caddo) and in South America (Tupí–Guaraní). Because some ancient languages (e.g., Elamite) also are characterized by features of the active type some have conjectured that this language type may represent an old layer in the evolution of the world's languages.

In most of the languages of the world, the operation of techniques typical of different types can be well observed. Modern English is a predominantly isolating language, with an additional inflectional component (e.g., the plural 's' or the 's' in the third person singular of the present tense in verb conjugation). Finnish grammatical structures are dominated by techniques of the agglutinative type. Through prehistoric contacts with Germanic languages, Finnish has adopted inflectional techniques which form an additional component in its grammar. Hungarian is characterized by similar proportions of agglutinative and inflectional techniques as Finnish. Many of the languages that operate with techniques of the active type also show features of other types (see Nichols, 1992, p. 97 ff., for an assessment).

3.6
Variation 3: Language and the Evolution of Functional Variety

The basic principle of variation is evident in the diversity of social functions that any language fulfils. Every complex language has some kind of internal variation. The most elementary variation is the distinction of dialects, which may diverge phonetically, lexically, or grammatically.

According to a wide-spread stereotype, some totally homogeneous languages, with not even dialectal variation, do exist. Icelandic is mentioned in such contexts. And yet, although the degree of linguistic homogeneity is fairly high in Icelandic, dialectal and social variation exists. Some words for certain things differ between the north (e.g., in the town of Akureyri) and the south (e.g., in Reykjavik). In addition, there is a social variety (sociolect) with a specialized vocabulary – the slang of schoolchildren.

Language varieties belong to two categories (Figure 3.3): historical–natural and intentional–functional. Every language shows historical–natural variation, that is, variation in language use that stems from its natural development in the course of time; or variation of spoken language in space, that is, dialectal variation. Intentional varieties are those that have been created intentionally. The elaboration of a written standard for a given language is intentional. The written standard of any language diverges in some way from the spoken variety, simply because the func-

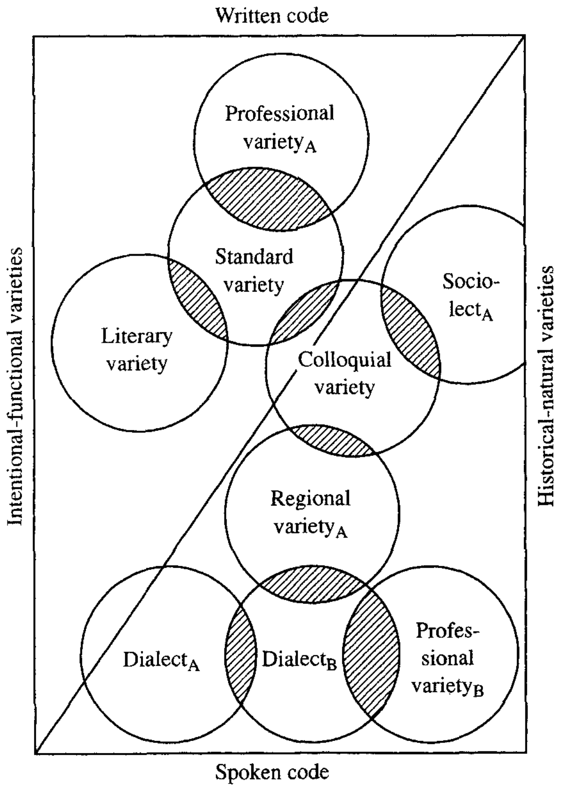


Figure 3.3 A hypothetical construct of functional variation in a historical language (adapted from Haarmann, 1991).

Notes:

(1) Each variety (see circles as graphic representations of theoretical constructs) overlaps with one or several other varieties. Since the varieties of a historical language represent variations on a linguistic continuum, no individual variety remains separated from the entire string of potential variations.

(2) The professional variety$_A$ is one which is written and incorporates features of the standard variety (e.g. the technical variety of juridical sciences). The professional variety$_B$ is not written and overlaps with a local dialect (e.g. the language of fishermen in a village on the seashore).

tions of the written code require the refinement of vocabulary and style. Intentional variation occurs in only a certain number of the world's languages. Written standards exist for some 1100 languages, although some may not regularly be written (Section 3.9).

In many speech communities one finds distinct professional varieties. A professional variety may be historical–natural, for example, the special language used by Portuguese fishermen in villages on the Atlantic coast. In modern society, language use proliferates so as to create a multitude of intentional professional varieties, for example, the specialized terminology in technology and science, which is under constant modernization pressure from English (Ammon, 2001).

Variation has been a major arbitrator of language use since antiquity. The earliest evidence for internal variation in a speech community comes from Mesopotamia, in particular, from the Sumerian cultural milieu. The literary texts of the 20th century BCE distinguish between an ordinary variety of Sumerian, called Emegir, and a specific variety for recording female speech, called Emesal. There is ample evidence that the Emesal variety is derived from the Emegir, which was the normal language. The Emesal variety carried all the attributes of a prestigious variety, and its social connotations are clearly revealed in the Sumerian loanword in Akkadian, emesallu ('fine taste, fine tongue, genteel speech').

Such an awareness of the finery associated with the Emesal variety matched its function well, since it was used in cult songs, laments, and love songs, in the so-called sacred marriage texts, to render the speech of female persons or goddesses. All literary texts in which Emesal is used alongside Emegir have religious content or are associated with a mythological context. Emesal is also associated with the speech of the kalu priests, who were not women.

> The occurrence of Emesal in cult songs is thus explained as due to the fact that the kalu priests who recited these songs were eunuchs, and not being regarded as men, they had to use women's language (Thomsen, 1984, p. 292).

The Emesal variety can be recognized by its phonetic and lexical features, which distinguish it from Emegir. However, there are no grammatical differences between Emesal and Emegir. With respect to the phonetic alterations, it is noteworthy that the sound differences in Emesal compared with the normal forms in Emegir are deliberately caused by a forward shift of the basis of articulation: e.g., Emegir 'u' (high back) is changed to Emesal 'i' (high front). Obviously, 'forward-flanged' phonemes, such as narrow vowels, and labial or dental consonants were considered 'finer' than their 'backward-flanged' counterparts. With respect to the lexicon, variation in Emesal was partly due to the phonetic changes (e.g., Emegir munus: Emesal nunus, 'woman'). In other cases, lexical differences are displayed in the parallelism of words of different origin in the two varieties (e.g., Emegir tum: Emesal ga, 'to bring'; Emegir a.na: Emesal ta, 'what?'). Lexical variation due to phonetic alteration is of more frequent occurrence than the use of expressions with different roots.

Sumerian, although the world's oldest evidence for women's language as a specific variety, does not stand isolated. In particular, the characteristics of phonetic and lexical variation excluding grammatical differences is known from other languages. "Tabus on the use of 'men's' words and 'men's' pronunciation is known the world over, particularly among peoples speaking structurally archaic, 'ergative' languages' (Diakonoff, 1976, p. 113 f.). Many communities with a traditional culture have a specific female variety of speech, a so-called tabu language, that is distinguished from the normal language solely by its deviant vocabulary. For example, among the Dyirbal who live in Northeast Queensland (Australia), family members, when talking to a relative of the opposite sex, use a special variety of speech (e.g., a man communicating with his mother-in-law) (Dixon, 1972, p. 32 ff.).

The distinction of a special language variety for women is not limited to the milieu of a traditional culture. In many modern societies, particularly in Asia, women use their own language variety. Japanese society is an illustrative example. Japanese is among those languages in which female speech is distinct on practically all levels (Haarmann, 1991, p. 193 ff.):

- Phonetic and prosodic features: Female intonation is among the most prominent features by which women's language is distinguished from men's language. Women's intonation is more 'melodious' than that of men, and this is closely related to the norms of polite speech. In a special subvariety, intonation is extremely marked; this is okusan kotoba 'the language of housewives'.
- Grammatical features: The most significant differentiation between female and male speech is in the pronominal system. Although forms such as atashi or atakushi (for the 1st pers. sg. of the personal pronoun) are used by women, the corresponding form in male speech is boku 'I'. Japanese women's language is characterized by a highly diversified set of pronominal elements to express varying degrees of formality and politeness.
- Syntactic features: The strategy of paraphrasing by applying various techniques (e.g., inserting hedges, putting a directive into a negative question, using final particles to 'soften' sentences) is frequently used in women's language to make expressions indirect, less straightforward, and/or less imposing.
- Lexical features: To a certain extent, one can distinguish between a specialized vocabulary of women's language and a general lexicon of men's language. For example, when women refer to the stomach, they use the term onaka (e.g., in the expression onaka-ga suita 'I am hungry'). Men use the expression hara, instead. Against the background of such a terminological difference, a term such as harakiri 'cutting one's stomach' (suicide committed as a sign of social shame) makes reference to male social relations in Japanese society. Suicide committed out of social shame among women is done by cutting one's throat with a dagger.

Women's language and polite speech are intrinsically interwoven, especially in view of the fact that Japanese women are more strongly subject to societal constraints than are men. One of the keys to understanding women's social and verbal behavior in Japanese society is the concept wakimae, which may be paraphrased in English as 'observing expected norms' or 'behaving in conformity with accepted standards'. Interaction in Japanese society has maintained a high level of formalization in social relations, and a Japanese woman is essentially expected to closely observe the social distance between the speaker and the hearer, role relations that include different implements of power, and her own status in society which, as a rule, is considered inferior to that of a man. Societal norms in Japan require that a woman not only behave socially like a female, but that she also talk like a woman.

The distinction of social status in language as an arbitrator is found in many Asian languages, particularly in Southeast Asia. In those languages, deictic categories reflect a marked degree of sophistication. The pronominal system is especially differentiated. In Khmer (Cambodian), for example, the following expressions for 'I' are distinguished, each associated with a specific social context (Table 3.1).

Table 3.1 Expressions for 'I' in Khmer and their specific social contexts.

Pronoun in Khmer[1]	***Specification of social status***
khnom	Historical form for addressing a house slave; today used to address outsiders
khnomkaruna:	Very polite, used especially when addressing a Buddhist monk
khnomba:t	Used only by monks
khnomcah	Used when addressing someone of superior social status; used especially by women
an	Used in familiar speech; used when an elder person addresses a younger person
kni:e	Expresses membership in a social group
je:n khnom	Used in official language, when someone speaks as a representative
khlu:en khnom	Expression of individuality (without any association to a group)

[1] The Khmer expressions are transliterated here in a slightly simplified orthography.

The marking of social status in language and the use of polite speech forms intermingle strongly, as in Vietnamese, where the following forms of address are in daily use (Table 3.2).

The marking of male and female social status is embedded in the general polarity of female and male speech. Even the most elementary deictic elements are distinguished according to gender. For examples, to say 'yes' Khmer men say ba:t and women say cah.

Table 3.2 Forms of address in Vietnamese.

Vietnamese expression[1]	***Functional range in various social contexts***
con	Used by parents and grandparents to address a child; the same form is used even after the child has grown up
co	Used to address a girl or an unmarried woman
chi	Used to address a woman aged 30 or older; also used among brothers and sisters
ba	Used to address a woman aged of 50 or older; also used as an honorific title for historical heroines, the Ba Trung who rebelled against Chinese colonial power in the 1st century AD
ong	Used to address a man aged 50 or older; also used as an honorific title for men
em	Used by older sisters or brothers to address younger siblings
anh	Used by younger sisters or brothers to address older siblings

[1] The Vietnamese expressions are presented here without the accents that mark tonemes.

Another variation in language that dates from antiquity is the distinction of a ritualistic language, "a special linguistic variety used in prescribed consecrated forms of behavior, governed by belief in mystical powers" (Du Bois, 1992, p. 335). Such variation can be readily assumed for the language of Palaeolithic man, because shamanistic rituals in connection with the bear cult are evidenced from that time. In traditional cultures, ritualistic language is usually marked by its deviant lexicon. Expressions of ordinary language are either metaphorically paraphrased or are replaced by specific words that are formally unrelated. For example, in the healing chants that are performed by the priests among the Kuna Indians in Panama, the ritualistic expression for 'woman' is walepunkwa (instead of the usual ome), and for 'eye', tala (instead of the usual ipya) (Sherzer, 1983).

3.7 Variation 4: Languages and their Genetic Affiliations

The identification process that forces modern humans to find their Self through self-awareness and to construct their cultural environment makes language a conditio sine qua non of all organizing forms of social relations. Because in modern humans the capacity to use language is spontaneous, it seems futile to search for one single source, that is, for the mother of all languages from which the languages of our modern world have derived. Therefore, it is not reasonable to assume that the language that modern humans used about 90 000 BP – at the time they left Africa and wandered into Asia – is the origin of all recent languages. Even if there had been anything like a 'primordial' language of modern man (representing stage 3), its traces have been lost in the horizon of time due to the dynamic power of variability.

During their colonization of Asia and Europe, modern humans encountered other hominid species. The issues of whether there is any biological heritage of *Homo erectus* in the gene pool of people in East Asia and whether there was gene flow between archaic and modern humans in western Europe are still much debated. In any case, the possibility of influences from contacts between hominid species on the language use of modern humans has to be considered. This makes interspecies contacts a promising field of future anthropological study.

Historical linguists have succeeded in establishing the genealogical affiliations of most languages of the world. But even today there are more than 100 languages for which no or no secure affiliation can be demonstrated. One of these language isolates is Basque. Basque is the oldest living language of Europe and has a remarkable history. This language is a remnant of a prehistoric linguistic layer that is remotely linked to the languages of those people who, in the Upper Palaeolithic Age, created the cave art of southwestern France and northern Spain (Haarmann, 1998). Among the language isolates are also vehicles of ancient civilizations, such as Sumerian, Elamite, and Etruscan (Haarmann, 2002a, pp. 62 f., 65 f., 190 f.).

The formative periods of many language families are shrouded in prehistoric darkness. The time depth of the oldest phyla that are represented in modern lan-

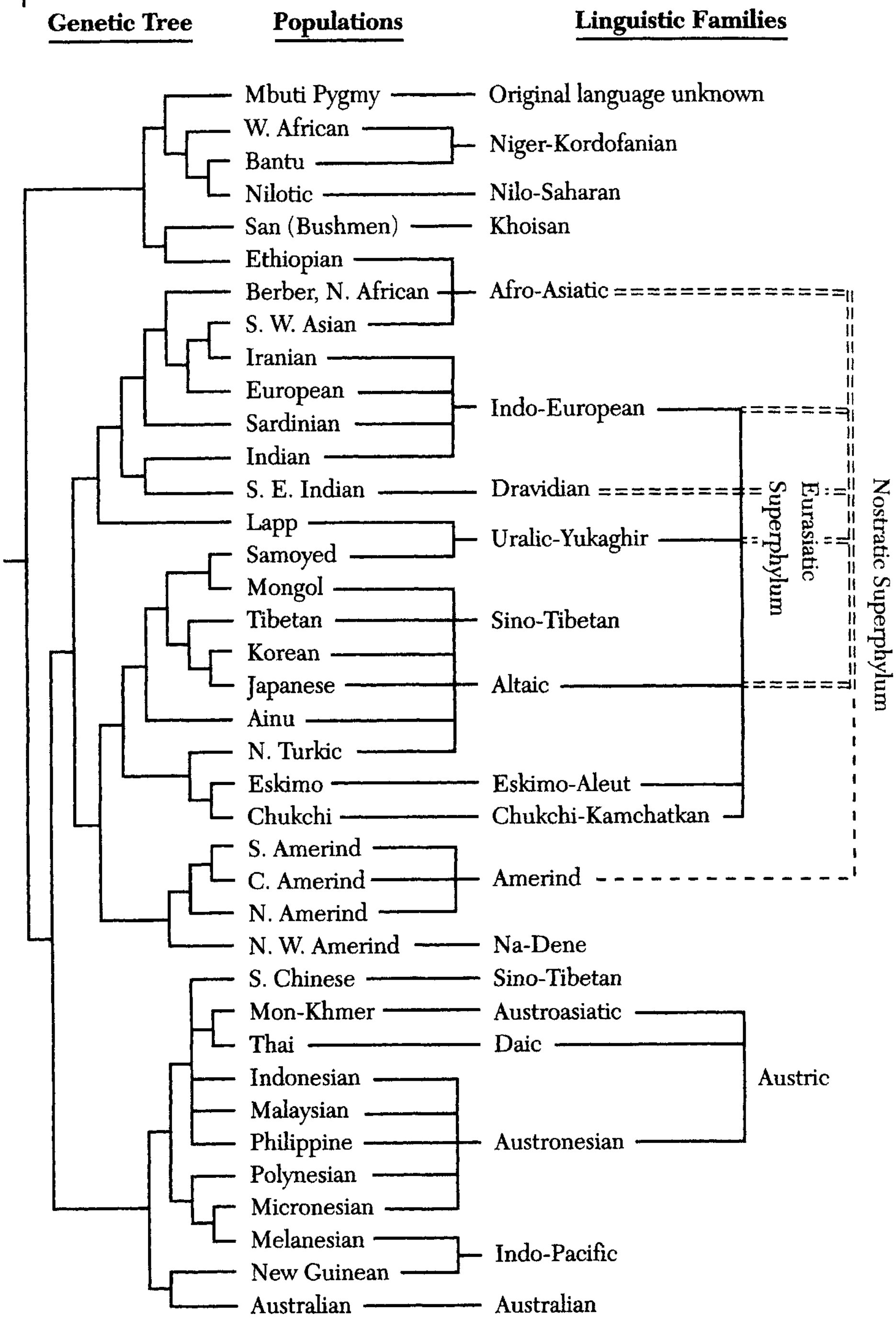


Figure 3.4 Correlation between genetic and linguistic trees (adapted from Cavalli-Sforza, 2000).

guages ranges between some 8000 and 12 000 years BP. What can be reconstructed with historical–linguistic methods are the assumed protolanguages, which originated much earlier than their reconstructed full-fledged state of existence. Arguably, the oldest protolanguages that can be reconstructed with any accuracy are Proto-Indo-European and Proto-Uralic, both fully developed by about 8000 BP. Nobody knows with any certainty what happened before that time.

Estimates of the chronological dispersion of languages into different parts of the world are closely associated with recent findings in human genetics. Geneticists have investigated the genomic profiles of various populations, modern and ancient (Cavalli-Sforza et al., 1994). Genetic structures are much more stable than linguistic structures, and therefore the migrations of early populations of modern humans can be traced by the genetic 'fingerprints' left in their genomes. When patterns of gene profiles are related to patterns of linguistic diversity in a tree model, details of areal configurations become evident (Figure 3.4).

The languages of the world belong to some 60 language families (phyla) (Table 3.3). Many of these phyla are subdivided into several branches. The Indo-European family includes the Germanic, Celtic, Romance, Slavic, Indo-Iranian, and other branches. Some phyla have many subdivisions, others not. A few phyla are distinguished by having a great number of individual languages: these are the Niger-Congo phylum (1436 languages), the Austronesian phylum (1236), the Trans-New Guinea phylum (539), the Indo-European phylum (418), the Afro-Asiatic phylum (371), and the Sino-Tibetan phylum (360). Except for Japanese, the big languages of the world (those spoken by 100 million or more speakers) belong to one of these language families (Section 3.8). We also find small and very small (dwarf) languages, that is, languages spoken by only a few hundred people (e.g., Argobba in Ethiopia or Veddah in Sri Lanka).

Upon inspection of individual language families and their internal subdivisions (branches), variations in space and time become evident. As an example I refer to the affiliation of languages in the Indo-European phylum (Figure 3.5). The development of branches such as Slavic or Baltic shows clearly how certain linguistic complexes may remain homogeneous for a long time before splitting into individual languages. In other branches the split occurred much earlier, as that between Germanic and Celtic. We also find individual languages that did not split at all and have preserved their linguistic identity throughout history, for example, Armenian. The continuity of Illyrian is characterized by a process of transformation of an older identity (Illyrian) into a modern one (Albanian).

Certain languages that flourished in antiquity have lost most of their historical varieties, and their continuity is based on a single variety that persists. An illustrative example is Greek. Mycenaean Greek was the first variety to be written (in Linear B from the 17th to the 12th centuries BCE). Mycenaean, like all other varieties of ancient Greek disappeared, except for koiné Greek (the common language), which evolved into Modern Greek. In one branch of Indo-European, i.e., the Indic subdivision of the Indo-Iranian branch, no modern language can be directly derived from any of the known written languages of the past. Neither Sanskrit nor the other historical languages (Prakrit, Pali) have direct descendants. Modern Indo-

Table 3.3 Language families (phyla) and language isolates
(Grimes and Grimes, 1996; Haarmann, 2001b, p. 235 ff.; adapted from Haarmann, 2001b).

Number of languages	*Language families (number of languages)*	*Main areas of spread*
> 1000	Niger-Congo (1436)	western, central, and eastern Africa
	Austronesian (1236)	Madagascar, Southeast Asia, New Guinea, Pacific islands
100–1000	Trans-New Guinea (539)	Papua-New Guinea
	Indo-European (418)	originally Europe and southern Asia, today global
	Afro-Asiatic (371)	Near and Middle East, northern Africa
	Sino-Tibetan (360)	China, Tibet, Southeast Asia
	Australian (257)	Australia
	Nilo-Saharan (194)	central and eastern Africa
	Austro-Asiatic (180)	Southeast Asia
	Oto-Mangue (173)	Central America (mainly Mexico)
	Sepik-Ramu (105)	New Guinea
10–100	Dravidian (78)	India, Pakistan
	Arawakan (74)	northern parts of South America, Caribbean
	Tupi (70)	Brazil, Paraguay, Peru, Bolivia
	Dai (68)	China, Vietnam, Laos, Thailand, Myanmar, India
	Maya (68)	Mexico, Guatemala
	Altaic (65)	Eurasia (European part of Russia, Siberia, Turkey, central Asia, northern China)
	Uto-Aztec (60)	USA[1)], Mexico
	Torricelli (48)	Papua-New Guinea
	Quechua (47)	Peru, Ecuador, Columbia, Bolivia, Argentina, Chile
	Athabascan (39)	western Canada, northwestern parts of USA
	East Papuan (36)	Papua-New Guinea, Solomon Islands
	Khoisan (35)	South Africa, Botswana, Namibia, Angola, Tanzania
	Uralic (34)	Finland, Estonia, Hungary, central Russia, west and north Siberia
	North Caucasian (34)	southern Russia
	Geelvink Bay (34)	Indonesia (Irian Jaya)
	Algic (33)	Canada, USA
	Hmong-Mien (32)	China
	Macro-Gê (32)	Brazil
	Carib (29)	Brazil, Columbia, Venezuela, Guyana
	Panoan (29)	Brazil, Peru, Bolivia

Table 3.3 (*continued*)

Number of languages	***Language families (number of languages)***	***Main areas of spread***
10–100	Salish (27)	Canada, USA
	Hokan (27)	USA, Mexico
	Penutian (27)	USA, Canada
	West Papuan (27)	Indonesia (Irian Jaya)
	Tucano (26)	Columbia, Brazil
	Chibchan (22)	Ecuador, Columbia, Panama, Costa Rica
	Siouan (17)	USA
	Mixe-Zoque (16)	Mexico
	Andamanese (13)	southern India
	Eskimo-Aleut (11)	eastern Siberia, Alaska, Canada, Greenland
	Palaeoasiatic (11)	eastern Siberia, northern Pakistan
	Totonacan (11)	Mexico
	Mataco-Guaicuru (11)	Brazil, Argentina, Paraguay
	Choco (10)	Columbia, Panama
Fewer than 10 isolates	Several dozen smaller groupings (e.g., South Caucasian, Araucanian, Caddo) and numerous language isolates having no identifiable genealogical affiliation with any other language (e.g., Basque, Japanese, Zuñi)	

[1)] USA means the 48 contiguous states (i.e., everything except Alaska and Hawaii).

Aryan languages such as Gujerati, Hindi, and Singhalese evolved out of a common Indic continuum during the early centuries of our era.

Several old Indo-European languages persisted for a long time before they fell out of use, as can be seen by looking at the history of Thracian, Tocharian, and Venetic. And all the languages of the Anatolian branch of Indo-European have died out. Of these, Hittite and Luwian flourished as written languages (Haarmann, 2002a, pp. 89 f., 126 f.).

In the evolution within a given phylum such as Indo-European, we may find long-term continuity (e.g., Armenian), dynamic processes of proliferation at a slow pace (as in Baltic) or at a more rapid pace (as in Celtic), or multiple splitting in the horizon of time. The Italic branch split early into various languages, including Oscan, Umbrian, Latin. In a secondary process, Latin then split into the range of Romance languages.

Attempts have been made to reconstruct possible genealogical affiliations among the phyla. There is a special field of linguistics in which such issues are addressed, glottochronology or linguistic taxonomy (see Ruhlen 1994 for an outline). Although, for individual language families, the time depth of reconstruction may shed light on a stage of development of about 8000 BP, the identification of macrophyla (that is, inter-family relations) takes us into a much more remote past. However, the methods of historical linguistics are not yet refined enough to achieve reliable results

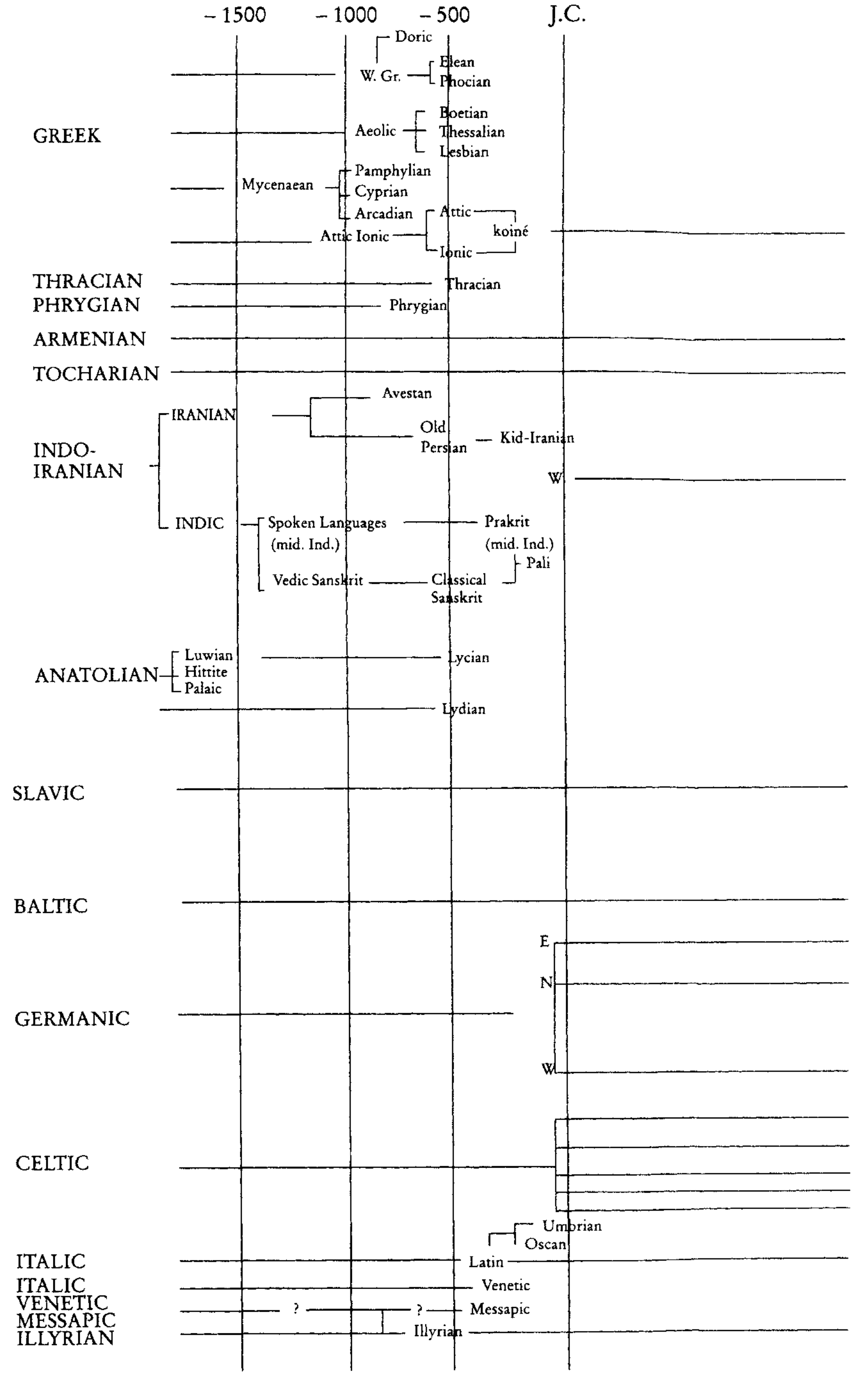
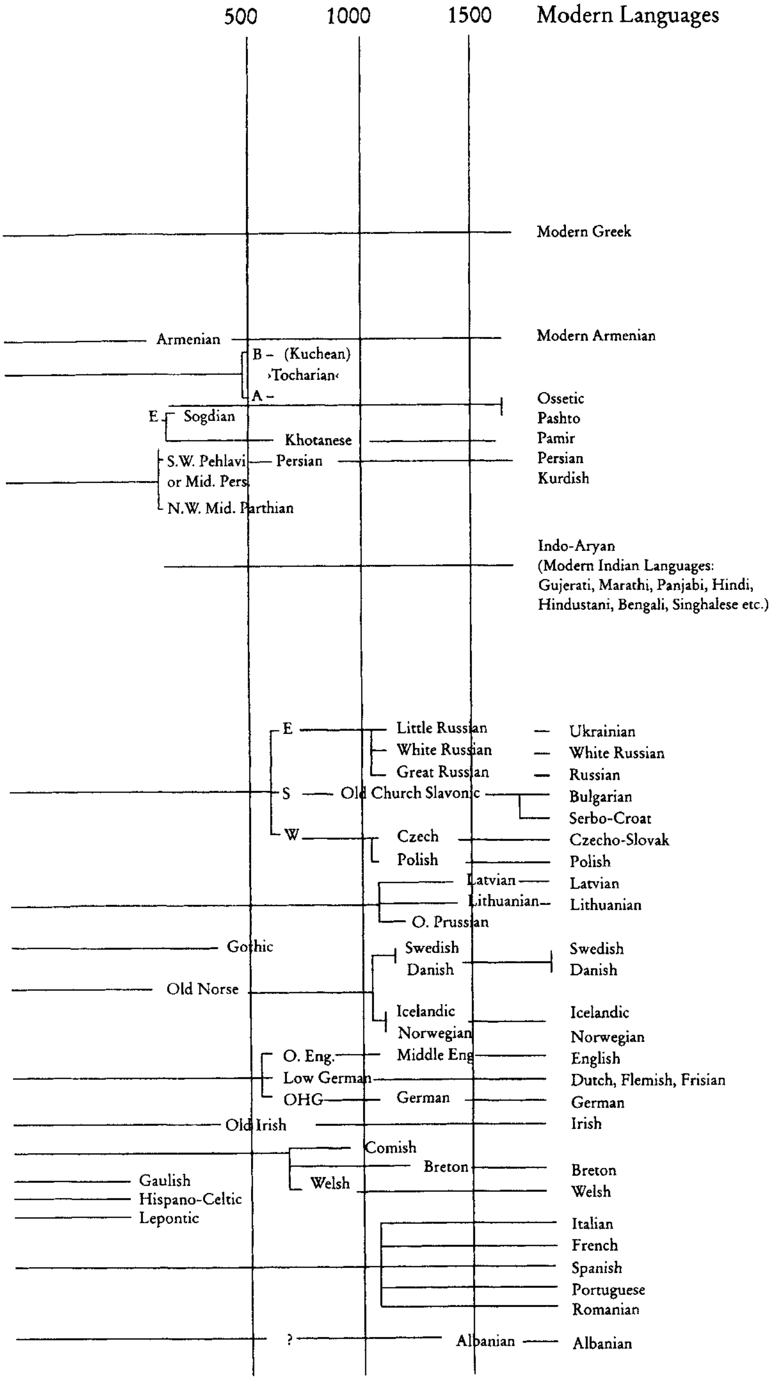


Figure 3.5 The evolution of individual languages in the branches of the Indo-European phylum (adapted from Mallory, 1989).



500
1000
1500
Modern Languages
Modern Greek
Armenian
Modern Armenian
B – (Kuchean)
›Tocharian‹
A –
Ossetic
E
Sogdian
Pashto
Khotanese
Pamir
S.W. Pehlavi
Persian
Persian
or Mid. Pers.
Kurdish
N.W. Mid. Parthian
Indo-Aryan
(Modern Indian Languages:
Gujerati, Marathi, Panjabi, Hindi,
Hindustani, Bengali, Singhalese etc.)
E
Little Russian
Ukrainian
White Russian
White Russian
Great Russian
Russian
S
Old Church Slavonic
Bulgarian
Serbo-Croat
W
Czech
Czecho-Slovak
Polish
Polish
Latvian
Latvian
Lithuanian
Lithuanian
O. Prussian
Gothic
Swedish
Swedish
Danish
Danish
Old Norse
Icelandic
Icelandic
Norwegian
Norwegian
O. Eng.
Middle Eng
English
Low German
Dutch, Flemish, Frisian
OHG
German
German
Old Irish
Irish
Cornish
Breton
Breton
Welsh
Welsh
Gaulish
Hispano-Celtic
Lepontic
Italian
French
Spanish
Portuguese
Romanian
?
Albanian
Albanian

of reconstruction. Therefore, much speculation is involved in the assemblage of macrophyla. One of the most popular concepts is that of the Nostratic (or Eurasiatic) macrophylum, which is comprised of Indo-European, Uralic, Altaic, South Caucasian (Kartvelian), Dravidian, and possibly Afro-Asiatic languages (see Figure 3.4).

3.8
Variation 5: Language Evolution and Linguistic Diversity

The linguistic diversity of the world is a vivid demonstration of how the evolutionary principle of variation works. Individual languages have a life cycle, as have their users. Languages emerge, change, and die. In this process, manifold transformations may occur. In the final stage of a language, its structures may be transformed to develop into one or several new languages. This process can be observed for Latin. Spoken Latin diverged from the written, more conservative Latin already in the Classical period. Spoken Latin spread into the provinces of the Roman Empire and became the basis for local vernaculars. From the 6th to the 8th centuries AD, the local varieties of spoken Latin developed into early stages of the Romance languages.

Since earliest times there have been contacts between local groups of people speaking different languages. In settings of language contact, influences may go either way, or one of the languages may dominate and have a unilateral effect on the other. Either way, the conditions of contact may change, even decisively, the direction of development of the languages involved. For example, the French language emerged out of a fusion process of spoken Latin and Gaulish, the language of the Celtic inhabitants of Gaul who assimilated. Romanian, has a Dacian element. The English language cannot be imagined without the strong Latin and French components of its vocabulary. Japanese would not operate as a linguistic system without the Chinese component with which indigenous structures are so intrinsically intertwined.

Yiddish is an illustrative example of a language whose linguistic structures have been predominantly varied through language contacts. Indeed, "fusion processes can be found in literally every nook of the language" (Weinreich, 1980, p. 32 f.). This means that the profile of Yiddish as an individual language was shaped mostly by Hebrew, German, Polish, and Russian.

The emergence of new languages is a process that can still be observed. During the political disintegration of the former Yugoslavia, the Slavic peoples in newly independent regions such as Slovenia, Croatia, and Bosnia-Hercegovina gained in national self-awareness, which has had long-term effects on their linguistic identity. The former linguistic unit (i.e., Serbo-Croatian) split into three independent languages, namely Croatian, Serbian, and Bosnian.

As of the beginning of the 21st century, 6417 languages exist, which are spread – highly unequally – among the fewer than 200 states and autonomous regions into which the world is divided. The largest concentration of languages is found in New Guinea, where 1073 languages are spoken. Of these, 826 are distributed in

Table 3.4 Distribution of the world's languages (adapted from Haarmann, 2001c).

Geographical area	*Total number of languages*	*Big languages*[1]	*Small languages*[2]	*Dwarf languages*[3]
Global (total)	6417	273 (4.2%)[4]	4162 (64.8%)	1982 (30.8%)
Asia	1906	126 (6.6%)	1549 (81.3%)	231 (12.1%)
Africa	1821	92 (5.1%)	1607 (88.2%)	122 (6.7%)
Pacific	1268	1 (0.1%)	507 (40.0%)	775 (61.1%)
America	1013	10 (0.9%)	428 (42.2%)	575 (56.7%)
Australia	266	–[5]	11 (4.2%)	255 (95.8%)
Europe	143	44 (30.7%)	69 (48.3%)	15 (10.5%)

1) Spoken by 1 million or more (e.g., English, Thai, Swahili).
2) Spoken by more than 1000, but fewer than 1 million (e.g., Basque, Maasai, Tahitian).
3) Spoken by fewer than 1000 (e.g., Ainu, Livonian, Sengseng).
4) Percentages are relative to the total number of languages in each area.
5) English is a common language in Australia, spoken by about 18 million people.
In this overview, however, it is not counted for Australia, because each language is counted only once, and English is counted for Europe. Accordingly, Chinese is counted for Asia and not for other continents.

the territory of Papua-New Guinea and 247 in that part of the island (the province of Irian Jaya) that belongs to Indonesia. In the entire Southeast-Asian archipelago (including Malaysia and Indonesia), about 1500 languages are spoken. These account for almost 25% of the total number of languages in the world.

When categorized according to the size of their speech communities the languages of the world show the following geographical spread patterns (Table 3.4).

The sizes of speech communities are extremely variable. Chinese in all its local varieties is spoken by 1210 million people. This is by far the largest speech community in the world. Despite its significance for global intercommunication, English comes in only a distant second, with 573 million speakers. Twelve languages in the world are each spoken by 100 million or more speakers (Table 3.5). These include all the languages that are called 'world languages' because of their international spread.

Given their importance for international communication and their functional dominance in certain regions, the big languages are spoken as a second language by many people with other mother tongues. Each language has developed its own ratio of first-language and second-language speakers (Table 3.5).

Table 3.5 Languages with 100 million or more speakers, including the numbers of first- and second-language speakers (adapted from Haarmann, 2001c).

Language	***Total number of speakers***	***First-language speakers***	***Second-language speakers***
	millions (percent of total)		
Chinese	1210	1139 (94.1%)	71 (5.9%)
English	573	337 (58.9%)	236 (41.1%)
Hindi	418	182 (43.5%)	236 (56.5%)
Spanish	352	266 (75.6%)	86 (24.4%)
Russian	242	170 (70.2%)	72 (29.8%)
Arabic	209	202 (96.6%)	7 (3.4%)
Bengali	196	189 (96.4%)	7 (3.6%)
Portuguese	182	170 (93.4%)	12 (6.6%)
Indonesian	162	21 (12.9%)	141 (87.1%)
French	131	76 (58.0%)	55 (42.0%)
Japanese	126	125 (99.2%)	1 (0.8%)
German	101	96.5 (95.6%)	4.5 (4.4%)

In the history of modern humans, many individual languages have emerged and died, leaving no observable traces. The state of linguistic diversity in the world today is the result of thousands of years of constant variation. Two thousand years ago, many of the present languages did not yet exist, e.g., the Romance, Germanic, Slavic, and Finno-Ugric and languages. On the other hand, many languages that existed then have died, and processes of language death will accompany us into the future.

3.9
Variation 6: Globalization and the Future of Language Evolution

We live in an era of globalization. Our time is also called the information age, because its technologies provide means that enhance globalization. What does this widely-used expression 'information age' mean? The term itself is as odd as its use. It suggests that, today, the flow of information about the world is continuously growing, and our perspectives are constantly widening. In fact, we have lived in the information age for many centuries, ever since Marco Polo (1254–1324) told the Europeans about life in China (Shen, 1996, p. 169 ff.), ever since Columbus discovered America, ever since Europeans set out on their voyages for exploring Arctic waters (Lainema and Nurminen 2001), ever since Alexander von Humboldt (1769–1859) embarked upon his expeditions in the Americas and in Siberia, ever since the sciences experienced their breakthrough in the 19th century.

What distinguishes our age from previous ones is a certain quality, and this is the electronic dimension of information transfer. We have long been living in the information age, but now we are constructing a network society. This term, popularized especially by Castells (1996–1998), was intended to remind us that, although the rate of accumulation of information about the world is accelerating, with the amount of information thus virtually exploding, the capacity of modern data banks to store this information seems unlimited.

Among the top priorities of the network society is the construction of knowledge (see Asher and Simpson 1994 for accumulated knowledge on the study of the languages of the world). Accumulating data is one thing, constructing knowledge is quite another. The computer facilitates the processing and storage of individual items of data, but – for the purpose of constructing knowledge – the human mind is needed to evaluate the electronic information and to select, categorize, and rank essential data. Knowledge is always a matter of how information is 'anthropologically' exploited, of how the human mind constructs order, and of how a relational network emerges from masses of unsystematically amassed data. And for constructing knowledge the human mind has to rely, now and in the future, on the oldest information technology that mankind possesses: language.

The network society has produced a new pattern of communication, which I call national-English bilingualism (NEB) (Haarmann, 2001b, p. 303 ff.). Regarding the infrastructure of NEB, this configuration of language components highlights a crucial contact situation in which a given national (non-English) language serves communicative purposes alongside English in the same domain and in similar functions, including digital literacy (Gilster, 1997). The information age has confronted us with a new dimension of sociocultural function of languages: using written code for the input and output of digitally processed data. 'National' is a generic term that refers to a given non-English language. The national component can be

- a language of broad distribution (e.g., Russian, German, French)
- a language with a local range but in regular use (e.g., Icelandic, Thai, Afrikaans)
- a less-used language (e.g., Welsh, Kurdish, Tahitian)

In Europe, we find a high density of local languages that participate in NEB. The smaller the national language and the less used, the greater the probability that a third language also participates, which extends the elementary pattern of bilingualism to one of local multilingualism. Examples of such an extension are Komi-Russian-English multilingualism (in the Komi republic), Catalan-Spanish-English multilingualism (in Catalonia), and Sámi-Norwegian-English multilingualism in northern Norway.

The English component in NEB may remain passive, and does not necessarily have to become active. This means that the reception of information in English (by reading and/or understanding) may suffice for participating in global intercommunication. However, any successful exchange of information in many fields of science depends on the ability to use English actively.

Given the functional implications of NEB, English as its component is represented by formal varieties, varieties that are rightly understood as 'bloodless international English'. This English is characterized by different sets of terminology: the vocabulary of internet jargon, the language used in the mass media, the various terminologies in the domains of science (natural sciences, information technology, etc.). As a rule, this English is stylistically poor and lacks any refined flavor.

NEB English is an asset for work in various professional fields, not a means of everyday life. Thus, there is hardly any danger that this English may eventually supersede the national component of bilingualism or even cause language shift. Where, outside English-speaking countries, less-used languages are under pressure, this is due to the impact of a local language of the state (e.g., Mordvin in relation to Russian, Hungarian in relation to Slovak, Quechua in relation to Spanish), rather than to the influence of international English.

When assessing the role of English as a component of NEB we have to bear in mind that we are dealing with a selection of formal varieties. There is much more to English than what we find in NEB. Recall that, in the historical process of spreading throughout the world, English also proliferated in terms of its internal variation. Speaking about English means speaking about the Englishes of the world. Linguistic variation reaches far beyond the well-known distinction between British and American English (Crystal, 1997).

There are many local and social varieties of English, including Hindish in India, the Australian outback English, ebonics in the USA (the language use of Afroamericans), and dozens of Pidgins and Creole languages that have emerged from the original source of European English. English deserves an entry in the Guinness Book of Records as the one language that has produced the greatest number of historical derivations. So, the global role of English is relative and is focussed on certain specialized functions.

In recent years, the problems of endangered languages have attracted the attention of a broad public throughout the world, primarily because of alarming statements made by experts concerning the dangers of their extinction. The worldwide scenario of a hopeless struggle of small languages for survival fits into the apocalyptic vision of an irreversible loss of local cultures in the face of advancing globalization. Krauss (1992) estimates the rate of loss of the world's languages to be about 90%, and the timeframe for their extinction to be about 100 years. Is the process of evolution unilaterally directed toward the extinction of languages? Will linguistic diversity ultimately dissolve?

Assumptions about the future development of speech communities and, in particular, predictions about the death of a language are often sentimental in nature and lack a substantial basis in empirical data. About 200 years ago, Wilhelm von Humboldt (1767–1835), who was the first to engage in a scientific study of Basque, predicted that this language would die out by about 1900. The death of Welsh, the Celtic language spoken in Wales, was predicted for the end of the 20th century. In fact, both languages are still spoken by more than half a million speakers. Similar statements have been made about numerous other languages that have survived predictions of their death.

It has become customary to lay the blame for the annihilation of cultures and languages on globalization. This strategy of blame has produced an atmosphere of conflict in which concepts such as 'local culture' and 'small language' collide with concepts such as 'network society' and 'global communication'. As it seems, the magnitude of threat that is involved in many experts' claims concerning the dissolution of linguistic diversity in the near future and the associated loss of cultural heritages creates radical patterns of behavior among concerned observers.

When linguists and anthropologists today ask "What can be done about the imminent disaster of language loss in the world?" the best advice that can be given to them is: it is perhaps worthwhile finding out whether the rate of loss is truly as disastrous as is claimed. Few seem to be willing to question the apocalyptic claims of massive extinction of languages or to inspect in detail the relationship between globalization and the vanishing of local cultures. Anyone who engages in a careful analysis of the world's small languages and of their ecological conditions will be surprised to find conflict settings less catastrophic than is generally assumed.

It is hazardous to make generalizations about the world's languages in crisis if one extrapolates from situations with specific local conditions (such as the USA). In a worldwide comparison of dwarf languages, that is, of extremely small languages each spoken by only several hundred individuals, no general trend toward extinction is evident. Rather, varied patterns of ecological conditions become apparent (Haarmann, 2001a, p. 21 ff.). In some regions language death is the general theme, as among most Aboriginal languages in Australia. In other regions, however, even small communities have succeeded in maintaining their cultural and linguistic identity because there is little outside contact, as in Papua-New Guinea where government officials contact many ethnic groups only once or twice a year. The Etoro in the Strickland-Bosavi region of the New Guinea Highlands, an ethnic group of some 950 members, have maintained their local language and culture throughout the ages (Kelly, 1993).

In regions with a multitude of languages, the local conditions of contact and the impact of conflict may vary considerably. Among Indian communities in Brazil, for example, continuity of their cultures and languages is guaranteed best where contact with white people is reduced to a minimum. It is obvious that, in the smallest communities of the world, it is not globalization or the impact of English that poses a threat to cultural continuity and language maintenance. Rather, it is the pressure of dominant languages (mostly other than English) on local non-dominant languages that provides the key to understanding why small languages vanish. Such situational pressure, which today causes many small communities to assimilate, has much older roots than the modern process of globalization, which does not directly affect the functioning of small languages. Only in surroundings where English is the dominant language (e.g., in the USA or Australia) can its traditional pressure on local languages be confused with its role as a vehicle of globalization.

In fact, most dwarf languages are found outside the English-speaking world, that is, outside countries where English is used as the first or second language. To this category belong almost 2000 languages, or about 30% of the world's languages. Not all these languages are endangered by any means. If one extends the range of inspection of languages in crisis to larger speech communities where languages suffer from functional deficits, one might conclude that about 40% of the world's languages are endangered. Although 2500 endangered languages pose an enormous challenge to those who engage in devising strategies for saving them, this portion of the world's languages is far from the hysterical rate of 90% that has been publicized.

The great majority of the languages in the world are 'small non-elaborated languages', because they lack written standards. This deficit excludes them from participating in the digital processing of data. In this functional perspective, a language may be identified as a 'small language' if it is not present on the web or, in other words, if the potential of information in that language is not made available through the channel of digital literacy. Most languages of the world today are in this category, and they have no access to digital literacy.

In the European context, there are few indigenous languages in this category. These are Livonian in Latvia, Izhorian west of St. Petersburg, Krimchak in southern Russia, Karaim in Ukraine, and some others. Although, in the linguistic panorama of Europe, languages of this category are the exception, they dominate the proportions in other parts of the world. Only about one sixth of the world's languages are written, and fewer than 800 are regularly used in written form. Of these, some 550 have crossed the threshold of Internet presence (Crystal, 2000, p. 142).

The great majority of languages will remain excluded from the realm of digital literacy. Knowing that information technology has an enormous impact on the construction of the network society, one could argue that the small languages without literacy are the true losers in the competition for survival. Such a view is plausible from a standpoint that gives priority exclusively to the accumulation of digitally processed knowledge. How can we call such people 'losers of the information age' if we do not share the knowledge they have accumulated throughout many generations and lack their cultural memory? The picture that people in the network society carry in their minds is distorted, because the accumulation of essential knowledge is not necessarily associated with the digital processing and storage of information, but may well be accumulated in cultural memory by means of oral tradition.

We have to become aware that there is another world, a world in which an incredible amount of knowledge about nature and culture is available, stored in the minds of individuals who speak small languages. This valuable knowledge about the world remains unexploited by the network society because no means exist for establishing a direct link between oral tradition and digital literacy.

The small languages of our modern era may have a history of development reaching thousands of years into the past. The communities of their speakers have succeeded in surviving throughout the ages with the help of an accumulated knowledge about lifestyles in surroundings determined by pertinent ecological conditions. Obviously, maintaining social order in a community and maintaining cultural identity among its members does not ultimately depend on the functioning of what we call 'civilization'.

If we are conscious of the values of small languages as vehicles of local culture and as means for making cultural knowledge operate, then we have to consider us the losers of the information age if we allow those small languages to die. When we think of the manifold problems – environmental, economic, sociocultural – that people in the network society are facing today and of the problems we will be facing tomorrow, then we have to make efforts to safeguard all the knowledge that is available about this world, whether constructed by means of digital literacy or accumulated in oral cultural memory, as a potential source for survival strategies that we may need in the future.

In view of this insight, any action that might be taken to facilitate the ecological conditions of small languages, to promote their maintenance, and to stimulate self-consciousness among their speakers is an ethical imperative. The issues of linguistic human rights, of moral status regarding the safeguarding of the functional range of languages, and of strategies in effective language engineering will remain on the agenda of activists in the years to come (Haarmann, 2001b, p. 142 ff.).

On the other hand, we are confronted with the reality that NEB is needed for keeping us in the currents of global information exchange. English as the second-language component poses a challenge rather than a threat to our cultural and linguistic identity. Globalization through the medium of English is not a process of an irreversible eradication of local identities, but rather one in which local cultures are challenged to mobilize their inner forces and to activate various patterns of adaptation.

In the era of an emerging network society, all cultures and languages that are involved experience change of some sort, locally differing in quality and magnitude. In this process of change, the influence exerted by English is a major variable. How the influence of global English affects local speech communities and whether modernization is always successful depend on many factors of language ecology. Much depends on the flexibility of local cultures to adapt to the requirements of modern communication.

Regarding the maintenance of local languages, this is always a function of people's consciousness and strength of mind. If Continental Europeans are determined to benefit from the network society, they will safeguard the advantage of being bicultural and bilingual. Biculturalism and bilingualism provide us with the opportunity to look at the world from different angles, which is a kind of mental capital that monolingual English-speaking people painfully lack.

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4
Social Evolution

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4.1
Introduction

From sociology's beginning as an autonomous discipline, sociologists have been striving to understand the causes underlying social development. As they witnessed rapid changes in the political, economic, and demographic spheres in 19th-century Europe, as well as the expansion of colonial rule over hitherto unknown regions, their search for an embracing explanatory framework was both necessary and unavoidable. Even if many modern sociologists would rather refrain from utilizing evolutionary theory to explain social development, influential 19th-century sociologists made extensive use of that theory, being impressed by structural similarities between the natural process and the development of societies. It appeared that, similar to the evolution of more complex species from simple single-cell organisms, human societies developed from small and simple to larger, more embracing types of association as well. There is, however, a major obstacle to insisting on the fruitfulness of the analogy, i.e., the problem of social regression: unlike in other species, complex human societies may fail and relapse into simple patterns. Other major problems in the theory of social evolution are notions of the basic directionality of the process, which are not compatible with the theory of evolution by natural selection, as well as evaluative labeling of progressions toward higher levels of adaptation. Although it cannot be denied that these and other problems impeded the theory of social evolution, attention should be given to the fact that social scientists are only partly responsible for the confusion over the theory of evolution. Recent advances in evolutionary biology, population ecology, and similar approaches have made it clear that some of the premises of the theory of evolution by natural selection need readjustment, due to findings about 'units of selection', 'inclusive fitness', and similar concepts. This chapter argues that applying these concepts to the study of social evolution may greatly enhance our understanding of this process. For instance, although it cannot be denied that competition and various forms of force play a role in social evolution, recent findings by evolutionary biologists and evolutionary anthropologists indicate that force is not

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in itself a decisive factor in social evolution but must be combined with other factors to cause development. Other findings relate to the fact that only a few areas of the world were conducive to the development of food production, the single most important cause of social evolution, and that people in those areas enjoyed selective advantages over people in other areas. With the adoption of food production, people were able to pass the boundary between the primordial hunting and gathering society and more embracing patterns of association. This in turn brought many new cultural institutions in its wake, such as chiefdoms, kings, scribes, and soldiers, to name but a few. Obviously, there were regularities at work in the evolution of the most dissimilar human societies, which throws the door open for an evolutionary understanding of societal development.

When Darwin's theory of evolution by natural selection was first published, the stage was already set for a new theory promising to account for the causes of development in a broad and embracing fashion. In those days, European societies were engaged in a thoroughgoing transformation of social and political institutions that was at least partly engendered by technological innovations. It is common knowledge that innovations such as Watt's steam engine were preconditions for the modern industrialized world. Compared with previous systems of production, the 19th century's factories enabled entrepreneurs to produce larger quantities of goods at lower prices and thus to out-compete any producers relying on obsolete means of production. From the outset, the industrial system attracted large numbers of laborers who, fleeing the modest conditions of life in villages and small towns, hoped for a better living in the industrializing cities. In England and other parts of the United Kingdom, the birthplace of the Industrial Revolution, these processes brought about major changes in society, namely urbanization with mass migration of peasants into the cities, as well as novel patterns of political participation. By leaving their homes in the countryside, industrial workers also abandoned their role in the feudal system of agrarian production, which was, in the late 18th and early 19th century, still the dominant mode of production in most of Europe. In the wake of these developments, new political structures evolved in 19th-century industrializing societies, namely trade unions, political parties, and new patterns of political participation in democratic processes.

The French Revolution was the other major development in this era, leading to the abolition of absolute monarchy and, despite Napoleon's resurrection of monarchic power, eventually resulting in the diffusion of the political ideals of republicanism and democracy. In fact, Napoleon became the executor of revolutionary ideas put forward by Rousseau, Montesquieu, and other social philosophers and ideologues of the time. As a consequence to these developments on a grand scale, large numbers of people, particularly the intellectuals, all over Europe came to accept 'liberté, egalité, fraternité' as a formulation of the inalienable rights of all mankind. In hindsight it seems obvious that these ideas should not only motivate men in other revolutionary movements, such as the Bolsheviks in Russia, or Mao's followers in China, but that their underlying ideals were to become foundation pillars for the developing social sciences as well. Although philosophers had been reflecting upon the human condition at least since Aristotle's time, the development of the social sciences was reserved for an era when traditional conditions of life, such as class structure, legitimacy of governance, and the prevailing mode of production were cast in doubt by economic, social, and political changes. Viewed against the background of the industrial and political revolutions in Europe, it seems unlikely that the relative temporal proximity of the publication of Smith's *Enquiry into the Causes of the Wealth of Nations* and Comte's *Cours de Philosophie Positive* was merely fortuitous. However that may be, Smith, who considered himself a moral philosopher, came to be the founder of modern economics, and Comte, a philosopher, came to be the first sociologist. Despite many differences in the perspectives of sociologists and economists, their primary concern in the early days of their respective sciences was the need for improved understanding of the workings of modern society, as it evolved in the wake of the social and political transformations outlined above. In the course of nearly 200 years of disciplinary development, large numbers of competing theories and hypotheses evolved, but it may still be fair to say that economists specialize in studies of people's rational strategies in the pursuit of their economic goals, whereas sociologists seek some general cause underlying the ongoing evolution of society. In summary, European societies were in fact undergoing profound changes in social, political, and economic structures, and so there was a growing need for a comprehensive account of the causes underlying these transformations.

There was, however, yet another sphere of social life fostering the need for an understanding of social development, namely the Enlightenment. As indicated above, followers of this philosophy were united in their search for the inalienable rights of all mankind, rights of which many people still were deprived. In a painstaking analysis of this philosophy, Mandelbaum (1971) draws special attention to the ideas of 19th century German philosophers such as Johann G. Herder and Georg W. F. Hegel. According to Mandelbaum, "at the heart of this new doctrine (enlightenment) was the conception of the organic nature of man's social life", as well as the idea

> that the various aspects of social life are to be conceived of as related to one another, and to the growth of the whole, as the component parts of a living thing are related to one another and to that thing as a whole (Mandelbaum, 1971, p. 57).

One of the first philosophers to use this view was Herder, who "used 'blossoming' as a root metaphor in his conception of history. Most important of all, he viewed nature as a single developing whole" (Mandelbaum, 1971, p. 58). With regard to the direct predecessors of sociology, it is interesting to note that Comte's teacher, Claude-Henri de Saint-Simon "espoused materialism [instead of] his German contemporaries' ... metaphysical idealism" (Mandelbaum, 1971, p. 63). Without going into further detail, I should emphasize that the idea of societies undergoing development by necessity, even the idea of social progress, were in no way alien to these philosophical traditions. In fact, as pointed out by Mandelbaum, Comte established his famous law of the three stages upon Saint-Simon's views, although this step required a complete reversal of Saint-Simon's notion of progression.

Turning to sociology, sociologists have always had a major goal of firmly establishing their science as an empirically oriented and antimetaphysical discipline, clearly distinguishing it from some of the more outspoken normative disciplines such as ethics. However, contrary to these antimetaphysical pretensions, influential sociologists have in fact pursued normative goals as well. According to Schimank, numerous social scientists adhere to the egalitarian ideals of the Enlightenment, proceeding from the assumption that social inequality is unjust (Schimank, 1996, p. 9) and considering one of the social sciences' most important tasks to be the unveiling and even rejection of any form of social inequality. Although it may be a noble task to censure social inequality, social scientists tend to thereby endanger their primary role as empirical scientists because, from an epistemological point of view, it is problematic if not strictly impossible to unite empirical statements and normative evaluations into one coherent theoretical approach. These reservations are also in place with respect to the theory of social evolution, when normative connotations are bound to carry evaluative categories such as 'progress' or 'degeneracy' into the theory, thereby seriously jeopardizing the theory's explanatory goals. To be clear, whereas there can be no doubt about the legitimacy of studies on the Enlightenment's impact on the development of European societies or its intellectual influence on individual social scientists, the introduction of Enlightenment norms and ideals into the context of general theories of social evolution poses serious dangers to the explanatory tasks of these theories. The first problem may be tackled by studies in the sociology of science, whereas the second problem, i.e., the causes of social evolution, calls for the identification of sets of causes, as well as of mechanisms underlying social evolution. What then are the general characteristics of a sociological approach to the study of social evolution?

Unlike historians who specialize in studies of singular events, sociologists and other social scientists strive to reveal basic regularities in the course of events; they try to find general and repeatable patterns that can account for convergent evolution (Sanderson, 1995, p. 3). The basic idea is that, despite obvious differences between societies, (1) there must be some general cause that sparked development in the first place, and (2) in spite of climatic and other environmental differences there are certain regularities in societal development all over the world. In this view, we can expect that a sociological study can, for instance, uncover similarities in the evolution of the state – in Ancient Egypt and Mexico – two areas geographically so distant from each other that it seems utterly unlikely that cultural diffusion could be the cause for the resemblance of social patterns in these societies. This chapter will show that social scientists have put forward numerous theories designed to account for the causes that sparked development in the first place, as well as for the ensuing regularities in societal development. As indicated above, a first major problem with these theories is, however, the degree to which they entail notions of progress or degeneracy, which are normative connotations; a second problem is the nature of the mechanisms that are thought to induce societal development. Special attention will be given to the use of the concept of evolution, a concept that, according to Sanderson (1993, p. 735), was one of the most influential in the history of the social sciences. However, before describing some of the classical theories of social evolution, some additional remarks on the historical conditions leading to the evolution of the social sciences are pertinent.

It may appear from the above considerations that the evolution of the social sciences occurred in response to the shocks caused by the scientific and technological advances that gave rise to the Industrial Revolution, the ideals and values of Enlightenment philosophy, as well as to the aftermath of the French Revolution. Because of these changes, everything that people felt to be obvious in society was suddenly cast into doubt, and they saw themselves exposed to a social situation of unprecedented complexity. In this situation, sociology emerged as a science "designed to observe society, and to provide means for an improved understanding of its operations" (Luhmann, 1990, p. 230). This happened when Comte, the founding father of sociology, published his *Cours de Philosophie Positive* in 1830, some 60 years after Smith's publication of his *Enquiry into the Causes of the Wealth of Nations* in 1776, a book that was soon to become the basis for the evolution of modern economics. With respect to the theory of social evolution, there is yet another discipline that has to be drawn into consideration, i.e., social and cultural anthropology.

Leaving aside historical reasons for distinguishing social from cultural anthropology, it is interesting to note that cultural anthropology, according to a sort of tacit agreement, was assigned the task of studying premodern societies, particularly stateless clans and tribes which due to 19th-century colonialism, came within reach of the evolving social sciences. With the expansion of European states in the era of colonialism and imperialism, it seemed to be useful to acquire scientific knowledge about the stateless societies of Africa, the Americas, Asia, Australia, and Polynesia. In the present context it is particularly interesting to note a tacit consent among sociologists, according to which a clear distinction should be established between sociology, the science specializing in studies of modern society, and social and cultural anthropology, focussing on premodern societies. To be sure, this view cannot be upheld against recent criticisms, according to which this traditional allocation of tasks must be regarded as arbitrary and superfluous. In contrast to the consent still prevailing in some sociology quarters, it is suggested that the advent of modernity did in fact not establish entirely novel conditions for social living, entirely different from those in less advanced societies. From an evolutionary point of view it seems utterly unlikely that social behavior should in fact be totally determined by the more-or-less arbitrary forces of modernity. Therefore, an evolutionary perspective proceeds from the assumption that, despite a variety of novel factors in modern society, there are certain general regularities in all types of society that can be accounted for by evolutionary theory.

According to Antweiler, there are basically three different meanings of the concept of social evolution: (1) "long term change of an unspecified nature", (2) directional changes more-or-less synonymous with notions of increasing societal complexity, and (3) "processes of adapting diverse societies to their physical and social environments" (Antweiler, 1991, p. 272). As Antweiler pointed out, this classification allows for integrating Herbert Spencer (1857) as well as Carneiro, one of his influential followers, into a 'directional change category', whereas Habermas' approach should be regarded as a peculiar brand of 'developmental logic' (Antweiler, 1991, p. 493). Despite the merits of this classification, this chapter presents yet another view by, on the one hand, suggesting that modern Darwinism sheds some fresh light on many time-honored problems of social theory, and on the other hand, proposing in a somewhat Spencerian fashion that increases in social complexity actually are a major factor in social evolution. However, unlike the teleological notions inherent in Spencer's theory, a truly Darwinian account has to take the role of physical and social environments, as well as the impact of unforeseeable events, such as warfare, into account.

As pointed out in the chapter on Evolutionary Theory, Darwin' s approach to explaining biological phenomena as products of natural selection is one of the most successful approaches in the history of science, and despite some reluctance, Darwin was also one of the first to apply his theory to the study of human behavior (Mandelbaum, 1971, p. 77). In his *The Descent of Man, and Selection in Relation to Sex* of 1871, Darwin provided valuable insights into the biological underpinnings of human emotions, as well as of other regularities in human behavior. Since then, these studies have served as a point of departure for the development of ethology, sociobiology, evolutionary psychology, and evolutionary sociology, as well as for other studies of the natural bases of human behavior. These disciplines shed some fresh light on the evolutionary underpinnings of human social behavior and compete with many of the more traditional views in the social sciences. Because of these advances in evolutionary science, it seems implausible that the historicist notion of total determination of social behavior by modern society can be upheld against naturalistic and evolutionary criticism (Albert, 1999, p. 225). For this reason, I should emphasize that the majority of mainstream sociological theories of social development and evolution, which have relied on historicism or have leaned on other forms of progressivist thinking, are incompatible with Darwinian theory. As Schimank (1996) pointed out, the underlying preference for antiindividualistic approaches in historicism is due to a rift between the two dominant sociological paradigms, namely the sociology of action and the sociology of social system (Schimank, 1996, p. 205).

Whereas the sociology of the social system specializes in studies of social institutions and their development, the sociology of social action takes the human individual, his or her needs, interests, etc., as its focal point. Viewed over the entire history of sociology, the systems perspective and its antiindividualism was far more influential than the other. According to Dawe's analysis (Dawe, 1978, p. 368),

> the contradiction between the two sociologies articulates the contradiction which is at the heart of the dominant modern experience and which permeates our life as a constant existential tension of our time and place (Dawe, 1978, p. 368 after Schimank, 1996, p. 205).

Dawe specifies (1978, p. 365):

> While we never cease to experience ourselves as acting, choosing, purposeful, aspiring human beings, we also never cease to be aware of the factory gates closing behind us, the office days that are not our own, the sense of oppres-

> sions by organizations nobody runs, the 'not-enough world' we are forced to inhabit most of the time (Dawe, 1978, p. 365 after Schimank, 1996, p. 205).

Leaving details aside, I should emphasize that most of the advances in understanding the biological underpinnings of human behavior relate to the sociology of social action, whereas most traditional studies of social evolution relate to the sociology of systems, mainly to the evolution of social institutions of various kinds.

Turning to some classical sociological theories of social evolution, Comte is famous for his law of the three stages, according to which civilization grows from an initial theological into a metaphysical stage, a process eventually leading to a positive stage (Comte, 1972, p. 111). It is interesting that Comte uses mainly psychological and epistemological categories in describing these stages, for instance, when he characterizes the first stage "by the search for essential causes ... and absolute knowledge" (Comte, 1972, p.112). According to Comte, the initial state is soon followed by two substages, the fetishistic and then the monotheistic. In the latter era an inevitable decay (Comte, 1972, p. 113) of monotheism begins, and civilization enters the second, metaphysical stage. Eventually, the entire process results in the positive stage, which is dominated by the renunciation of 'absolute knowledge', and consequently the dominance of "observation as the only legitimate means of our striving for knowledge" (Comte, 1972, p. 117). Superficially, it seems obvious from these citations that Comte viewed social development as a law-like progression from one stage to the next and that this process was not based primarily on society but on individual cognitions. According to Mandelbaum, this would, however, be only part of the truth, because "it is society which determines the social characteristics of the individual" (Mandelbaum, 1971, p. 68) and not the other way around. From the Darwinian point of view, there is, however, yet another major problem in Comte's theory, i.e., the analogy between human ontogeny and evolution in its entirety. The analogy is mistaken insofar as ontogeny is predominantly under genetic control, whereas evolution, particularly social evolution, is not. However, despite the theory's shortcomings, Comte was to become one of the 19th century's most influential sociologists.

The first sociologist to address social evolution in the literal sense was Herbert Spencer, definitely one of the most influential sociologists in the discipline's history. According to him, the course of social evolution was predetermined to some extent because it was part of the more embracing process of organic evolution, proceeding "from incoherent homogeneity to coherent heterogeneity" (Schimank, 1996). In a more comprehensive formulation Spencer suggests

> whether it be in the development of the earth, in the development of life upon its surface, in the development of society, of government, of manufactures, of commerce, of language, literature, science, art, this same evolution of the simple into the complex, through successive differentiation, holds throughout. From the earliest traceable cosmic changes down to the latest results of civilization, we shall find that the transformation of the homogeneous into the heterogeneous, is that in which progress essentially consists (Spencer, 1857, p. 40 after Schimank, 1996, p. 29).

In a nutshell, this formulation contains one of the crucial concepts of most theories of social evolution, i.e., the notion of social differentiation, which was used one way or another in most theories of social change.

Similar to Comte, Spencer's description of evolution views the process as a law-like progression from simple to more complex forms, or in Spencer's words, a process analogous to the "development from a grain of seed to the tree" (Spencer, 1972, p. 122). The problem with this view is that, unlike ontogenetic development, which is under genetic control, social processes are not solely determined by genetic information. In general, there are more differences than similarities between Comte and Spencer's notions of the causes underlying social development. For instance, unlike Comte, Spencer pays much more attention to the empirical knowledge available in his day, for instance when he talks about the evolution of authority in stateless societies (Spencer, 1972, p. 124) or the impact of roads and other means of transportation on progress in social differentiation. Despite these advantages of Spencer's ideas on social evolution, his theory needs to be classified as one of the theories of 'directional change' (Antweiler, 1991, p. 273). Moreover, according to Mandelbaum, Spencer insists on a concept of total evolution in accordance with one comprehensive law. Although Spencer "did not insist that every society had progressed", he claimed that "social evolution had proceeded in terms of the one general, overarching law of development" (Mandelbaum, 1971, pp. 105–106). From the viewpoint of modern evolutionary theory, any notion of directional or telic change must, however, be considered seriously flawed, because it is not very likely that the natural process pursues some goals that have been built into organic matter from the outset. Therefore, Spencer's analogy between the emergence of the tree from the seed and social differentiation is most problematic, because these processes are located on different levels of evolution. As pointed out before, the change of a seed is under strict genetic control, whereas social differentiation is at least partly determined by novel causes arising from unprecedented conditions in the course of human history.

One of the merits of Spencer's theory of social evolution is his treatment of warfare as an important factor. According to him "warfare among men, like warfare among animals, has had a large share in raising their organizations to a higher stage" (Spencer, 1873, p. 193). Obviously, Spencer felt that war "played a vital role in emancipating humans from an unruly, savage state" (van der Dennen, 1999, p. 166) and should therefore be considered a factor conducive to 'progress' and improvement of human affairs. With the wisdom of hindsight, this assessment is regarded as irritating or even disturbing; however, the fact remains that Spencer was the first sociologist to put forward a systematic study of this relationship (Maryanski and Turner, 1992, p. 131), and the importance of his insights is still cherished by many experts in the field, as pointed out in some detail below. Spencer also was perhaps the first social theorist to develop (Corning, 1983, p. 304) population-pressure theory, a theory that has more recently been taken up by Carneiro, Cohen, and Sanderson (Sanderson 1995, p. 37), to name but a few. Another major advantage of Spencer's work, although more on the psychological level, is his contribution to an evolutionary understanding of human emotions (Izard, 1981). Other implications of Spencer's work have recently been regarded less favorably, particularly his role in the generation of Social Darwinism. Some critics have argued that Spencer was in fact the founding father of this doctrine, and that his theory should therefore be rejected. According to one of these critics, Lewontin (1968, p. 209), Spencer's concept of the survival of the fittest played a major role in legitimizing laissez-faire capitalism, and Buchan (1966, p. 34) points to the undue identification of modern warfare with biological competition.

There can be no doubt about Social Darwinism's importance in the legitimization of power politics, and its undue reliance upon normative statements, but as Flohr (1987, p. 279) points out, the use of this doctrine was not restricted to any particular political movement; in fact it has been utilized by members of the political right, conservatives, and fascists, as well as by left-wing politicians. Despite its considerable influence in political life, Social Darwinism was, however, founded upon several misunderstandings; in particular, it invoked a vastly exaggerated role of violent conflict in social life. The first misunderstanding is, however, related to the use of Darwin's name in the name of this doctrine. Darwin was in fact not an advocate of anything that is now identified with Social Darwinism, and his books contain numerous passages in which he emphasizes the role of sympathy in human social life and argues in favor of supporting the poor (Winkler, 1994, p. 104). A second misunderstanding relates to the concept of the struggle for existence, as used by advocates of Social Darwinism in an attempt to raise the role of competition and conflict to the single most important factor of social life. However, Darwin was as clear as possible about the role of his concept of struggle for existence when he said that he wanted to use the concept "in a large and metaphorical sense, including dependence of one being on another, and including not only the life of the individual, but success in leaving progeny" (Darwin, 1968, p. 459). Whatever the impact of Social Darwinism on the history of society, it was based on misinterpretations of the Darwinian theory of evolution by natural selection (Barash, 1980, p. 108; Corning, 1988, p. 148) from the outset, and therefore the political uses and misuses of this doctrine cannot be used to damage the theory of evolution.

If Social Darwinism was a seriously flawed doctrine from the very beginning, many of the classical theories of social evolution also were established on misunderstandings of evolutionary processes. From an epistemological point of view, Popper (1963) critiques any theory of social development "according to which this development obeys certain universal causal laws, so-called laws of history". Unlike such philosophers of history as Hegel and Marx, as well as some of the most influential early classics of sociology, mainly Comte and Spencer, we must "accept the obvious: there are not and cannot be any general theories of social change" (Boudon, 1984, p. 189 after Schimank, 1996, p. 23). We might infer that assuming these laws introduces an over-deterministic notion of social development and, in consequence, precludes the rise of evolutionary novelties. For instance, as far as our knowledge of human history goes, ancestral human populations used to live in small-scale associations, without any institutions resembling modern political institutions. However, at a certain point in human history, political institutions arose independently in many populations that were otherwise completely different. If the evolution of novel types of social institutions were totally determined by some general law of history, it would have been necessary for similar institutions to arise in all human societies more or less at the same time. This is, however, not true. Quite the contrary, many populations have never evolved full-blown political institutions, such as the aborigines of Australia and New Guinea. The story to be learned from this is that (1) similar institutions may arise in dissimilar societies; (2) such institutions do not, however, evolve in all human societies – in fact in some societies political institutions have never evolved at all; and (3) there obviously is no universal law-like progression – rather, certain conditions evoke the evolution of similar institutions in some but not all human societies. Therefore, there are law-like phenomena in social development but they depend upon certain conditions, just like Boyle's law on the boiling point of water presumes 'at sea level'. At other levels, water boils at a different temperature, but Boyle's law, is still a law. The evolution and diffusion of social institutions obviously did not comply with typical 19th-century notions of the laws of history or with dualistic typologies such as Tönnies' community vs. society, Durkheim's mechanic vs. organic solidarity (Reimann, 1991, p. 125), or other such dichotomous constructions. These notions provided vague, over-simplified ideas of the real processes, which is why they were abandoned in the beginning of the new century (Tenbruck, 1989, p. 59) and were replaced by more embracing typologies.

4.2 Typologies of Societies

The following sections portray typologies of social evolution. Rather than trying to present a historical account of the evolution of typologies, I focus on some crucial concepts and their underlying assumptions. This descriptive part is followed by a critical assessment of some of the underlying theories and a closer look at the developments in some social institutions. For instance, several theories emphasize the role of warfare in social evolution, others point to the impact of population pressure on the course of events. It seems, however, that an understanding of warfare's impact on social evolution presupposes a cautious analysis of this institution's development, and the same is also true for related institutions.

There is nearly unanimous agreement among social scientists that the hunter-gatherer band was the first human society (Maryanski and Turner, 1992, p. 69; Lenski, 1966, p. 95). This type of society was, however, not only the first but also the most stable type of human association, because it has prevailed from time immemorial to this very day in some remote areas of the globe, such as in parts of the Namib desert, in the rain forests of New Guinea and South America, and in other parts of the world. If one is looking for a general characteristic of this type of society, 'simplicity' seems to be all pervading, for instance membership is limited to 50–80 people (Maryanski and Turner, 1992, p. 86), a size that allows for periodic interactions among the band's members. Many authors agree that simplicity prevails throughout social institutions in this type of society, in fact, besides the sexual division of labor, age-group specific and the shaman's activities (Lenski, 1966, p. 100), there are hardly any additional specialized social institutions. Due to the low level of division of labor, hunter–gatherer bands typically are highly egalitarian and lack political institutions.

According to Lenski's influential *Power and Privilege* (1966), simple horticultural societies are the next step in social evolution; Maryanski and Turner use the term 'horticulture' to designate this type of society. According to these authors, prior to the evolution of this type of society, the invention of improved hunting technologies may have caused the growth of populations, which in turn prepared people for accepting a new mode of living. The use of these weapons may have "led to a decrease in big game animals in a region, forcing hunters to become farmers; and as they did so, their numbers grew and forced them to remain horticulturalists" (Maryanski and Turner, 1992, p. 92). Leaving changes in other institutions aside, it is interesting to note that population density grew during the transition to horticulturalism, and in consequence, people turned to semipermanent settlements. However, this development brought in its wake certain structural problems, namely the constant problem of resource depletion, as well as incessant warfare (Maryanski and Turner, 1992, p. 96; Lenski, 1966, p. 129). These are just some examples of regularities arising in social evolution, more or less independent of other cultural factors.

The advent of societies of the agrarian type tends to further intensify population growth and, according to Maryanski and Turner, population size now ranges from a few hundred thousand to several hundred million (Maryanski and Turner, 1992, p. 120). The basis for this population growth were further advances in technology, mainly the invention and diffusion of the plow. As Childe puts it (1936, p. 100, after Lenski, 1966, p. 190),

> The plow heralded an agricultural revolution. Plowing stirs up those fertile elements in the soil that in semiarid regions are liable to sink down beyond the reach of plant roots. With two oxen and a plow a man could cultivate in a day a far larger area than can a woman with a hoe. The plot (or garden) gives place to the field, and agriculture really begins.

People now typically live in villages and towns, very much like those still existing in most parts of Europe and in other regions of the world. Furthermore, the agrarian system requires advances in the division of labor, because farmers depend on rapid sale of their excess products, and various classes of merchants specialize in marketing these goods. Industrial society, the most recent type of society, brings in its wake further population growth, continued urbanization and mass migration of workers into the core industrializing areas. According to Maryanski and Turner, division of labor is "becoming dramatically more differentiated and complex" (Maryanski and Turner, 1992, p. 149). As is well known, the industrial system evolves due to the invention and diffusion of various types of machinery, such as James Watt's steam engine or the spinning mule (McNeill, 1970, p. 692), the combination of which brought about a dramatic increase in the production of textiles. In short, industrialization was the single most influential economic factor since it began in 18th-century England; it has, however, not only affected the means of production, but also exercised an influence on all aspects of social life.

Obviously, the primary focus of this sketch is on population growth, and one of its major causes, i.e., technological innovation, which helped provide the means of subsistence for ever-growing numbers of people. There is, however, no clear causal relationship between these variables, so a typology relying solely on these variables is far from providing an account of the entire process. Despite its scanty information, there may, however, still be merit in this typology in drawing one's attention to two crucial points, namely (1) the growth in size, social differentiation, or complexity, and (2) the similarity to the natural process. Turning to the growth in size and social differentiation, I should note that the majority of classical sociologists have emphasized this point, in fact some, like H. Spencer and T. Parsons, have seen increases in social differentiation as a sort of inbuilt goal of social evolution. Superficially, the increase in social differentiation seems to be analogous to the growth of differentiation in the natural process, as expressed in Spencer's comparison of processes in the seed with social differentiation. It seems to be in keeping with Spencer's notions that in phylogeny, there is a growth of internal differentiation in living systems, with the older single-cell species, such as the amoebae, being established on comparatively less genetic information than mammalian species. Therefore, the extent of genetic information in a given species seems to be suitable as an indicator of its level of differentiation because, according to Riedl (1975, p. 219), providing the blueprint for a multicellular organism requires genetic information of considerably larger scope than doing so for a single-cell organism. Although there may be considerable redundancy in the genetic blueprint of more advanced species, comparatively larger quantities of genetic information are required for storing all relevant traits of multicellular organisms than for single-cell organisms. The more recent and phylogenetically 'higher' species require more individual yes/no decisions, as well as genetic hierarchies, and are therefore more differentiated than the simpler and 'lower' species. We may infer that, by ascending the ladder of living beings from comparatively simple species to more complex organisms, there is a concomitant increase in the total scope of genetic information, as well as of overall internal differentiation.

Although these conclusions seem to make sense with regard to the evolution of organisms, there is, however, a major obstacle to analogizing it with social evolution, namely the fact of social regression. It is well known that highly differentiated empires relapsed into evolutionarily antiquated social states, for instance, when comparatively backward tribal and feudal types of political organization succeeded the western Roman empire, which was the leading state in terms of social differentiation at the time. The same is true for the Mayan empire in Central America, which declined prior to the Spaniards' arrival, most ethnic Maya returning to tribal ways. Some general causes for the decline of empires are presented in a later section; in the present context the fact of regression may serve as a reminder of major differences between organic and social evolution. In organic evolution, there is, however, nothing similar to social regression because, according to mainstream Darwinian theory, there is a biological relationship between living and extinct species. The point is not merely that currently existing species descended from those extinct; over and above it, living and already extinct species share large amounts of genetic information. For instance, although the mammoth's genetic information may no longer be viable, it is nevertheless, still present to some extent in their living successors, the elephants. In contrast, the social institutions underlying the Mayan empire, in particular its central political authority, did not survive the exhaustion of natural resources, which probably was the cause of the breakdown of the empire, and the people returned to tribal ways, with comparatively simple social institutions.

It seems that a major difference between the two types of evolution is in the type of information carrier, DNA and individual genes organic evolution vs. cognitive and cultural information in social evolution. To be sure, genetic information plays a role in social evolution as well, as R. Boyd, P. Richerson, W. H. Durham (Boyd and Richerson, 1885, p. 38; Durham, 1990, p. 194), and others have demonstrated, but its primary purpose is to serve as the substratum for cognitive and cultural processes. The causal relationship between different types of information, namely between genetic, cognitive, and cultural information, is in itself a difficult and complex scientific problem; it will, therefore, suffice to say that genetic information is a necessary but not a sufficient condition for the evolution of cognitive and cultural information. These latter types could not have evolved unless genetic information had paved the way for them, but the mere existence of genetic information was not sufficient to bring about cultural information. An example may illustrate the point. The evolution of water depended on the existence of both oxygen and hydrogen, but both substances did not possess the novel, unprecedented properties of water. Similarly, the unprecedented characteristics of cognitive and cultural processes cannot be reduced to properties at the genetic level, although the existence of genetic information is a precondition for the evolution of these novel types of information. In this respect it is interesting to note that, according to recent findings, a total of 3659 genes have so far been identified (Wilson, 1998, p. 132) that function in the development of the individual human brain. Although these genes have been made by natural selection to control the development of the brain as an organ, their task definitely was not to impose total genetic control over the brain's processes, with some thirteen billion (Gazzaniga, 1992, p. 50) neurons, which in turn may have up to 50 000 synapses per neuron. From an evolutionary point of view it wouldn't make any sense to invest in the evolution of the brain, humans' costliest organ in terms of energy consumption, unless the benefits to be expected from its operation were likely to exceed the costs of the investments. To cut a long story short, it seems that the evolution of the human brain was favored by natural selection, because its unprecedented complexity vastly enhanced the chances of survival. Unlike with other animal species, the human species' development was not constrained by nature once for all; rather, our organic complexity threw the door open for a novel and much faster type of evolution, i.e., social evolution.

In the present context, these considerations may help us understand that there are new and unprecedented phenomena in cognitive and cultural processes, which cannot be understood by reducing the entire process to the genetic level. Therefore, Sanderson's suggestion (1995, p. 7) makes sense, according to which random processes are typical of organic evolution, whereas deliberate and purposive elements prevail in social evolution. It seems that human actors differ from most nonhuman organisms in their capacity for cognitive and rational planning of actions, part of which is further determined by cultural traditions. Although the impact of cognition and culture on human behavior cannot be denied, an overemphasis on these phenomena seems, nevertheless, to be out of place for two main reasons. The first reason is that, according to recent findings, purposive action and culture are not as distinctly human as formerly thought, therefore they are not suited for marking a boundary between animals and humans (Bonner, 1980). Although we cannot deny that culture in the full-blown sense is a peculiarly human characteristic, some animal species have certain capacities for culture at their disposal too. There is, however, a second and more important reason for avoiding undue emphasis on 'deliberate and purposive' elements in human social action, namely the impact of the unintended consequences of human social behavior.

Numerous social theorists have stressed that, despite intentional and rational elements in human social behavior, there is by necessity a large domain of unintended consequences in it. For instance, according to Elias (1988, p. 77), any individual action sparks a chain of subsequent behavioral reactions, the consequences of which cannot be foreseen by the individual. Similarly, Weber's work (1973, p. 76) on the origins of the "spirit of occidental capitalism" emphasizes the unintended, even involuntary consequences of the Protestant Reformation that brought about that 'spirit'. As pointed out by Coleman (1995, p. 11), Weber's approach is not entirely satisfying, because he fails to specify how individual religious beliefs can cause changes at the societal level. Although Weber is in fact rather vague on this particular point, it seems that his reasoning regarding the impact of unintended consequences on macroscopic change is nevertheless compelling. Similar to Weber, an evolutionary approach puts emphasis on the impact of novelties and unpredictable elements in social behavior. In fact, this is in keeping with suggestions by Weber and other social scientists, according to which sociology should be understood as a science specializing in the study of the unintended consequences of social behavior. Even in economics, a science that in general highlights rational behavior, followers of A. Smith's concept of the invisible hand point to the impact of unintended consequences for understanding economic processes. According to Radnitzky (1984), F. A. Hayek's concept of the emergence of spontaneous order seems to suggest that the emergence of order cannot be accounted for in terms of individual volitions and that economic theory must therefore take the role of 'spontaneous' elements into consideration.

Similar to social theorists, natural scientists have pointed to the roles of statistical information systems and cybernetic control systems, which were designed by natural selection to warrant a certain degree of purposefulness. In Th. Dobzhansky's words: "Purposefulness, or teleology does not exist in nonliving nature. It is universal in the living world ..." (Corning and Kline, 1998). We may add that living systems will never succeed in totally controlling their environment's complexity, because, as Luhmann (1985, p. 291) puts it, "the environment's complexity is always beyond the system's complexity". In summary, I should emphasize that, despite cognitive and cultural elements of foresight and planning, i.e., elements of teleology, it is utterly unlikely that human actors will ever succeed in keeping the social consequences of their individual acts under control or that they will restrain societies' impact on other creatures and the physical environment. With regard to social behavior, this leads to a major problem, mainly the need for a certain degree of predictability.

Any system of social behavior requires a certain degree of predictability because, in a broad sense, the term 'social' presupposes some sort of mutuality in interactions. Despite profound differences in the proximate causes underlying ants', wolves', or humans' social behavior, a species-specific system of communication is common to all of them, by which individual organisms relate to each other and establish preconditions for social behavior. For instance, in some ant species, communication seems to be based mainly on the exchange of chemical substances, whereas wolves employ sounds, odors, and visual signals, as well as postures and gestures, in their system of communication, and human organisms, in addition to these mechanisms, can use language. Whatever the differences between these mechanisms, they sufficed to spark the evolution of species-specific patterns of shared goal orientations, as well as of other elements of social behavior. In the human species, the comparatively high degree of unpredictability of social acts called for the evolution of a peculiarly human system of cultural institutions, as well as of social rules of various kinds, providing for at least a limited degree of mutual foresight.

In this regard, there is considerable consensus among social scientists that it is in fact the major function of cultural institutions to provide just that minimum of predictability. It should, however, be emphasized once more that neither cultural institutions nor social rules in general are a warrant against deceit. In stark contrast to notions of norm-obeying, 'over-socialized' (Wrong, 1961) individuals, which prevailed in mainstream sociology for some time, evolutionarily minded researchers have pointed to the necessity of taking into consideration the importance of deceit for understanding social behavior. Some aspects of this discussion are dealt with below. The following section turns to a sketch of cultural institutions as they relate to the process of social evolution, the underlying idea being that, with regard to social evolution, changes in the nature and function of institutions seem to be a major proximate cause of this type of evolution. More specifically, we may assume that population growth, as well as increases in specialization, are major causes of social evolution.

Turning to the concept of cultural institutions, it is interesting to note that, despite profound cultural differences between societies, there is a set of institutions that occurs in all human societies. In this regard, Murdock (1945, p. 124) lists 72 universal cultural elements and institutions, including age-grading, bodily adornment, incest taboos, and kinship terminology. In addition, Parsons (1964, p. 341) mentions religion, language, kinship, and stratification as well as a few other 'evolutionary universals', and Boehm (1986, p. 169) insists that social control and ostracism are universal cultural institutions as well. Leaving aside some problems as to the precise definition of institutions, there seems to be considerable agreement that there are in fact some universal elements in human culture. I should emphasize that the very existence of universals poses a problem for any type of culturalism, insofar as this framework presupposes culture to be a nonreducible entity, an assessment that cannot be upheld from an evolutionary point of view. According to Durham (1990, p. 200), some confusion can be avoided by distinguishing primary from secondary cultural institutions and considering that the evolution of primary institutions was favored by natural selection, whereas secondary institutions are shared by social transmission (Durham, 1990, p. 200). Therefore, their evolution presupposes a secondary type of selection, i.e., social evolution. For instance, one may suggest that the primary mechanism underlying the evolution of the human family is the emotion of bonding (Brown, 1991, p. 47), emotions and human affectivity being products of natural selection, whereas the family is a secondary institution, its actual form being dependent on social evolution as well. Although emotions are not an example of primary institutions, they can, nevertheless, serve as foundations for the evolution of secondary institutions. So, what are institutions, and how can they be distinguished from other phenomena?

Although there is not much consensus among social scientists as to a clear definition of cultural institutions, there is, however, considerable agreement that institutions should be regarded as some set of social rules (Giddens, 1988, p. 430) that are constantly being reproduced by societies. Unfortunately, Giddens, who suggests this view, does not address the problem of why some types of social rules evolved universally, nor does he offer a clear distinction from other types of social rules. In this regard, Melville's suggestion seems more convincing, according to which a major characteristic of cultural institutions is their intimate relation to symbols, and, hence, this symbolism may be used to distinguish institutions from social rules. According to Melville (1997, p. 19), this symbolism suggests stability and constancy, characteristics that in turn provide individuals with a sense of certainty and predictability. In view of the universality of some primary cultural institutions, we may therefore assume that natural selection provided humans with a "biologically transmitted tendency to learn, recognize, or behave in one fashion rather than the other" (Somit, 1990, p. 562). Recently, the term 'epigenetic rules' has come to be used to denote causes underlying 'softwired' (Somit, 1990, p. 569) preferences for certain behaviors. According to Lumsden and Wilson (1983, p. 117), "the more successful epigenetic rules spread through the population ... along with the genes that encode them".

In the present context, it may suffice to point to epigenetic rules, a concept that promises to open the door to a fresh understanding of the interface of 'hardwired' genetic determination on the one hand and 'softwired' processes on the other hand. Although for the time being geneticists have not succeeded in identifying any particular gene that controls an individual epigenetic rule, the examples given in the literature (Wilson, 1998, pp. 172–201), as well as the concept itself, seem quite promising. With regard to social evolution, we may assume that natural selection provided the human species with a set of primary cultural institutions that, on the one hand put all human societies into a single participatory universe (Prigogine and Stengers, 1991, p. 268) and on the other hand established a firm natural basis for social evolution. To be clear, social evolution is a process with new, unprecedented characteristics, but, despite this fact, there is a feedback loop to natural selection underlying the entire process. At least this seems to be a legitimate inference from the fact of social regression: after the collapse of the Mayan empire, not only did its cultural infrastructure vanish – there was a concomitant decrease in population size.

4.3 Cultural Institutions in Social Evolution

Despite major differences, animal and human behavioral systems have very much in common, in particular their dependence on physical environments. As is well known, evolutionary theory proceeds from the assumption that natural selection imposes developmental constraints on any living system, favoring those traits that tend to enhance survival in a given environment. In this view, there is ongoing competition between individual members of the same species, as to which of their traits are going to stand the test of selection. As a result, the winners are likely to pass their traits to sizeable numbers of offspring, others leave less progeny, and still others have no offspring at all. According to mainstream evolutionary theory, any trait of a living species emerges as a product of cumulative selection, a process that may have taken hundreds of thousands or even millions of years. Due to these processes, 'ultimate causality' evolved, i.e., a set of causes that, in a particular environment and situation, sparked proximate causes, which in turn preceded and caused the organism's actual behaviors. As pointed out above, the universal system of human affectivity and emotions and the design of the human brain, as well as some universal cultural institutions, are part of ultimate causality. The major problem to be dealt with in this section is therefore that of why human societies, which started from more-or-less similar biological underpinnings, have evolved differently in the course of human evolution? What were the causes for the progression of some primeval hunter–gatherers to horticulture and other advanced socioeconomic stages, while other hunter–gatherers never crossed the dividing line to more advanced types of economy and society?

Before embarking on a discussion of these questions, I have to deal with the problem of what exactly should be regarded as the unit of social evolution. Is it the individual gene as in the natural process (Dawkins, 1978), or the human individual, the clan, the tribe, or what? In this regard, Sanderson (1995, p. 14) suggests a useful distinction, according to which "individuals are units of adaptation", but in social evolution it is "necessarily social groups, structures" that evolve. In another passage he points out that "social groups and societies cannot be adaptational units because they are only abstractions. Only concrete, flesh-and-blood individuals can be adaptational" (Sanderson, 1995, p. 10). In this view, natural selection provided human individuals with emotions, the capacity for language (Pinker, 1994), and various epigenetic rules, the joint operation of which established a set of primary cultural institutions. In other words, these features are the result of human adaptation, as well as the evolutionary basis of human social behavior. These primary institutions are, however, comparatively vague, and therefore they are not suited to prepare people for any particular type of society, nor do they determine a general preference for any particular type of physical environment. Quite the contrary, because human populations have succeeded in adjusting to the most varied ecological niches, the vagueness of underlying biological information must have been an advantage,because it allowed for adaptation to different environments without at the same time jeopardizing the evolutionary underpinnings of social behavior.

Viewed against this background, adaptation to any particular environment presupposes secondary cultural institutions that, according to Durham (1990, p. 200), make use of social transmission rather than genetic transmission and are based on capacities for storing and processing learning inputs in the human mind. It is important to note that, whatever precise meaning may be assigned to the term 'culture', its evolutionary basis is the human mind; in other words, culture would not exist without flesh-and-blood individuals. So, with respect to social evolution we may ask why some societies developed secondary or tertiary cultural institutions that enabled them to progress, whereas other societies remained more or less unchanged in the initial stage? Is progression started by some particular feature in the environment or by certain 'structural' characteristics of human groups? From an epistemological point of view, it is clear that any kind of answer to these sweeping questions presupposes a theoretical framework.

Although of course scientific statements don't make sense unless their frame of reference is clear, for didactic reasons this chapter first describes the data. In the present context, this type seems justifiable for two main reasons, namely (1) because I dealt with evolutionary theory in some detail in the above sections and (2) because an overemphasis on theoretical considerations is out of the place in an introduction to the field. With regard to the theory of evolution by natural selection it is, therefore, enough to say that it includes, in addition to a theory of descent, an emphasis on the scarcity of vital resources, as well as of concomitant intra- and inter-species competition. Keeping this in mind, in the following sections we turn to an analysis of various cultural institutions.

Concerning the role of physical environments in social evolution, there is nearly unanimous agreement among specialists in the field that due consideration of environmental conditions is a prerequisite to any theory of social evolution. A well-known example is White's reference (1975, p. 46) to the role of energy extraction in social evolution. Similarly, Adams (1975, p. 55) points to the importance of energy sources in the evolution of higher levels of social power, as well as in social evolution in general. Even ancient philosophers pointed to the environment's impact on the evolution of society, for example, Aristotle said that some types of country are more suitable for horse breeding and, therefore, for the evolution of a class of aristocratic horsemen and their peculiar social and political ways. The idea that some physical environments may be more conducive to the evolution of social complexity has been elaborated by numerous social scientists and is in fact one of the major topics of the theory of social evolution. There are, however, different ways in which environments may influence the evolution of social patterns. One is the availability of vital resources such as food and water in any given environment; another is the suitability of a particular region for travel and transportation, as highlighted by Spencer.

Human populations have settled in the most varied regions of the planet, some fertile, with an abundance of food and water supplies, others barren, lacking plants and game that were suited for foods. For example, the northwestern coastal regions of the USA provided an abundance of game and plants, as well as recurring salmon runs; therefore, the local Amerindian tribes were, on the whole, able to subsist without experiencing food scarcities. As portrayed by Bohannan (1963, p. 254), the Kwakiutl, one of the indigenous peoples, lived in a country where "there were forests of giant cedar and fir; animal life abounded. The sea teemed with fish, mammals, porpoises, and shellfish. Probably no other part of the world offered such riches for so little work". Not very surprisingly, "the Kwakiutl standard of living was among the highest the world has known" (Bohannan, 1963, p. 254). In contrast, the Kalahari Desert provides local !Kung San tribes with few resources:

> Drought makes many resources inaccessible for much of the year, and there are fluctuations in the seasonal and yearly productivity of wild vegetable foods (Wiessner, 1982, p. 64).

According to Wiessner (1982, p. 62), the !Kung San people developed a social system for reducing risk, mainly the omnipresent risk of starvation, the mainstay of which is a special pattern of reciprocity. Although it is difficult if not impossible to compare the social systems of the !Kung San people, who are hunter–gatherers, with that of the Kwakiutl, whose technology, according to Bohannan, was comparatively highly developed, these examples may give prominence to environmental effects on the evolution of social patterns.

Regarding the availability of natural resources, Bohannan points to yet another important aspect when he stresses that resources "do not exist except insofar as they can be exploited by the technology of the people who control the territory in which the raw materials exist" (Bohannan, 1963, p. 212). For instance, diamonds were of no interest to the indigenous people of the Kalahari, but European immigrants brought an interest in these materials with them, as well as a technology for digging them from the earth. Similarly, the Bedouin of the Arab peninsula neither took an interest in oil nor could they employ a technology to drill it from the soil, but when the British Navy began to use oil instead of coal as fuel for its vessels, a rush for these resources began. We may infer from this that the mere existence of resources in any particular environment is not a sufficient condition for starting social evolution; rather, there must be a suitable technology available, as well as a decision to employ it. According to Spencer (1972, p. 127), the suitability of some environments for transportation of goods is another aspect worth mentioning. Some regions or waterways are better suited to these purposes than others and therefore tend to attract populations who specialize in these tasks. I should note, however, that this suitability for transportation is not a quality of the regions themselves; rather, it depends on the relative development of local populations. For instance, hunter–gatherer bands are not likely to take advantage of the potential benefits of these locations because they lack the technologies and even the need for these benefits. This brings me to a closer look at human populations, namely the causes of population growth as they relate to social evolution.

According to Maryanski, ancestral human populations lived in small bands of fewer than 100 individuals (Maryanski, 1994, p. 381; Lenski, 1966, p. 100). Regarding the institutional structure of bands, Maryanski and Turner stress "a very low degree of differentiation among economy, religion, and kinship" (Maryanski and Turner, 1992, p. 79). Although there is ongoing discussion among specialists in the field for a definition of the term 'band', there is considerable agreement that "a band is a network of kinsmen (blood) and affines (marriage) who live and work well together" (Maryanski and Turner, 1992, p. 82). In the present context it suffices to note that hunter–gatherer bands come close to being a fully egalitarian system (Maryanski and Turner, 1992, p. 85), that there is a clear distinction of male and female roles, and, most important for the present purposes, that stable numbers are maintained through abortion, infanticide, and birth spacing (Maryanski and Turner, 1992, p. 86). With respect to the differentiation of cultural institutions such as stratification and political authority, Maryanski and Turner point to prestige differences between male and female roles, differences that serve as bases for the evolution of full-blown cultural institutions in more recent types of social organization. Although prestige differences between the genders may partly derive from the males' prestigious deeds in warfare, bravery in war was not to become the basis for a full-blown institution prior to the advent of chiefdoms and politically organized societies – when warrior societies were established, in many societies their members appropriated honor and prestige nearly exclusively for themselves. Unlike in these more advanced types of society, egalitarianism seemed to be the single most important imperative in hunter–gatherer societies, and reciprocity was the major foundation of this system.

In Gouldner's (1960) formulation, "the norm of reciprocity holds that people should help those who help them and, therefore, those whom you have helped have an obligation to help you". As pointed out by Trivers (1971), reciprocity is, however, not a peculiarity of the human species; rather, it was a concomitant of social life even before the human species entered the scene. Thus, reciprocity may well be an example of a primary institution upon which human societies tend to impose secondary cultural institutions. From an evolutionary point of view, one may therefore assume that the primary institution evolved because it provided survival benefits to members of animal species as well as to human populations. However, these benefits can be expected only if free riders and various kinds of defectors are likely to be detected and punished.

"To play the reciprocity game, they need to recognize each other, remember who repaid a favor and who did not, and bear the debt or the grudge accordingly" (Ridley, 1996, p. 69). Similarly, Alexander (1986, p. 107) pointed to the need for mutual recognition as a precondition for the operation of 'indirect reciprocity', which occurs whenever rewards come from individuals other than those directly involved. Recently, Boyd and Richerson (1992) made it clear that, although reciprocity is definitely a primary institution, it is a dependable guarantee only in small-scale social patterns, particularly in dyadic relations, but it fails to operate in larger groups unless punishment is introduced. In larger social settings, in the absence of absent ubiquitous social control, it is easier for defectors to make use of their 'Machiavellian intelligence' (Gigerenzery 1997), trying to gain benefits without returning investments to those group members who were the original investors. According to Boyd and Richerson (1992), group members must therefore expect punishment upon detection, even if there is a long period of time between the treacherous act and detection. As Corning (1998) stresses, "reciprocity is likely to be more beneficial than kin selection, provided that cheaters can be detected and excluded from the system". More important for the present argument, however, is reciprocity's impact on the evolution of various cultural institutions, namely of feuding and warfare, as well as of moral systems.

Many authors agree that feuding is in many respects a precursor to full-blown warfare. In a discussion of feuding's evolutionary underpinnings, Daly and Wilson point to H. Kelsen's statement, according to which "lethal retribution is an ancient and cross-culturally universal recourse of those subjected to abuse" (Daly and Wilson, 1988, p. 226). Kinsmen of a slain individual are likely to impose blood revenge upon the killer's kinship group and, since there is no natural limit to the circle of killing, feuding more often than not turns into a virtually incessant violent relation between these groups. Although there is ongoing discussion as to the universality of feuding, Daly and Wilson's conclusion (1988, p. 227) seems convincing: "the inclination to blood revenge is experienced by people in all cultures". Returning to reciprocity's impact on the development of other institutions, it is interesting to note that both institutions, i.e., blood revenge and feuding, are established upon reciprocity's basic premise, according to which you have to help those who have helped you. In general, people tend to assume that it is their kinsmen – their parents, siblings, and other close relatives – to whom they are most obliged, and this is probably why revenge and feuding are by necessity offshoots of reciprocity. I point out below that the origins of the institution of warfare are intimately related to blood revenge and feuding. Since influential authors have attributed to warfare a major impact on the course of social evolution, this point deserves closer analysis as well.

With respect to the evolution of morality as an institution, Daly and Wilson (1988, p. 254) point to the universality of notions of right and wrong, which, in a social context, are indispensable for attributing beneficial or detrimental deeds to individual actors. Because individuals in ancestral environments were constantly exposed to threats by predators or inimical groups, they relied on the observance of rules of right and wrong in addition to those of reciprocity, and tended to punish violations at once. In this respect we should note Boyd and Richerson's remark (1992, p. 185) that, once people realized that groups often persist much longer than individuals, observance of these rules must have been further endorsed. Based on the recognition that groups persist beyond individual lifetimes, blood revenge and feuding may have evolved as fully developed cultural institutions, guaranteeing revenge for kinsmen even beyond death and thereby contributing to the intergenerational stability of the group's moral basis. However that may be, numerous authors agree that blood revenge is a universal and ancient institution (Mühlmann, 1962, p. 220; van der Dennen, 1995, p. 317). In the present context it is particularly interesting to note that these institutions remind people of the comparative longevity of social groups and hence cause them to bear in mind their moral obligations even beyond a kinsman's violent death. Belated blood revenge may well lead to an increase in ambivalent feelings, as Boehm points out (1989, p. 928), but the ambivalence is still an indication of the persistence of the obligation to moral retribution even beyond a considerable length of time. In view of this, it seems convincing that even though "sympathy, prescriptive social rules, reciprocity, and peacemaking" (Arnhart, 1996, p. 143) are practiced by some animal species too, the observance of obligations towards deceased group members may well be a peculiarly human institution. In summary, we may suggest that morality as a cultural institution was based on a set of primary institutions, some of which humans share with other animals. In the human context, the institution serves to control reciprocal interactions (Badcock, 1991, p. 116), reminding people of their obligations towards their kinsmen, those alive as well as those deceased. Although it may be interesting to note the evolutionary underpinnings of these cultural institutions, the problem arises as to what role these institutions may have played in social evolution.

In a concise formulation of the causes underlying social evolution, Carneiro (1987, p. 111) suggests that, as a general rule, simplicity precedes complexity, and he goes on to say "the complexity that exists today does so because it conferred survival on those organisms which developed it" (Carneiro, 1987, p. 113). As an example, he points to the competition between the Kayapó and the Yanomamö, both tribal Amerindian societies in South America: "When pitted against each other... the simpler society almost invariably succumbs to the more complex one" (Carneiro, 1987, p. 113), which in this case is the Yanomamö society. According to Carneiro, numerical superiority was a major advantage to Kayapó society, which in turn was based on its capacity for integrating comparatively large numbers of people into its social structure. However, the capacity for quantitative growth as such was not the real cause of the more complex society's superiority over simpler social structures; rather, quantity was a mere precondition for the evolution of social complexity. According to Carneiro, village size is a distinct advantage in the violent competition between these people and, because Yanomamö villages, due to their structural simplicity, do not manage to grow beyond certain limits, they regularly succumb to the Kayapó. Therefore, although there can be no doubt as to the importance of quantitative parameters in competition between societies, it is nevertheless important to pay attention to Sanderson's warning (1995, p. 99) that "qualitative transformation, the development of something new rather than simply something greater" is social evolution's decisive feature. Therefore, the question arises as to which factors caused the transformation from simple types of social structure to more complex ones in the first place. More specifically, we must address the problem as to which causes sparked the transition of some hunter–gatherer people to complexity, whereas simplicity prevailed in other hunter–gatherer societies. Is social structure in fact the single most important cause of social evolution, as Carneiro seems to suggest?

Recently, J. Diamond made a major contribution to a new understanding of the main causes underlying these processes. Unlike most specialists in the field, he proceeds from the assumption that physical environments are not more-or-less alike, providing similar starting conditions for the transition from hunter–gatherer types of society to horticultural and agrarian types of society. According to him, some environments provided wild plants and animals that lent themselves more easily to gathering and hunting or even to domestication than others did; therefore, people in these environments enjoyed various advantages over people in other regions, as the Kwakiutl example suggests. Regarding the transition from the hunter–gatherer stage to horticulture, it seems that the Fertile Crescent in the Near East offered the most advantageous conditions for the transition from simple to more complex types of society. As pointed out by Diamond (1998, p. 142), "as late as 9000 BC people still had no crops and domestic animals ... but by 6000 BC some societies were almost completely dependent on crops and domestic animals". So, within a comparatively short period of time the majority of local hunter–gatherer bands must have passed the threshold between social simplicity and complexity. During these events, tribal organization began to emerge in the Fertile Crescent: "A tribe ... differs in that it consists of more than one formally recognized kinship group, termed clans, which exchange marriage partners" (Diamond, 1998, p. 271). Regarding competition between societies, the tribes' more elaborate social structure provided advantages over simpler band organization, as may be recalled from the Yanomamö–Kayapó example. Typically, the more advanced groups had food production at their disposal and could therefore out-compete bands by their sheer numbers. According to Mühlmann (1962, p. 220), these advantages caused the displacement of bands into some of the planet's most remote deserts and jungles, where some of them prevail to this very day.

Turning to a closer look at some of the causes underlying this transition, Diamond (1998, p. 126) points to the domestication of wild plants in the Fertile Crescent, such as emmer wheat, einkorn wheat, barley, peas, lentils, and chickpeas – cereals and pulses that still belong to the modern world's 12 leading crops (Diamond, 1998, p. 125). Food production provided enormous advantages because,

> by selecting and growing those few species of plants and animals that we can eat, so that they constitute 90 percent rather than 0.1 percent of the biomass on an acre of land, we obtain far more edible calories per acre. As a result, one acre can feed many more herders and farmers – typically, 10 to 100 times more – than hunter–gatherers (Diamond, 1998, p. 88).

Regarding the transition from the hunter–gatherer economy to food production, Diamond suggests that hunter–gatherers acquired food production as an unintended consequence of their long-standing familiarity with domestic plants' wild ancestors. From an evolutionary point of view, it seems utterly unlikely that people pursued any rational planning of social consequences when turning to tillage; rather, some small groups may have realized the advantages of cultivation of certain areas, but other groups did not. Needless to say, cultivating fertile soil is likely to provide better harvests than barren areas do, and the availability of water is an additional precondition of successful farming. However, once people realized the benefits to be expected from cultivating fertile areas, fierce competition was sparked between adjacent populations over control of these areas, conferring evolutionary advantages on those social groups who had superior fighting techniques at their disposal.

Phillips (1987, p. 235) describes similar processes in Mesoamerica, when, after experimenting with maize, genetic changes in that cereal were achieved, which vastly increased harvests.

> Starting with what may have been (initially) accidental deviation in the system, a positive feedback network was established which eventually made maize cultivation the most profitable single activity in Mesoamerica (Flannery, 1968, p. 80).

In the ensuing competition over fertile areas, Toltecs and Aztecs, both comparatively backward tribes, succeeded in dominating populations in the fertile areas and in establishing empires. I should stress that, before the advent of horticulture there was no shortage of land, because hunter–gatherer groups were comparatively small; hence, there was no need for competing over the control of land. In summary, I should stress that the social consequences of domestication could be predicted neither in the Fertile Crescent nor in Mesoamerica. As a consequence of the spread of domestication, population growth accelerated beyond limits previously known, and cultural institutions such as writing and, most importantly, political organizations came into existence. Furthermore, due to the scarcity of land suitable for tillage, as well as of water resources, competition between societies was elevated to a new and unprecedented level, and full-blown warfare evolved. I should emphasize that these new characteristics evolved as 'regularities' (Sanderson, 1995) in the most diverse societies. Let us take a closer look at these developments.

In a synopsis of relevant theories, Sanderson suggests that population-pressure theory is probably the most popular theory regarding the transition from hunter–gatherer to horticulture societies. According to M. Cohen, tillage requires more time and energy than hunting and gathering, therefore people would not have adopted the new technology unless increasing numbers (Sanderson, 1995, p. 37) of group members forced the shift upon them because the new technology provided 10 to 100 times more calories per unit of land than foraging did. Sanderson considers Cohen's population-pressure theory "the very best of all current theories of agricultural origins" (Sanderson, 1995, p. 42) and infers that population growth is "an inherent tendency of human population(s)" (Sanderson, 1995, p. 40), which can be accounted for by people's wish to maximize 'inclusive fitness', as suggested by sociobiology. According to Sanderson, population growth theory may be combined with the 'overkill hypothesis', according to which hunters exterminated large-animal species in Australia, New Guinea, and North America: "Most large wild mammal species that might otherwise have later been domesticated by Native Americans were thereby removed" (Diamond, 1998, p. 47), putting a strain on local food supplies. The situation was further intensified by the fact that only a few animal species were suitable for domestication, and most of the 'major five' originated from Eurasia. In particular, these are sheep, goats, cows, pigs, and horses (Diamond, 1998, p. 160). The so-called 'minor nine' (Diamond), including camels, llamas and alpacas, donkeys, etc., were of major importance in some areas but, on the whole, raising cattle or breeding horses was likely to provide more benefits in terms of calories, because the animals' manure could be used to increase soil fertility. In addition to these impacts on food production, horse breeding became the basis for the evolution of novel types of social life, namely of nomadic herders in the steppes and deserts of Africa and Asia, as well as the mounted bison hunters of North America. These were in fact some of the major causes of the evolution of social complexity, as is pointed out below.

There can be no doubt about food production's impact on the course of social evolution; in fact, it was the major source of surplus production, in terms of calories that freed a sizeable numbers of individuals for specialized work, such as scribes, bureaucrats, and warriors, who, due to increased overall productivity, did not themselves have to engage in hunting, gathering, or tillage. Due to the increase of productivity in horticultural societies, people could specialize in these activities, and, because the division of labor regularly brings higher yields in its wake (Ridley, 1996, p. 42), more caloric intake per capita was possible. According to Sanderson, we should be aware of the "allegedly adaptive benefits of social complexity" (Sanderson, 1995, p. 131; Tainter, 1988). Unlike functionalists, who proceed from the assumption that social evolution is a process producing increasingly well-adapted societies, Sanderson (1995, p. 131) points to the costs of complexity as well:

> Growing complexity may be a good thing for elites, in whose interests it is generally carried out in the first place. But it is of dubious worth, or actually maladaptive, for the bulk of the population who must pay the costs of complexity.

For example, the "Maya's commitment to greater and greater complexity turned out to be inherently self-defeating" (Sanderson, 1995, p. 131). In fact, there are numerous examples of societies that collapsed due to various concomitants of social complexity, such as "resource depletion, ... natural catastrophes, competition with other societies", to name but a few (Sanderson, 1995, p. 27). In summary, although increases in social complexity definitely provide benefits to parts of the group, it is not entirely clear if complexity increases the overall adaptation of any given society.

Turning to some institutions that typically arise in the transition from hunting and gathering to food production, farming and cattle breeding are examples of specialized work that did not exist prior to the advent of these types of economic activities. Both farming and cattle breeding led to the evolution of distinct social rules, encompassing customs, mores, rituals, and religious beliefs that were in some way related to these peculiar economic activities. For instance, since water supplies or recurrent rainfall was a precondition for harvesting, farmers in many parts of the world developed amazingly similar religious beliefs. For instance, the

Aztecs believed that Tlaloc, the god who directed rain, demanded recurring human sacrifices (Hagen, 1974, p. 101). Similar notions can be found in other parts of the world as well, where irregular rainfall poses problems of the same kind to local people and, in general, one may hypothesize that religions are in fact part of peoples' survival strategies (Reynolds and Tanner, 1983, p. 106).

Other institutions that typically arise along with food production, and the ensuing availability of surplus, are bureaucracies specializing in collecting and distributing parts of the surplus and military organizations designed to maintain control over the production of surplus (Maryanski and Turner, 1992, p. 107; Lenski, 1966; Sanderson, 1993, p. 737) and to defend it against invaders. Turning to the evolution of bureaucracies, it is interesting to note that the functions of land surveying, the imposition of taxes, and other types of bureaucratic work presupposed the existence of systems of writing and of numeral systems that were, however, not readily available in hunting and gathering societies. Recent findings indicate that the evolution of semiotic systems was in fact dependent on the previous establishment of food production. According to Meermann, the first system of writing to evolve in the Fertile Crescent was unfit for distinguishing quantities of certain goods, for instance of sheep vs. cereals, from the objects themselves. So, this original system did not in fact employ numbers in the full sense of the word, rather it designated the objects themselves (Meermann, 1991, p. 3), and considerable time elapsed before more abstract systems of numbers and characters evolved. It is noteworthy that these semiotic systems, as well as the social functions of the scribe or the accountant are in fact secondary cultural institutions that presuppose human language. From an evolutionary point of view, it seems likely that these secondary institutions evolved as unintended consequences of food production. Once full-blown semiotic systems were available, however, they easily lent themselves to uses in religious matters, to the evolution of literature of various kinds, and to the establishment of central political control.

It seems that religion, or a belief in supernatural powers, is a cultural universal too. Quoting Radcliffe-Brown, Lenski (1966, p. 105) notes that in most simple societies, "honor and respect are accorded to three kinds of people: (1) older people, (2) people endowed with supernatural powers, and (3) [people having] valued personal qualities, notably skill in hunting and warfare". In another passage, Lenski (1966, p. 128) points out: "In many simple horticultural societies, magical skills or religious powers are the most valuable resource of all" and therefore "actual power was often in the hands of the shaman." Typically, the shaman's privileged position in society was, however, contingent upon successful performance. According to Wallace's classification,

> bands and tribal organizations have religions of an 'individualistic' or 'shamanistic' nature, chiefdoms and kingdoms have what he refers to as 'Olympian' religions, religions that come from some larger, more distant, more encompassing wellspring (Adams, 1975, p. 237).

It suffices to say that, due to the evolution of tribal and, later, even more encompassing social structures, local cults were subdued and became dominated by the gods of victorious elites. As Adams (1975, p. 263) puts it, "religion lies at the bottom of political centralization", that is to say, religion played a major role in the evolution of new social structures, particularly in providing legitimacy for new political authorities. In this regard, religion had to undergo changes, because traditional clan and tribal mythologies had to be compatible with prevailing social structures. Therefore, it was unavoidable that cultural selection provided for mutually compatible social structures and belief systems.

I should emphasize once more that the major cause underlying the evolution of societies was the transition to food production. A commonly used name for this transition is the Neolithic Revolution, during which populations grew and people turned to more-sedentary lives. In the present context it is particularly interesting to look at changing patterns of legitimacy. As indicated above, bands and tribes were strongly egalitarian societies, and leadership was mostly temporary, contingent upon the leader's personal achievements, and legitimized by the kinship system. I should stress that, despite various types of relations between the tribe's parts or segments, "there is no overarching political structure uniting the villages into a single functioning whole" (Sanderson, 1995, p. 54). However, with the evolution of the chiefdom, a new political system enters the scene, in which power and control were concentrated in the hands of a chief (Sanderson, 1995, p. 94). Unlike in bands and tribes, permanent control by a paramount chief (Carneiro, 1981, p. 45; Sanderson, 1995, p. 54) is being established. In fact, this marks a major step in the evolution of political systems, particularly with regard to patterns of legitimacy. Whereas there was no need for legitimizing temporary leadership in hunter–gatherer bands or simple tribal societies, the permanent concentration of power in the chief's hands required extensive support by religious authorities.

For instance, the political unification of Egypt was "probably based upon political units which antedated the unification of the Two Lands (Upper and Lower Egypt), but the authority exercised locally by priests, chieftains, or priest–kings" (McNeill, 1970, p. 71) must have been comparatively undeveloped, compared with the situation in Sumer where local rulers were much stronger. However that may be, according to McNeill (1970, p. 72), there is a striking similarity between Sumer and Egypt in that there was a "division of society ... between a peasant mass and the household of a god". The Egyptian king, "being a god, was believed to enjoy immortality" (McNeill, 1970, p. 78) and with regard to legitimacy of rule, this quality may already have been more or less sufficient for impressing the people. There were, however, other developments in Egyptian religion as well, which additionally buttressed the legitimacy of rule, namely the Pharaoh's identification with two gods with distinct local backgrounds:

> Horus and Osiris may originally have stemmed from different parts of Egypt. Certainly their characteristics suggest that the one harked back to a nomadic and comparatively warlike past, while the other embodied a distinctly agricultural concern with the seasons and the renewal of vegetable life (McNeill, 1970, p. 78).

With regard to changing patterns of legitimacy in the shift from one type of society to another, it is interesting to note that in Egyptian religion, the cultural background of the various gods was obvious throughout the dynastic era. Given the structural similarity of social processes in the Neolithic Revolution, it seems justifiable to assume that religion, as well as other patterns of legitimacy, evolved more or less along similar lines in other regions as well.

As mentioned above, the chiefdom was the first type of society with permanent control by a paramount chief (Carneiro, 1981, p. 45). In their discussion of economic and other causes underlying the evolution of chiefdoms, Maryanski and Turner (1992, p. 114) point to the impact of periodic resource scarcity, which in turn tends to intensify competition between adjacent societies for resources. According to these authors, this situation leads to the evolution of a new institution, i.e., the 'big man', "who can coordinate economic activities, promote defense, negotiate peace or wage war" (Maryanski and Turner, 1992, p. 114). An important precondition for evolution of the 'big man' system is the production of economic surpluses that can be extracted by the leader. The availability of surplus was even more important for the evolution of full-blown chiefdoms because, according to Maryanski and Turner (1992, p. 114),

> chiefdoms generally (1) organize larger territories, (2) create clear lines of authority and hierarchy among the paramount chief(s) ... (3) undertake large economic tasks (capital improvements, exchange and trade, the coordination of labor, and the storage of surplus), (4) mediate internal disputes more closely, and (5) coordinate larger military operations.

Obviously, the evolution of chiefdoms is another regularity in social evolution and, as pointed out by Flannery (1972, p. 403), it is intimately related to changes in religion:

> Often, chiefdoms have not only elaborate ritual but even full-time religious specialists; indeed, the chief himself may be a priest as well. Further, the office of 'chief' exists apart from the man who occupies it, and on his death the office must be filled by one of equally noble descent.

In summary, one may suggest that, whereas there is a remarkable degree of similarity among economic and technological causes that sparked social evolution, "they do not necessarily call forth similar social organizations or similar ideologies" (Corning, 1983, p. 224). Developments in economy or religion may lead to similar results but "may call forth alternatively an Athens or a Sparta" (Corning, 1983, p. 224); therefore, there must be additional factors that cause differences in this regard. Cultural traditions seem to be the main factor; these traditions have been selectively favored by their environments, mainly the dominant features of the physical and sociopolitical environments, and have had a decisive influence upon social evolution. With regard to the role of chiefdoms in social evolution, Sanderson's suggestion (1995, p. 55) makes sense, according to which they are "a form of sociopolitical organization intermediate between tribes and states, and an organizational form that is an essential precursor of the state".

Sanderson (1995, p. 56) further suggested that

> the distinction between chiefdoms and states should be made on qualitative rather than quantitative grounds. I would define a state as a form of sociopolitical organization that has achieved a monopoly over the means of violence within a specified territory.

Sanderson's emphasis on a monopoly over the means of violence is reminiscent of Max Weber's famous definition of authority, which gives the state's 'legitimate' control over the means of violence special importance too. Although there can be no doubt about the usefulness of paying attention to state control over the means of physical violence, it seems to be an erroneous assumption that violence was not a behavioral option in prestate societies. In his discussion of Carneiro's and Giddens' views on this point, Sanderson (1995, p. 56) stressed that, although he does not deny the role of violence in prestate societies, the monopoly on force does not have to be complete or total, but it should nevertheless be sufficient to crush rebellions against state power (Sanderson, 1995, p. 57). Such details may seem unnecessary in a chapter on social evolution, but it becomes clear below that they are in fact unavoidable in assessing the impact of various types of violence on social evolution.

In general, an acceleration in the specialization of institutions occurs concomitant with the rise of states. For instance, experts in land surveying are needed to lay the foundations for imposing the rule of law over a given territory; in addition, scribes and juridical specialists are needed to gain control over food production and tax collecting. With regard to the long-term stability of the state and its institutions, specialists in the use of physical violence must be permanently available and are therefore organized into police forces and armies. On the one hand, recruitment and training of these experts required considerable resources; on the other hand, even more surplus was needed to guarantee the permanent loyalty of these people to political authority. So, with regard to the structure of society, these developments brought a dramatic increase in social inequality in their wake. The underlying major causes of these developments were better harvests, a concomitant increase in surpluses, and the gradual separation of political authority from kinship. As compared to hunter–gatherer societies, food-producing societies enjoyed 10 to 100 times more calories per acre, an obvious advantage in evolutionary perspective; however, this advantage had to be compensated for by growing needs of labor, as well as by an increase in competition for fertile areas. In consequence, higher reproduction rates of farming people were selectively favored, and competition over fertile soil and water supplies led to a rise in the magnitude of warfare. Regarding the progression from chiefdom to state, Lenski (1966) pointed to the impact of technological innovations, mainly the invention and spread of the plow which increased the farmer's productivity dramatically, an assessment that still seems to be valid. Despite long-term problems caused by population growth, larger populations enjoy various advantages over smaller populations, mainly in warfare – not however because of sheer size, rather because social structure can be much more elaborate in larger populations (Carneiro, 1987, p. 115). These are some of the major causes underlying the evolution of states in the Fertile Crescent, as well as in other regions of the world.

Turning to changing patterns of legitimacy, Sanderson (1995, p. 57) stresses that "the specialized institutions of the state are at least partially independent of the kinship system, whereas the political institutions of the chiefdom are still strongly rooted in kinship connections". Similarly, Diamond (1998, p. 280) suggests "that states are organized on political and territorial lines, not on the kinship lines that defined bands, tribes and simple chiefdoms". According to Breuer (1989, p. 28), the king is now typically regarded as a god who, unlike in tribal times, now not only represents the community vis-à-vis the gods, but is a god himself. It is clear that the king's divine nature served as a firm buttress of the legitimacy of his rule and its supporting institutions. For instance, since the Egyptian pharaoh was considered a god, he "was taboo, and it was he who guaranteed and maintained the cosmic order as well as its counterpart, law and order on earth" (Sanderson, 1995, p. 60). Due to his divine nature, the pharaoh could pass on these bases of legitimacy to his children or to other members of his family. No wonder that these foundations served as a warrant for the stability of the dynastic system across many generations. Moreover, the stability of rule gave rise to a number of specialized institutions that had not existed previously.

In view of the pharaoh's godlike nature, there must have been a strong need for reverence among the people, which led to the construction of temples, palaces, and huge pyramids or magnificently decorated tombs for the pharaoh and for members of his family. Moreover, the institution of permanent rule brought about the establishment of a privileged stratum of officers, bureaucrats, and military officers who were in charge of palace guards and the empire's borders. From a sociological point of view, it would be expected that these specialized institutions led to the evolution of aristocratic elites who enjoyed many privileges as compared to ordinary people. In fact, the ruins of Ancient Egypt have many illustrations of a highly stratified society, the tombs of the nobles being second in pomp only to the pharaoh's own funeral site, whereas there are hardly any traces of ordinary people's remains.

However, the world's first states arose in the Fertile Crescent, more specifically in Mesopotamia. According to Sanderson (1995, p. 59), the "first Mesopotamian state was centered around the city of Uruk". Unlike in Egypt, where the unification of the Two Lands was attained in a comparatively early stage of development, the Mesopotamian, or rather, the Sumerian state consisted of some 13 politically autonomous city-states (ibid., p. 59). With respect to a general pattern of social evolution, it is noteworthy that the world's first full-blown system of law originated with Sargon of Akkad, one of the most important kings in the later period. According to Hoebel, "law is present when some kind of 'court' operates and when 'legitimate use of physical coercion' is present" (Hoebel, 1954, p. 470 after Boehm, 1986, p. 196). Although systems of law existed in tribal societies as well, they were in general comparatively simple and unsuited for the needs of highly differentiated societies, which required much more elaborate systems of law. Therefore, the evolution of full-blown systems of law may be regarded as another example of a cultural institution that prevailed from times immemorial but, due to increases in social differentiation, had to acquire new characteristics, such as systematic training of juridical experts, the establishment of authorities with clear-cut competencies, maintenance of written files and all the other characteristics of bureaucratic processes which Max Weber portrayed in detail.

As already pointed out, reciprocity is one of the major foundations of systems of morality and law. More specifically, the function of law can be defined as a system of rules that "spell out the behaviors that are serious enough to cause harm that may be regarded as 'societal'. The intent of the law is to deter such behaviors or to prevent their recurrence when they do happen" (Barner-Barry, 1986, p. 144). Typically, tribal societies define some rather broad protected interests, mainly those concerning preservation of life, the right of taking revenge for a kinsman's slaying, and preemptive ostracism of individuals who tend to endanger social order. Although protection of these interests may have sufficed to maintain social order in strictly egalitarian societies, additional principles of law were needed after the evolution of food production, which led to a considerable degree of social inequality. In addition to protecting the integrity of members' lives, economically more advanced societies had to keep individual's property rights safe. Moreover, the evolution of aristocratic elites brought a vast array of prerogatives in social life in its wake, which had to be guarded by law. In general, oral traditions of law, which prevailed in tribal societies, proved insufficient to provide for the juridical necessities of stratified societies, so the evolution of written systems of law must have been favored in social evolution. The first systems of writing evolved in Mesopotamia and lent themselves to use in juridical matters, as well as in other domains of life. To summarize, from an evolutionary point of view it seems utterly unlikely that the emergence of the world's first systematic text on law, i.e., Sargon of Akkad's famous monument, was merely fortuitous; rather, this juridical text evolved as a concomitant to growing social complexity.

At a certain point of social evolution, when innovations in technology had sparked food production, which in turn led to population growth and progressive social differentiation, the evolution of the state was an unavoidable necessity. According to Diamond (1998, p. 286), the major problem to be dealt with by the state is "conflict between unrelated strangers. That problem grows astronomically as the number of people making up society increases". Diamond goes on to point out that lethal conflicts in band and tribal societies usually lead to unending cycles of feuding; therefore,

> a large society that continues to leave conflict resolution to all of its members is guaranteed to blow up. That factor alone would explain why societies of thousands could exist only if they develop(ed) centralized authority to monopolize force and resolve conflicts (Diamond, 1998, p. 286).

Another important factor, furthering the evolution of the state, was the need for a redistributive economy (Diamond, 1998, p. 287), i.e., a market mechanism or some type of authority to make decisions about the distribution of surplus production. Since the majority of new institutions, such as scribes, bureaucrats in general, law experts, priests, and last but not least members of the political and military elites, are usually exempt from producing food, allocation processes within the state presuppose the existence of such a center. From an evolutionary point of view, it seems obvious then, that the state and its specialized institutions conferred survival value upon populations that had this type of organization at their disposal. Although it may be undeniable that the state was beneficial in functional terms, the question arises as to who was the main beneficiary of this development. In general, "very few of the spoils accrue to the mass of the population" (Sanderson, 1995, p. 85); most often, the experts in violence, as well as other members of the elite, gain most from the evolution of a state (Andreski, 1968; Meyer, 1977).

The state, as the political organization of horticultural and particularly of agrarian societies, prevailed in many parts of the world since its establishment in antiquity. Superficially, it seems that the evolution of societies and their political organization pursued a course of ever-increasing social complexity, because this was the best way to gain selective benefits. The well-known facts of evolutionary regression, i.e., devolution, are however a most welcome reminder of the poverty of this notion. History holds many examples of empires that have collapsed, not only because they succumbed to foreign invaders, but also because they had been growing to the point of exhaustion. The collapse of the Mayan Empire offers a telling illustration of some of the causes of exhaustion:

> At its peak Mayan civilization was an extremely densely populated preindustrial society... The Maya had been investing for hundreds of years in sociopolitical complexity, and the costs of this investment had to be borne entirely by the peasant agricultural population. With the buildup of severe population pressure over time, the bulk of the population had great difficulty meeting their own daily needs, let alone providing for the support of a large administrative superstructure (Sanderson, 1995, p. 131).

According to Sanderson, growing differentiation and complexity, therefore, are no guarantees of enhanced adaptation, because the costs of complexity may exceed the benefits to be gained from it. Similar to the Mayan Empire, the causes of the breakdown of the Roman Empire were mainly the decline of population and "the increased military and administrative costs (that) had to be borne by fewer individuals" (Sanderson, 1995, p. 129). So, their defeat by Teutonic invaders was not so much the result of the invaders' military superiority, rather it was caused by the exhaustion of resources in the Roman Empire, which led to the weakening of its military defenses.

After the fall of the Roman Empire, societies in western Europe resorted to tribal kingdoms for a considerable period of time, before states could be reestablished. Despite the existence of the medieval state, the general level of civilization was inferior in most western European societies to that of Roman times. Throughout this era, agriculture was the mainstay of most societies in western Europe, and the peasantry was the main basis for the production of surplus. These societies were at the same time highly stratified, the feudal aristocracy being able to extract a sizeable part of the surplus. As pointed out by Wallerstein (1974, p. 18),

> when we speak of western European feudalism, (it) is a series of tiny economic nodules whose population and productivity were slowly increasing, and in which the legal mechanisms ensured that the bulk of the surplus went to the landlords who had noble status and control of the juridical machinery.

In general, feudalism is a system of private land ownership; "however, such land ownership is not unconditional or absolute, acquired once and for all and without strings. Rather, land is acquired in the form of a fief. A fief is a grant of land given by a superior lord to a lesser lord in return for the performance of certain obligations, especially military service and personal protection" (Sanderson, 1999, p. 235). Therefore, the nature of the state was quite different than in the Roman era; in fact, the state was, according to Wallerstein (1974, p. 31), personified by

> the prince whose reputation was lauded, whose majesty was preserved, who little by little was removed from his subjects. And it was the bureaucracy which emerged now as a distinctive social grouping with special characteristics and interests, the principal ally of the prince.

As described in detail by Wallerstein, in the European Middle Ages, there existed a Christian civilization, but neither an empire nor a world economy. Obviously, the evolution of a world economy, as well as of new empires, presupposed new methods of labor and relatively strong state machineries (Wallerstein, 1974, p. 38). Many of these causes are economic in nature, which is dealt with in more detail in the chapter on evolutionary economics#Q5#. There are, however, important factors that are overlooked in many analyses, for instance, the role of force in this era and in other periods of social evolution, which deserve special attention and are looked at more closely below.

Feudalism was a peculiarly European, or even western European, phenomenon, and Tokugawa Japan was probably the only region in the world with similar patterns of stratification. In other regions, for instance in Tsarist Russia, the peasant masses were kept in bondage until their formal liberation in the late 19th century. Other societies, such as China and Korea, were highly stratified according to the Confucian tradition and the hierarchical patterns of the Chinese empire. In short, there was no uniform social pattern that prevailed in all agrarian societies. In fact, S. N. Eisenstadt proposed 5 basic types of agrarian societies (Sanderson, 1995, p. 98), namely:

- Patrimonial empires, such as the Carolingian empire.
- Nomad or conquest empires, such as those of the Mongols.
- City-states, the most important example of which is probably ancient Athens.
- Feudal systems, such as existed in the European Middle Ages and Tokugawa Japan.
- Historical bureaucratic empires, such as various Chinese empires, the Roman Empire, and the Mogul Empire in India.

Whatever differences existed between these types of society, there were common characteristics as well, such as high degrees of social inequality, as well as considerable longevity of these social structures and their underlying causes. For instance, agrarian societies prevailed from the introduction of food production in the Fertile Crescent until the Industrial Revolution in the late 18th and the 19th centuries, and in many societies agriculture is still the dominant mode of production today. As pointed out in the Introduction, the advent of industrial production gave rise to sociology as well as other social sciences. The new mode of production and its effects on urbanization, on the evolution of class differences, and on the formation of novel patterns of political participation seemed to justify the occupation of these new academic disciplines, which were designed to study the ongoing process of revolutionary change in industrial societies. Meanwhile, the causes underlying the transition from agrarian to industrial society spread across the globe, at first in the course of European colonization, more recently by the determination of local governments or other political actors to introduce industrial production. This type of production may be hazardous, bringing depletion of resources, negative consequences to the environment, and other detrimental results in its wake; nevertheless, influential actors seem to agree that industrialization is the only means available to cope with overpopulation, power disequilibria among states, and some other aspects of uneven distribution of the instruments of power and influence. Many causes underlie the evolution of industrial society, even if one restricts one's perspective to economic factors.

When the Industrial Revolution commenced in mid-18th-century England, there were three major competitors in Western Europe for leadership in economic and political affairs – France, the Netherlands, and the United Kingdom. From an economic point of view, it is noteworthy that "the English had an agricultural revolution circa 1650 to 1750 and the French did not" (Wallerstein, 1980, p. 263). According to Wallerstein, the military rivalry with France stimulated metallurgy, because metals were needed for the production of armaments; this in turn may have sparked inventions such as Watt's steam engine. Another major factor was, according to Wallerstein (1980, p. 268), "the emphasis on foreign trade that led to Britain's emphasis on the navy and the colonies, which, in turn, permitted her the military triumphs of the long struggle with France". In addition to these economic factors, there were, however, myriads of scientific, technological, and other factors, which were preconditions for evolution of the Industrial Age in the United Kingdom. According to Max Weber, one of the most influential sociologists of all time, the Protestant religion in general, and Calvinist and Puritan denominations in particular, provided believers with the spirit of capitalism; however, Borkenau (1976), a sociologist who has fallen somewhat into oblivion, emphasized feudalism's impact on the formation of Western individualism, which he regarded as the most important precondition for industrial capitalism. Last but not least, Parsons (1975), an eminent 20th-century sociologist, stressed the impact of antiquity's 'seedbed societies', Greece and Israel, on the formation of the intellectual and social preconditions for the emergence of modern society. Some of these theories are compatible with an evolutionary perspective and are therefore dealt with below. However, a general discussion of these theories goes well beyond the scope of this chapter.

4.4 Causes of Social Evolution

In view of the immense amount of data collected by biologists, palaeontologists, and other specialists, it is difficult to deny that evolution is a fact. Although there is ongoing discussion as to which theory provides the best explanation for these data, there is considerable agreement on the reality of evolution, if creationist arguments may be left aside. At least, this may be concluded from Ridley's reader on this topic (Ridley, 1997). Regarding the applicability of evolutionary theory to societal development, there are, however, many influential sociologists, for instance Giddens (1988, p. 42), who are extremely skeptical. Although we cannot deny that Giddens' criticism is valid in some respects, his approach appears to fail to pay attention to many regularities in human behavior and in the evolution of human societies. Therefore, the following considerations proceed from the assumption that evolutionary theory, particularly Darwin's theory, may still shed some fresh light on various problems of social evolution. I refrain from discussing theories that tend to deny the fruitfulness of evolutionary thinking entirely. Emphasis is instead placed on theories that have for whatever reasons gained prominence in debates about social evolution. It is important to note that no attempt is made here to fully cover these discussions, because this would definitely go beyond the scope of this chapter.

According to one of the most influential traditions in the history of social theory, force was the prime mover in social evolution. As pointed out by Kammler (1966), this theory was endorsed in antiquity by Plato, as well as by Ibn Khaldun, and in more recent times by F. Oppenheimer and A. von Rüstow, among many others. Definitely the most influential proponent of this theory was, however, H. Spencer, one of the founding fathers of modern sociology. In a relevant passage he suggests:

> Warfare among men, like warfare among animals, has had a large share in raising their organizations to a higher stage. The following are some of the various ways in which it has worked. In the first place, it has the effect of continually extirpating races which, for some reason or other, were least fitted to cope with the conditions of existence they were subject to. The killing off of relatively feeble tribes, or tribes relatively wanting in endurance, or courage, or sagacity, or power of cooperation, must have tended ever to maintain, and occasionally to increase, the amounts of life-preserving powers possessed by men. Beyond this average advance caused by destruction of the least-developed individuals, there has been an average advance caused by inheritance of those further developments due to functional activity ... A no less important benefit bequeathed by war has been the formation of large societies. By force alone were small nomadic hordes welded into large tribes; by force alone were large tribes welded into small nations; by force alone have small nations been welded into large nations (Spencer, 1873, pp. 193–194).

In another passage, Spencer emphasizes that

> we have ample proof that centralized control is the primary trait acquired by every body of fighting men, be it hordes of savages, groups of brigands, or masses of soldiers. And this centralized control, necessitated during war, characterizes the government during peace (Spencer, 1876, p. 576 after van der Dennen, 1999, pp. 165–166).

According to Spencer, force is the single most important factor in social evolution because antagonism with other societies is more or less constant (van der Dennen, 1995, p. 231), and violent conflict, therefore, is unavoidable. These passages are as clear as can be in demonstrating that Spencer assumed that force was a major cause, in fact a prime mover, of social evolution.

With his emphasis on force, Spencer was undoubtedly one of the most influential proponents of Social Darwinism (Service, 1977, p. 335), but in the present context, rather than attempting a general critique of this line of thought, it is more important to show that Spencer's suggestions regarding the course of social evolution are seriously flawed. To be clear, this criticism does not use moralistic undertones against Spencer's notions, but refers you to some recent findings regarding the evolution of complex types of society, what Spencer calls 'nations'. In this regard, Spencer obviously assumes that such nations and their specialized institutions evolved because centralized control was an asset in warfare. Although there can be no doubt about the advantages of centralized control in warfare, there is ample evidence that warfare persisted for ages in many societies without bringing central control in its wake; therefore, we may hypothesize that the causal relation between the use of force and the evolution of differentiated societies is much more complex than Spencer assumed. Prior to a closer look at these causes, some methodological considerations are, however, advisable.

A major problem regarding the origin of warfare as an institution is the scarcity of compelling evidence for war and other types of collective violence in prehistoric times. Due to the primitive nature of weaponry in those days, most of which were made of wood, stone, or similar materials, there is little reliable information regarding armaments, levels of organization, and other factors, which would enable us to make an assessment of the type of warfare. In many cases, only one-sided data are available, for instance when cracked skulls are used as evidence of a battle. Therefore, many analyses of ancestral warfare resort to ethnographic reports from more recent times, mainly tribal societies of the 19th and 20th centuries. Making analogies between 'modern' tribal societies and prehistoric groups does not, however, provide direct proof for any particular hypothesis, so any theory on the role of warfare in those days must be met with caution. Needless to say, evidence for chiefdoms and full-blown states is much more reliable, not necessarily because written records of contemporary scribes are generally to be trusted, but because there is a multitude of other historical sources that allow the texts to be verified.

Keeping these reservations in mind, it may be suggested that 'primitive' or 'submilitary' (Turney-High, 1971) war prevailed from time immemorial until this very day in some remote areas, whereas complex patterns of warfare evolved in other regions, particularly in areas that easily lent themselves to food production. According to Turney-High (1971, p. 8), a leading expert on primitive warfare, "war is primarily a sociological art, and the art of war improves so slowly that Alexander's principles of combat are still standard". Regarding the distinction of sub-military from military war, Turney-High suggests the following criteria: (1) tactical operations; (2) definite command and control; (3) ability to conduct a campaign to reduce enemy resistance if the first battle fails; (4) some clarity of motive; and (5) adequate supplies. Regarding point 4, "the war must have a group motive rather than an individual one ... True war is above the plane of feuds; it is a political device, properly so-called" (Turney-High, 1971, p. 30; Keegan, 1995, p. 144). It is easy to realize why tribal warfare does not meet most of these standards: Usually, there is neither clear command and control of operations, nor are there strategic plans for operations beyond a first defeat. Due to the comparatively small size of tribal populations and their general primitivity, there are no specialized institutions available for warfare. In general, every adult male person is obliged to join war parties, assuming he does not want to be excluded from social intercourse, as well as from sexual privileges, which are often granted to victorious warriors. With regard to supplies, it is easy to see that tribal societies are typically unable to provide for large-scale supplies of war parties.

Most wars among tribal people were in fact feuds and, according to Turney-High's definition, should be classified as sub-military or primitive war; the term 'primitive' denoting merely a lack of specialization and foresight in operations, definitely being devoid of any pejorative connotations. Recent analyses by Keeley and van der Dennen tend to cast the value of this simple classification in doubt. According to these authors, warfare in stateless societies comprises pitched-battle encounters, i.e., more or less ritualized fighting, as well as lethal raids (van der Dennen, 2000). However, in the present context it suffices to emphasize the general primitiveness of tribal warfare, as compared to the use of military force by chiefdoms and particularly by states. As somewhat of an oversimplification, it seems that typical motivations underlying primitive war are moralistic, e.g., in feuding, or are part of reproduction, when mating and marriage privileges are reserved for successful warriors. According to some anthropological studies of warfare among the Jivaro and Mundurucu tribes of South America, headhunting and similar indications of bravery were related to notions of fertility, and marital status was reserved for successful warriors (Meyer, 1981, p. 68). In these tribes, the social status acquired by the successful warrior, i.e., the cultural evaluation of a certain type of behavior, was directly related to this person's legitimate ability to reproduce, i.e., to differential reproduction in the strictly biological sense (Meyer, 1994). Last but not least, "a very profound motive for going to war is to resolve life's tensions, to escape from unhappiness caused by frustration in other realms of existence" (Turney-High, 1971, p. 141).

Returning to Spencer's hypothesis on the role of force in social evolution, it is important to note that sub-military war had no sizeable impact on this process. If the basic characteristics of 'modern' forms of sub-military war may be attributed by way of analogy to this type of war in the past, it may be inferred that warfare did not exercise an influence on social evolution, as Spencer suggests. However, the invention of food production sparked new patterns of violent competition over scarce resources, and in the long run gave rise to full-blown military patterns of warfare. The cultural invention of novel types of resources, such as new varieties of maize (Phillips, 1987, p. 235), of new weapons, such as the longbow in medieval England (Montross, 1960, p. 158), or new tactics, such as the Macedonian phalanx, brought about new patterns of warfare (Meyer, 1981, 1995). As presented in more detail in other publications, warfare developed into an independent variable throughout certain phases of social evolution (Keegan, 1995; Meyer, 1977, 1981), although it was dependent on economic, religious, or other variables in most phases of human history (Keegan, 1995, p. 314; Meyer, 1981). Summarizing Spencer's general assessment of force, although he definitely overstates its impact in some respects, one cannot deny that full-blown warfare exercised a major influence on social evolution.

It is important to note that this assessment of the role of force in social evolution is fully compatible with evolutionary theory, particularly with Darwinian theory. According to Darwin, competition over scarce resources is a problem that all living systems have to cope with in some way. However, unlike Spencer, Darwin (1968, p. 459) made it clear that the concept of the struggle for existence should be used "in a broad and metaphorical sense, including dependence of one being on another, and including not only the life of the individual, but success in leaving progeny". From a Darwinian point of view, one would expect that, although conflict between individual actors may arise in some situations, cooperation among individuals is a precondition for their survival in most environments. For instance, killing a person may force his kin to strive for legal retribution by blood revenge or other means; however, in most other situations these very same clans may depend upon cooperation to secure survival against predators or inimical groups. Therefore, people do in general try hard to return to internal peace after outbursts of violence or even actively avoid violent interactions with neighboring populations by ostracizing individuals who endanger peace (Boehm, 1986). To cut a long story short, conflict and cooperation are both necessities in a world of dangerous beasts and competitive groups; therefore, it does not come as a surprise that warfare and other forms of coordinated collective violence had their part in social evolution. However, unlike in Spencer's, Bagehot's and Sumner's day (van der Dennen, 1999), when the impact of force on social evolution was vastly exaggerated, recent analyses of mainstream sociologists have more often than not ignored these factors altogether. In part, this may be an outcome of Social Darwinism's overemphasis on force and violence; other factors may have been the enormous material and intellectual destruction caused by the World Wars, which induced sociologists to neglect the problem of force in social evolution. Only very recently are sociologists like R. Aron, R. Collins, M. Mann, S. K. Sanderson, and A. B. Schmookler beginning to reconsider the impact of force on social evolution. However, over the past decades, mainstream sociology was dominated by approaches that did not pay much attention to either the role of force in general or the impact of warfare in particular, but instead emphasized processes of social integration and social differentiation.

A short look at some of these theories should begin by pointing to the two most influential sociological paradigms, namely the 'sociology of action' vs. the 'sociology of social systems' which, according to Schimank (1996, p. 205), dominated discussions within the discipline in recent decades. For several reasons, which cannot be dealt with in the present context, the systems perspective gained much greater influence in the discipline than the did the action perspective. Accordingly, sociologists were much more concerned with problems of how people are integrated into social systems, such as groups or societies, than in the causes of disagreement, conflict, and other social problems. Somewhat oversimplifying, one may suggest that the systems view specializes in studies of the ways people adjust to a given normative infrastructure, for instance by looking at socializing processes, whereas conflict theorists delve into the causes of the divergence of individuals' interests. In general, the first view is likely to stress functional requirements of social integration, whereas the second view lays stress upon conflicts of interest, the use of force, and similar behaviors. From a sociological perspective, both problems are worth being dealt with, but from an evolutionary point of view, which is primarily interested in tackling the problem of how organisms manage to survive in a world of scarce resources, preference is given to conflict theory.

According to Parsons (1975, p. 39), one of the most influential proponents of the functionalist–systemic tradition, social differentiation is likely to promote enhanced adaptation. Parsons explains that some societies in antiquity served as seedbeds for developments in other societies, for instance, ancient Israel and Greece contributed greatly to the system of modern society, although these ancient societies did not prevail as politically autonomous societies for long times. More specifically, this contribution originated from cultural factors transcending their own politically organized community (Parsons, 1975, p. 161), such as the Greek idea of the polis or the Israelite notion of a universal god. With regard to the theory of social evolution, numerous critics have pointed to a hidden teleology underlying Parsons' notion of 'enhanced adaptation' as an inbuilt developmental goal of social systems (Schmid, 1986, p. 7). According to Corning and Hines (1988, p. 156), Parsons, although using a different terminology, did in fact subscribe to Spencer's orthogenetic notion of evolution, i.e., similar to Spencer, he assumed a basic directionality of the evolutionary process. Yet another critic, Sanderson, censures Parsons' notion that "social evolution [is] growing differentiation or complexity and that such a process produces increasingly well-adapted societies". According to Sanderson (1995, p. 131), "growing complexity may be a good thing for elites, in whose interests it is generally carried out in the first place. But it is of dubious worth for the bulk of the population who must pay the costs of complexity". To sum up, from an evolutionary point of view, Parsons' functionalist theory of social evolution must be refuted as a seriously flawed account.

More recently, Niklas Luhmann reestablished the functionalist–systemic approach in sociology, by combining it with the theory of autopoietic systems. As pointed out by Maturana and Varela, living systems operate in isolation from one another. Whereas von Bertalanffy, the founder of systems theory, assumed that living systems must be open to the flow of matter and energy from the environment, Maturana and his followers focus on nervous systems' internal states. According to Maturana, that system is "an isolated network of interactions, in which each change of relations between its individual elements is likely to affect all other elements as well". In further following Maturana, we may infer that living systems 'make themselves', i.e., they are 'autopoietic' because they are continuously reproducing the very elements that are prerequisites of their own existence (Maturana, 1982, p. 141). According to Luhmann, any type of system, including social systems, basically operates in a similar manner; therefore, systems, by utilizing their peculiar codes and programs, are isolated from each other, and hence, no direct interaction between them is feasible. Regarding social evolution, Luhmann starts from the assumption that differentiation is the single most important cause of social evolution, bringing the development of peculiar binary codes and programs in its wake. Due to social differentiation, modern societies are characterized by numerous specialized subsystems, such as the economic, the political, and the scientific, none of which have direct access to each other. Although Luhmann puts considerable emphasis on the naturalistic and evolutionary underpinnings of his theory (Luhmann, 1985, p. 10; Luhmann 1997, p. 413), there is no clear concept of the causes underlying social differentiation. Instead of offering an explanation for that process, Luhmann presents a critique of Darwinian theory in general, and Neo-Darwinian accounts of social evolution in particular. In following S. J. Gould's considerations, Luhmann casts the concept of external selection in doubt and pleads for introducing internal selection, as well as the concept of the coevolution of structurally connected autopoietic systems (Luhmann, 1997, p. 427). Despite some additional conjectures about the persistent fruitfulness of Lamarck's evolutionary thinking (Luhmann, 1997, p. 504), as well as descriptions of various evolutionary achievements, Luhmann decides that "there are no unequivocal causes for evolutionary achievements, such as the development of agrarian production" (Luhmann, 1997, p. 507). Not a very impressive result of his extensive deliberations!

Unlike these functionalist–systemic approaches, theories of coevolution are more easily compatible with action-centric and conflict perspectives of social evolution. According to Lumsden and Wilson (1983, p. 19), coevolution of biological imperatives and culture occurs, in fact, "culture is generated and shaped by biological imperatives while biological traits are simultaneously altered by genetic evolution in response to cultural evolution". Unlike the systems approach, this theory proceeds from the assumption that individuals, or rather, their inbuilt biological imperatives, play a role in social evolution and spark the evolution of new cultural patterns. According to Lumsden and Wilson, the concept of epigenetic rules is suited for designating the interface between human biology and culture, a system that enables human individuals to establish cultural rules and institutions that are at least partly independent of biological determination. Regarding social evolution, this theory attaches great importance to epigenetic rules as biological underpinnings of mental and cultural factors, which seems to be in keeping with arguments presented in this chapter. Unfortunately, however, Lumsden and Wilson's concentration on the biological foundations of mind and culture prevents them from giving due consideration to the impact of physical environments on the evolution of culture. Undoubtedly, there are a variety of universal elements of human culture that can be accounted for by evolutionary biology, but a full understanding of culture presupposes attention to the role of environments and resource distribution.

Other versions of coevolution theory have been presented by Durham, and by Boyd and Richerson. According to Durham (1990, p. 192), a major concern of evolutionary culture theory is to demonstrate that cultural and social factors are independently variable yet mutually interdependent. In another passage he describes culture as a secondary "evolving system of information inheritance, separate from (though interacting with) the genetic inheritance system" (Durham, 1990, p. 194). Regarding social evolution, Durham suggests that, unlike strictly Darwinian views, which stress differential reproduction, evolutionary culture theory points to the impact of different teachings as a major factor of cultural transmission: "If natural selection increasingly turned control, so to speak, over to culture, it was because culture, as a general rule, did a better job" (Durham, 1990, p. 201).

Similarly, Richerson (1997, p. 40) stresses that the "advantage of having a cultural nature is the flexibility and relatively rapid evolution of culture". Cultural transmission is faster and, once it is established, it is likely "to reduce the cost of individual decision making still further" (Boyd and Richerson, 1985, p. 288). As pointed out by Degler, coevolution theory evolved in the course of discussions on kin-selection theory, one of the bulwarks of sociobiology. Boyd and Richerson, as well as Durham, "take a more positive position on defense of the use of kin selection theory in explaining human behavior" (Degler, 1991, p. 281).

According to Maynard Smith and Szathmáry (1995, p. 259), the basic idea of that theory is that "by helping a relative, an individual is propagating its own genes, or more precisely, copies of those genes". The crucial point regarding the theory's applicability to culture theory then is whether human adaptations evolve by "increasing the fitness of individuals relative to others within the same social group" or "by increasing the fitness of social groups as collectives, relative to other social groups" (Wilson and Sober, 1994, p. 600). Obviously, there are opposing views regarding the role of genes in social evolution, sociobiology advocating direct causality, and coevolution theory being somewhat more cautious in this respect.

In their discussion of coevolution theory, Maryanski and Turner (1992, p. 4) credit the theory as being "more viable and intriguing" than sociobiology, but they also note that "it is not clear that (it) can explain the complexities of sociocultural evolution". Yet another influential author in the field of social evolution, Sanderson (1999, p. 39), is even more positive about sociobiology's explanatory potential but, similar to Maryanski and Turner, feels that it has to be combined with other theories, to adequately cover social evolution. According to him (Sanderson, 2001), Darwinian conflict theory can fill the gap between sociobiology and the theory of social evolution, because this type of materialism provides a basis for taking humans' most important interests and concerns into account, mainly reproductive, economic, and political (Sanderson, 1998, p. 14). In fact, Sanderson's view seems convincing that sociobiology, which focuses on reproduction, needs to be supplemented by a theory promising to take economic and political interests into account as well.

As pointed out by Sanderson, synthetic materialism is based on previous theories, such as Marxian and Weberian conflict theory, Marvin Harris' cultural materialism, Immanuel Wallerstein's world system theory, as well as sociobiology. According to Sanderson, explanations of people's economic and political interests and concerns provided by these theories can be connected to sociobiology, a theory which, unlike others, throws the door open to a new understanding of human preferences and needs. In fact, many sociological theories proceed from rather vague assumptions about the nature of human preferences, and so from an evolutionary point of view must be regarded as seriously flawed. This chapter argues in favor of sociobiological accounts, according to which human behavior and its underlying genetic, emotional, mental, and cultural structures evolved to enhance inclusive fitness. For instance, viewed against the background of evolution, mental and rational patterns have not evolved in their own right but because they contributed to human survival. As pointed out by Sanderson (1998, p. 7), "as is well known, rational choice theory has great difficulty accounting for the origin of human preferences", because it dwells on traditional exchange theory's assumptions on human behavior and does not take the evolutionary background of these preferences into consideration (Somit and Peterson, 1999), as more recent evolutionary psychologists do (Barkow et al., 1992).

To summarize, this chapter proceeds from the assumption that taking the biological bases of cultural institutions into account may vastly enhance explanations of social evolution. In this view, mental and cultural processes, as well as human social behavior in general, far from being arbitrary, are firmly based on evolutionary foundations. In addition to these universal conditions of social behavior, human groups live in vastly different environments, which may or may not spark social evolution. At present, it is difficult to decide the extent to which social evolution was synonymous with the rise of genetic differences between human populations, as theories of coevolution suggest. There is, however, some evidence suggested by Cavalli-Sforza et al. (1994, p. 380), according to which there are "important correlations between the genetic tree and what is understood of the linguistic evolutionary tree". From an evolutionary point of view, it therefore seems unlikely that genetic differences did not influence social evolution at all, as Diamond (Diamond, 1998, p. 241), as well as mainstream social science, suggests. Fortunately, however, there is no need for this chapter to present any solutions to this urgent problem, because the main lines of social evolution can be analyzed without pretending to have an answer to this complex question.

In social evolution, many cultural institutions acquired new and unprecedented characteristics. For instance, force and collective violence have played important roles in human social behavior since time immemorial; or at least this may be inferred from historical and ethnographic data. However, feuding and other types of primitive warfare did not exert notable impulses on the evolution of social complexity, unless the instrumental (Meyer, 1981) returns of warfare had been discovered by people. Whereas chiefdoms and states fought wars over the control of territories and other scarce resources, i.e., they used armies as an instrument for conquering these resources; clans and tribes generally did not pursue material goals in war. According to Ferguson, conquering other groups' land was not a typical goal of tribal warfare because it was 'spirit infested' (Ferguson, 1984, p. 30), hence, useless.

However, once the instrumental utility of land, military organizations, and strategic planning had been understood, full-blown warfare evolved and gained considerable influence on social evolution. With respect to institutions' roles in social evolution, it is interesting to note that the psychological disposition toward blood revenge, which played an important role in primitive war, persist even in modern war. As pointed out by Smith (1991), modern states, in preparing their populations to war, resort to kinship terminology, just–unjust dichotomies, and similar practices reminiscent of primitive war. We may infer that, despite novel characteristics of warfare, primitive psychological dispositions prevail to this day.

I should emphasize once again that most progressions in social evolution evolved unintentionally, without deliberate planning. For instance, there is some evidence that, prior to the spread of horticulture, an improvement in hunting technologies may have caused population growth, which in turn forced hunters to become farmers (Maryanski and Turner, 1992, p. 92). The diffusion of farming then sparked the evolution of centralized authority, bureaucracies, systems of writing, and many other features of complex society. Furthermore, it is important to note that previously 'primitive' people in various parts of the world crossed over the boundary between tribal society and statehood without any discernible change in their genetic makeup. However, once the more complex society existed, there was in fact a feedback loop on natural selection because the emphasis on functions, such as scribes or accountants, favored the selection of certain talents from the gene pool.

Similar to evolution by natural selection, social evolution is an open-ended process without inbuilt teleology. Despite many differences between people in various parts of the world, there are, nevertheless, remarkable regularities in social evolution. To some extent, these similarities are caused by mankind's common biological heritage; others are products of environmental conditions. As pointed out by Dawkins (1986, p. 191), certain limits or constraints exist in nature: "Take running speed, for instance. There must be an ultimate limit to the speed at which a cheetah or a gazelle can run, a limit imposed by the laws of physics." Similarly, there were certain constraints in social evolution, bringing the evolution of remarkably similar social characteristics in the most dissimilar societies in its wake (Sanderson, 1995, p. 388). Understanding these constraints on social evolution tells us why the basic unity of mankind persisted, despite deep-seated cultural differences, which at first sight dominate our perception of social evolution.

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5
Evolution of Morality

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5.1
Explaining Moral Behavior

Can human moral behavior be explained in terms of evolution by natural selection? The question of whether moral behavior can be understood as a phenomenon that appeared by means of natural selection was posed by Darwin, who pointed out, in favor of this idea, the existence of equivalents of human moral conduct in other animals. In Chapter IV of the *Descent of Man*, Darwin (1871, p. 474) says:

> In Abyssinia, Brehm encountered a great troop of baboons who were crossing a valley: some had ascended the opposite mountain, and some were still on the valley; the latter were attacked by the dogs, but the old males immediately hurried down from the rocks, and with mouths widely opened, roared so fearfully, that the dogs quickly drew back. They were again encouraged to the attack; but by this time all the baboons had reascended the heights, excepting a young one, about six months old, who, loudly calling for aid, climbed on a block of rock, and was surrounded. Now one of the largest males, a true hero, came down again from the mountain, slowly went to the young one, coaxed him, and triumphantly led him away – the dogs being too much astonished to make an attack.

This is just one of the many examples given by Darwin of animals that help a distressed group member. However, in this particular case, Darwin uses a word that we would like to emphasize: the baboon that comes down from the mountain is called "a true hero". 'Hero' is, beyond any reasonable doubt, an ethical concept. Is Darwin using it with a metaphorical or a technical import?

Darwin belongs to an intellectual tradition originating in the Scottish Enlightenment that uses 'moral sense' as the element that, based on sympathy, leads human ethical choice. In his account of the evolution of cooperative behavior, Darwin states that any animal with well-defined social instincts – like parental and filial affections – "would inevitably acquire a moral sense or conscience, as soon as its intellectual powers had become as well, or nearly as well developed, as in man" (*Descent*

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of Man, p. 472). However, this is a hypothetical issue – no animal has ever reached the level of human mental faculties, language included. In fact, Darwin points out that even if some animal could achieve a human-equivalent degree of development of its intellectual faculties, we cannot conclude that it would also acquire exactly the same moral sense as ours (*Descent of Man*, p. 473). Therefore, human moral behavior is a product of natural selection, but it is humankind's exclusive attribute. No other primate displays ethical codes with such a huge quantity of discussions and arguments. No equivalent of the enormous variety of human moral options is within the reach of any other species.

Two years after the end of the *Beagle*'s voyage, Darwin gathered the most modern literature available on human moral behavior. He acquired the latest books by Martineau, Mackintosh, and Abercrombie, together with William Paley's classic. Some of these authors (Martineau, Paley) defended ethic's mere conventional character, using an argument often exploited in our days: the diversity of moral codes. In those times, the proliferation of ethnographic voyages had brought to light the great variety of moral customs and rules. This is something Darwin had noticed in his profound observations on South American Indians. But this apparent dispersion had not confused him. On the contrary, he saw the diversity as an adaptive response – as it would presently be called – to the environmental conditions unique to every different place.

5.2
Deep Capacities

Such an adaptive response could very well derive from some deeper capacities, a common substrate unique to the whole human race, and capable of orientating in multiple directions. This *universality* could certainly not be eternal: it would be subject, after all, to evolution by natural selection, and Darwin understood that different cultures manifested successive stages of a 'positive' moral evolution. Most important was the presence of this universal and common foundation, capable of turning humans into beings endowed with an ethical capacity.

Darwin ended up turning to a special feature possessed only by the human species, moral sense. This attribute would turn a rescue carried out by a human, but not by a primate, into a heroic act, although both species may be acting altruistically. Needless to say, however, unless we know what this ad hoc mechanism comprises, the relations and differences existing between an altruistic baboon and a human altruist are not clear.

Darwin does not leave many clues regarding this issue. He associates moral sense with the vague idea that human beings make an assessment in order to make decisions, an ability that does not exist in animals. The most important point of his analysis is the fact that moral altruism appears as a behavior similar to that of other beings, with certain added aspects. If we adhere to this evolutionary line of thought, we cannot dismiss human altruism with a simple moral behavior model in the form of automatic responses to genetic determinations (otherwise we would not exclude the biological altruism as immediate as that of hymenopterans). But neither can we ignore the presence of a certain amount of fixed impulses during the phylogenetic process, when our ancestors exhibited an altruistic behavior shared with that of their close relatives. Hominids that developed sophisticated social habits, including a new moral behavior, had to do so in circumstances under which those shared biological altruistic traits were present. Thus, the final result of the process, that is to say, what we now refer to as 'moral altruism', must show some features close to biological altruism and others, exclusive to the human species, that deviate from it.

In a certain way we could assert that Darwin is the last author in the stream of those that searched, since the times of the Enlightenment, for a justification of modern moral codes. And in that sense the model of *The Descent of Man* is exemplary. Human beings, by means of a nature that includes moral sense, and with the help of a sympathetic mechanism, construct societies in which ethical behaviors and approval codes for such behaviors appear. Initially the group benefiting from this set of actions and codes is small, but gradually, by means of intellectual, material, and moral progress, morality's scope grows. Primitive beings respect and help their closest relatives; then they extend their sympathy to the tribe; later to a whole village. In time, Darwin concludes, the whole human race will form a single body of morality expressed in a universal code and a generalized sympathy. Would this be accomplished by means of the progress of an instinct or of a perfected rationalization? The key to Darwin's naturalism is in the union of these two factors.

Darwinian heredity theory comprises, as is known, the addition to the genetic pool of phenotypic transformations, or, in more usual terms, the heritability of acquired characteristics. The formula, proceeding from Lamarck, is a guarantee of the joint progress of sympathetic instincts and ethical codes, given that new generations benefit from each new finding in a parallel and compatible way. Faithful to the thought in *Descent of Man*, ethics shapes man, transforming the so-called primitive peoples into a modern citizen. The intersection of being and duty arrives at its most refined and complete formulation.

With the definitive acceptance of August Weissman's hereditary theory (in complete contrast to the acquired characteristics of Lamark's inheritance), Neo-Darwinism had to forget the hope for progress and harmony. The concerns of Neo-Darwinism's founders about human moral behavior were intense and, from a speculative standpoint, fruitful, but had to very carefully pull back from any 'hard' foundation of ethics such as that which Darwin had bound to hereditary mechanisms. Sociobiological models of altruism had to appear in order to recover the battle flag of contemporary naturalism.

These models appear with an important novelty. The ethical naturalism inaugurated by Darwin had the virtue, or flaw, of turning morality into something dependant on human nature, but without saying how. Neither does Neo-Darwinism. The intended *scientific* approach to moral phenomena does not often go beyond suggesting the existence of some bonds that are never detailed. We know that human beings possess a 'moral sense' that makes them different from the rest of animals, and we deduce the great importance this sense has for the phylogeny of the human species. Nevertheless, when the time comes to explain what specific features of behavior are influenced by such biological structures, the naturalistic model abandons its scientific spirit and settles, at the most, for certain vague speculations about possible universals, such as the incest taboo.

5.3 Sociobiological Models of Altruism

In the last quarter of the 20th century a naturalist topic appeared that did justice to the pretensions of bringing ethics closer to biological laws and models. This was the explanation of the altruistic phenomenon as a function of certain combinations of genes. Without the problem that altruistic behavior represents for the evolutionary standpoint, it would have been difficult for anyone to pay such careful attention to the phenomena of group adaptation. A brief explanation of the problem serves to show its importance.

Natural selection improves the adaptation of the individuals to their environment. Genetic variations arise by mutations and recombination. Individuals that possess variants that improve their adaptation to the environment (say, that improve vision or fleetness) are likely to survive better and produce more offspring than others. The adaptive variants will, therefore, increase in frequency over the generations; that is, they will be favored by natural selection. The rate of increase in frequency is measured by the parameter known as "Darwinian fitness" or simply "fitness". The term fitness is used by evolutionary geneticists in two senses: in the vernacular sense of being fit, well adapted to the environment; and as a measure of the rate of frequency change of genetic variants. Variants that make individuals better adapted to the environment (i.e., that are more fit in the vernacular sense) also have greater Darwinian fitness (i.e., will increase in frequency over the generations). The process of natural selection entails, therefore, an increase in adaptation to the environment. Thus, according to the model, we would expect to find individuals everywhere exhibiting adaptive behaviors, genetically inherited, and capable of promoting that aptitude.

But altruistic behavior seems to escape the evolutionary model. Far from increasing individual fitness, it has the opposite effect: *it decreases it.* An altruist squanders nutritive resources it has obtained, shares its territory and may even put its life at risk, for example by warning the group of the arrival of a predator. It is difficult to understand how it is capable of transmitting its characteristics to the next generation with sufficient guarantees to insure that, in time, there will be altruists among the population. Regardless of the degree to which the group benefits in general terms from the presence of the altruist, this does not explain its adaptive success. Neo-Darwinist theory of evolution by natural selection demands that an *individual* behavior be able to assure the transmission of genetic characters. Otherwise, the presence of a selfish mutant in a group of altruists would rapidly lead (in few generations) to the whole group being composed of selfish individuals, because these would benefit from very superior possibilities of producing offspring.

The first plausible explanation for the evolution of groups as the units for natural selection had to wait more than a century after the publication of the *Origin of Species*. In the 1960's Wynne-Edwards (1962, 1963), an author interested in ecological matters, posited the existence of certain effective mechanisms in some animals allowing them to avoid overexploitation of their habitats. The way to achieve this consisted in self-limitation of their reproductive capacities. In other words, some animals seem to voluntarily accept having fewer offspring for the benefit of the population. Wynne-Edwards gave the example of the English tit, a species of bird in which the female lays an average of 13 eggs, but under adverse environmental conditions she limits the number to 9 or 10. Something like this comes into conflict with Darwin's contrary idea of maximizing the total number of descendants. But the most interesting feature of Wynne-Edwards' model is the proposal of social mechanisms as the means by which beings living in groups obtain information about the group's size and its relation to the environment's resources. This would explain the advantages of living in groups. A self-limited behavior like this, technically called altruism, undoubtedly benefits all the individuals that form part of the society. Wynne-Edwards' idea, usually called group selection theory, could be faced with the same theoretical difficulties as Darwin's intuition about the group being the selective unit. Williams (1966) pointed to an essential question: What advantage does a specific member of a group obtain by limiting its own progeny? The use of mathematical game theory in population genetics, mainly by Maynard Smith (1976) and Maynard Smith and Price (1973) introduced a very powerful concept against the idea of the group as the selective unit: the evolutionarily stable strategy (ESS). An evolutionarily stable strategy is one that cannot be surpassed by a different and alternative strategy. The strategy of the altruistic members of the group is very efficient in keeping the collective healthy and, thus, of ensuring the biological efficiency of its members, but it is not evolutionarily stable. If an individual that refuses to cooperate appears in the group, its situation is unbeatable: it receives all the benefits of living in the group but, at the same time, does not waste any of its own resources. If the rest of the members of the group altruistically limit their progeny, it may opt for the opposite, for reproducing as much as it can, benefiting from the excellent opportunities for doing so. This selfish strategy is clearly superior and, in the long run, the offspring of the selfish individual will predominate in the group, which means the end of the group as a collective of cooperating beings.

There is only one exception to this situation: that in which the components of an altruistic group organize themselves well enough to prevent this from happening. Detection and punishment of selfish individuals is a good means of defense. But if we are talking about birds, or even social insects, how can we think this to be possible? Leaving aside Walt Disney films in which ants have Woody Allen's character and initiative, there is no way of imagining how a beehive or a termite colony might detect and prevent selfish individuals. But in these societies neither dissidents nor cheaters exist.

5.4
Kin Selection: Genetic Altruism and Moral Altruism

About the same time that Wynne-Edwards hypothesized group selection, an alternative and much more elegant, mathematically speaking, model finally resolved the problem of social insects and their peculiar way of reproducing and behaving. The answer was given by Hamilton (1963, 1964), using a similar resort to that of supporters of group selection, that is, changing the selective unit. If Wynne-Edwards had passed from the individual to the group, enlarging the unit, what Hamilton did was reduce it from the individual to the gene. It would be tedious to repeat his arguments here, but, in essence, he stated that biological efficiency must be measured in terms of the presence of an allele in the population's gene pool, dispersed in the cells of the individuals that constitute the population. The allele of a queen bee has biological success thanks first to the help given her by the workers, carriers of the same gene – after all, they are her sisters – and, second, to the mechanism of haplodiploidism, with a very high percentage of shared genes.

Kin selection theory, the name of Hamilton's model, was for the past several decades the preferred explanation for the existence of altruistic individuals. If we consider that it can explain the altruistic behavior of ants and rats reasonably well, is it also useful in explaining human altruism? In other words, are we referring to the same phenomenon when talking about altruism in both ants and human beings?

Given the complex relations between human altruism and the biological or genetic altruism of other animals, finding a simple answer to this question seems unlikely. Authors the worth of Betram (1982), Voorzanger (1984, 1994), Wilson (1992), and Settle (1993), among many others, have treated the problem, showing, at least, the many difficulties found when transferring models and theories established for the interpretation of hymenopteran behavior to humans. Sober (1988) has indicated in a simple way the essential difference between what is commonly called 'altruism', that is, a way of behaving called vernacular altruism, and genetic altruism, or evolutionary altruism as Sober calls it. The first implies a mind, because it refers to the psychological motives that a person may have for acting, which turn him or her into an altruist or a selfish person despite the results obtained. However, genetic altruism does not require a mind in the sense Sober understands it; instinctive behavior is enough to produce inversion of one's own resources in favor of another individual. Thus, the real question, if we are talking about moral evolution in hominids, is double: (1) to what extent might certain inherited features be detected in the undoubtedly altruistic behavior, in the form of moral altruism, of most human beings, and (2) to what extent can the presence of altruistic behavior, beyond the imperatives of genetic altruism, be identified in our ancestors.

It is easier to distinguish the concepts of genetic altruism and moral altruism than to delineate the frontier between them when referring to human behavior. What is, for example, a mother's loving care of her children? Mere expression of an instinctive behavior? Altruism in the most magnificent sense of the word? To intend to clearly separate these two concepts, assigning some behaviors to one and other behaviors to the other, would require returning to pre-evolutionary times, when Kant understood human morality as having nothing to do with the world of nature, being an element pertaining to the domain of rationality and thus completely excluded from the domain of the senses. Kant (1790), in the first *Critic*, argued that the world of moral values and the world of facts, be they biological, social, or even political, are irreversibly separated and not even a common frontier exists between them. But if we do find in moral altruism certain aspects shared with genetic altruism, naturalism will come through.

Moral Naturalism, of course, is shared by Darwin, Neo-Darwinists, ethologists, and sociobiologists. But it would be convenient to insist on something that, being obvious, is often forgotten. Claiming that moral altruism is a form of biological altruism does not reduce ethics to biology. It merely states that there are connections between moral and biological altruism that are impossible to overlook. If the concept of biological altruism being discussed is the one put forward here (that is, a behavior producing a decrease in biological fitness of the organism behaving in such a way), it is difficult to deny that moral altruism also leads to this kind of handicap. This fact is evident, despite any resistance one might have towards biologicisms.

5.5
An Evolutionary Model of Moral Behavior – Interpretation

Although, generally speaking, the features defining moral altruism are usually related to rational aspects, the presence of emotional features arouses suspicions that biological altruism and moral altruism are not absolutely separate. Some phylogenetic motives point to that relative proximity: moral traits shared between great apes and human beings lead to positing the existence of a certain degree of continuity in their behaviors. As Darwin (1871, Chapter IV) pointed out, difficulties are met when one attempts to distinguish between two similar acts, carried out by a person or a baboon helping a wounded companion.

What sociobiologists maintain is that sacrifice in favor of close individuals with whom we share many genes is encouraged by natural selection. We do not yet know how genes manage to control such behaviors (the model is still a black box), but undoubtedly, progress has been noteworthy. If we apply kin-selection theory to the human species, we come up with a much more firmer bridge than we could find before between the world of what is (hereditary nature) and of what should be (moral codes) – an adaptive bond predicting that those behaviors capable of favoring kin will be established in the form of ethical rules. Hume's intuition about how benevolence becomes progressively weaker as we move from relatives to friends to strangers is relevant here.

Of course, such an extrapolation, from social insects to the human species, can give rise to many doubts about its legitimacy. Assuming that insects of the Hymenoptera order do sacrifice themselves in favor of their close relatives, can this be considered a moral behavior, in the sense used by philosophers? We could say that the question is absurd. After all, termites are too far from us in evolutionary terms for comparison or to look for saints and heroes among them. Unfortunately, this argument does not allow us to evade the problem, because it is easy to find phylogenetically closer examples.

Is there much difference between the act of a baboon saving its young from harassment by wild dogs and the act of a man jumping into the water to rescue a drowning child? Darwin explicitly poses this question in his *Descent of Man*, concluding that both behaviors are similar, but that the ethical distinction of 'hero' makes sense only for human beings, because only we have that 'moral sense' we mentioned earlier. The argument is somewhat circular, of course. What is being discussed is, really, if an individual may be called 'altruistic' when it sacrifices itself because its genes order it to do so. Is a gene that impels these sacrifices for its own good 'altruistic' or instead selfish? Popular philosophical speculations about altruism and selfishness, with Dawkins' famous *The Selfish Gene* (1976) in the fore, were the battle horse on the popular side of sociobiology. But when referring to genetic altruism, we must remember that 'altruist' is a technical concept. It is defined as the characteristic of an individual who invests his own resources in the survival of others. The definition goes neither into questions about intention nor into valuations of behaviors. Hamilton's theory is safe from philosophical critiques.

Nevertheless, it is not safe from other kinds of criticism. Visscher and Camazine (1999) verified that the type of cooperative behavior that occurs in bees depends on very simple cognitive tasks, although insects – fruit flies (*Drosophila*), at least, according to Liu et al. (1999) – can perform more complex tasks than were initially expected. Hamilton's model explains social insects' behavior perfectly, but what to say about other gregarious beings with much higher cognitive capacities? Highly social behavior, technically known as 'eusocial' behavior, has appeared at least four times in the history of life. It exists in social insects, in the parasitic shrimps of the coralline sea sponges (*Synalpheus regalis*) (Duffy, 1996), in the naked mole-rat (*Heterocephalus glaber*) (O'Riain et al., 1996), and of course in primates. We must admit there are no cheaters among termites, nor perhaps among *Synalpheus* shrimps. We know very little, by the way, about mole-rats. But it is known that both chimpanzees and human beings are capable of cheating, avoiding duties, and profiting from circumstances. To do this, they posses well-developed facial identification capacities, as documented by Parr and de Waal (1999), who used computerized manipulation of those species' faces. But regarding human beings, there is no doubt about the abilities to detect facial features and to guess intentions. Then, in what manner does the behavior of humans relate to those other altruisms that are accounted for by theories such as kin selection?

The relevance of a mutual relationship between genetic altruism and the emergence of a more complex moral behavior, at the time when the human species was developing its cognitive capacities and articulated language, seems to be beyond any doubt. Evolutionary transformations probably shaped primitive moral behavior, and those groups that depended on generalized altruistic behavior for survival benefited from it. The by-products of such adaptive strategies, based on the cognitive complexity of human beings, led, in the long run, to our enormous moral richness. But the way in which evolution took place forces us to distinguish between two essential aspects of human moral behavior. It is important, when referring to moral values, to distinguish between the tendency to behave morally, following – to a certain extent – the prevailing values in our group, and the content of those values. The tendency to behave in a certain moral way is universal in practice and may be understood as a specific trait of our species, with enormous adaptive value, that appeared by natural selection when the evolution of our cognitive capacities allowed it. Despite this fact, there is no proof of the existence of particular values that evolved in such a way. Some sociobiologists, such as Crook (1980), have suggested that the values of societies, such as the Greek in the aristocratic period and the traditional Chinese, are controlled by the genetic code and follow the so-called *r* and *K* strategies, respectively, established by analysis of their population curves. As we already mentioned elsewhere (Cela-Conde, 1986), the interpretation of Greek and Chinese values seems incorrect, and their identification as a genetically fixed behavior seems to go beyond empty speculation, into circular arguments. Faced with the universality of the tendency to behave morally, the historical and geographical diversity of ethical codes is patent. But not all these codes are equally efficient in terms of adaptation. The group's 'tendency to act morally' + 'effective codes' favor the group's behavior, and the achieved result of that sum is what provides the adaptive key. Beliefs leading to the destruction of the group (for example, those encouraging collective suicide) would obviously go extinct as soon as the group accepting them disappeared. Thus, it is not strange that cultural anthropology has tried to explain the presence of certain moral taboos, like those forbidding certain foods, as a function of their adaptive values. Nevertheless, at this point it is very difficult to escape circular arguments that consider very adaptive those moral patterns that survive, solely because they manage to do so.

5.6 Early Moral Behavior

If we accept the idea of a moral behavior appearing by natural selection and adopting very different values in different groups, it is worth asking when could the tendency to act in such a way have appeared. The answer is, necessarily, speculative, but since Konrad Lorenz (1963), the adaptive role of moral behavior has been contemplated as a key to the understanding of the adaptation of the first hominids.

Our Pliocene ancestors had to face a rapidly deteriorating environment. The tropical forests of East Africa were giving way to great extents of open savanna, creating many frontier zones between thick forests and tall grasses. Hominids of the genus *Australopithecus* could not compete for the forest habitat, for which their close relatives, the great apes, were better prepared. Neither could they dispute for the savanna with the faster and stronger ungulates and predators. Their survival during several million of years is certainly a mystery, but it is assumed that the frontier zones between the forest and savanna acted as a precarious habitat. To profit from it, they had to resolve problems of environmental interpretation and anticipation of behaviors that generally required the production of very complex knowledge. Nevertheless, their brains were very small: approximately the size of a present-day chimpanzee's brain. What was their advantageous ploy?

It is probable that a combination of manual abilities suitable for the elaboration of simple tools and a very high degree of biological altruism, capable of founding family groups based on the division of labor and cooperative behavior, allowed the successful procreation of a relatively large number of descendants. What seems beyond any doubt is that such groups of *Australopithecus* existed, and that, as with the genus *Homo*, the construction of Oldowan tools and the problems of a cooperative way of life implied an intense selective pressure for increased brain complexity.

As that complexity grew, the organization of groups must have necessarily included the control of altruism by means of traditions, which would mean the transition towards ethical behavior as it is presently understood. It is possible that, without the emergence of language, which took place in the last stages of human phylogeny, such traditions could maintain and transmit only very simple codes. But what is known about the origins of language points to the fact that the imperative mode must have had a special importance at that time. It is unnecessary to insist that normative aspects of moral language are closely related to that mode.

Can the process by which moral behaviors appeared be specified beyond this general sketch? Can we maintain that a specific hominid species made the jump forward to carry out and value altruistic actions? Some authors have done so, but by relating moral behavior to certain material indices. For example, Lorenz (1963) recognized the need for establishing emotional relationships linked to moral patterns in the first hominids that made stone tools, to resolve the survival problem posed by the existence of effective killing weapons, behavior at least as aggressive as that of other primates, and absence of the aggression-inhibiting signals found in predators. Lorenz (1963) felt that Australopithecines possessed that capacity. But it is evident that, if *Homo habilis* was the first toolmaker, then this species would be, in accord with Lorenz, the first hominid with a moral sense.

It is impossible to show whether *H. habilis* or any other toolmaker behaved morally; just as impossible as demonstrating it did not do so. But Neanderthal burials suggest certain keys recording pressure of morals. Burying a close relative indicates certain levels of thought that may be related to moral practices. But beside this circumstantial reasoning, given that the tombs preserve the skeletons very well, they constitute an important source of information about the state those beings were at the moment of death. Thus, we may ask how was it possible for such a Neanderthal as the 'old man' from La-Chapelle-aux-Saints to reach such an old age, lacking almost all his teeth. It seems reasonable to suppose he was looked after and fed by other members of his group. The same may be said about the Shanidar I specimen, an adult Neanderthal who died between 30 and 45 years old, and whose remains are very well preserved. Trinkaus (1983) notes that Shanidar I had so many atrophies, malformations, and fractures that it is impossible to think he could have survived so many years with these handicaps if he had not received care from his social group. Day (1986) warns against overestimating the suggestions of mutual help provided by burials. Maybe the few teeth of the old man from La-Chapelle-aux-Saints were enough for him to eat, albeit with difficulty. Perhaps some of the Shanidar deformities had some aesthetic intention (although that would be a different indication of a high cognitive level). But it cannot be denied, in the first place, that Neanderthals of advanced age are numerous in the record and that, also, most of them have important lesions or pathological deformities. The conclusion is that it is necessary to see in these beings an indication of a behavior that, among us, is considered moral.

5.7
Gene–Culture Coevolution

How could such behavior become fixed, phylogenetically speaking? The weight of adaptation in the development of humans' moral behavior has been treated, if not exhaustively, at least with a certain frequency by philosophers, psychologists and, of course, sociobiologists. Campbell (1975, 1983), Durham (1982), and Maxwell (1982), from different theoretical viewpoints, have argued that biological and cultural evolution must be understood in terms of the relations maintained between each other, that is to say, in terms of 'coevolution'. They have all especially emphasized the need to understand the phylogenetic mechanisms in order to better answer some of our current questions. But Lumsden and Wilson have made the most notable contributions to the existing model of coevolution between genes and culture.

Lumsden and Wilson's analysis of the mental process of phylogeny, which, by the way, brought into being the so-called 'second sociobiology', is found in *Genes, Mind and Culture* (Lumsden and Wilson, 1981). The main objective of their work is to establish a model for gene–culture interaction. In *Promethean Fire*, Lumsden and Wilson (1983) insist on these ideas, giving further attention to the species' phylogeny. (We feel that Lumsden and Wilson's model is too convoluted. And, even worse, all their mathematical apparatus may be insufficient for explaining something as complex as human social and mental behaviour. Lewontin, Rose and Kamin (1984) are right in pointing out that the worst feature of naturalist reductionism is its pretence of explaining things, however imprecisely. But in their critique of Lumsden and Wilson (1981) they go too far – it does not seem that *Genes, Mind and Culture* can be characterised as extremely deterministic.)

Lumsden and Wilson present the influence of the genetic endowment on moral behavior (not directly, of course, but as a part of broad social behavior) as something that cannot be expressed in all-or-nothing terms. There is a gradual influence, changing as a function of specific social behavior, which can only be analyzed with probability curves. Confronted with a certain adaptive problem, such as hunting to obtain food, some predator species use highly instinctive strategies, that is, strategies that are mainly genetically controlled. Other species can accumulate 'traditions' that transmit the appropriate techniques from generation to generation.

The biological resources necessary to genetically control very complex strategies are out of the question. Therefore, an elemental parsimonious principle leads us to understand that determination cannot get very far. But a totally free behavior would be surpassed by a kind of behavior for which certain genetic influences limit the necessity for very broad decision-making. Genes and behaviors are entwined by tendencies guiding probable behaviors, following a model originated from Waddington's 'epigenetic valley'.

Let's return to the hunting example. A variety of possible cultural solutions can facilitate hunting antelopes. They range from simple harassment by an individual with empty hands to more complicated cooperative strategies of a whole group possessing sophisticated tools. Lumsden and Wilson (1981, 1983) suggest that, among all those possible and multiple solutions, exist some to which humans will mostly tend, accumulating traditions in that direction. The tendency is genetically controlled, but only in a probabilistic sense: the 'chosen' behavior occurs only if we abide by the laws of the greater number. It is very possible, even frequent, to find individuals who choose other solutions, with less adaptive efficiency, but with enough to maintain a balance between adaptation and genetic resources. As the complexity of cultural strategies increases, the necessary genetic resources to secure them tightly would be immense and utopian. Unfortunately, Lumsden and Wilson's model, despite its formalization via differential equations, barely refers to how the cognitive mechanism that subjects use to analyze problems and apply their probabilistically-driven strategies can be understood. Only a reference to Quillian's (1968) multi-storage memory model is found. However, given that moral behavior is a by-product of means that appeared evolutionarily and turned human knowledge into something very complex, some interesting keys should be found down that direction. Could they be further specified?

The most promising pending task toward developing a coherent naturalism is an analysis of the cognitive mechanisms underlying general human actions (specifically, the interiorization of society's moral codes and the processing of this information in ethical assessment and decision-making). (Krebs (1970) and, later, Trivers (1981) earlier proposed studying cognitive features as a basis for an acceptable model of altruism. Later, Krebs (1978, 1982) developed those ideas, but following black box models like those proposed by Piaget and Kohlberg. We believe we can be more ambitious today, in light of the Churchland's work (Paul Churchland, 1986; Patricia Churchland, 1986).) If we take into account the general features of the process by which specific individuals include themselves in a group, from the different viewpoints explained here, each individual embodies the unique and unrepeatable actualization of information from two different collective sources: on the one hand, the genetic pool in which all the possible combinations are found and in which the individual's specific genetic endowment is a particular subgroup; on the other hand, an ethical pool accumulating as the universe of social values, interiorized as a body of personal values by learning and enculturation.

Neither of these collective groups of information is permanent: both evolve by means of their actualization in different individuals. The process of evolution is complicated and difficult to analyze in detail, because, obviously, any new ethical value originates from an individual's initiative, i.e., an individual's action, but it does not become part of society's moral pool until it is shared by a reasonable number of actors. The relation between an individual and the social response represents a problem similar to that of the incorporation of words and lexical concepts in a language: it has an individual feature and a collective one. Only the interaction between both of them can explain the phenomenon of moral evolution.

If we compare both pools, moral values and genetics, the rate of evolution is very different, of course, but in a structural sense, it is worth taking into account both domains as significant for understanding the way in which these collectives influence the design of a particular individual. Biological naturalism explains how the genetic pool is capable of influencing an individual's moral behavior. But cognitive naturalism, which starting to emerge through models of semantic representation (mainly schemes models), should have much to say on this subject. Given the connections found between the biological substrate and the activity of knowledge production, it seems that advances in ethical naturalism will depend upon advances in knowledge of the human mind.

5.8 Group Selection Reborn

Accepting and following the group's moral codes would be enough to ensure the way to Campbell's ultrasociability. But the reason why humans do that is yet to be explained. If kin selection explains the social evolution of bees, ants, wasps and termites, how do we explain human groups?

The best answer until recently was Trivers' reciprocal altruism model (Trivers, 1971; Trivers, 1983; Trivers, 1985), which follows from the enormous development of game theory. Very succinctly, Trivers claimed that group behavior is based on strategies about predictable behaviors of others: I scratch your back, and you scratch mine. Evidently such a model is effective only in species with a high cognitive development that allows them to elaborate plans for the future. Trivers gave, however, many examples from ethological descriptions of gregarious species. It is also notable that reciprocal altruism is not mutually exclusive with kin selection theory. Among the primates, the way in which members of a horde behave towards a female and her young is very different from how they behave towards other members. Maternity does not seek reciprocities.

With the more relaxed versions of the second sociobiology (like that of Lumsden and Wilson, 1981) and reciprocal altruism, we have moved far from the hard line of biological determination of moral behavior. In this case, a 'universal ethical code' is not appropriate, but a 'universal tendency to accept ethical codes' is. If we accept this viewpoint, the relation between genetic control and moral behavior must be understood, at least in regard to human altruism, in a soft sense. Here we are very close to Neo-Darwinist proposals (Waddington, 1941, for example), suggesting that genes limit their control to establishing mere dispositions towards moral action.

Going beyond these soft proposals is difficult – not because of a lack of speculative models about morality as a mechanism depending on natural selection, but because of the fact that giving valid empirical proof about the evolution of altruistic behavior and about the biological foundations of such a complex behavior is such a tremendous hurdle. In recent years, ethology, sociobiology, and ecology have generated many interpretations explaining social behavior by means of kin selection and reciprocal altruism. Game theory's mathematical support has allowed reaching such elegant and sophisticated models as that of Nowak and Sigmund (1998). Using computer simulations they explain the existence of very subtle social behaviors, based on the advantage brought about by displaying a cooperator appearance to gain the group's appreciation.

In some cases, however, the elegance of models is imposed upon empirical evidence of what is entailed in observed behaviors. Thus, referring to one of the favorite illustrations of altruistic behavior, that of sentinels warning of the presence of predators, Bednekoff (1997) expressed some doubts, pointing out there was insufficient evidence that sentinels were victims of predators more often than the rest of the animals. Clutton-Brock and colleagues (1999), studying the African mongoose *Suricata suricatta*, have confirmed this impression. These animals live in highly social groups of between 3 and 30 members. Their cooperative behavior is efficient and depends on the number of group members: larger groups have fewer victims of predators than do smaller groups. The job of the sentinels is certainly responsible for this adaptive success. However, looking out for predators is not a behavior that depends on either the number of close relatives in the group or on reciprocity. Immigrant members, with no close relatives in the group, do not show a higher or lower tendency to being a lookout, and taking turns in the labor of looking out does not happen, indicating no reciprocal behavior. The only pattern found by Clutton-Brock and colleagues is eating. Satiated animals tend to spend more time as sentries than those who have not eaten enough. None of the sentries observed by Clutton-Brock's team became victims of predators. To the contrary, they managed to escape and hide easily. Although these conclusions cannot be extended to other social species, African mongooses follow behavior patterns explainable by motives of convenience, that is to say, selfishness. If there is no other animal looking out, it is advantageous for a satiated mongoose to become a sentinel.

Some social behaviors seem to be explainable without turning to highly complex models. Darwin's revered idea of individual efficiency is enough. Other behaviors, in contrast, seem to be very complicated and out of reach of simple reciprocity or kinship, as with some primates' 'Machiavellian intelligence' (Byrne and Whiten, 1988). Macaques, chimpanzees, and, obviously, humans, establish highly complex alliances to attain advantages from life in groups. From the standpoint of evolutionary biology, which is the explanatory key to such a complex social behavior? In the first place, it would be difficult to sustain that it is superficial and has no sense in adaptive terms. At least regarding our species, socialization is indispensable for language and brain development. At the risk of falling into extreme adaptationist positions, such a phenomenon is usually considered to depend greatly on genetic information. In this sense, language-learning theories, such as Noam Chomsky's, appear. But if insects' social behavior may be considered as genetically fixed, it is very difficult to determine precisely to what degree our behavior follows those patterns. As stated earlier, the determined genetic tendency to behave altruistically toward other members of our social group is one thing, but the development of ethical codes and laws that have nothing to do with the content of DNA is another, very different thing. But what is still lacking is an explanation of the biological key to the tendency to behave more or less according to a society's moral norms. It could be true that the tendency to act in such a fashion was genetically determined and that it is impossible to explain it with the means we presently have. To better understand the difficulties of trying to reach such an explanation, it is worth discussing a very recent model of human moral and social mechanisms proposed by Wilson and Sober (1994, 1998), who, after examining different attempts to reintroduce group-selection theory into the social sciences, maintain that the group may be considered an important selective unit.

The reasons for rescuing group-selection theory originate from the need of environmental sciences, especially ecology, to explain the laws of evolution of units larger than the pool of genes considered by selfish gene theories. Such a short-sighted view cannot account for ecological phenomena occurring, for example, in a disappearing tropical forest. Here, the aim is not to explain the interactions among the members of an ant colony, but to explain interactions among different groups of animals and plants. Genetic replication laws do not say anything about the development of endangered ecosystems: we need a wider perspective. It is a problem that appears when talking about levels of emergence, that is to say, when it is necessary, in explanatory terms, to pass from physics to chemistry or from chemistry to biology. The present example consists in passing from biology to ecology or even to psychology. In fact, cognitive questions are of great importance, as we shall soon see, in the reappearance of group selection theory.

Wilson and Sober wrote a book, *Unto Others: The Evolution and Psychology of Unselfish Behavior* (1998), in which they try to offer a view of group-selection that is not naïve, i.e., concerning individuals considered as subjects of game theory applied to Darwinian evolution. That means that if individuals belonging to a gregarious species that possesses high cognitive capacities, such as our own species, choose to continue in a group, it is because they find acting in such a way to be beneficial. Individuals are, after all, selfish – in the technical sense that they are willing to maximize their reproductive success – so they must consider that the group offers advantages for individual interests. For Wilson and Sober (1994), individuals recognize adaptations at group level when they are exploited by one of these groups, but when they are protected or when exploitation is not possible due to a particular situation, group-level adaptations are seen as examples of individual interest.

If an individual finds himself in a situation similar to the second or third examples described by Wilson and Sober – being protected individuals or being in situations in which exploitation is not possible – he believes his interests are favored. But now we have encountered a psychological problem. What does it mean that a certain individual *A* considers situation *X* to favor her interests? Subject *A* could make a mistake but in fact she would be acting as if situation *X* were favorable. The true question lies then in knowing how individuals belonging to a group understand what their interests are. This is a very usual perspective in neoclassical economy, which, let us not forget, supplied the mathematical apparatus used by game theory.

According to the studies carried out in this field by Doménech (in press), neoclassical economy states that individuals have desires and beliefs and use available resources to satisfy their desires in accordance with their beliefs. Once we know individuals' beliefs and desires, we can anticipate their actions. If their actions and desires are known, their beliefs can be imagined. If their actions and beliefs are known, we may deduce their desires. Basic knowledge is thus needed to apply the laws of behavior, be they economic, biological, or social. This is so only if we assume that humans act rationally, which is often difficult to argue convincingly. Many psychological studies carried out in the 1970s and 1980s (Cohen, 1972; Rosenhan, 1978; Batson et al., 1981; Hoffman, 1981; Rushton, 1982; Toi and Batson, 1982) have shown that empathic mechanisms often intervene in cooperative behaviors.

Wilson and Sober acknowledge that the psychological motivation of individuals belonging to a group has seldom been studied, but they predict that this will be a fertile research line in the future. In fact, this task has already begun, even though the theoreticians of sociobiology and ethology do not pay much attention to progress made in this field. To give an example, neural correlates of decision making in primates (rhesus monkeys) have already been detected in the posterior parietal cortex and possibly in the prefrontal cortex (Platt and Gimcher, 1999, for example). Even the basic mechanisms of brain functioning intervening in social judgments are beginning to come to light. The team led by Hanna and Antonio Damasio has indicated the role the amygdala plays: brain lesions affecting the amygdala prevent patients from making judgments about the trust they can have in other individuals (Adolphs et al., 1998). This may be due to an incapacity to interpret facially expressed emotions when the amygdala is injured (Adolphs et al., 1994). But despite the promising studies, we must admit that, beyond this basic mechanism of supporting the social role of emotions, we know very little about them. It seems clear that psychological motivation can be very different among different members of the same group. Thus we now have no way out. How can we deduce general laws about altruistic behavior if individuals may be moved by very different motivations?

The recovery of group selection made by Sober and Wilson places us before a true dilemma. It emphasizes the need to know the appropriate cognitive mechanisms required to act altruistically (that is, cooperatively) or selfishly (that is, uncooperatively). We cannot say that we ignore them from the collective viewpoint. Social norms, laws, punishment threats, and police forces are instruments forcing individuals to act in a civilized and cohesive fashion. Punishments are very frequent among social animals of high cognitive level and are used to prevent uncooperative behavior and to protect the reproductive interests of the dominant members of the group. But if we descend to the individual cognitive level, we are immersed in a slippery terrain in which ignorance thrives.

Some critics of Sober and Wilson's work, such as Nunney (1998) have warned of the need to explain the motivation at the individual level if group selection is to be defended beyond speculative questions, given that it is based, ultimately, on individual choices. But motives to act may be so different that the actual feasibility of such a theory is low, unless we turn to alleged universals of a 'human nature'. Thus, we are trapped in the same circle as is neoclassical economy. If we want to predict individual behavior, we must know their desires and beliefs, that is, their motives to act. But these motives can, for the moment, only be deduced from observed behavior. Either we eliminate the cognitive perspective, as with social insects, in which altruistic behavior is forced by the genetic code and follows kin-selection patterns, or we accept that the theory necessary to explain the motives leading to action is at present far from our reach. In the latter case, the only statement we can make regarding group selection is that societies must have mechanisms to identify selfish individuals and means to punish them. Such a general consideration, almost common sense, is admitted by classical group-selection theories without the need for any revival whatsoever.

Many years have passed since the appearance of the first hypotheses about altruistic behavior, and we are still at the same level of explanation – or lack of it – as in the 1960s. Resorting to kin-selection theory, it seems possible to interpret the behavior of hypersocial societies, such as haplodiploid insects, but human behavior escapes those models. On the other hand, group selection is an interesting alternative, but it cannot for the moment go beyond the limits of folk psychology. We need to devote a great deal of effort to research on the cognitive domain to establish a firm-enough foundation to explain individual behavior.

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6
The Evolution of Politics

Peter A. Corning

6.1
Introduction

Aristotle characterized humankind as the distinctively political animal (*zoon politikon*), and political theorists ever since have used Aristotle's evocative term as a touchstone. But what does it mean? And, equally important, how did this trait – if indeed it is distinctive – originate and develop as the human species evolved over several million years, from an arboreal primate ancestor?

Unfortunately, there has never been a consensus even on how to define politics, much less how to explain it. In fact, the cumulative index for the eight-volume *Handbook of Political Science* (Greenstein and Polsby, 1975), the most comprehensive synthesis of political science ever attempted, does not even include a reference for a definition of politics.

Nor is the term 'political evolution' listed in the index.[1] But this is not surprising. It is only within the past 35 years, dating back to the emergence of the so-called biopolitics movement, that a serious effort has been made to account for political behaviors from an evolutionary/biological perspective (see especially Somit, 1968,

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[1] The more recent single-volume compendium, *A New Handbook of Political Science* (Goodin and Klingemann, 1996), represents only a marginal improvement over the original. The editors define politics as the "constrained use of social power", which they acknowledge follows in the tradition of Weber, Lasswell, Dahl, Duverger, and others (p. 7). However, they also concede that the concept is "well known to be a fraught conceptual field". Rather than getting bogged down in this controversy, they opt for the Weberian approach, which stresses the 'nonviolent' power of one person over another – whatever that may mean. (Falling in love may powerfully influence a person's life, but is it politics?) On the other hand, the editors say, unconstrained power (or 'force') is "more the province of physics", or maybe military science (Goodin and Klingemann, 1996, p. 7). Among other shortcomings, this is hardly consistent with the widely accepted claim that the state is defined by its monopoly over the 'legitimate' use of force. Later in the *New Handbook*, moreover, Young (Goodin and Klingemann, 1996, pp. 479–80) tacitly contradicts this definition by invoking Arendt's vision of politics as activities relating to the concerns of the political community – a throwback to Plato and Aristotle (see below). The *New Handbook* also conspicuously fails to mention the relationship between biology and politics or the contributions of the biopolitics movement, much less the concept of political evolution.]

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1976; Corning, 1971, 1974, 1983; Tiger and Fox, 1971; Alexander, 1974, 1979; Masters, 1975, 1983, 1989; Willhoite, 1976, 1981; Wiegele, 1979; Schubert, 1981; White, 1981; de Waal, 1982; and many others.) Traditionally, political theorists either have treated the subject in an ahistorical manner or have traced its roots back only to the classical Greeks (or to some hypothetical state of nature).

Nevertheless, over the course of the past three decades much has been learned – in several different disciplines – that sheds new light on these issues. It may well be that an evolutionary perspective can serve as an arbiter – or, better, a bridge – that can reconcile and integrate the competing schools of political theory. In this chapter, I attempt to point the way toward such a reconciliation. But more important, I review the evidence that political behaviors (as defined here) exist in many other species, and I summarize a causal theory that seeks to explain the evolution of organized political systems, in both nature and humankind. I conclude that the evolutionary roots of our politics and political systems date back several million years.

6.2
Defining Politics

6.2.1
The Idealist Model

We begin with the problem of how to define politics and with the writings of Plato and Aristotle (who in turn may have been inspired by the teachings of Socrates). In his classic dialogue, the *Republic*, Plato proceeded from the core premise that the *polis* (or polity) is fundamentally an economic association; it is very different in character from an amorphous aggregation of individuals who happen to share a common language, territory, or culture and may or may not engage in arms-length exchanges. A polity is characterized by a specialization of roles and a division of labor (or, more precisely, a combination of labor) and, equally important, interdependence with respect to the satisfaction of various needs and wants. As Plato observed:

> A city – or a state – is a response to human needs. No human being is self-sufficient, and all of us have many wants ... Since each person has many wants, many partners and purveyors will be required to furnish them ... Owing to this interchange of services, a multitude of persons will gather and dwell together in what we have come to call the city or the state ... [So] let us construct a city beginning with its origins, keeping in mind that the origin of every real city is human necessity ... [However], we are not all alike. There is a diversity of talents among men; consequently, one man is best suited to one particular occupation and another to another ... We can conclude, then, that production in our city will be more abundant and the products more easily produced and of better quality if each does the work nature [and society] has equipped him to do, at the appropriate time, and is not required to spend time on other occupations ... (Book II, 369, 370b,c, 371c).

In other words, an organized polity, or state, produces mutually beneficial economic synergies; it is quintessentially a collective survival enterprise – a functionally interdependent 'superorganism' (for more on superorganisms, see Corning, 2002a). We will return to this key point later on.

However, this is not the only purpose that the state may serve. Plato went on to argue that it should also strive to attain 'the good life' (in both a material and a moral sense), although he advanced this objective as a continuing quest, not a ready-made formula. Moreover, and this was one of Plato's most profound insights, human nature is inherently at war with itself. There is a double edge to the human psyche. Our 'lower-level' appetites and urges manifestly serve our needs, but they can also become destructive, to both the community and ourselves. As Aristotle (Plato's star student) observed in the *Politics* (1, 2: 1253a, 31 ff.): "Man, when perfected, is the best of animals, but, when separated from law and justice, is the worst of all."

Our prodigious appetites must therefore be constrained by the higher-level dictates of 'reason', along with our social and ethical impulses, and by the collective actions of the community to protect and preserve itself. To Plato, therefore, ethics and justice are not primarily derived from some higher metaphysics. Nor are they reducible to a tug-of-war over our 'rights' as individuals. Social justice is concerned with equitable rewards for the proper exercise of our abilities and our calling, and our conduct, in a network of interdependent economic relationships.

Aristotle, in the *Politics*, supplemented his mentor's views in some important ways. First, Aristotle emphasized that physical security – both external and internal – is also a fundamental function of the state, one of its principle raisons d'être (a point Plato also made later in the *Laws*). The collective survival enterprise is not, therefore, exclusively an economic association. Aristotle also stressed that human nature is not an autonomous agency. It entails a set of innate aptitudes that are uniquely fitted for society and that can only be developed in a network of social relationships. Thus, social life involves more than being simply a marketplace for economic transactions. It also involves a life in common; we are all enriched by it. Indeed, a hermit is not only economically deprived; he or she is not fully human and, equally important, has no evolutionary future. (We will also return to this important point.)

Aristotle also devoted much attention to the fundamental political challenge, well appreciated by Plato, that a society is composed of many different, often competing, interests. Indeed, Aristotle seconded Plato's conclusion that the basic, seemingly inescapable cleavage between the few who are rich and the many who are poor is potentially the most dangerous social division of all and the underlying cause of much civil unrest. The key to preserving any political community, therefore, is to strike a balance between the members' conflicting interests. To this end, the law must be sovereign and must serve as an impartial arbiter – "reason unaffected by desire". Moreover, there must be moral equality before the law. The law cannot be used as a tool to favor the rich and powerful but must be an instrument for achieving social justice, which he defined as "giving every man his due".

Aristotle also discussed the role of government institutions. Recognizing that Plato's proposal in the *Republic* for rule by specially trained, benevolent dictators (philosopher kings) was impracticable, if not dangerous, Aristotle proposed that the best alternative was a mixed state, with elements drawn from a cross section of the community. (Plato himself conceded the point in his later writings.) The state should strive to achieve social justice, not as an end in itself but as an instrument for preserving and even improving society as a stable, self-sufficing community. The objective of the state should be to achieve a balance among various interests and factions, and the ultimate measure of its success in doing so is the willing (uncoerced) consent of the citizenry. Another way of putting it is that politics is ultimately concerned with the overarching interests, problems, and needs of the collective survival enterprise – the public interest.

This paradigm, which has often been termed the idealist view of politics, has many modern echoes. Wolin (1960, pp. 2–3, 10–11) speaks of activities related to or affecting the community as a whole. Deutch (1966, p. 124) calls politics "the dependable coordination of human efforts and expectations for the attainment of the goals of the society". Easton's (1965, p. 21) definition, though a bit ambiguous, is probably the most widely employed by contemporary political scientists. He termed politics the processes through which "values are authoritatively allocated for a society". But perhaps the modern apotheosis of the idealist stance is Arnhart's normatively laden definition in *Dawinian Natural Right* (1998, p. 1): "The ultimate aim of politics is to form the character of human beings to promote some conception of the best life." This is so, Arnhart says, because "every political debate depends fundamentally on opinions about what is good and bad, just and unjust". These moral opinions, Arnhart concludes, express "a universal human nature".

6.2.2
The Realist Model

Unfortunately, many theorists over the years have disputed the claims of the idealists (also referred to as holists). What has been called – at times with a supercilious tone – the realist (and sometimes materialist) view of politics traces its origins back at least to the classical Greeks, including the Sophists, Skeptics, Cynics, and Epicureans (their very names give the game away). These theorists advanced a radically different, individualist definition of the good life and of politics. For them, the claims of the community, and the very concept of a public interest, were rejected as a chimera; the primacy of individual self-interest was posited as the foundation of social life. Justice, according to the character Thrasymachus in Plato's *Republic*, is nothing more than the interest of the stronger.

Typical of this genre was the Epicurean school, which arose when the Greek city-states were in decline. The Epicureans advocated a thoroughgoing materialism and an individualistic pain–pleasure ethic that long predated the social contract theorists, utilitarians, and other conservative modern thinkers. To the Epicureans, individual self-interest is the driving force in humankind, and the 'good life' amounts to nothing more than the satisfaction of our personal appetites and material wants. States are formed primarily to provide security against the depredations of others, and anything beyond this represents, in effect, a set of conditional, contractual arrangements to facilitate our personal self-interests.

In the Epicurean paradigm, moreover, there is no instinctive preference for, or obligation to, society, and justice is solely a matter of expediency. According to the Golden Maxims of Epicurus, the school's founder:

> There never was an absolute justice but only a convention made in mutual intercourse, in whatever region, from time to time ... Whatever in conventional law is attested to be expedient in the needs arising out of mutual intercourse is by nature just, whether the same for all or not, and in case any law is made and does not prove suitable to the expediency of mutual intercourse, then this is no longer just ... For the time being, it was just, so long as we do not trouble ourselves about empty terms but look broadly at facts (quoted in Hicks, 1910, p. 177 ff.).

The Cynic school was even more hostile to the community and the state. Rejecting all social life, all rules of social intercourse or conventions, or even the benefits of learning, the Cynics' attitudes ranged from rugged individualism to utopian anarchism and an idealized communism. The modern libertarian novelist Ayn Rand (much admired in conservative circles) provides us with a high-decibel echo of these ancient theorists. In her two best-selling novels, *The Fountainhead* and *Atlas Shrugged*, Rand's protagonists were defiant individualists:

> Just as life is an end in itself, so every living human being is an end in himself, not the means to the ends or welfare of others – and, therefore, man must live for his own sake, neither sacrificing himself to others nor sacrificing others to himself (Rand, 1962, p 35).

Rand's political philosophy seems paradoxical: "Civilization is the process of setting man free from men" (Rand, 1943, p. 685).

Needless to say, there have been many variations on the realist theme over the past 2000 years. For example, in Niccolò Machiavelli's darkly cynical masterpiece, the *Prince*, politics is portrayed as the pursuit of self-interest clothed in altruistic rhetoric ("who gets what, when, how", in the words of the modern political scientist Harold Lasswell), and political power is often an end in itself. In Machiavelli's view, human nature is incurably selfish, aggressive, and acquisitive. Only the raw power of the state can prevent anarchy. (In the cutthroat political environment of 16th century Italy, there was, unfortunately, much truth to this claim – a point that we will revisit later on.) Indeed, Machiavelli was the very father of the argument that Machiavellian machinations – the use of deception, chicanery and naked force – were necessary if a ruler hoped to obtain his ends (see Sabine, 1961).

Thomas Hobbes, whose outlook was deeply affected by the turmoil of the English civil wars, purveyed an equally dour vision of the political community. If economics is the 'dismal science' (in Carlyle's epithet), Hobbes was the perpetrator of a dismal political science. In the state of nature, Hobbes claimed in the *Leviathan* (1962, p. 161), humans are totally, relentlessly egoistic. "I put for a general inclination of all mankind, a perpetual and restless desire for power after power, that ceaseth only in death." Since all men are more or less equal in strength and cunning, Hobbes asserted, the state of nature is a "war of every man against every man" (ibid., p. 189). Although peaceful cooperation may also be conducive to our self-preservation, fear of punishment is the only reliable way to curb our egoistic behavior. "Covenants without the sword are but words, and of no strength to secure a man at all" (ibid., p. 223). Therefore, the state is primarily an instrumentality for curbing our natural appetites and assuring mutual self-preservation; it amounts to nothing more than a contingent social contract. Furthermore, only an absolute monarchy (a 'leviathan') can be truly effective in preventing anarchy. Hobbes, like the Epicureans, also viewed 'justice' as a meaningless term. It amounts to whatever a person can get and keep, and the good life is merely the sum of our separate self-interests.

The other great English social contract theorist, John Locke, lived in a very different, less turbulent period and pursued a different political agenda. As a self-appointed spokesman for a rising middle class that wanted to curb the power of the monarchy, Locke adopted a sharply contrasting set of assumptions about the state of nature. Whereas Hobbes viewed his fellow men darkly as the slaves of restless, irrational passions, Locke, in his *Two Treatises of Government* (1970), portrayed humankind as fundamentally rational; the state of nature was therefore a condition of peace and mutual aid. Humans are also endowed with certain inherent 'natural rights', especially property rights. Hence societies (and governments) exist to preserve and enhance these rights; in effect, a society is a voluntary association for mutual benefit. According to Locke, the state does not exist to serve some vision of what is good for the community as a whole or some disinterested concept of justice. The state's claims to power are circumscribed by its limited, contractual purpose. If this sounds familiar, it is because the writers of the American Constitution were greatly influenced by Locke's thinking (see Sabine, 1961). As Grady and McGuire (1999) point out, modern constitutions are as much concerned with imposing constraints on the exercise of sovereign power as with any conception of the general welfare.

6.2.3
The Ethological Model

A new chapter in this ancient debate opened with the emergence of the science of ethology in the 1960s. Although the systematic study of animal behavior dates back to Darwin's day – as evidenced in his landmark 1873 book on *The Expression of the Emotions in Man and Animals*, as well as in the pioneering work of the so-called comparative psychologists during the latter 19th and early 20th centuries – many social scientists of the 20th century rejected the evolutionary/biological paradigm as irrelevant to humankind. Human nature was widely assumed to be a tabula rasa that was shaped exclusively by cultural influences. In a famous, much-cited passage, the well-known anthropologist of that era, Ashley Montagu (1949, also 1952, 1955), asserted that, except for a fear of falling and of sudden loud noises, human beings have no instincts.

However, support for this ideologically tainted model began to erode with the publication of various ethologically grounded books by Konrad Lorenz, Nicholas Tinbergen, Desmond Morris, Robert Ardrey, Irenaus Eibl-Eibesfeldt and others, along with the rise of the biopolitics movement in political science and, somewhat later, the founding of sociobiology and evolutionary psychology. (The origins of ethology predated World War II, but only in the 1960s did its contributions become widely known – and debated.) The new debate over the nature of politics and its role in human evolution was initiated by Lionel Tiger and Robin Fox in their provocative popularization, *The Imperial Animal* (1971). What they did, and with a certain relish, was to equate politics in human societies with dominance competition in the natural world. Thus, politics is a world of winners and losers. The political system, they claimed, is synonymous with a 'dominance hierarchy'.

At first glance, it may seem that Tiger and Fox were promoting the Machiavellian vision (seconded by such modern-day theorists has Hans Morgenthau) that politics is essentially a struggle for power. As the character O'Brien put it in Orwell's (1949) masterpiece, the novel *1984*, "power is not a means; it is an end ... the object of power is power". Yet Tiger and Fox also recognized that dominance competition in nature also has a purpose. It is related to competition for scarce resources – nest sites, food, and especially, mates. Tiger and Fox concluded that "the political system is the breeding system". Having thus flagrantly caricatured this ancient term, Tiger and Fox were then forced to concede that politics in human societies serves very different purposes. It is more often associated with leadership, the division of labor and cooperative activities of various kinds. It has become dissociated for the most part from breeding functions (with some notable exceptions, like Genghis Khan). Unfortunately, Tiger and Fox did not bring this crucial distinction into focus. In the end, they left us mainly with a loose analogy.

A more coherent case for the proposition that human politics is related to dominance behaviors in other species was developed in a succession of works by the primatologist Frans de Waal, beginning with his *Chimpanzee Politics: Power and Sex Among Apes* (1982) (see also de Waal, 1989; Harcourt and de Waal, 1992; de Waal, 1996). Drawing on his own extensive research in captive chimpanzees, as well as the many long-term field studies of these animals, de Waal offered a deeper, richer perspective on the issue. The struggle for power and influence is ubiquitous among these animals, he acknowledged. From the animals' motivational perspective, this may well be an end in itself. And, yes, the dominant animals may gain advantages in terms of such things as nesting sites and breeding privileges. But there is much more to dominance behaviors than this. The competition for status very often involves coalitions and alliances; it is often a group process rather than an individualistic, Hobbesian 'war'. Indeed, there is much evidence that social constraints on dominance behaviors are common, in both these and other social animals; coalitions sometimes form to thwart the actions of a dominant animal. And in bonobos (or pygmy chimpanzees), a loose female hierarchy seems to form the organizational backbone of the group; females often band together to constrain an aggressive male (de Waal, 1997). Also relevant is the evidence for what

Boehm (1993, 1997, 1999) calls an egalitarian syndrome in small-scale human societies like hunter–gatherer bands (see also Knauft, 1991).

More important, stable dominance hierarchies in chimpanzees and other social animals also have functional importance for the group – maintaining peace, arbitrating disputes, limiting destructive competition, mobilizing collective action, even defending the group against outside threats. The intense interdependence of social animals like chimpanzees and bonobos also leads to a degree of reciprocity and generosity, such as food sharing. More recent work in chimpanzees, bonobos, orangutans, and other socially organized species also suggests that interpersonal social relationships and interactions can be very complex and that cultural influences may also play an important part (see especially de Waal, 1989, 1996, 1999, 2001). In fact, there may even be a degree of 'democratic' participation in various group decision-making processes (Conradt and Roper, 2003). Nor does one size fit all. The dynamics may differ from one group to the next or even within the same group over time. (In addition to the de Waal references, see also Kummer, 1968, 1971; E. O. Wilson, 1975; Lopez, 1978; Strum, 1987; Dunbar, 1988; Wrangham, 1994; Boesch and Tomasello, 1998; Whiten et al., 1999; van Schaik et al., 2003.)

Frans de Waal (1982, p. 213), invoking Aristotle, concluded that chimpanzees are also political animals: "We should consider it an honour to be classed [along with chimpanzees] as political animals." (For the record, this is also consistent with Aristotle's usage, as Arnhart points out. Aristotle applied the term to any socially organized species that cooperates in jointly pursuing various aspects of the survival enterprise, from honeybees to wild dogs and killer whales. For obvious reasons, Aristotle placed humans at the pinnacle of this category.)

In sum, the ethological model indicates that both the holistic (idealist) model of politics and the egoistic (realist) model have some validity; they are not mutually exclusive. As de Waal (1996, pp. 9, 102) points out, we also need to ask "what's in it for the subordinate?" His answer:

> The advantages of group life can be manifold ... increased chances to find food, defense against predators, and strength in numbers against competitors ... Each member contributes to and benefits from the group, although not necessarily equally or at the same time ... Each society is more than the sum of its parts.

In other words, cooperative social groups may produce mutually beneficial synergies. Again, we will return to this key point.

Accordingly, in the modern version of the ethological model, dominance behaviors may take on the functional attributes of leadership, and a dominance hierarchy may provide a framework for organizing various cooperative activities, including a division (combination) of labor (see Corning, 1983; Masters, 1989; Grady and McGuire, 1999; Rubin, 2002). Such organized 'political systems' are characterized by overarching collective goals, decision making, interpersonal communications, social control processes, and feedback. In short, political systems are cybernetic systems.

6.2.4
The Cybernetic Model

Robert Dahl (1970, p. 8) has written that a definition is in effect "a proposed treaty governing the use of terms". The treaty I have long promoted embraces both idealist and realist models, and much more. It defines politics as being isomorphic with social cybernetics. To be specific: *A political system is the cybernetic aspect, or subsystem of any socially organized, cooperating group or population. Politics in these terms refers to social processes that involve efforts to create or to acquire control over a cybernetic social system, as well as the process of exercising control.* Power, in this definition, is essentially a means, not an end. Moreover, political power can be attained in many different ways, including family inheritance, acquired wealth, seniority, expertise, merit, drawing straws, elections, lethal force, and, yes, the often potent influence of amorous love. Indeed, Gandhi – and many others since – have shown that political power can also be exerted by withholding cooperation or through the use of nonviolent "civil disobedience" (see Schell, 2003).

This definition of politics is not original. The term 'cybernetics' can be traced back to the Greek word *kybernetes,* meaning steersman or helmsman, and it is also the root of such English words as 'governor' and 'government'. In the 19th century, André Ampère took to using the term cybernetics as an equivalent for politics. More recently, the term has been employed by, among others, political scientists Deutsch (1966), Easton (1965), Steinbruner (1974), Corning (1974, 1983, 1987, 1995, 1996a, 2001a, 2002b), Corning and Hines (1988), Miller (1995), and François (1999). The cybernetic model is also widely employed by life scientists, engineers, and physicists, and numerous books and several scientific journals are devoted to this subject.

The single most important property of a cybernetic system is that it is goal-oriented. Consider this problem: When a rat is taught to obtain a food reward by pressing a lever in response to a light signal, the animal learns both the instrumental lever-pressing behavior and how to vary its behavior patterns in accordance with where it is in the cage when the light signal occurs, so that whatever the animal's starting position, the outcome is always the same.

How is the rat able to vary its behavior in precise, 'purposeful' ways so as to produce a constant result? Some behaviorist psychologists of the 20th century promoted a mechanistic model in which environmental cues were said to be modifying the properties of various stimuli that were acting on the animal, thus modifying the animal's behavior in a deterministic way. But this model is implausible. It requires the modifying cues to work with quantitative precision on the animal's nervous system; these cues are hypothetical and have never been elucidated; and most important, this model cannot deal with novel situations in which the animal has had no opportunity to learn modifying cues. A far more economical explanation is that the animal's behavior is 'purposive': the rat varies its behavior in response to immediate environmental feedback in order to achieve an endogenous goal (food), which in this case also involves a learned subgoal (pressing the lever).

The pioneer systems theorist William Powers (1973a) has shown that the behavior of a cybernetic system can be described mathematically in terms of its tendency to oppose an environmental disturbance of an internally controlled quantity. The system operates in such a way that some function of its output quantities is nearly equal and opposite to some function of a disturbance of any of the environmental variables that affect the controlled quantity, with the result that the controlled quantity remains nearly at its zero point. The classic example is a household thermostat. In this model, feedback plays a key role in controlling the behavior of the system. In other words, cybernetic processes are always the result of a system–environment interaction (Figure 6.1).

Needless to say, more complex cybernetic systems are not limited to maintaining any sort of simple, eternally fixed steady state. In a complex system, overarching goals may be maintained (or attained) by means of an array of hierarchically organized subgoals that may be pursued contemporaneously, cyclically, or seriatim. Furthermore, homeostasis shares the stage with homeorhesis (developmental control processes) and even teleogenesis (goal-creating processes). But in all cases, cybernetic systems are goal-oriented.

What is the justification for 'dehumanizing' politics and converting the multifarious real-world processes to an abstract analytical model? One advantage is that it reduces the many particular examples to an underlying set of generic properties that transcend any particular institutional arrangement, not to mention the motivations and perceptions of the actors who are involved. The cybernetic definition is also functionally oriented: It is focused on the processes of goal setting, decision making, communications, and control (including the all-important con-

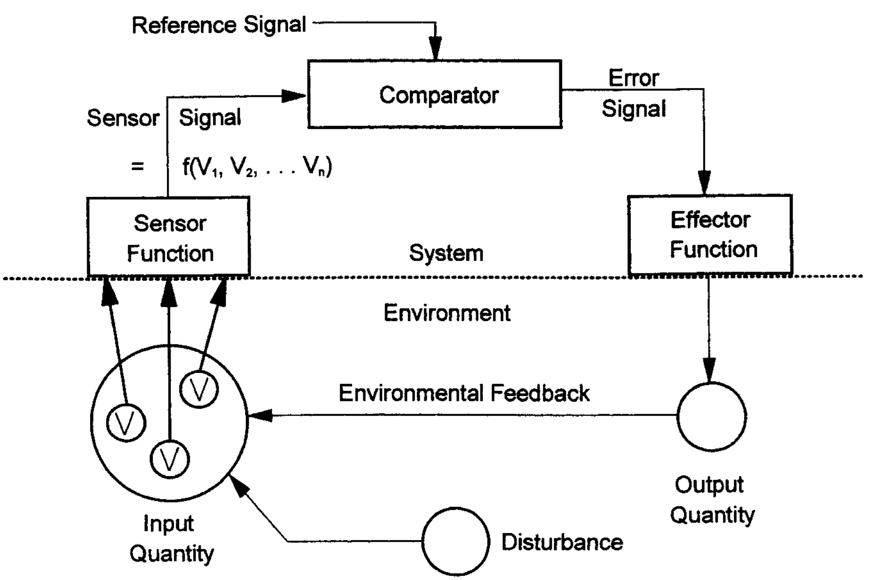

Figure 6.1 A cybernetic control system (from Powers, 1973b).

cept of feedback), which are in fact indispensable requisites for all purposeful social organizations. Indeed, cybernetic regulatory processes exist in families, football teams, business firms, and at all levels of government. To quote Dahl again (1970, p. 1):

> Whether he likes it or not, virtually no one is completely beyond the reach of some kind of political system. A citizen encounters politics in the government of a country, town, school, church, business firm, trade union, club, political party, civic association, and a host of other organizations ... Politics is one of the unavoidable facts of human existence.

However, in the cybernetic model, relationships of "power, rule or authority" (Dahl's definition of politics) are not ultimately ends in themselves but the means to various ends (goals). Moreover, these goals can range from very personal and self-interested – in conformity with the realist model – to public goals that are widely or even universally shared – in accordance with the idealist model. Or, very often, the system may reflect an admixture of personal and public goals. (The synthesis of realist and idealist models proposed here was implicit in my previous renderings of the cybernetic model, but not so clearly stated.) Needless to say, this model also accommodates a range of alternative decision-making processes, from autocratic fiats to head-to-head (zero-sum) competition among various contestants to negotiated decisions, democratic voting processes, or even entirely self-organized voluntary processes (see below).

The relevance of the cybernetic model can be illustrated with another diagram (Figure 6.2). It involves an adaptation of Powers's original generic model to serve as a model specifically for the government of a modern nation-state.

In the cybernetic paradigm, the struggle for power – or 'dominance competition' in the argot of ethology – is relevant and may (or may not) affect the Darwinian fitness of the participants, but this aspect is subsidiary to the role of politics qua cybernetics in the operation of any social system. Equally important, power struggles are a subsidiary aspect of the explanation for why such systems evolve in the first place. Social goals (goals that require the cooperation of two or more actors) and the anticipated or realized functional outcomes are the primary drivers.

Another advantage of this definition is that it enables us to view human politics as one variant among the array of functionally analogous (and sometimes even homologous) cybernetic regulatory processes that are found in all other socially organized species – from bacterial colonies to army ants and wolf packs – and in all known human societies, including by inference our group-living protohominid ancestors of more than 5 million years ago (see below). Although there are great differences among these species, and among human societies, in how political/cybernetic processes are organized and maintained, both the similarities and the differences are illuminating. They are variations on a common theme.

Thus, a cybernetic definition of politics is grounded in a biological – and functional – perspective and is related, ultimately, to the biological problem of survival and reproduction in and for organized societies. Politics in these terms can be viewed as an evolved phenomenon that has played a significant functional role in

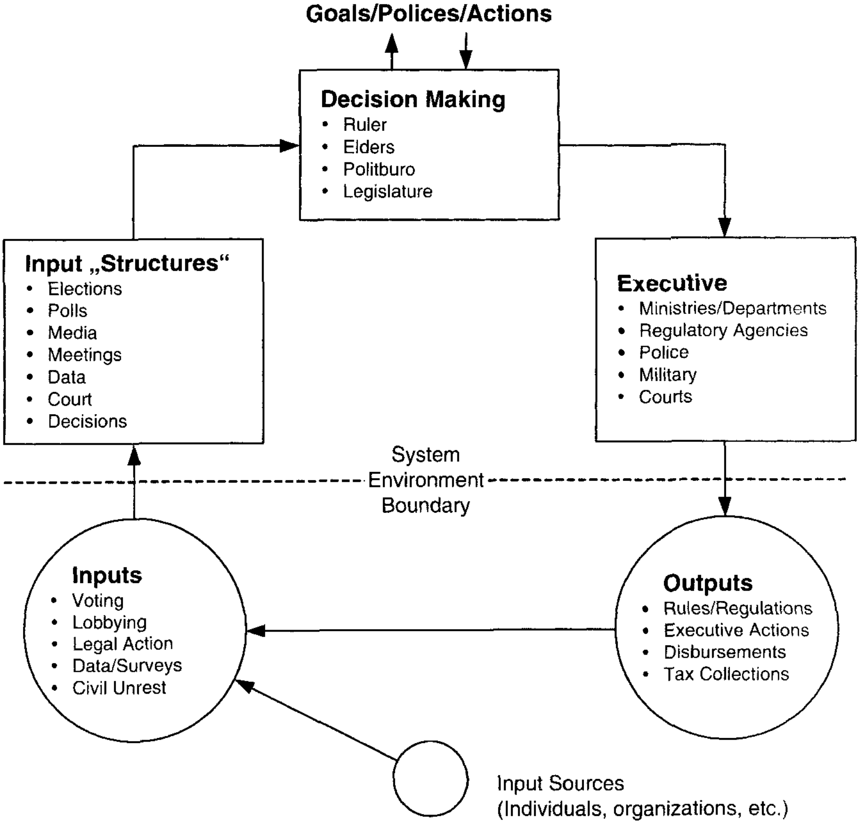

Figure 6.2 A cybernetic model of a modern political system.

the evolutionary process; political evolution has been inextricably linked to the synergies that have inspired the 'progressive' evolution of complex social systems – in nature and human societies alike. Not only is the cybernetic model compatible with both realist and idealist models (and the modern ethological model) but it fully conforms with Aristotle's (and Plato's) enduring vision.

6.3 Theories of Politics

6.3.1 Human (and Animal) Nature in Politics

Many of the most famous theories of politics over the past 2000-plus years were derived from rather simplistic (and often one-sided) assumptions about the basic propensities of human nature. We noted earlier how the realist model was/is based on the claim that egoism and the pursuit of naked self-interest has energized and shaped the evolution of politics. The most extreme rendering of this viewpoint was encapsulated in Hobbes's image of the state of nature (i.e., without the constraining influence of 'leviathan') as a war of every man against every man. (In fact, recent research in behavioral economics, evolutionary psychology, and other fields has challenged this assumption. Human nature is far more complex. (More on this below.)

We should note that, although Machiavelli is often lumped together with Hobbes, his views were actually more complex. As Sabine (1961) pointed out many years ago, there are really two Machiavellis, or rather two sides to his political theory. Most famous are his writings in the *Prince*, which were concerned with how a ruler must cope with a corrupt, anarchic, and perhaps revolutionary society. The other side, articulated in other writings, had to do with how to govern a stable society. Here Machiavelli borrowed ideas from Aristotle, Polybius, Cicero, and others.

The other extreme view of human nature was perhaps most boldly articulated in the writings of one of the other great social contract theorists, Jean Jacques Rousseau, whose 18th-century publications, especially the *Discours sur l'inégalité* and *Du Contrat Social*, were grounded in his deeply rooted conviction that man is innately good. In the state of nature, Rousseau claimed, humankind enjoyed a natural morality and lived the idyllic life of a 'noble savage'. Humans are also innately social and are 'completed' by their social relationships. Hence, society is fundamentally social rather than contractual in nature; it originated in the state of nature.

Accordingly, society is prior to civil government, and the state should serve only to further what he called the general will (*volonté générale*) – the good of the community. For Rousseau, it is the corrupting influence of civilization, and especially the unbridled pursuit of selfish material interests, that has turned us into the calculating, rapacious egoists described by Hobbes. The insatiable lust for property that civilization induces has perverted us and led to the enslavement of the masses of humankind. In sharp contrast with Locke, Rousseau concluded that all rights, including property rights, exist only within the community; they have no prior claim: "The right which each individual has to his own estate is always subordinate to the right which the community has over all." Rousseau passionately believed in human freedom, but the dark side of his vision, as many critics have pointed out, is that, in elevating the will of the community (the collective good) to a superordinate claim to power, it could be used as a justification for authoritarian or even totalitarian regimes. (Indeed, Robespierre, Lenin, Mao, and Hitler, among others, did just that.)

By contrast, Plato and Aristotle – notwithstanding the 'idealist' label that some opponents have pinned on them – occupied a middle ground between the extreme individualist and radical collectivist visions of human nature and politics. As noted above, Plato and Aristotle recognized that an organized society is based on a division (combination) of labor and various forms of collective action to satisfy human needs and wants. It represents a network of cybernetic systems, from families to factories, markets, and perhaps multiple layers of government. Aristotle's famous observation in the *Metaphysics* (Book, H., 1045: 8–10) says it all: "The whole is something over and above its parts, and not just the sum of them all." To reiterate, a society can be characterized as a collective survival enterprise – an interdependent 'superorganism' that produces mutually beneficial synergies; it is organized to provide for our basic survival and reproductive needs. (For an in-depth discussion of 'basic needs' as an empirically grounded concept, along with an explication of the Survival Indicators project, see Corning, 2000.)

However, Plato and Aristotle were also well aware of the fact that there is an inherent tension between the public interest and the sometimes destructive self-interests of various individuals and factions. Societies are not, unfortunately, self-equilibrating. (This is precisely why the concept of social justice played such an important part in their political thought.) Accordingly, there is no standard model to which all governments conform. In practice, Plato and Aristotle argued, governments can range from a highly exploitative tyranny to a top-heavy oligarchy, mixed democracy, or anarchic mob rule. Needless to say, this profoundly important distinction between different types of government – and their political biases – has been overwhelmingly confirmed in the past 2000 years of political history. (The research on politics in primates, especially the great apes, documented by de Waal and many other primatologists, also provides supporting evidence.)

6.3.2
Neo-Darwinism, Sociobiology, and Political Theory

A word is also in order about the influence on political theory of Neo-Darwinism and sociobiology (and lately, evolutionary psychology). The Neo-Darwinian approach to social behavior is based on a radically individualist model – epitomized by Dawkins's (1989) 'selfish gene' metaphor. The core assumptions are that the individual organism is the basic unit of survival and reproduction (genetic self-interest is the driver), and that cooperation and sociality are constrained to be consistent with the reproductive interests of the participants. Thus, Neo-Darwinism is a spiritual cousin of Hobbes and Locke (and of the neoclassical economists).

However, as originally formulated, Neo-Darwinism (and sociobiology) seemed to offer little in the way of a theoretical basis for social life. In his seminal papers on the genetic evolution of social behavior, William Hamilton (1964a, b), identified only three possible categories of social behavior: (1) altruism, (2) exploitative (zero-sum) selfishness, and (3) spite. Only later did he add reciprocity. Accordingly, Hamilton initially equated social cooperation with altruism, which made it appear to be a very problematic phenomenon.

Hamilton's truncated formulation was seconded by E. O. Wilson in his discipline-defining volume *Sociobiology: The New Synthesis* (1975), where he identified altruism as the central theoretical problem of sociobiology (p. 3). The implication, which guided much of the early theory and research in sociobiology, was that cooperative behaviors are a theoretical 'problem' that can be overcome only under exceptional circumstances. Since the differential selection of altruistic groups was considered to be highly improbable – in the wake of Williams's (1966) widely accepted critique of group-selection theory – this left mainly Hamilton's model of 'inclusive fitness' (or what John Maynard Smith called kin selection) to account for social behavior in the natural world.

The basic idea, which actually traces back to Darwin's concept of family selection, is that altruism (sociality) might be a viable option if an individual's genetic self-sacrifices were offset by gains to close kin that shared many or most of their genes in common. Early on, the only other theoretical 'window' for social behavior was Robert Trivers's (1971) concept of reciprocal altruism – which, on close scrutiny, was not really altruism but a mutually advantageous reciprocity with a delayed repayment schedule. (For a more in-depth analysis of this issue, see Corning, 1983, 1997, 2003.)

Gary R. Johnson (1992) relied on this constricted theoretical framework in advancing a sociobiological explanation for the origin of human polities. Politics, in Johnson's view, is derived from reproductive competition (shades of Tiger and Fox). Moreover, its role in furthering cooperative efforts was seen by him as secondary, as a causal explanation for government, to the containment of individual conflicts (shades of Hobbes). Johnson also adopted the sociobiological assumption that there are only three grounds for social organization, all of them rooted in individual reproductive interests, namely, altruism (or nepotism toward closely related individuals), reciprocity, and exploitation. Nepotistic kin selection, he concluded, was the primary force responsible for the emergence of societies and political systems among evolving humans.

As we shall see, kin selection/inclusive fitness (that is, reproductive self-interest) may very well have facilitated some of the earliest steps in hominid social evolution (as Darwin himself supposed). However, kin selection is neither a *sufficient* explanation nor is it even necessary as a precondition for cooperation, and it certainly cannot be called a force. Reproductive self-interest is universal in nature and always imposes a constraint on social behavior. So the question is, why have some species exploited various modes of cooperative behavior while others have not? In many species, in fact, close kin do not cooperate at all. Conversely, there are a great many examples of cooperation in nature that do not involve closely related individuals (see Corning, 1996b, 1997, 2003, and references therein). Also, there are many species that engage in symbiotic partnerships with altogether different species, in total disregard for their biological relatedness. For that matter, kinship is often irrelevant in human cooperation. Thus, something more than kinship is required to explain social life.

Part of the answer to this paradox derives from the growing realization, backed by a large body of research, that cooperation is not equivalent to altruism (there can be egoistic cooperation as well as altruistic cooperation) and therefore does not depend on genetic relatedness. In fact, much of the cooperation in the natural world is based on reciprocities and win–win mutualism (see Corning, 1996b, 1997, 2003). Cooperation can more fruitfully be viewed in economic terms – in terms of costs and benefits – rather than in terms of genetic relationships (or lack thereof).

One source of support for this proposition comes from the rapidly expanding literature in game theory. First introduced into evolutionary biology by Maynard Smith (1982a, 1984), game theory models of cooperation are distinctive in being totally indifferent to the genetic relationships among the 'players'. The key to cooperation in game theory models is, in fact, the synergy – the 'economic' gains that are assigned to the payoff matrices, though various steps may also be required to prevent defection, or cheating. Thus, in the famous tit-for-tat (or iterative) model of Axelrod and Hamilton (1981), only 1 point each was allowed for mutual defection, whereas asymmetrical cooperation yielded 5 points for the defector and none for the cooperator, and mutual cooperation yielded 6 points, evenly divided. Since defectors would be penalized by mutual defection in the next round, after two rounds the mutual cooperators would out-gain a defector.

Likewise, in the model developed by Novak and Sigmund (1993), called 'Pavlov', the players could in effect punish cheaters by excluding them from future rounds in the game. As it turns out, Pavlov (and similar models developed since) conform well with the reality in nature. It is now recognized that 'policing' of cooperation and punishment of cheaters is common and that cooperation is not so constrained by the threat of cheating as early game theory models implied (see especially Boyd and Richerson, 1992; Clutton-Brock and Parker, 1995; Frank, 1995, 1996; Michod, 1996, 1999).

Another major source of support for the economic model of cooperation comes from the realization that some of the most important forms of collaboration in nature involve interactions that produce combined effects (synergies) that are self-policing because they are interdependent. This frequently occurs in symbiotic partnerships, where each participant contributes different capabilities or resources, and in species like humans that depend on a division/combination of labor.

Maynard Smith and Szathmáry (1995) suggested a useful metaphor to illustrate this distinction. Suppose that two oarsmen decide to cooperate in rowing a small boat across a river. In one alternative configuration, a sculling arrangement, the oarsmen each have two oars and row in tandem. In this situation, it is possible for one oarsman to slack off (to cheat) and let the other one do most of the work. This represents the classical game theory relationship. Now imagine instead a rowing arrangement. In this configuration, each oarsman has only one opposing oar, and their relationship to the performance of the boat is interdependent. If one of the oarsmen slacks off, the boat will go in circles and will not reach its goal.

Thus, functional interdependence may have the effect of making a cooperative relationship self-policing. Maynard Smith and Szathmáry (1995, p. 261) conclude that the rowing model is a better representation of how cooperation (and complexity) evolves in nature than are game theory models of arms-length exchanges. "The intellectual fascination of the Prisoner's Dilemma game may have led us to overestimate its evolutionary importance." (We will return to this crucial point below.)

Closely related to this is the fact that existing game theory models exclude one of the most common forms of cooperation in animal and human societies alike, namely, teamwork that produces what I call 'corporate goods'. In the corporate goods model (which can include any number of players), the participants may contribute in many different ways to a joint product (say the capture of a large game animal or the manufacture and sale of an automobile). However, unlike 'collective goods' that are indivisible and must be equally shared (possibly even with nonparticipants and cheaters), corporate goods can be divided in accordance with various principles, or rules, or contracts. The division of the spoils is thus not preordained, as is true of the payoffs in game theory models; the payoff matrix can be manipulated. Indeed, the question of how the goods are divided up may be crucially important in determining if the game will be played at all. If this sounds familiar, even commonplace, it is because corporate goods games are, in fact, ubiquitous in human societies. Yet, surprisingly enough, this phenomenon has not been treated systematically in either sociobiology (evolutionary psychology) or game theory, to my knowledge.

Some other problems with the conventional game theory paradigm – and with Neo-Darwinism – should also be noted. For instance, there are many examples in nature in which the alternative to a win–win cooperative effort is not zero (the lowest possible value in a game theory payoff matrix) but death. If you were a small animal faced with the prospect of confronting a large predator, cooperative defense might be the only logical choice. Cheating would be self-defeating. Another problem is that game theory models have not as a rule dealt with multiple interests, where cooperation in one area – say mutual grooming – may also affect cooperation in other areas, like hunting, meat sharing, coalition building, or mutual defense. Nor does game theory capture the sometimes complex interplay between the costs and benefits associated with various choices or strategies.

A further problem, inherent in the game theory paradigm and in Neo-Darwinism generally, is that it is particularly insensitive to synergies of scale – the many examples in which collective action produces combined effects that would not otherwise be possible. Lee Dugatkin (1999) cites an example (based on research by Susan Foster) involving the collective behavior of the wrasse, a tropical reef fish that preys on the abundant supply of eggs produced by the much larger sergeant-major damselfish. Because female damselfish aggressively defend their nests, no single wrasse, or even a small group, can overwhelm the damselfish's defenses. However, very large groups can do so and are rewarded with a gourmet meal of damselfish caviar. Since success in raiding a damselfish's nest can only be achieved by a large group of wrasse acting in concert, it is an unambiguous example of a synergy of scale. Dugatkin calls this byproduct mutualism (an incidental byproduct of individual actions), but this is a misnomer. If an animal only engages in a dangerous activity (like mobbing a predator) in concert with other animals and reliably chooses flight when it is alone, such collective behaviors are not simply statistical artifacts.

One other mode of cooperation in the natural world should also be mentioned, namely reciprocity. One well-studied form of this behavior is called indirect reciprocity. It involves a class of cooperative actions that do not seem to have any relationship at all to reproductive fitness. For instance, helping behaviors among unrelated individuals – say meerkat 'babysitters' or the 'helpers at the nest' in various bird species – appear to be an evolutionary puzzle. What do the helpers gain from this? Some years ago, Alexander (1987) developed the concept of indirect reciprocity as a possible explanation. Alexander's argument was that, in a stable ongoing network of cooperators, a donor might ultimately receive a fair return indirectly for a helping behavior if it later became the recipient of some other member's generosity. It amounted to a formalization of the old expression "what goes around comes around".

Much more thought and analysis has been devoted to this phenomenon in recent years, and the consensus seems to be that indirect reciprocity may well be a factor in sustaining socially organized species, independent of kinship (see especially Boyd and Richerson, 1989; Mumme et al., 1989; Mesterton-Gibbons and Dugatkin, 1992; Nowak and Sigmund, 1998a, b; Gintis, 2000a, b; Clutton-Brock et al., 2001; Clutton-Brock, 2002). Significantly, this phenomenon seems to occur under the conditions that, most likely, also characterized the evolution of the human species (see below).

Also important is the work by Gintis (2000a, b), Fehr and Gächter (2000a, b, 2002), Sethi and Somanathan (2001), Fehr et al. (2002) and others on 'strong reciprocity' as a cooperation-enhancing mechanism. As the term implies, strong reciprocity is cooperation that is egoistic, not altruistic and is therefore dependent on an equitable distribution of the benefits (i.e. corporate goods), as well as on aggressive punishment to prevent cheating or defection. Closely related to this is the expanding body of work on 'fairness' as a facilitator of cooperation in humankind (see especially Corning, 2002c; also Rabin, 1993; Fehr and Schmidt, 1999; Fehr and Gächter, 2000a, b, 2002; Henrich and Boyd, 2001; Henrich et al., 2001; Price et al., 2002). Also important is the work by Boyd and Richerson (2002) and others on the role of group-serving norms in securing cooperation.[2]

Finally, the recent revival of group selection theory should be mentioned because, among other things, this phenomenon is particularly relevant to the explanation of human evolution and the evolution of human political systems (see below). Very briefly, the widespread opposition to group selection theory was largely due to the theoretical misperception described above. If social cooperation is presumed to require altruism, then it would seem improbable that cooperating (altruistic) groups composed of non-kin could be favored by natural selection. However, if much (perhaps most) of the cooperation in nature involves reciprocity or mutualism – where all the participants are likely to benefit – the theoretical obstacle to group selection dissolves. David Sloan Wilson, who has been most closely associated with the resurrection of group selection theory in recent years, likes to call it 'trait group' selection (see especially D. S. Wilson, 1975, 1980, 1999; Wilson and

2 The scientific evidence that a norm of fairness and reciprocity is a universal aspect of human nature can fairly be called robust and continues to grow. Indeed, fairness is a day-in, day-out issue in any society. (It is found in virtually every society, and the few pathological exceptions seem to prove the rule.) There is also a large experimental literature on this phenomenon in psychology, game theory and experimental economics. Most noteworthy, perhaps, are the so-called "ultimatum games", an experimental paradigm which has been used (repeatedly) to demonstrate that people are willing to share with others in ways that do not reflect their own "rational" self-interest but reflect instead a sense of fairness. Equally important, it appears that people are far more willing to invest in policing fairness and punishing deviants than classical economic theory predicts. There are even some rudimentary examples of a sense of fairness in other species – the most conspicuous being sharing behaviors and reciprocity. To be sure, we also have a tendency to rationalize fairness away when it suits our interests. And, in the real world, power (and greed) often trumps fairness.

Sober, 1989, 1994; Sober and Wilson, 1998). Maynard Smith (1982b) developed a similar model, which he called 'synergistic selection'. I refer to it as Holistic Darwinism (Corning, 1997, 2003, in press), because it implies that selection can act on wholes that have irreducible functional properties. These wholes are not only greater than the sum of their parts but their 'wholeness' may be the difference that makes a difference (to use anthropologist Gregory Bateson's mantra) to natural selection.

We can illustrate the idea of group selection with a variation on the sculling and rowing models described earlier. Recall that in the sculling model, one of the two tandem oarsmen could defect (cheat) without undermining the attainment of their joint objective. Of course, this is a hypothetical situation. In the real world of small boating, a high wind, a strong current, or a distant goal might demand the combined efforts of both oarsmen. But now imagine a very different situation, where the boat is in a race against another boat. If the two oarsmen want to win the race they most likely have to make an all-out effort. It has become a group selection game, and the fate of the two oarsmen is totally interdependent, even if they are rowing in tandem.

As an aside, I might point out that Dawkins himself acknowledged the role of group selection in one of the less-frequently quoted passages of *The Selfish Gene* (1989, p. 39). The genes are not really free and independent agents, he explained. "They collaborate and interact in inextricably complex ways ... Building a leg is a multi-gene, cooperative enterprise." To underscore the point, Dawkins himself employed a metaphor from rowing: "One oarsman on his own cannot win the Oxford and Cambridge boat race. He needs eight colleagues ... Rowing the boat is a cooperative venture" (ibid., p. 40). Furthermore: "One of the qualities of a good oarsman is teamwork, the ability to fit in and cooperate with the rest of the crew" (ibid., p. 41). In other words, a group selection game creates a 'public interest'.

6.3.3
The Synergism Hypothesis

The liberation of sociobiology and evolutionary psychology – not to mention social theory in general – from the constraints of inclusive fitness theory have created a climate in which the synergism hypothesis – a causal theory of sociopolitical evolution that is focused on the 'bioeconomics' of the process (the phenotype) rather than on the genes – can now flourish. (Although this theory was first proposed in 1983, the theoretical climate was not then propitious.)

The synergism hypothesis is based on a fundamental characteristic of the material world, namely, that things in various combinations – sometimes with others of like kind and sometimes with very different kinds of things – have been a prodigious wellspring of evolutionary novelties. Moreover, these novel cooperative effects have over the past 3.5 billion years or so produced at every level of life distinct, irreducible 'higher levels' of causation and action whose constituent 'parts' have been extravagantly favored by natural selection. Indeed, in many instances these 'wholes' have themselves become parts of yet another new level of combined effects as synergy begat more synergy.

The formal hypothesis is that synergistic effects of various kinds have been a major causal agency and a key source of creativity in biological evolution (see Corning 1983, 1998, 2003). The synergism hypothesis posits that the functional (selective) advantages associated with various forms of synergy have undergirded the evolution of complex, functionally organized biological and social systems. In other words, underlying each of the many particular steps in the 'complexification' process, a common functional principle has been at work.

Evolutionists often speak metaphorically about natural selection (as did Darwin himself) as if it were an active selecting agency, or literally a mechanism. Thus, Edward O. Wilson (1975, p. 67) assures us that "natural selection is the agent that molds virtually all of the characters of species". Ernst Mayr (1976, p. 365) tells us that "natural selection does its best to favor the production of programs guaranteeing behavior that increases fitness". And George Gaylord Simpson (1967, p. 219) asserted that "the mechanism of adaptation is natural selection". The problem is that natural selection does not do anything; nothing is ever actively selected (although sexual selection and predator–prey interactions are possible exceptions). Natural selection refers to whatever factors are responsible in a given context for causing the differential survival and reproduction of genes, or genic 'interaction systems' (in Sewall Wright's term), or genomes, or phenotypes, or populations, or species. It is the functional effects produced by various units of selection that matter. Indeed, evolutionary causation is actually iterative; it also runs backwards from our conventional notion of cause and effect. In evolution, functional effects are also causes.

Evolutionists have traditionally tended to focus their research efforts on a particular factor or selection pressure, or on the functional properties of a gene. This has proven to be a useful heuristic device, but in fact the dynamics of evolutionary causation are always interactional, relational, and iterative. To cite a textbook example, genetically based differences between the light, cryptic strain of the peppered moth (*Biston betularia*) and the darker, melanic strain (*carbonaria*) played a role in the documented change in their relative frequencies in the English countryside during the Industrial Revolution. But the color differences between these strains became significant only because industrial soot progressively blackened the lichen-encrusted tree trunks that were the moths' favored resting places. Moreover, this change in background coloration was significant only because the moths were subject to avian predators that used a visual detection system – as opposed, say, to the sonar systems used by bats (Kettlewell, 1955, 1973). In other words, the mechanism that was responsible for this microevolutionary change was the relationships among genetically determined traits, the background color of the trees, the behavior of the moths, and the nature of their predators.

Accordingly, any factor that precipitates a change in functional relationships – that is, in the viability and reproductive potential of an organism or the pattern of organism–environment interactions – represents a potential cause of evolutionary change. It could be a functionally significant gene mutation, a chromosome rearrangement, a change in the physical environment, or, most significant for our purpose here, a change in behavior. In fact, a sequence of changes may ripple through an entire pattern of relationships: a climate change might alter the ecology, which might induce a behavioral shift to a new environment, which might lead to changes in nutritional habits, which might precipitate changes in the interactions among different species, resulting, ultimately, in the selection of morphological changes. A well documented case in point is the long-term study in the Galápagos Islands of 13 different species of birds, known as Darwin's finches, that recently diverged from a common mainland ancestor (Grant, 1986; Grant and Grant, 1989, 2002).

What, then, are the sources of creativity in evolution? There are many different kinds, but the role of behavioral changes as a 'pacemaker' of evolutionary change should be emphasized. To quote Mayr (1960, pp. 373, 377–378):

> A shift to a new niche or adaptive zone requires, almost without exception, a change in behavior ... It is very often the new habit which sets up the selection pressure that shifts the mean of the curve of structural [and he might have added functional] variation ... With habitat selection playing a major role in the shift into new adaptive zones and with habitat selection being a behavioral phenomenon, the importance of behavior in initiating new evolutionary events is self-evident ... Changes of evolutionary significance are rarely, except on the cellular level, the direct result of mutation pressure.

However, this model also begs the question: What causes behavioral changes? Although this is obviously a very complicated subject, one important underlying principle can be identified. In fact, behavioral changes often involve a proximate causal mechanism – the immediate rewards and reinforcements that Thorndike (1965) associated with his famous Law of Effect, which forms the backbone of behaviorist psychology. At the behavioral level, in other words, there is a proximate selective process at work that is analogous to natural selection. I call it Neo-Lamarckian selection. Moreover, this mechanism is very frequently the initiating cause of the ultimate changes associated with natural selection (see Corning, 1983, 2003; also Skinner, 1981; Bateson, 1988; Plotkin, 1988).

One example of this mechanism is the evolution of giraffes, which is frequently cited in elementary biology textbooks as an illustration of the distinction between Lamarckian and Darwinian evolution. Evolutionists like to point out that the long necks of modern giraffes are *not* the product of stretching behaviors that were somehow incorporated into the genes of their short-necked ancestors (as Lamarck supposed). Instead, natural selection favored longer-necked giraffes once they had adopted the habit of eating tree leaves. And that is the point. A change in the organism–environment relationship among ancestral giraffes, occasioned by the adoption of a novel behavior, precipitated a new selection pressure for morphological change. (So Lamarck was half right.) This example of adaptionist theorizing is also supported by the fact that there happens to be a short-necked species of Giraffidae called the okapi (*Okapia johnstoni*) in Africa that inhabits a very different environment from that of the prototypical giraffe (woodlands) and, as expected, employs a very different feeding strategy.

This is where the phenomenon of functional synergy fits into the picture. It is the immediate functional payoffs from synergistic innovations in specific environmental contexts that are the causes of the biological/behavioral/cultural changes that, in turn, have led to synergistic longer-term evolutionary changes in the direction of greater complexity, both biological and cultural/technological.

Consider these two illustrations, one in bacteria and the other in a complex human society. Among the many examples of a division (combination) of labor found in nature, one of the most remarkable involves *Anabaena*, a colonial cyanobacterium that engages in both nitrogen fixation and photosynthesis, a dual capability that gives it a significant functional advantage. However, these two processes happen to be chemically incompatible; the oxygen produced by photosynthesis inactivates the nitrogenase required for nitrogen fixation. *Anabaena* has solved this problem by complexifying. When nitrogen is abundant in the environment, the cells are all uniform in character. However, when ambient nitrogen levels are low, specialized cells called heterocysts are developed which lack chlorophyll but are able to synthesize nitrogenase. The heterocysts are then connected to the primary photosynthesizing cells by filaments. Thus, a compartmentalization and specialization of functions exists which benefits the whole (Shapiro, 1988).

The second illustration involves a well-known example from Adam Smith's *The Wealth of Nations* (1964). Smith drew a comparison between the transport of goods overland from London to Edinburgh in broad-wheeled wagons and the use of sailing ships between London and Leith, the seaport that serves Edinburgh. In six weeks, two men and eight horses could haul about four tons of goods to Edinburgh and back. In the same amount of time, a merchant ship with a crew of six or eight men could carry 200 tons to Leith, an amount that, in overland transport, would require 50 wagons, 100 men, and 400 horses.

The advantages of shipborne commerce in this situation are obvious. Indeed, shipment over water has almost always been an economically advantageous form of long-distance transport, as many different societies have discovered. But the causal explanation for Smith's paradigmatic example is not so straightforward as it might appear. In part, it entailed a division of labor and the merging of an array of different human skills; in part it required the fairly sophisticated technology of late 18th-century sailing vessels; it also required the capital needed to finance the construction of the ships; it required a government that permitted and encouraged private enterprise and shipborne commerce (including the protection afforded by the British navy); it also required a market economy and the medium of money; in addition, it required an unobtrusive environmental factor, namely, an ecological opportunity for waterborne commerce between two human settlements located (not coincidentally) near navigable waterways with suitable tidal currents and prevailing winds.

In other words, the causal matrix involved a synergistic configuration of factors that worked together to produce a favorable result. And the result – which played an important role in the rise of the British Empire – represented a significant step in the ongoing process of societal evolution. However, I should also emphasize that, if any major ingredient were to be removed from the recipe, the result would not have occurred. If you were to take away, say, the important component technology of iron smelting, there would have been no ocean-going merchant ships. Thus synergistic causation is always configural, relational, and interdependent; the outcomes are always codetermined. (The synergism hypothesis is discussed in much greater detail in Corning, 1983, 2003.)

6.3.4
Explaining Political Evolution

How, then, do we account for the evolution of political systems, both historically and in the often puzzling contemporary cases? In *The Synergism Hypothesis* (Corning, 1983), a chapter was devoted to what was called an 'interactional paradigm' (which was really a synthesis of various interdisciplinary paradigms that have been put forward over the past few decades). Here I can only provide a sketch of that causal framework. In brief, the pattern of causation in something as complex and variegated as the evolution of human societies requires a framework that is multidisciplinary, multileveled, 'configural' (or relational), functional, and cybernetic. It involves geophysical factors, biological and ecological factors, an array of biologically based human needs, and many derivative psychological and cultural influences, as well as organized economic activities, technology (broadly defined) and, of course, political processes, all of which interact with one another in a path-dependent, cumulative historical flux (Figure 6.3).

This framework compels us to focus explicitly on the many *codetermining* factors that, in each example, interact synergistically, rather than singling out some mono-

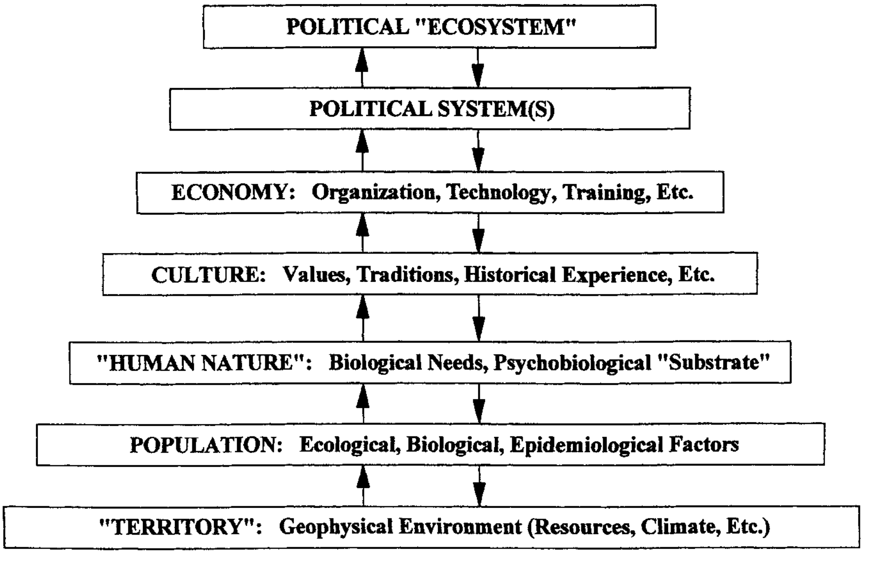

Figure 6.3 The interactional paradigm.

lithic causal variable that is ultimately destined to fall short. Also, it requires recognition that the process of political evolution is always situation-specific, even when there may be invariances and recurrent patterns of covariance within the total configuration of factors. (The development of the new fields of evolutionary economics and bioeconomics over the past decade or so have introduced a similar perspective into economic theory.)

Some of these variables are obvious to political scientists. They involve the staples of conventional political analyses. But other variables are not always appreciated or may even be treated as a given. One case in point is fresh water resources, which have played a key role (necessary but not sufficient) in codetermining both the locations and the rise and decline of various civilizations – not to mention the conflicts between them. Thus, recent research has indicated that a major climate change most likely precipitated the sudden collapse of the Akkadian empire in ancient Mesopotamia about 2200 BC and possibly the disappearance of some other early civilizations as well (Weiss et al., 1993; Weiss, 1996, 2000; Weiss and Bradley, 2001). I refer to this phenomenon as 'synergy minus one'.

Two examples may suffice to illustrate the synergistic nature of such evolutionary changes and the integral role of politics. The rise of the Zulu nation in the 19th century provides an instructive example of the interplay of among environmental, technological, and political factors (Gluckman, 1940, 1969; Morris, 1965). Until the early 1800s, the people of mainly Bantu origin that inhabited what came to be known as Zululand (part of the modern South African province of Kwa-Zulu Natal), were a disorderly patchwork of cattle herding and minimally horticultural clans that frequently made war on one another. The most common *casus belli* were disputes over cattle, grazing lands, and water rights, but the ensuing combat was usually brief. For the most part it entailed prearranged pitched battles at a respectable distance between small groups of warriors armed with assegai (a lightweight, six-foot throwing spear) and oval cowhide shields. Injuries and fatalities were usually few.

However, the Bantu were hemmed in geographically, and, as the human and cattle populations increased over time, they began to experience increased crowding. Robert Carneiro (1970) calls it environmental circumscription. This led to a corresponding increase in the frequency and intensity of warfare among the clans until a radical discontinuity occurred in 1816, when a 29-year-old warrior named Shaka took over leadership of the Zulu clan. Shaka immediately set about transforming the pattern of Bantu warfare by introducing a new military technology involving disciplined phalanxes of shield-bearing troops armed with short hooking and jabbing spears designed for combat at close quarters.

Shaka's innovation was as great a revolution in that environment, as was the introduction of the stirrup, gunpowder, or tanks into European warfare. After ruthlessly training his ragtag army of some 350 men, Shaka set out on a pattern of conquests and forced alliances that quickly became a juggernaut. Within three years Shaka had forged a nation of more than a quarter of a million people, with a formidable and fanatically disciplined army of about 20 000 warriors who were motivated in part by Shaka's decree that they were not allowed to marry until they were blooded in battle. Shaka's domain had also increased from about 100 to 11 500 square miles. There was not a tribe in all of black Africa that could oppose the new Zulu kingdom, and soon Shaka began to expand his nation beyond the Bantu peoples' traditional boundaries.

The further evolution and ultimate downfall of the Zulu nation at the hands of the Europeans in the latter part of the century is another chapter (but with a similar theme). What is significant here is the profound structural and functional changes – changes involving the superposition of an integrated political system – that occurred among the Zulu by virtue of decisive political entrepreneurship stimulated by population pressures and coupled with synergistic changes in military techniques and organization. Again, the causal process was configural and interactional, with cybernetic control processes being an integral part of the synergies that resulted.

The second example comes from some elegant fieldwork many years ago by Charles Drucker (1978) among an isolated Philippine population called the Igorot. The Igorot occupy a remote mountainous area of Luzon, where for centuries they have practiced irrigated rice cultivation with an awe-inspiring system of earthwork terraces, dams, and canals that were laboriously carved with simple tools out of the precipitous mountainsides. It was once thought that these massive structures, characterized by early explorers as the eighth wonder of the world, were thousands of years old and had taken thousands of years to build. But in fact they are much more recent – the product of a heroic response to the Spanish conquest and their seizure of the choicest lowland and coastal areas in the 16th century, which produced a wave-like flight of the resident natives into the mountains. The Igorot people had traditionally practiced a low-intensity, seasonally shifting, slash-and-burn (or swiddening) form of cultivation, but the sudden increase in the population density and the demand for food in the more mountainous areas prompted a radical change in the Igorot's food production technology.

The introduction of a rice terrace farming system is only part of the story, however. The remarkable sustained yields achieved by the Igorot's rice paddies also depend on constant replenishment of soil nutrients, especially nitrogen. Yet the environmental sources of nitrogen in this area are totally inadequate. The solution, and one key to the Igorot's successful adaptation, is the presence in the ponds of a nitrogen-fixing bluegreen algae that lives in a symbiotic relationship with the rice plants. Respiration from the plant roots generates carbon dioxide that the algae need for photosynthesis and nitrogen fixing. At the same time, the plant leaves shade the rice terrace mud where the algae live, keeping the temperature cool enough for the algae to thrive. The supply of nitrogen in turn stimulates the growth of the rice plants. The result is extremely high productivity coupled with great ecological stability. For the past several centuries the Igorot have been able to grow almost enough staple food on a single hectare (2.47 acres) to feed a family of five.

But there is one more critical element in the Igorot system. The ancestral Igorot lived in isolated family groups that were well-adapted to a shifting, small-scale plant cultivation strategy, but adoption of the rice terrace technology required these families to coalesce into a large, integrated organization. Sustained cooperative efforts were necessary, first to design and build this remarkable agricultural system and then to utilize, maintain, and expand it over the course of time. Indeed, without constant weeding and repairs the system would rapidly deteriorate. Accordingly, the Igorot had to invent a social and political system to coordinate the activities of the many individual family groups in a disciplined manner. The result is that the Igorot today have a political system that would be unrecognizable to their pre-Hispanic ancestors. It represents an interwoven set of ecological, technological, social, and political elements – a synergistic system. How do we know it's synergistic? Just remove a single element – say the bluegreen algae – and observe the consequences.

6.3.5
Explaining Political Devolution

A major challenge for any theory of political evolution is that it must be able to account not only for 'progressive' complexification but also for 'regressive' changes, for the episodic decline (devolution) of political systems. Some climate-related examples were noted above, and climate changes are also implicated in the dissolution of the Mayan and Teotihuacán civilizations. Other examples of devolution include the Easter Islanders, where the decisive factors were (apparently) exhaustion of their wood supply and soil depletion. For the Ik in Africa, a drought apparently did them in. For the Moriori of the Chatham Islands (in the Pacific), it was a genocidal foreign invasion. For the Aboriginal Australians, the South African San people, the Mississippian chiefdoms, and many other Native American civilizations, it was imported disease epidemics.

In short, if synergy refers to the combined effects produced by wholes, the removal of even a single major part should (synergy minus one) should have a negative effect on the performance of the whole and may even be fatal. And if political-cum-cybernetic control systems arise to facilitate the operation of complex synergistic systems at all levels of social organization, then the fate of the political system is necessarily tied to the functional viability – the economic well-being (in a broad sense) – of the system and its parts.

To be sure, the term 'devolution' can be defined in several different ways. On the one hand, it can refer only to reduced economic complexity. Or it can mean the complete collapse, dissolution, or physical extinction of a population. Similarly, it could refer either to a voluntary disaggregation or to an externally imposed or coerced change. In light of the definition of politics proposed above, the focus here is limited to the cybernetic processes – the systems of communications and control among various individuals, groups, and populations.

To be specific, if we associate the 'progressive' evolution of political complexity with the emergence of decision making, communications, and control processes designed to mobilize people and resources for one or more collective purposes, then the converse involves a decline or collapse of a cybernetic (political) system and its capabilities. In these terms, political devolution can be voluntary or coerced. It can involve only a limited functional decline or it can be accompanied by the physical disappearance of a population. In any case, the hypothesis is that both the development and the dismemberment of any political (cybernetic) system is ultimately determined by the underlying economic situation – its integral (and necessary) relationship to the production of various functional synergies.

Many forms of political devolution involve the termination of a system that was intended to be only temporary, narrowly focused, and ephemeral. The research literature on primates and social carnivores provides many examples: for instance, coalitions of lions, hyenas, or chimpanzees that coordinate individual efforts for the purpose of joint predation, for collective defense against another group, to compete with other males for mating privileges, or even to contain and resist a dominant animal. Here, devolution occurs when the job is done.

Likewise, the ethnographic research literature concerning human societies provides many examples of ephemeral political systems. One of the most famous involves the Great Basin Shoshone of the American Southwest. Until very recently, the native Americans who inhabited this dry, harsh environment survived mainly by foraging in small family groups for various plant foods – nuts, seeds, tubers, roots, berries, and the like. Occasionally, however, these families would gather into larger groups numbering 75 or more when there were opportunities for a large-scale rabbit (or antelope) hunt under the leadership of a 'rabbit boss'. These joint ventures involved highly coordinated efforts with huge nets (rather like tennis nets, only hundreds of feet long) that were used to encircle and capture large concentrations of prey. Nevertheless, when the hunt was completed and the prey were consumed, the family groups dispersed once again (Steward, 1938, 1963; Johnson and Earle, 1987).

In a similar vein, the native Americans of the northern Great Plains were legendary for their massive summer encampments. Dozens of small foraging bands, each with 50 members or fewer, would congregate into tribes numbering in the thousands once each year under a tribal council and a chief, who were responsible for organizing and directing various tribal activities, especially the annual buffalo hunt (Carneiro, 1967).

There are also many examples of ephemeral political systems in contemporary human societies. When the basketball game is over, the team members go home for the night. When the play is over, the actors disperse. And when the collective response to a local disaster has achieved its immediate objectives, the ad hoc political system that arose to coordinate the efforts of various agencies (fire, police, repair services, housing, food distribution, volunteers, etc.) is disbanded. Such temporary systems have been studied in depth by Comfort (1994a,b, 1998).

Similarly, in the business world there are innumerable joint ventures and partnerships between different firms that are short-term and single-purpose and many others that are multifaceted and enduring. Some are highly successful, but others are abject failures that are quickly abandoned. In any case, devolution is a common occurrence in the private sector as well. The downsizing of many 1960s conglomerates during the 1980s provides one obvious example. By the same token, innumerable military alliances among bands, tribes, chiefdomships, and states (in the anthropologists' terminology) over the past few millennia have lasted only so long as there was a common enemy to be resisted, or attacked.

However, the most significant examples of political devolution involve systems that are associated with the overarching 'collective survival enterprise' – i.e., a human population that is more or less permanently engaged in the joint procurement or protection of the requisites for meeting their basic survival needs. For example, how can we account for the collapse of the Soviet empire, which, as Kenneth Jowitt points out, "was not supposed to happen"? Or, for that matter, how can we account for the recent 'Balkanization' of the Balkans? There is, needless to say, a long tradition of scholarship on the political devolution of human societies, from Gibbon's *Decline and Fall of the Roman Empire* to the writings of Spengler, Toynbee, Simon, various systems theorists, catastrophe theorists, chaos theorists, and, of course, many modern-day environmentalists (the Club of Rome and the 'limits to growth' theorists come to mind).

Especially important, however, are the data and case studies on political devolution in anthropology, archaeology, and ancient history. Over the past several millennia, a great many societies have downsized, disaggregated, or disappeared. Some were defeated on the battlefield and put to the torch. Others disappeared mysteriously. Still others seem to have been burdened by a complicated nexus of destructive factors – a negative synergy. By the same token, in some cases the society's central places were completely depopulated but in others the population continued to grow in succeeding centuries, albeit under new management. The list of relevant case studies includes, among many others, the Mayans, Incas, Aztecs, Olmec, Teotihuacán, Anastazi, Hohokam, Sumerians, Babylonians, Akkadians, Hittites, Minoans, Mohenjo-Daro, Easter Islanders, Moriori, Tasmanians, Maasai, the Hawiian and Zulu kingdoms, Han China, Carthage, and, of course, Rome.

Indeed, Rome provides the classic example of an involuntary decline that was influenced by many complex, interacting factors. To modify the ancient saying, Rome was neither built nor destroyed in a day. The sack of Rome by Alaric in 410 AD and its ignominious aftermath culminated several centuries of progressive decline involving a complex nexus of ecological, economic, social, and political factors. No doubt this is one reason why the fall of Rome is a source of endless fascination – and endless scholarship. Rome provides a relatively well-documented example of a multifactored, 'dysergistic' process, but it is not unique. (For a more detailed analysis of Rome's rise and decline, incorporating recent scholarship and new insights, see Corning, 2003.)

A more benign example of political devolution – theoretically significant because it exemplifies the many temporary systems that are created to meet a defined, short-term goal and then later dissolved – can be found in, of all places, the United States of America. Although the image of 'big government' and election campaign rhetoric about the federal government as a 'bloated bureaucracy' have been a recurring theme in American politics over the past two decades, the reality is quite different if one contrasts the size and scope of the government and the level and intensity of cybernetic control over the population in 1944 (the height of World War II) and in 1994, 50 years later.

The conversion of the United States from a depression-plagued peacetime economy with a very small military (350 000 in 1939) to a huge war machine (the

'Arsenal of Democracy'), with 11.4 million uniformed military personnel and 3.3 million civilian employees, is well documented. And this does not count the many millions of Americans who became involved in war production work (17 million new jobs were created during the war, a 34% increase in the labor force), or the 10 million organized civilian volunteers of various kinds. In short, the war produced a radical economic, political, and military transformation, a national mobilization (cybernation) at every level of society; and the degree of regimentation and control exerted over the population and the economy were totally unprecedented in the U.S. before or since. To be sure, this massive undertaking succeeded only because the population was united against two formidable enemies and (by and large) willingly accepted the sacrifices and constraints that were imposed. Nevertheless, the changes were radical and convulsive. (For more details, see Corning, 2002b.)

Even before the war was over, the U.S. government began planning for 'reconversion' to a peacetime economy. A special concern was how to meet the pent up demand for consumer goods, from automobiles to washing machines, without causing runaway inflation. (Despite the high level of wartime taxes, liquid assets waiting to be spent had increased from \$ 50 billion in 1941 to \$ 140 billion in 1944.) So industries that were expected to experience a rapid surge in demand after the war were given priority in shifting out of war production work. In this and many other areas, the government deliberately planned for demobilization and downsizing (and a devolution of the federal government's role) that was not only successful but, despite the Cold War that followed, never reverted to anything approximating the broad scope and pervasive power that were exercised during World War II.

Fifty years after the war ended, the statistics tell the story. Federal employment in 1994, including the military, amounted to 1.53% of the total U.S. population, versus 10.7% during the war. In fact, the absolute number of civilian and military personnel combined in 1994 represented less than one-third the number in 1944. Despite the contrary perceptions of most Americans, federal employment as a share of the total population was only half a percentage point higher than in 1939. Likewise, total federal government outlays as a percentage of GDP amounted to 21.1%, less than half the 1944 percentage (or 46.8%) and roughly equivalent to the percentage in 1939 after subtracting transfer payments for Social Security, welfare, and the like, plus interest on the national debt (again, see Corning, 2002b).

The conclusion seems well-justified. The 'reconversion' that occurred in the U.S. after World War II fulfilled the theoretical expectation that political devolution can result from either success or failure. By the same token, it can be either voluntary or coerced. From a functional, synergy perspective, this duality is not at all paradoxical. In this example, it was a direct consequence of the disappearance of the underlying functional need, which was clearly survival-related. No other theory that we are aware of can reconcile this seeming paradox.

6.4 The Evolution of Political Systems

6.4.1 Animal Politics

Much insight into the evolution of political systems in humankind can be gained from observing cybernetic social processes at work in other species. There are many illuminating examples. One of the most impressive involves the social insect *Eciton burchelli*, a species of army ant found in Central and South America (see E. O. Wilson, 1975; Hölldobler and Wilson, 1990, 1994). These creatures form highly organized colonies of about 500 000 members, with four distinct castes that divide up the responsibilities for colony defense, foraging, transport, and nest making and care of the brood. The big submajors (or porters), for instance, sometimes team up to carry very large prey which, if split into pieces, would be more than each individual submajor could carry alone.

The army ants' highly coordinated foraging system is also legendary. In a single day, a raiding party of up to 200 000 workers – armed with potent stingers and marching in a dense phalanx – might reap some 30 000 prey items, many of which are then split up and hauled back to the nest for all to share. Because they forage en masse, army ants can also collectively subdue much larger prey than would otherwise be possible – even lizards, snakes, and nestling birds. It's an impressive example of synergy of scale.

Perhaps the most remarkable form of synergy in army ants though, involves the way the colony builds its nests. The workers form the nest out of many thousands of their own interlinked bodies. Not only are these living nests quick and efficient to construct but, most impressive, they are able to maintain a constant internal nest temperature that varies by no more than ±1 °C. (These nests are also ideally suited for a tropical species that must frequently relocate its home base when the local food supply is exhausted.) Although a full understanding of the decision making, communications, and control processes in army ants still eludes us, it appears to be a self-organized, even 'democratic' process based on distributed control rather than a centralized control process. Aggregations of chemical signals in threshold-breaking concentrations seem to play an important role in mobilizing army ant behaviors.

Another example of a superorganism in nature is found in naked mole rats (*Heterocephalus glaber*). The mole rat is an African rodent species that lives in large underground colonies (usually numbering 75–80 but sometimes over 200). They subsist by eating plant roots and succulent tubers. Affectionately dubbed 'sabre-toothed sausages' because they are hairless and have two outsize front teeth used for digging, the naked mole rats represent a particularly significant model of a division/combination of labor in mammals. In fact, these odd-looking animals utilize specialized worker castes and a pattern of breeding restrictions that is highly suggestive of social insects.

Typically (but not always), breeding is done by a single queen, with other reproductively suppressed females waiting in the wings. The smallest of the nonbreeders, both males and females, engage cooperatively in tunnel digging, tunnel cleaning, nest making, transporting the colony's pups, foraging for food, and hauling the booty back to strategic locations within the colony's extensive tunnel system. (Robert A. Brett found a mole rat 'city' in Kenya that totaled about two miles of underground tunnels and occupied an area equivalent to 20 football fields.) Paul Sherman and his co-workers, who have studied these animals extensively, wrote the following description of the mole rats' tunnel-building activities:

> The animals line up head-to-tail behind an individual who is gnawing [with its outsized, powerful front teeth] on the earth at the end of a developing tunnel. Once a pile of soil has accumulated behind the digger, the next mole-rat in line begins transporting it through the tunnel system, often by sweeping it backward with its hind feet. Colony mates stand on tiptoe and allow the earthmover to pass underneath them; then, in turn, they each take their place at the head of the line. When the earthmover finally arrives at a surface opening, it sweeps its load to a large colony mate that has stationed itself there. This 'volcanoer' [so-named because its actions appear to an observer outside to produce miniature volcano eruptions] ejects the dirt in a fine spray with powerful kicks of its hind feet, while the smaller worker rejoins the living conveyor belt (Sherman et al., 1992, p.78).

The vital and dangerous role of defense in a mole rat colony is also allocated to the largest colony members, who respond to intruders like predatory snakes by trying to kill or bury them and/or by sealing off the tunnel system to protect the colony. The mole rat 'militia' also mobilize for defense against intruders from other mole rat colonies.

Students of animal behavior find many analogies between the naked mole rats and eusocial insects like army ants and honey bees. But in their politics and government, the mole rats are more convergent with other social mammals, like chimpanzees or humans. As with many other socially organized species, naked mole rats exhibit a combination of self-organized cooperation (volunteerism) and social controls that are enforced by various coercive measures (policing).

The cybernetic control role of the breeding queen is of central importance. The queen is usually the largest animal in the colony (size determines the dominance hierarchy), and she aggressively patrols, prods, shoves, and vocally harangues the other animals to perform their appointed tasks. Indeed, her aggressiveness varies with the relative urgency of the tasks at hand. In addition, the queen acts to suppress breeding and reproduction by the other females, who are always ready to take over that role. (Occasionally other females are allowed to share the breeding function with the queen; why this happens is not known.) The mole rat queen also intervenes frequently in the low-level competition that goes on among colony members over such things as nesting sites and the exploitation of food sources. And when the reigning queen dies, there is a sometimes bloody contest among the remaining females to determine her successor.

All of this control activity is facilitated by an elaborate communication system (and information sharing) that includes 17 distinct categories of vocalizations –

alarms, recruitment calls, defensive alerts, aggressive threats, breeding signals, etc. In fact, the mole rats' communication system rivals that of some primate species in its sophistication.

A famous example of a self-organized, ephemeral political system in baboons is also noteworthy; it involved the development of cooperative hunting behavior in a troop of olive baboons (known as the Pumphouse Gang). While studying a group of 49 baboons on a huge ranch near Nairobi, Kenya, over a period of several years, Shirley Strum, Richard Harding and several coworkers observed the emergence and spread of a new 'cultural' pattern (Harding, 1973; Strum, 1975a, b; Harding and Strum, 1976). At first it was confined to a few adult males that opportunistically pursued and captured newborn antelopes or hares. It was a solitary activity and there was no food sharing. But over the course of time the pattern changed. The amount of predation increased, females and juveniles began to participate, food sharing became more commonplace, hunting skill and efficiency improved, and most important, the troop began to evolve systematic searches and coordinated attacks. In sum, it was the synergies (the proximate rewards) that drove the behavioral changes, not genetic mutations or natural selection, and it was not a hierarchically organized activity controlled by a single dominant animal. It was a voluntary coalition. Indeed, the new behavior was eventually abandoned – though it was not clear why.

A final example involves a unique symbiotic partnership between two different species that entails systematic behavioral coordination. The African honey guide is an unusual bird with a peculiar taste for beeswax, a substance that is even more difficult to digest than cellulose. To obtain beeswax, however, the honey guide must first locate a hive and then attract the attention of a co-conspirator, such as the African badger (or ratel). The reason is that the ratel can attack and destroy the hive, after which it rewards itself by eating the honey while leaving the wax behind for the honey guides. However, this unusual example of cooperative predation by two very different species depends on a third co-conspirator. It happens that the honey guides cannot digest beeswax. They are aided by a symbiotic gut bacterium that produces an enzyme that can break down wax molecules. So this improbable but synergistic feeding relationship is really triangular (Bonner, 1988).

What makes this example of a cross-species partnership particularly apropos is the fact that the honey guides also form symbiotic partnerships with humans, the nomadic Boran people of northern Kenya. Hussein Isack and Hans-Ulrich Reyer (1989) conducted a systematic study of this behavior pattern some years ago and found that Boran honey hunting groups were approximately three times as efficient at finding bees' nests when they were guided by the birds. They required an average of 3.2 hours to locate the nest compared with 8.9 hours when they were unassisted. The benefit to the honey guides was even greater. An estimated 96% of the beehives that were discovered during the study would not have been accessible to the birds had the humans not used tools to pry them open. The honey guide–human partnership is also aided by two-way communications – vocalizations that serve as signals.

6.4.2 The Evolution of the 'Political Animal' – A Synopsis

A major challenge for the synergism hypothesis as a theory of political evolution is the growing body of evidence regarding the evolution of humankind. Since this issue is addressed in some detail in Corning (1983, 2001b, 2003), here I will be brief. The underlying thesis, first articulated in *The Synergism Hypothesis* (1983), is that there was no prime mover in human evolution. Rather, the process was propelled by proximate behavioral innovations and choices; the common thread was various forms of functional synergy with significant payoffs for the immediate problems of survival and reproduction, in accordance with the model described above.

In the truest sense, the evolution of humankind involved an entrepreneurial process – a pattern of behavioral invention, trial-and-error learning, selective retention, and the subsequent natural selection of supportive anatomical changes. Humankind in effect invented itself. Moreover, much of our ancestors' inventiveness was focused on new forms of synergy; synergy played a key role in this evolutionary change. It generated potential bioeconomic benefits and payoffs of various kinds – new synergies of scale, combinations of labor, functional complementarities, sharing of costs and risks, tool and technology symbioses, and more. (My sources include full-length textbook treatments by Campbell, 1985; Klein, 1999; Wolpoff, 1999a; and other sources cited below.)

6.4.2.1 The Rise of the Australopithecines

Three distinct transitions can be seen in the 5–6 million-year process of human evolution. The first, and perhaps most momentous, involved the shift from an arboreal lifestyle to terrestrial living. Most likely this did not happen all at once. For one thing, it involved substantial costs and risks. As foraging ranges expanded, so did the time and energy required to exploit them, and the early Australopithecines were imperfect bipeds – competent but not as efficient as later *Homo erectus/Homo ergaster*. More important, the exploitation of a mosaic environment introduced serious new risks from predators and competitor species, not to mention rival protohominid groups. Some theories of human evolution have downplayed these threats, but it was in fact a major challenge, with life-and-death consequences (see especially Anderson, 1986; Cheney and Wrangham, 1987; Dunbar, 1988; van Schaik, 1989; Cowlishaw, 1994; Iwamoto et al., 1996; Wrangham, 2001). There is substantial evidence for the proposition that our remote ancestors were subject to serious predation pressure (Brain, 1981, 1985; Foley, 1995; Isbell, 1995; Lee-Thorp et al., 2000).

Accordingly, the question is: How did a diminutive ape with constrained mobility on the ground and no natural defensive weapons solve the problem of shifting to a terrestrial habitat, broadening its resource base, and, over time, greatly expanding its range? (By three million years ago, Australopithecines had spread through much of Africa.) Political organization – the creation of superorganisms – was very likely a key factor. In a patchy but abundant environment that was also replete with predators, competitor species, and sometimes-hostile groups of conspecifics, group foraging and collective defense/offense was the most cost-effective strategy. There were immediate payoffs (synergies) for collective action that did not have to await the plodding pace of natural selection. Indeed, the odds of survival were greatly enhanced. It is also likely that the earliest of these protohominid pioneers stayed close to the safety of the trees. However, as they began to venture further from their safe havens, the risks increased commensurately. (Many other theorists over the years have endorsed the group-defense model, including George Schaller, Alexander Kortlandt, John Pfeiffer, Richard Alexander, Richard Wrangham, and others.)

There may very well have been group selection involved in this process, but it was not based on altruism. It involved collective goods. Nor did it require a 'cooperative gene'. It required only a degree of intelligence about means and ends, costs and benefits. Moreover, because these superorganisms were most likely formed around a nucleus of closely related males (an unusual pattern among the primates), individual selection, kin selection, and group selection would have been aligned and mutually reinforcing – just as Darwin originally proposed in *The Descent of Man* (1874). Indeed, only 6% of the 167 primate species studied to date have male-based groups, and this may have been one of the keys to the emergence of the hominid adaptive pattern (Wrangham, 1987; Lee, 1994).

Why would the males defend the females and infants? For one thing, the males might not have known their paternity if the females followed a reproductive strategy of promiscuous mating and, perhaps, disguised ovulation (as bonobos evidently do). Another factor was that all of the infants would have been closely related –nephews, cousins, or even younger siblings. A third point is that, in an extremely 'K-selected' species with a very long reproductive cycle and a short life span, each offspring was relatively more valuable. Finally, in a tightly organized, interdependent group it was not significantly more costly to defend the offspring of close kin than it was to defend one's own progeny and oneself; it was not a matter of altruism or reciprocal altruism but of teamwork in a win–win (or lose–lose) situation – a synergy of scale. One appropriate analogue, as many other theorists have noted, is the organization of savanna baboon troops (see especially Cowlishaw, 1994, and references cited therein; for a general review of primate social patterns, see Pusey, 2001).

Was there also a division/combination of labor? Contemporary hunter–gatherer societies, not to mention most modern societies, typically have a division of labor along sexual lines, and it is possible that a rudimentary version of this pattern existed also among the early Australopithecines. It seems likely that the females would have been primarily responsible for carrying the infants and shepherding the juveniles, while the males served as the primary (though not necessarily exclusive) guardians for the group. We may never know for certain about this and many other details relating to human evolution, but group living/group foraging and a cooperative division of labor allowing for increased access to a more dangerous but abundant terrestrial environment is likely to have been primordial in the hominid line. It would have involved the most-limited incremental behavioral changes with the most-cost-effective payoffs for the participants; it was highly synergistic. Moreover, as time went on the group-living mode of adaptation led to other forms of social cooperation and more elaborate political organization.

One other innovation may also have played a crucially important role in the transition of our ancestors from arboreal to terrestrial apes, namely a synergistic 'soft technology' of wood and bone implements, and perhaps thrown objects as well. There have been many tool-use advocates over the years, from Darwin to Dart, Szalay, Washburn, Birdsell, Coursey, and Mann (Wolpoff, 1999a). Tool use can have a revolutionary effect. It can be the functional equivalent of opening a new ecological niche or a whole new adaptive mode. Sources of food that would otherwise be unattainable can suddenly become a reliable, even abundant, part of an animal's diet. Also, the payoffs are immediate; they need not await the workings of natural selection (see also discussions in Lewin, 1993 and Kingdon, 1993).

It seems unlikely that the early Australopithecines could have adapted successfully to a terrestrial lifestyle and survived, even prospered, for perhaps three million years without the acquisition and skilled use of various natural objects such as digging sticks, hammers, carriers, and the like. Indeed, chimpanzees, elephants, capuchin monkeys, and many other species are frequent users of tools for procuring food and sometimes in conflict situations as well.

By the same token, it seems likely that weapons also played an indispensable part in the successful transition to a terrestrial lifestyle. One can hardly exaggerate the value to a diminutive, relatively slow-moving biped, lacking the baboon's outsized canine teeth, of being able to use a short stick (similar to the modern billy club) or a large femur, or even a well-aimed rock, as a defensive weapon (as Darwin himself argued in *The Descent of Man*). A group of Australopithecines traveling together in dangerous or unfamiliar country with digging tools/weapons carried at the ready would have been far more likely to hold their own in any life-and-death situation. These creatures may not always have been subject to predation, but even one incident in a lifetime would have been one too many.

This is not to say that the influence of individual competition, status rivalries, internal social conflicts, etc., somehow magically disappeared. Then as now, it is likely that there was a sometimes precarious interplay between competition and cooperation, between various individual self-interests and the interests of the group. As noted earlier, a dynamic tension between individual and group interests is also a common phenomenon in other social mammals, just as it is in modern humankind (see especially de Waal, 1996).

The key to Australopithecine sociality lay in the relative costs and benefits to each individual of cooperation or noncooperation. Why should the males, even if they are closely related, cooperate with one another? And why should the females help one another if they are unrelated and perhaps rivals for social status and the attentions of the males? Reciprocity and reciprocal altruism may help to explain it. But the benefits associated with being included in the group – and the high cost of ostracism – may also have been a major factor. The social group was a vitally important survival unit (it produced corporate goods that were measured in terms of life and death), which each individual had a stake in preserving and enhancing.

In other words, the 'public interest' was rooted in the group's potential for generating collective synergies. For instance, a larger group was more likely – all other things being equal – to benefit from synergies of scale in confrontations with predators or competitors (not to mention potential prey). These collective synergies provided an overarching incentive for containing conflict and enhancing cooperation – and for punishing cheaters and free riders.

6.4.2.2 **Enter Homo Erectus**

The same principle of corporate synergy (and policing to maintain it) may well have contributed to the next major transition in human evolution. In the scenario described above, systematic group hunting was evidently not part of the picture. The current consensus seems to be that the Australopithecines may have opportunistically scavenged meat and hunted easily captured small prey as components of a diversified food quest (see especially Stanford, 1999). No doubt, seasonal fluctuations and the specific opportunities and constraints in different habitats played a role. However, there are also indications that major behavioral changes began to occur about 2.5 million years ago. A recently discovered 2.4-million-year-old species, *Australopithecus garhi* (or an as-yet unidentified contemporary) at Gona, Ethiopia, was already adept at transporting flaked stone tools over some distance and using them for chopping, cutting, smashing bones, and perhaps skinning both antelopes and wild horses (Asfaw et al., 1999).

The importance of these 'crude' Oldowan tools (so-named because they were first discovered at the Olduvai Gorge by Louis Leakey) can hardy be overstated. It really amounted to a technological revolution, because it enabled our ancestors to become systematic hunters and scavengers and to exploit the teeming herds of large animals that populated the open grassland areas in East Africa and beyond. Once stone tools were deployed, moreover, the carcasses of these animals provided raw materials – horns, bones, skin, and sinew – for many other uses as well. Just as digging sticks and handheld weapons may have played a key role in the success of the early Australopithecines, the invention of stone tools vaulted our ancestors into a new ecological niche. Equally significant, this adaptive revolution evidently predated the emergence of *Homo erectus/Homo ergaster* by several hundred thousand years. In other words, synergistic behavioral changes – including technological innovations – preceded and supported the major anatomical developments that are reflected in the fossil record much later on.

The most plausible explanation for the transition from Australopithecines to *Homo erectus/Homo ergaster*, I (and others) believe, is that a major behavioral shift occurred and that this shift was the pacemaker for succeeding anatomical changes (see Wood and Collard, 1999; Wrangham, 2001). In the half million years after stone tools became a standard part of their tool kit, our hominid ancestors joined the ranks of top carnivores and learned how to hold their own in confrontations with other carnivore competitors – not to mention potential predators. This conclusion is not original, of course (e.g., Washburn and Lancaster, 1968; Shipman and Walker, 1989; Wrangham and Peterson, 1996; Stanford, 1999; Wolpoff, 1999a).

But I would add that it is also the most parsimonious explanation for the anatomical changes that occurred.

Other scenarios are also possible, of course, but the group hunting/scavenging/foraging plus food sharing/provisioning scenario seems most consistent with other evidence – tooth wear patterns, tool use patterns, and the anatomical changes that are found in *H. erectus/H. ergaster*. Over time, progressive improvements in toolmaking skills (as reflected in the Developed Oldowan and Acheulean traditions) also occurred, as well as more selective use of raw materials, more complete processing of animal carcasses, and evidence of more specialized tools for different uses such as wood working, skinning, and plant food processing.

The package of behavioral synergies that undergirded the anatomical development of *Homo erectus/ergaster* in turn provided a foundation for many other improvements that followed. Among other things, this pattern allowed for the elaboration of the group – the superorganism – as a unit of collective adaptation, with greater social and political organization, more coordination of activities, and especially, a division (combination) of labor. One important example was the adoption of consistently occupied home bases, or encampments. This led to a significant improvement in economic efficiency for the group as a whole, because it allowed for a more elaborate combination of labor. Resources as needed – meat, plant foods, stone tool cores, animal skins, water, firewood, etc. – could be carried to a safe haven and then shared and utilized through a network of reciprocities (for a primate model, see Kortlandt, 1992).

Another important technological innovation, often underrated these days perhaps because it is old news and a veritable cliché about human evolution, was the adoption and controlled use of fire. 'Revolutionary' is by no means too strong a word to use for the consequences of this multipurpose invention. Moreover, fire may have begun to play a major part in our evolution at a much earlier date than has traditionally been assumed. The so-called Karari sites analyzed by Bellomo (1994) suggest that hearths were used by hominids at least 1.6 million years ago (see also Campbell, 1985). However, Wrangham and colleagues (1999) (also Wrangham, 2001) believe there are fossil 'signals' that go back to 1.9 million years ago.

Eventually, fire came to have many other valuable uses as well – defending against predators, chasing competitors away from carcasses, tenderizing meat, killing harmful bacteria, breaking down toxic chemicals in the many plant foods that could not be eaten raw, hardening wooden tools, drying skins, deterring insects, providing warmth (especially in colder, temperate climates), and even facilitating long-distance signaling and communications. Indeed, Wrangham (2001) postulates that the adoption of cooking was a key to the emergence of *Homo erectus/ergaster*, because it vastly expanded our ancestors' nutritional repertoire and necessitated home bases.

However, the invention of more efficient food-procurement technologies was only half the story. 'Culture' – the accumulated know-how and experience of the group – also became an increasingly important part of the hominid behavioral package. Larger cooperating superorganisms were able to exploit many new opportunities for social synergy, including the sharing of costs and risks, pooling information, a more elaborate combination of labor and, not least, many synergies of scale against competitors, predators, and prey. Likewise, mutual aid, or 'succorant behaviors', could increase the odds of surviving an injury or illness, and the joint policing of free riders and cheats could reduce internal conflicts (see de Waal, 1996). Boehm (1996, 1997) also stressed that political processes, such as group decision making, can even become a factor in between-group selection. Recent research on culture in other primates, most notably chimpanzees (Whiten et al., 1999) and orangutans (van Schaik et al., 2003) suggests that the roots of human culture may trace back 14 million years.

The fossil record also suggests that, beginning with *Homo erectus/ergaster*, culture became cumulative and an increasingly potent adaptive tool; new ideas and inventions were not only preserved and communicated to subsequent generations, but were refined and improved upon over time. Boesch and Tomasello (1998) call it a ratchet effect. The group as a whole became a transgenerational repository of adaptive information and an engine for the invention of more synergies. Spears, for example, came to be made of better raw materials; they were more finely shaped and balanced; their tips were fire-hardened; barbed tips were added to increase their penetrating and holding power; and wooden spear throwers were invented as a way to increase their range, striking force and accuracy; finally, bows and arrows were invented as a lightweight alternative that could increase the hunter's range and precision, and (not least) multiply the hunter's supply of ammunition. Each of these inventions represented a major economic advance. More food could be acquired more dependably with less time, effort, and collective risk. However, effective political organization was an essential concomitant.

6.4.2.3 **The Emergence of Homo Sapiens**

The last major transition in hominid evolution, the emergence of anatomically (and culturally) modern *Homo sapiens*, perhaps 100 000–150 000 years ago, is currently a focal point of controversy. The self-flattering image of humankind as the product of a saltatory leap of some kind seems irresistible (e.g., Pfeiffer, 1977; Wills, 1993, 1998; Diamond, 1997; Tattersall, 1998, 2002; Klein, 1999, 2000). However, the final 'sprint' to humankind was preceded by a long period of progressive cultural and anatomical changes throughout the Middle Pleistocene (from about 750 000 to 250 000 years ago) and beyond (reviewed in Wolpoff, 1999a). The trend to modernity was already well along when the final Rubicon was crossed, and there are currently two major alternative theories regarding this transition.

One is the so-called multiregional model (see Wolpoff, 1984, 1999a, b; Wolpoff et al., 2001), which postulates that the emergence of humankind was a worldwide process "with populations connected by gene flow and the exchange of ideas and technologies that spread across the inhabited world" (Wolpoff et al., 2001, p. 293). The other model is based on the much-publicized 'Out-of-Africa' hypothesis. An increasingly compelling body of genetic evidence – mitochondrial DNA and Y chromosome data in particular – suggest that all modern humans trace their lineages back to a very small population in East Africa about 100 000–150 000 years ago.

The data also suggest that this founding population grew larger over time and began to migrate out of Africa, starting about 50 000 years ago or perhaps earlier. In other words, various genetic markers indicate that there was an epicenter for the final leap to humanity and that modern humans effectively replaced all the other hominids in various parts of the world in short order, including (needless to say) the Neanderthals in Europe and the Middle East (see especially Cann et al., 1987; Cavalli-Sforza et al., 1988, 1994; Stoneking, 1993; Hammer, 1995; Nei, 1995; Pääbo, 1995; Relethford, 1995; Jin et al., 1999; Klein, 1999, 2000; Su et al., 1999; Ehrlich, 2000; Semino et al., 2000).

There are problems with both scenarios, however. Briefly, the multiregional scenario requires an implausible flow of genes and cultural information over huge distances and diverse populations, while the Out-of-Africa scenario is based on genetic indicators that bear no direct relationship to any known anatomical differences (more detailed critiques can be found in Ehrlich, 2000 and Corning, 2003). On the other hand, there are data that support both hypotheses. Accordingly, I propose a third alternative. It is possible that the migrants from Africa had some slight advantage (to use a Darwinian expression) which, nevertheless, made a great difference in terms of the balance of power between competing populations. In other words, the modern human 'revolution' – the explosive growth and worldwide spread of humankind – was a culturally driven process that utilized new forms of social synergy and political organization (a more potent superorganism).

Many theorists – Cavalli-Sforza and Cavalli-Sforza (1995), Diamond (1997), Tattersall (1998), Wills (1998), Klein (1999, 2000), Ehrlich (2000), and others – hold that the perfection of human language and the emergence of a more advanced technology were major factors in the modern human diaspora. It is significant that the timing of the African exodus – if true – coincided with the flowering and spread of the Aurignacian industry, which encompassed a range of technological improvements. Needless to say, a more advanced cultural 'package' would have provided an important economic advantage – namely, the means to support a rapidly growing population in diverse habitats. However, the Aurignacian technology may also have given our East African ancestors a major military advantage. It seems likely that the great human diaspora of 50 000 years ago was not a peaceful trek into virgin territory but a more hostile invasion of already occupied lands; the human wave was often (perhaps not always) accompanied by coercion and warfare. This is not a new theory (see reviews by van der Dennen, 1995, 1999), but it deserves a new look.

I hasten to add that we are not talking here about wars of conquest or imperialism in the modern sense; the terminal Pleistocene humans were not necessarily warlike in temperament nor seeking dominion for its own sake. More likely, the process was driven by a pressing need for resources to support a growing, mobile population in a changing environment. (The last major ice age began about 75 000 years ago, intensified about 33 000 years ago and peaked about 20 000 years ago.) Call it the 'resource acquisition' model of warfare – and of human evolution. This scenario is discussed in more detail in Corning (2001b, 2003).

To summarize the argument, potent new forms of cultural (and political) synergy with immediate functional benefits may have been responsible for the spread of modern humankind out of Africa and around the world. Coercion is very likely to have played a major part in this dynamic, but it would be wrong to treat warfare as a prime mover. The ability to make war was itself the product of a synergistic package of capabilities. More important, armed conflict is, after all, an instrumentality for attaining various ends; it is not an end in itself. The odds of violence are almost always influenced by a more-or-less explicit calculation of costs, benefits, and risks. A shorthand slogan for this calculus is, again, the balance of power (or more to the point, an imbalance of power). But this venerable concept implies a many-faceted analytical process, not a narrow statistical exercise.

In sum, human evolution, a process that may have taken six million years and is still ongoing, included three distinct transitions – three 'great leaps forward' in the current formulation. The first, and in many ways the most important, transition involved our ancestors' shift from an arboreal to a terrestrial mode of adaptation. This momentous change, I have argued, was accomplished by a synergistic behavioral package that included sociocultural and political synergies and a crucially important tool/weapon symbiosis.

The second transition, which entailed a dramatic 'hominization' – a suite of major anatomical developments – was the result of synergistic new pattern of social behaviors, including potent new tools, systematic hunting, and, quite likely, the exploitation of fire, the adoption of home bases, the invention of a more elaborate division/combination of labor, and, not least, more elaborate political organization.

Finally, the worldwide diaspora that resulted in the replacement of archaic *Homo sapiens* and Neanderthals by modern humans about 50 000 years ago was also a synergistic cultural and political phenomenon, as larger groups with more advanced technology and organization overwhelmed other hominid populations, not to mention many other 'megafauna', in a worldwide spasm of extinctions. In each of these major transitions, moreover, functional synergy and political/cybernetic processes played an important part.

6.4.3
The Evolution of Complex Societies

6.4.3.1 Prime Mover Theories

The explosive rise of complex, technologically sophisticated human societies since the Paleolithic has inspired many prime mover theories (for more detailed reviews, see Corning 1983, 2003). Herbert Spencer deserves credit for developing the first full-blown modern theory. In his monumental multivolume *Synthetic Philosophy*, an outpouring of works that spanned nearly 40 years and influenced many other theorists of his era, Spencer formulated a Universal Law of Evolution that encompassed physics, biology, psychology, sociology, and ethics. In effect, Spencer deduced society from energy by positing a sort of cosmic progression from energy (characterized as an external and universal 'force') to matter, life, mind, society, and, finally, complex civilizations. Spencer defined evolution as a process characterized by "a change from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity through continuous differentiations [and integrations]" (1892, p. 10).

With regard to the evolution of humankind, Spencer (1852) argued, increasing complexity provides functional advantages, but the proximate cause of progress in human societies has been the pressure of population growth – the Malthusian dynamic:

> It produced the original diffusion of the race. It compelled men to abandon predatory habits and take to agriculture. It led to the clearing of the earth's surface. It forced men into the social state; made social organization inevitable and has developed the social sentiments. It has stimulated men to progressive improvements in production, and to increased skill and intelligence. It is daily pressing us into closer contact and more mutually dependent relationships.

Although Spencer ultimately a became a pariah among many 20th century social scientists (an ideologically tainted episode), he nevertheless inspired many subsequent prime mover theories. For instance, White (1949, 1959) adopted the Spencerian notion that progress is closely associated with the ability to harness and control energy and developed what he called the Basic Law of Evolution. In White's words, "culture advances as the amount of energy harnessed per capita per year increases, or as the efficiency or economy of the means of controlling energy is increased, or both"(1959, p. 56). Calling himself a cultural determinist, White claimed that cultural evolution is independent of our will: "We cannot control its course, but we can learn to predict it" (1949, pp. 39, 330, 335).

Another modern-day prime mover theory invokes population growth, although Spencer's prior claim to that idea is generally not acknowledged. In the 1960s, Boserup (1965) proposed that population growth might have played a key role in the development of agriculture. Dumond (1965) focused on the relationship between population growth and cultural evolution in general. But Cohen (1977), in a closely reasoned book-length treatment, adopted the most Spencerian posture. Calling population growth the cause of human progress, he asserted that population pressure is an inherent and continuous causal agency in cultural evolution: "Rather than progressing, we have developed our technology as a means of approximating as closely as possible the old status quo in the face of ever-increasing numbers" (p. 285).

Unfortunately, this explanation is too simple. All species have the potential for exponential growth and all species ultimately have limits. Humans are not unique in this regard. Not only do human societies practice various means of birth control to limit population growth, but various external factors, from wars to diseases, droughts, and famines may impose severe population constraints (as Malthus pointed out). More important, human populations do not grow in a vacuum; they grow only in favored locations and at propitious times, when the wherewithal exists in the natural environment for their sustenance and growth. And this in turn has depended on a favorable environments and specific cultural adaptations.

Social conflict – internal or external – is also frequently touted as the engine of cultural evolution, and there is certainly good reason to believe that violent confrontations between human groups have ancient roots (as noted earlier). But many theorists have claimed that warfare also accounts for the evolution of 'civilization', from hunter–gatherers to advanced nation-states. Darwin, Spencer, and a host of Social Darwinists stressed social conflict to varying degrees, but some theorists have gone much further. They attribute cultural evolution to our supposed aggressive and acquisitive instincts. Sir Arthur Keith, who wrote *A New Theory of Human Evolution* (1949), was probably the first and least-known theorist of this genre, and the writings of Lorenz (1966), Ardrey (1966, 1976), and Bigelow (1969), among others, caused something of a furor in the latter 1960s and 1970s. (Some, like Bigelow, stressed the complementary role of cooperation as well.)

Richard Alexander (1979) took perhaps the strongest position on this issue: in his so-called balance of power scenario, Alexander saw the process of cultural evolution as driven by competition between human groups, which in turn is an expression of inclusive fitness maximizing behavior. In other words, it is a form of reproductive competition by other means (a more militant version of Tiger and Fox). Although various economic hypotheses are neither necessary nor sufficient explanations for large-scale societies, Alexander claimed, warfare *is* both necessary and sufficient. (Paul Rubin, in *Darwinian Politics* [2002], seems to be closely aligned with Alexander. He calls competition between groups the main force in human evolution. However, his views are not systematically developed. Indeed, Rubin also recognizes the important role of cooperation and economic development, albeit with a bias toward free market capitalism.)

The theory of cultural/political evolution proposed by Robert Carneiro (1970) is more subtle (it relies on a functional argument rather than a presumed instinctual urge), but it too is monolithic: "Force, and not enlightened self-interest, is the mechanism by which political evolution has led, step by step, from autonomous villages to states." Although state-level political systems were invented independently several times, warfare was in every case the prime mover, Carneiro claimed. However, Carneiro's prime mover had a prime mover of its own. He argued that the mechanism of warfare is the result of an underlying dynamic that he called environmental circumscription – a context in which a population is ecologically constrained by mountains, deserts, limited resources, or even by other human populations. Once a growing, circumscribed population reaches its Malthusian limit, Carneiro reasoned, warfare and conquest become the only alternative to starvation. So Carneiro's theory is really a theory about a predictable reaction of human groups to population pressures.

It is clear that organized warfare has been a major source of synergy in the evolution of human societies. There are, for instance, the synergies of scale and threshold synergies associated with the relative number of combatants on each side. There are the human–tool synergies produced by the appalling number of technologies that humans have invented for killing one another. And there are the synergies that arise when there is a division (or combination) of labor – e.g., the 5000-person crew of a modern aircraft carrier. The evidence is overwhelming that warfare has played a significant role in shaping the course of recorded human history. For instance, a major study of this issue some years ago examined 21 instances of state development, ranging from 3000 BC to the 19th century AD and found that coercive force was a factor in every instance and that outright conquest was involved in about half of them (Corning, 2001b).

But is warfare the necessary and sufficient cause of complex societies? If warfare involves grave and possibly fatal risks to the combatants, we need to probe more deeply into why wars occur. In fact, there is a vast research literature on this subject, spanning several academic disciplines, which supports at least one unambiguous conclusion: Warfare is itself a complex phenomenon with many potential causes and many different consequences. Wars cannot simply be treated as the expression of an instinctive urge or an uncontrollable external pressure. There are too many anomalies and too many exceptions for any monolithic theory to be acceptable. Why is it that some quite warlike societies – like the Yanomamö of Venezuela or the Dani of New Guinea – did not evolve into nation states? Why did some societies achieve statehood and then subsequently collapse or even disappear? And why did the first pristine states appear during a very small slice of time in the broader epic of evolution, within a few thousand years of one another at most? Finally, there are the examples in which population pressures were relieved by increased trade or an intensification of subsistence technologies (Corning, 2001b). Indeed, there is evidence that in many cases political evolution preceded and perhaps precipitated warfare between societies, rather than the other way around (see especially Hackenberg, 1962; Brumfiel, 1976; R. Cohen, 1978a, b, c; also the discussion and references in Corning, 1983, p. 371).

Technology has also been a popular candidate for the role of prime mover in cultural evolution. And nobody would dispute the fact that technology has played a major role, with synergies that are very often quantifiable. For instance, a !Kung San hunter–gatherer living in the African Kalihari desert in the 1960s extracted 9.6 calories of energy from the environment for every calorie expended, according to the classic study by Lee (1968). In contrast, an American of the 1960s returned 210 calories for every calorie invested. Since Americans worked twice as many hours as their Kalihari counterparts, they were able to secure 46 times as many calories per person.

Many other technological synergies have been documented by human ecologists (see especially Salisbury, 1973). A native Amazonian using a steel axe can fell about five times as many trees in a given amount of time as could his ancestors using stone axes, and a chain saw adds literally hundreds of multiples to a lumberjack's bottom line. Similarly, a shotgun is at least two to three times more efficient at bagging game on the hoof than is a bow and arrow. A farmer of the Middle Ages, with a horse and wooden moldboard plow, could turn over about one acre a day. His modern-day counterparts, with specially bred draft horses and steel plows, can cover at least two acres, and a farmer with a tractor and modern farm machinery can plow 20 acres per day and sometimes much more (see Corning, 2003 for more examples).

However, there are problems associated with elevating technology to the status of the prime mover in cultural evolution. One is that technology is not a force or a mechanism. It is not even confined to tools or machines. It is really an umbrella concept – a broad label that we use to identify the immense number of cultural techniques that we have devised for earning a living and reproducing ourselves. At bottom, the term refers to human activities involving the use of various inventions – behaviors, tools, objects, or even other organisms that have been appropriated, developed, or fabricated to serve human purposes. Some technologies are mainly a matter of deploying knowledge and skills. Thus, many agricultural practices – the use of dung as a fertilizer, crop rotation, interplanting, controlled watering regimes, and much more – are very important technologies. Likewise, many of our common plant and animal food products are the result of countless generations of selective breeding (genetic engineering) for various desired properties – size, texture, color, nutritional content, disease resistance, and the like. Similarly, domesticated animals are, in essence, some of humankind's oldest and most important technologies.

Many other human technologies involve the more or less skillful manipulation of objects in the environment. We have already noted the role of fire, one of our earliest and still most vital technologies. The techniques required to gather, process, and cook various plant foods played an important role in our evolution. The use of pits, dead falls, cul de sacs, and other stratagems for capturing game were also very likely among the early hominid food-getting technologies. The diversion of water for irrigation purposes was a critically important step in the development of large-scale agriculture. So were dams, walls, fences, weirs, and many other early cultural innovations. In other words, technology is not really some external agency; it is a synergistic relationship involving human knowledge, human skills, and the manipulation of various external objects.

A second key point about technology is that it almost always requires organized cooperative (cybernetic) activities by humans – what Karl Marx called relations of production. The Boeing Aircraft Corporation, for instance, as of 2001 had 42 major facilities, 200 000 employees, and some 10 000 suppliers – many of them major corporations in their own right – that are scattered throughout North America and, indeed, the world. A Boeing 747 is the product of a vast cooperative effort. A third point is that every technology is embedded in a specific environment. It is enmeshed, so to speak, in the historical context; it is not a separate, autonomous agency but is always part of a larger economic and cultural system. More important, both the natural environment and the specific historical/cultural/political venue exert an important causal influence; they are codeterminants (recall the Igorot example cited above).

Technological innovations have the following things in common: (1) they arise from human needs and human purposes in a specific historical context; (2) they utilize but also modify past cultural and technological attainments; (3) they are interdependent parts of a larger synergistic system; (4) they involve highly purposeful, goal-oriented development processes, as well as many progressive improvements over time; and (5) they are subject to a Neo-Lamarckian selection process; that is, the outcomes are ultimately epiphenomena – the combined result of many individual user choices among the available options. There is at least a tacit benefit–cost calculation associated with each individual decision, although many other cultural influences may also contribute. Yet in the final analysis it is the synergies that determine the emergence and diffusion of a new technology; it is the payoffs that induce the positive selection of each new innovation, in accordance with the backwards logic we talked about earlier. The wellspring of innovation in human societies is organized intelligence, but it is the functional effects – the synergies – that shape the selection process (pro or con).

The main problem with prime mover theories is that they don't work. They may highlight important influences but they are manifestly inadequate – perhaps necessary but certainly not sufficient – to explain cultural evolution. This is especially apparent when you begin to ask historical questions. Why did a particular breakthrough happen when and where it did? And why not at some other time or place? Nor can prime mover theories account for the manifest influence of other important movers. But more important, societies do not change in some automatic way or follow a unilinear path. Often the path leads downhill; prime mover theories are at a loss to explain political devolution.

6.4.3.2 The Case for the Synergism Hypothesis

Accordingly, I believe the synergism hypothesis is also applicable to the ongoing process of cultural evolution in complex societies. There is nothing predestined about this process, any more than there is a deterministic directionality in biological evolution. Moreover, each succeeding generation in effect reevaluates the technologies and sociopolitical institutions and practices that it inherits. A given technology/practice is sustained over time by a cultural analogue of what is known in population genetics as stabilizing selection, just as various functional improvements over time are products of directional selection within and across each new generation of users. By the same token, the many examples of an older technology/practice being supplanted could be likened to adverse selection in nature. In any case, it is always a synergistic process.

One example, among many, illustrates this point. Jared Diamond in his landmark study, *Guns, Germs and Steel* (1997), takes up the forbidding challenge of accounting for the rise of large complex civilizations in humankind over the past 13 000 years or so – not simply the reasons why this trend occurred but also why it happened where and when it did, and why it did not happen elsewhere or at some other time. A key aspect of Diamond's approach, one that directly contradicts some of the deepest metatheoretical assumptions of the social sciences, is that it is not possible to explain such fundamentally historical phenomena in terms of some deterministic (law-like) mechanism. Context-dependent factors have played a crucial role in the process. Each major breakthrough in the evolution of complex human societies, as well as each replication of the process in some other geographic venue, was the result of a site-specific nexus – a convergence of many 'ultimate' and 'proximate' factors (terms Diamond borrows from evolutionary biology but uses in a different sense). Diamond does not use the term synergy. He refers instead to a 'package' of contributing factors. But the meaning is the same; each instantiation involved a combination of necessary and sufficient elements that worked together.

In the agricultural revolution, the development of food production and the creation of food surpluses was a key factor, Diamond argues, but this in turn depended on many other factors. One important precursor was the prior emergence of anatomically modern humans, including our language skills and our sophisticated cultural resources, perhaps 100 000–150 000 years ago. Another factor was the decline and mass extinction of many of the large megafauna on which evolving humans had come to depend, coupled with an increase in human population levels. This demand–supply imbalance created a growing pressure to find suitable supplements to the standard hunter–gatherer diet. The fortuitous co-location only in the Fertile Crescent of key 'founder crops', especially emmer wheat (which could be domesticated with a single gene mutation), together with legumes and animal husbandry (which allowed for a balanced diet), meant that this was the most likely location for a technological breakthrough that could provide food for a large, sedentary, concentrated population. Equally vital, however, were such cultural inventions as fire, tools, food storage, draft animals, record keeping, and, not least, complex political systems.

As Peter Richerson and Robert Boyd (1999) have pointed out, synergy is not enough to account for our recent cultural evolution. Large-scale societies also require workarounds to compensate for the lack of the face-to-face social influences that facilitate cooperation and constrain antisocial behaviors in small groups (see especially Boehm, 1993, 1997, 1999; de Waal, 1996). In comparison with army ants or small hunter–gatherer societies, Richerson and Boyd argue, a large, complex human society is at best a 'crude superorganism'.

The workarounds that Richerson and Boyd refer to have been many. They include such things as ruling councils, law codes, legislatures and representative government, electoral systems, an independent judiciary, a free press, bureaucracies, police forces, and much more. (Political scientists lump many of these together into three broad functional categories: legislative, executive, and judicial.) These and other political/cybernetic practices and institutions have evolved over the past 11 000 years (or more) through a process of trial-and-success (to borrow a term from paleontologist George Gaylord Simpson). Moreover, as human societies have grown in size and complexity, many new political (cybernetic) challenges have arisen. Thus, political evolution has closely tracked the larger process of societal evolution.

The evidence on behalf of this theory was developed and presented in considerable detail in Corning (1983), especially in chapter six. Updates can be found in Corning (1987, 1996a, 2002b) and in Corning and Hines (1988). Here I provide just a few data points. One of several propositions that were derived from this theory was the prediction that there is always a close relationship between population size, sociocultural complexity, and political complexity, and many studies over the years have confirmed these relationships. One confirming example is an analysis done by Carneiro (1967). Carneiro first developed a list of 354 societal traits (including political traits), ranging from craft specialization to markets, governing councils, and so on. This list was then winnowed to the 205 traits that he judged as best able to represent a society's organizational complexity. Carneiro then assembled a carefully screened list of 100 societies (using various criteria), from which he extracted a subset of 46 that consisted of a single community. Carneiro found that the number of societal traits in these societies approximated the square root of the size of the population.

Elsewhere, Carneiro (1970) produced a more pointed analysis involving all 100 of his selected societies, in which he attempted to correlate each of the categories in his list of 354 societal traits with 33 selected traits that he judged to be related to the degree of political organization. These traits ranged from the presence of a permanent headman (81 of the 100 societies had one) to the presence of a professional civil service (only 4 had one). The results are summarized in Table 6.1. Each cell in the table shows the rank-order correlation coefficient for the two categories that intersect at that cell. The categories all correlate extraordinarily well ($p \leq .001$).

To test whether similar correlations can also be found in contemporary societies, I undertook a study using demographic and economic data from the Inter-University Consortium for Political and Social Research for 145 societies covering the year 1967 (Corning, 1983, pp. 358–359). Specifically, I examined the relationships between (1) population size, (2) GNP, (3) GNP/capita, (4) total land area, (5) urbanization, (6) government expenditures, (7) military expenditures, and (8) the number of government employees (Table 6.2). The results were less uniform (some correlations were not statistically significant), but the most important categories (theoretically) were highly correlated, especially the number of government employees in relation to population size, GNP, and land area, as well as government expenditures and GNP.

To be sure, there may be some 'play' in the relationship between the political system and the economy. This is illustrated with data from the *Ethnographic Atlas* (Murdock, 1967) that was used (though recognizing the imperfect categories devised by anthropologists) to compare the levels of economic and political develop-

Table 6.1 Pairwise correlations between seven categories of cultural traits (from Carneiro, 1970).

	Economics	Social Organization and Stratification	Political Organization	Law and Judicial process	Warfare	Religion
Warfare						.713
Law and Judicial process					.804	.735
Political Organization				.875	.834	.708
Social Organization and Stratification			.804	.803	.826	.648*
Economics		.813	.791	.815	.751	.721
Subsistence	.73	.707	.737	.787	.764	.673

* Cell with asterisk is not statistically significant.

Table 6.2 Pairwise correlations between some sociopolitical categories and central government size (145 countries) (from Corning, 1983).

	Urbanization	Population	GNP/Cap	GNP	Military Expenditures	Government Expenditures	Number of Government Employees
Government Expenditures							.98
Military Expenditures						.91	.97
GNP					.88	.98	.96
GNP/Cap				.30	.20	.32	.06*
Population			–.02*	.38	.42	.44	.98
Urbanization		–.06*	.52	.21	.14*	.24	.30
Land Area	.09*	.50	.12*	.4	.81	.66	.93

* Cells with asterisks are not statistically significant.

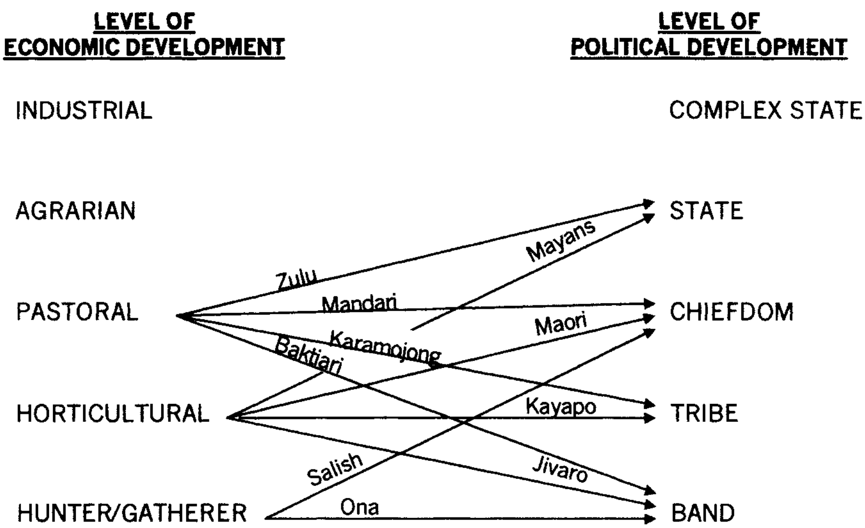

Figure 6.4 The 'play' in political evolution – an illustration.

ment in various societies. As Figure 6.4 indicates, there are limits to the amount of 'play' that is possible. No hunter–gatherer society has ever achieved statehood, nor has any pastoral society been able to support a complex nation-state. Indeed, 90% of the 147 hunter–gatherer societies listed in the *Ethnographic Atlas* were nomadic bands, whereas only 4% of the 377 horticultural societies were nomadic.

In a major review of 150 cross-cultural studies, Naroll (1970) concluded that the following findings are historically valid in broad outline: (1) a strong allometric trend between population growth and occupational specialization (except for a spurt since the Industrial Revolution); (2) a corollary trend toward greater accumulation and dissemination of information; (3) a similar trend in the evolution of more diverse and complex organizational types; (4) and a clear-cut historical trend toward growth in political system complexity. In other words, 'progressive' evolution of political processes has been an integral part of the larger systemic process by which societies, cultures, and economies have evolved. Carneiro (1973, p. 108) likened the process to the workings of a train of gear:

> A sociocultural system may be likened to a train of gears in which each gear represents a different sphere of culture. In the operation of this system the gears are generally in mesh. The gears differ, however. Some are larger than others, some have finer teeth, some turn faster, etc. Moreover, some are drive gears and engender motion to the others, while other gears are passive and do not impart motion of their own, but merely transmit the motion they receive.
>
> The gears also vary in the closeness with which they engage one another. If the mesh between any two were perfect and continuous, then the movement of one would automatically produce a corresponding and equivalent movement in the other. But in sociocultural systems, the gears never engage perfectly or continuously. Now and then a gear slips out of mesh and may move forward half a turn without causing perceptible motion in the others.
>
> Yet by and large the gears move together. A certain position of one gear is not compatible with just any position of some other gear. Thus, leaving our metaphor aside and looking at sociocultural systems directly, we cannot imagine, for example, divine kingship fitting with cave dwelling, trial by jury with percussion flaking, parliamentary procedure with human sacrifice, or cross-cousin marriage with nuclear reactors. When culture advances in one sphere, other spheres do no long remain unaffected. They tend to advance as a single coordinated system.

The evidence briefly described here and reviewed in greater detail in Corning (1983) supports the contention that cybernetic social processes – political processes – have been an integral and necessary element in the ongoing evolution of human superorganisms (see also Corning, 2002a). Politics is not simply an artifact of competing self-interests but a vitally important functional aspect of the ongoing collective survival enterprise that has sustained us and our ancestors literally for millions of years.

6.5
The Future of Politics

Cybernetic social processes are ubiquitous in nature – from the self-organized foraging behavior of army ants to the authoritarian harangues of mole rat queens, the ad hoc hunting parties of baboons and woodland chimpanzees, and the highly orchestrated rice terrace system of the Igorot. Although politics as we have defined it here often entails the pursuit of narrow self-interests (in accordance with the realist model), it also takes place within a larger context – the purposes and interests of the collective survival enterprise as an interdependent system (in accordance with the idealist model). Both of these classical renderings of politics have merit; they are not, in fact, mutually exclusive. Indeed, there is an inherent interplay, and very often a tension, between them.

The reality of the human condition is that the 'superorganism' is the key to our survival and reproduction, as it has been for millions of years. However, this vision of the 'public interest' does not negate or ignore our individual self-interests. Rather, it represents an aggregation of those interests into an immensely complex system of synergies based primarily on mutualism and reciprocity. The superorganism serves our self-interests in a multiplicity of ways; it provides both collective goods and corporate goods. And the public interest consists of preserving and enhancing these benefits.

Accordingly, the state has evolved as an instrumentality for self-government and the pursuit of the public interest – although its overarching purpose is all too often subverted. Plato and Aristotle apprehended the overarching purpose of the collective survival enterprise (and its inherent vulnerability) in their conception of the polis, and Aristotle prescribed a 'mixed' government under law as our best hope for ensuring that the public interest would be faithfully served. Plato and Aristotle also recognized that a fair-minded form of 'justice' is an essential element of the public interest; this is the only way to ensure the long-term stability and 'legitimacy' (the willing consent) of the members of the community. Over the past 2000 years we have added very little to this vision that is fundamentally new, although we have made many important improvements in the machinery of self government.

What is sobering, even dismaying, is that we seem forever to be forgetting and then relearning this ancient lesson. Witness the former British Prime Minister Margaret Thatcher, who famously claimed that "there is no such thing as society". The response to her contemptuous remark is that a society exists when people believe it does and act accordingly (or vice versa). Plato and Aristotle, and many others since, have stressed that the political order can be what we make of it. To a significant degree, our actions create self-fulfilling prophesies. If honesty, trust, mutual respect, courtesy, and a spirit of compromise are the prevailing norms, and deviants are ostracized and penalized, a society and its institutions likely reflect these values, by and large. Conversely, if the cultural climate encourages deception, vicious partisanship, the demonizing of opponents, and an uncompromising no-holds-barred attitude toward opposing interests, the social and political environment more closely fit the paradigms of Machiavelli and Hobbes. In the final analysis, our politics is a matter of choice, not a mindless reflection of human nature. Thus, if we choose to remain captives of destructive racial, religious, cultural, or economic class divisions, shame on us.

In any case, the bottom-line conclusion of Plato and Aristotle remains valid today. For better or worse, our evolutionary future is dependent on the goods and services that are provided (or not) by the collective survival enterprise, along with the decisions and actions that we undertake collectively (or not) in the public interest. For this reason, the continuing quest for social justice and the good life remains the central challenge for every organized society, as well as for each one of us. It is a goal worth striving for, because our own survival, and certainly that of our descendants, may very well depend upon it. Nothing less than our evolutionary future is at stake. To paraphrase the American founding father, Benjamin Franklin, in the long run either we will survive together or go extinct separately.

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7
Evolution of Economics

John M. Gowdy

7.1
Introduction: Economics and Biology

Like the living systems they describe, the connections between economics and evolution are complicated, convoluted, and characterized by mutually reinforcing hierarchical relationships. Not only has the evolution of the market economy had a profound effect on theories of biological evolution, these theories have in turn provided a rich source of inspiration to economists as well as an ideological justification for the sanctity of market outcomes. Controversies in evolutionary biology continue to have great relevance for the field of economics. In recent decades two trends have emerged from the field of biology to challenge the prevailing orthodoxy in economic theory. One trend is the growing importance and even dominance of evolutionary biology and theoretical ecology in the philosophy of science. The other is the mounting evidence of the conflict between the growing economy and the earth's life-support systems.

Since the early 1970s evolutionary biology has witnessed a revolution in thinking about evolutionary change. For most of the 20th century the majority of biologists saw evolution as taking place through small incremental adaptations within a fairly constant external environment (Gould and Lewontin, 1979). This view of the world had much in common with that of neoclassical economics, with its emphasis on continuity, marginal change, and progress through increasing efficiency. This is not surprising, since both economics and biology matured in the common intellectual and social milieu of mid 19th century England. Today biologists recognize the importance of macroevolutionary processes in evolutionary outcomes. Accidents of history, coevolution, and hierarchical selection processes, as well as micro-level adaptation at the level of individual organisms, all influence the course of evolution. The debates in biology over the mode and pace of evolutionary change, the hierarchies of selection controversy, and the resurgence of theories of group selection have all had a profound effect on social science and especially on economics. Economists working in such diverse fields as industrial organization and innovation diffusion (Dopfer, 1994; Witt, 1997), technological change (Nelson, 1986),

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and the diversification of regional economies (Jacobs, 2000) increasingly draw on biological rather than mechanical analogies. Exclusive reliance on methodological individualism is falling into disfavor in the face of new evidence and concepts of group decision making, self organization, and higher-order selection processes.

Recent decades have brought an increasing awareness of the relationship between human activity, particularly economic activity, and the biophysical world. As we recognize the extent of the impact of human activity on global climate, biodiversity, and the course of biological evolution itself, long-held tenets of economists, such as unlimited growth and the goal of Pareto optimality as the prime welfare objective, are being called into question. The attempt to reconcile economics and biology by placing economic values on features of the natural world has exposed a number of fault lines in economic theory. It is becoming more and more difficult to reconcile the view of human nature embodied in 'economic man' with the empirically based models of human decision making being developed in the fields of psychology, physiology, and artificial intelligence. The demise of economic man will have profound consequences for the public policy recommendations of economists.

The connections between biology and economics reach back well over a hundred years. Charles Darwin and Alfred Russel Wallace developed their theories of evolution through natural selection after reading the work of the philosopher and political economist Thomas Malthus describing the operation of competitive markets. The ideas of gradualism, progressive change, and perfection through competitive selection provided a common framework for the natural as well as the economic world in Victorian England, where modern biology and modern economics began (Ruse, 1997). The idea of survival through competitive advantage and natural selection moved from economics to biology, and it came back to economics in the form of 'survival of the fittest', a term popularized by Herbert Spencer. Spencer was the most well known evolutionist of the 19th century, in fact better known than Darwin (Hodgson, 1993a). Spencer was a great influence on the development of economics in the late 1800s and early 1900s, particularly on Alfred Marshall, who is considered to be the first great synthesizer of neoclassical economics. Hodgson (1993a) quotes Marshall recounting the excitement that Spencer's ideas held for him: "A saying of Spencer sent the blood rushing through the veins of those who a generation ago looked eagerly for each volume of his as it issued from the press." It was the Spencerian version of evolution as gradual and progressive that was incorporated into the folklore of economics.

Just as the idea of evolutionary progress through natural selection played a major role in the history of economic thought, so too did ideas from economics find their way back to biology, particularly in the new science of ecology. According to Worster (1977), around 1900 ecologists began to view nature as an economic workshop. In 1910 Hermann Reinheimer described organisms as 'traders' or 'economic persons'. He wrote:

> Every day, from sunrise until sunset, myriads of (plant) laboratories, factories, workshops and industries all the world over, on land and in the sea, in the earth and on the surface soil, are incessantly occupied adding each its little contribution to the general fund of organic wealth (quoted in Worster, 1977, p. 291).

August Thienemann moved ecology closer to economics when he introduced the terms producer, consumer, reducer, and decomposer to describe ecological relationships. More recent biologists who have adopted the tools of economics to describe ecosystems include Cody (1974), Rapport and Turner (1977), and Ghiselin (1978, 1992).

Today a flurry of interdisciplinary work is being done at the intersections of biology, psychology, and economics. New scientific findings are telling us more and more about the evolution of human cognition, how individuals actually make decisions, and how genetic structure shapes human behavior (Wilson, 1998; Morrison, 1999; Gintis, 2000). This new interdisciplinary work promises to move the social and natural sciences toward E. O. Wilson's vision of consilience among the basic understandings of all fields of inquiry. Economics and biology are both concerned with the evolution of living systems. It is not surprising therefore that many of the theoretical controversies in the two disciplines mirror each other (Gowdy and Ferrer Carbonell, 1999).

This chapter discusses several broad questions: How has the human economy changed through time? That is, how has the basic economic problem of making a living in a world with limited resources been met throughout human history? How have theories of economic evolution evolved over the years? What are the connections among biological evolution, economic evolution, and evolutionary theory? What is the relationship between the biological and the economic world? Specifically, how has the ideology of the market come to dominate human decisions about using the resources of the natural world, how has the natural world been affected by these decisions, and how will these effects feed back into the human economy? Understanding the connections between markets and ecosystems, and between evolutionary theories in economics and biology, is fundamental to understanding how we got where we are today and to assessing our prospects for the future (Wuketits, 1990, 1998).

7.2
The Evolution of the Human Economy

For most of human history we had very simple economies with simple technologies and, judging from accounts of recent hunting and gathering societies, complicated kinship, social, and religious systems. Today the situation is much the opposite, with very complicated technologies and economies and comparatively limited social relationships and kinship systems. For most of our existence as a species we lived within the confines of local ecosystems; today the entire planet is dominated by one type of economic system, the market economy, and human activity now affects the entire planet. There is no corner of the earth that is not now under the influence of human activity. The expansion of material culture was accompanied by important changes in how humans viewed the natural world and each other.

7.2.1 Hunter–Gatherers: Humanity's First Two Million Years

A defining characteristic of our species is the extensive use of exosomatic (outside the body) instruments to enhance our chances for survival (Lotka, 1924; Georgescu-Roegen, 1977). Tool making was once defined as *the* characteristic that separated humans from other animals (Oakley, 1961). Recently, numerous studies have documented the purposeful use of tools by nonhumans. Chimpanzees in the Ivory Coast not only use stone tools to crack nuts, but also store particularly good stones for future use. Chimpanzees also fashion twigs to gather termites, a skill that takes years to develop and one which humans find difficult to learn (De Waal, 1996). Green-backed herons in Japan use carefully selected twigs as bait to attract fish. (These and other examples are discussed in Griffin, 1992.) The tool-making behavior of birds, animals, and insects is much more complex than originally thought. Spiders learn how to hunt using their woven nets and modify their hunting techniques based on past experience. Even social insects, once thought to be pure automatons, are capable of a wide variety of learned behavior. The distinction between 'instinct' and 'purpose' that was thought to clearly separate humans and other animals is becoming increasingly blurred.

Complex tool making by humans goes back several million years. Evidence indicates that tools were common in Africa by about 2.5 million years ago and were probably made by an early human ancestor known as *Australopithecus*. This genus probably evolved into *Homo habilis* and then to *Homo erectus* about 1.7 million years ago. *Homo erectus* was the first human ancestor to leave the African continent and the first to have a sophisticated tool-making tradition. Although they differ somewhat in form from place to place and through time, the characteristic *Homo erectus* tool, the Achuelean hand axe, can be traced from 1.5-million-year-old sites at Olduvai Gorge in Tanzania to the Isimila site dated about 260 000 years ago (Gamble, 1994, p. 125). Thus the Achuelean tradition of beautifully crafted hand axes lasted well over a million years and had a geographical distribution ranging from Africa to Europe to East Asia. Numerous other tool-making traditions have been identified by archeologists, each adapted to its own ecosystem and culture.

Tool making, or more broadly the widespread use of flexible exosomatic instruments and the associated changes in cultural behavior, may in fact be the reasons humans survived an extremely unstable climatic period in eastern and southern Africa between 5 and 2 million years ago. Many mammalian species went extinct during this period and those that survived did so because they were better able to respond to changing climatic conditions than those who did not. Brain sizes became larger not only for humans but also in a variety of mammalian species. Humans, by evolving flexible technology and cultures rather than endosomatic (phenotypic) adaptations, were able to quickly respond to changing environments by modifying their tools as the resource base changed. Flexibility and the ability to substitute one resource for another may be a genetically based characteristic of our species.

By about 50 000 years ago there was a marked increase in the complexity and variety of human material culture. In Upper Paleolithic Europe, bone tools began to appear along with a variety of stone tools designed for very specific purposes such as scrapers, spear throwers, harpoons, and bow and arrows (Diamond, 1997, p. 39). About 38 000 years ago an explosion of creativity began in ice-age Europe. The best known manifestation of this increasing sophistication of Upper Paleolithic peoples is the magnificent paintings found in the caves of Southern Europe, especially in France and Spain. Increasingly sophisticated art and personal ornaments have been found in Africa a few thousand years before the blossoming of art in Europe, leading to speculation that a worldwide diffusion of art began about 50 000 years ago. The discovery of the dramatic increase in technological sophistication during the Upper Paleolithic has touched off a number of controversies relevant to current debates about technology, culture, and environmental sustainability. Some see this as the beginning of the human domination of the planet that we see today. Martin (1967), Diamond (1997), and others argue that the demise of big game animals in Europe and later in North America and Australia was directly due to human hunters with sophisticated technology. Others argue that the evidence for a major human role in Pleistocene extinctions is inconclusive since the disappearance of Pleistocene megafauna coincided with dramatic climate changes, in particular the disappearance of the glaciers, whose trailing edges provided the lush vegetation upon which many of those animals fed (for rebuttals to Martin see Harris, 1977, pp. 29–33; Kretch, 1999, Chapter 1). Cause and effect here is probably so entangled that a clear answer to the debate is impossible. The most reasonable explanation is 'coevolutionary disequilibrium' (Graham and Lundelius, 1984). The retreat of the glaciers set in motion a complex series of environmental changes which reduced the number of big game animals and, in that context, human hunting could have played a role in their final demise. It may well be that humans were the direct cause of the extinction of big game animals in Europe and the New World, but one should remain skeptical because so far the evidence is sketchy. Also, the story fits too neatly with two pervasive cultural myths: (1) that humans are inherently destructive, and (2) that humans are outside and different from the rest of nature. In any case, even a limited role for humans in the extinction of Pleistocene megafauna shows that the impact of human technology on the natural world is not a new problem.

Another Upper Pleistocene controversy is the relationship between Cro-Magnon and Neanderthal peoples. Diamond (1997, pp. 40–41) wrote:

> Some 40 000 years ago, into Europe came the Cro-Magnons, with their modern skeletons, superior weapons, and other advanced cultural traits. Within a few thousand years there were no more Neanderthals, who had been evolving as the sole occupants of Europe for hundreds of thousands of

> years. That sequence strongly suggests that the modern Cro-Magnons somehow used their far superior technology, and their language skills or brains, to infect, kill, or displace the Neanderthals, leaving behind little or no evidence of hybridization between Neanderthals and Cro-Magnons.

Again, this story reflects the view that the end result of superior technology is domination and elimination. There is some evidence that the Neanderthal story may be more complex. First, Neanderthals and Cro-Magnons lived in the same parts of Europe and the Middle East for tens of thousands of years; second, there is evidence that they lived in very different habitats and may have only rarely come into close contact; and third, there is some, albeit scanty, evidence that when they did come into close contact they interbred.

7.2.2
The First Divide: The Rise of Agriculture

Undoubtedly, the most dramatic change in the evolution of human technology was the widespread adoption of agriculture that began about 10 000 years ago. During the past three decades there has been a revolution in the interpretation of the transition to agriculture. Until the 1970s it was generally accepted that the 'discovery' of agriculture was a great leap forward that freed humans from a life that was 'nasty, brutish, and short'. Typical of the earlier, and erroneous, view of hunter–gatherers is that of the anthropologist Braidwood (1952, p. 122, quoted in Sahlins, 1972): "A man who spends his whole life following animals just to kill them to eat, or moving from one berry patch to another, is really just living like an animal himself." It is now known that, although there is tremendous variety in hunter–gatherer lifestyles (Kelly, 1995), most hunter–gatherer societies had much more leisure time than do people in agriculture or industrial societies and a rich and rewarding social life (see articles in Gowdy, 1998). Furthermore, although hunter–gatherers certainly had an impact on the natural environment, they had an incentive to preserve environmental integrity since they depended directly on day-to-day flows from the natural world and lived off the land in an extensive fashion using a large variety of plants, animals, and raw materials. Ethnographic accounts of hunter–gatherers detail the human propensity to deal with an uncertain environment though knowledge, flexibility, and substitution. As illustrated in Figure 7.1, well-being in hunter–gatherer economies depended directly on environmental services unmediated by roundabout agricultural production or complex technology.

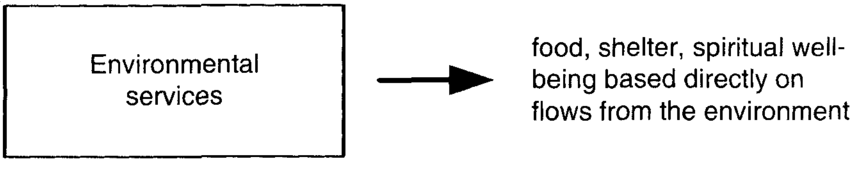

Figure 7.1 Direct use of environmental flows by foraging societies.

With the adoption of agriculture, people made their living by intensively using a greatly reduced number of plants and animals. Indeed, a central problem in economic evolution is to understand the processes that drove the intensification of production in so many varied and seemingly unrelated instances, including tribal societies and early agricultural civilizations. Forces that today threaten the integrity of the planet's life support systems – overpopulation, runaway economic growth, and intensification of the use of the environment – began with the wide-scale adoption of agriculture. The phenomenon of economic growth in the modern industrial state may be orders of magnitude larger than anything that has happened in the past, but the forces driving it are not new.

Although technology may be the defining characteristic of our species, it is clear that for most of human history technological progress was neither the rule nor the measure of evolutionary change. Gamble (1994, Chapter 9) gives several examples of technological decline, including the loss of technological sophistication in Tasmania after it was separated from the Australian mainland by sea level rise some 12 000 years ago. Diamond (1993) contends that there was a marked deterioration in technology and in artistic style in Upper Paleolithic Europe at the close of the last ice age. Tainter (1988), Ponting (1991), Morrison (1999), and many others claim that overshoot and collapse is a recurring characteristic of complex societies. Just from past human cultures progress is not inevitable even with regard to technology.

7.2.2.1 **Intensification of Production and Environmental Decline: The Tehuacán Valley**

Richard McNeish (1972; see also Harris, 1977, pp. 33–34) has reported in detail the process of intensification and resource depletion in the Tehuacán Valley of Mexico. The process began during the Ajuereado period 9000–7000 years ago. In the early part of that period horses and antelope were hunted to extinction, then jackrabbits and giant turtles. During the next period, the El Riego 7000 to 5400 years ago, the percentage of meat in the diet fell sharply and continued to decline and, by the time of intensive agriculture about 2800 years ago, animal protein had apparently become a luxury. According to Harris (1977, p. 34):

> The implacable decline in the proportion of animal protein in the Tehuacán diet was the result of a continuous series of intensifications in the technology of hunting. As each species was depleted, the hunters attempted to compensate for the declining return in the effort they invested by using more efficient hunting weapons and techniques. Lances, spear throwers, darts, and finally the bow and arrow were pressed into service, all to no avail.

McNeish (1972) documents the decline in labor efficiency (calories obtained divided by calories expended) as each new technology was introduced in an effort to maintain meat in the diet. Although MacNeish's classification of technologies in Tehuacán has been criticized recently (Hardy, 1996, 1999), his intensification hypothesis seems to have held up. Moreover, the same pattern of intensification and depletion was present after the adoption of agriculture and irrigation in the Tehuacán Valley.

The adoption of agriculture had profound consequences for the organization of human society. In fact, some archaeologists argue that the transition to agriculture was more of a cultural revolution than an economic one. For a variety of physiological, economic, and social reasons, including increased fertility, partly due to a greater percentage of body fat in females, and the need for a larger labor force, human populations grew rapidly with the expansion of the agricultural way of life, and human exploitation of the environment became more selective and more intensive (Balter, 1998). With agriculture came division of labor, hierarchical organization of society, and an intensive exploitation of local environments. The striking feature of early agricultural societies is the almost universal pattern of colonization of a new area, gradual expansion, a rise in population and, eventually, social disintegration and collapse. This pattern was followed by an astonishing number of cultures occupying a variety of climate zones and ecosystems, including the Easter Islanders (Bahn and Flenley, 1992; Erickson and Gowdy, 2000), Sumeria (Ponting, 1991), the Mayans (Coe, 1993; Martin and Grube, 1995), Chaco Canyon (Tainter, 1988), the Akkadian empire in Mesopotamia (Weiss et al., 1993), and numerous others (Tainter, 1988).

The agricultural way of life became dominant within a few millennia and with it came a profound shift in human social evolution. Societies became increasingly hierarchical and organized around new religious beliefs centered on the necessity of mobilizing a large workforce for the agriculture enterprise. The relationship between humans and the natural world also changed dramatically. The human economy no longer flowed in tandem with the ebb and flow of nature. The adoption of agriculture ushered in the age of human-dominated ecosystems. This meant homogenization and control of nature on the one hand, and destruction of that part of nature not useful to humans on the other. According to Potts (1996, pp. 248–249), a key feature of the development of agriculture was the increasing capacity to buffer environmental disturbance. But this ability to anticipate and plan for environmental disturbance came at a price. As agriculture became more intensive, there was a loss of personal freedom compared to the hunting way of life, and many times, the cost of maintaining human-dominated parts of the environment was the destruction of other ecosystems.

Two final points are worth making before we leave the topic of the adoption of agriculture. First, recent evidence suggests that crop cultivation was practiced for millennia before agriculture was widely adopted (Kelly, 1995). Hunter–gatherers cultivated rye in the Near East over 13 000 years ago, squash was being planted in the tropical forests of Ecuador, and wild rice was being cultivated by hunter–gatherers on the banks of the Yangtze river by 10 000 years ago (Pringle, 1998, p. 1446). Why did agriculture become the dominant way of life within a few thousand years, after several million years of a successful hunter–gatherer lifestyle? The traditional answer that the invention agriculture was a great intellectual achievement that gave people more leisure time and a more rewarding lifestyle is no longer accepted. An intriguing answer to the question Why did agriculture arise? may lie in the fact that the last 10 000 years or so has been a period of remarkable climate stability. Compared to earlier periods, the Holocene has been remarkably warm, and fluctuations in temperature, rainfall, and the composition of the atmosphere have been smaller than at any time during the past several hundred thousand years (Taylor et al., 1997; Alley et al., 1999; Steig, 1999). Richerson et al. (1999) argue that it was this climate stability that made the growing of crops less risky and thus favored the gradual substitution of cultivated for wild food resources. Agriculture was probably impossible in the Pleistocene because of extreme climate fluctuations (Bradley, 1999). Richerson et al. (1999, p. 9) write:

> Holocene weather extremes have significantly affected agricultural production (Lamb, 1977). It is hard to imagine the impact of the qualitatively greater variation that characterized most if not all of the Pleistocene. Devastating floods, droughts, windstorms, and the like, which we experience once a century, might have occurred once a decade.

Even as climate stabilized, the adoption of agriculture was relatively gradual, as borne out by recent discoveries that suggest that large settlements of humans are possible, perhaps as many as 10 000 people in the case of Çatalhöyük (Balter, 1998), with only rudimentary agriculture. The population of these settlements was supported by domesticated cattle and sheep as well as hunting and gathering wild species. Over the more than 1000 year history of Çatalhöyük, domesticated plant species gradually became a larger and larger portion of the diet.

The second point is that once reliance on cultivated crops reached a certain point, the agricultural way of life became locked in, for several reasons. An increasingly sedentary population meant higher rates of fertility and an increase in population size (Harris, 1977). Although several recent studies have shown that large settlements preceded widespread agriculture and that the switch from hunting and gathering to agriculture was a complicated process, in the context of the length of time our species has existed the rapidity of the change in the basic way humans lived should not be forgotten: 10 000 years ago most people on the planet lived in small bands of hunter–gatherers, and only 5000 years later most humans lived in settled communities. Over millennia the growing hierarchical organization of society and the emergence of religious and political elites favored the continuance of a way of life that benefited the dominant, and controlling, social group regardless of the consequences for the majority of the population.

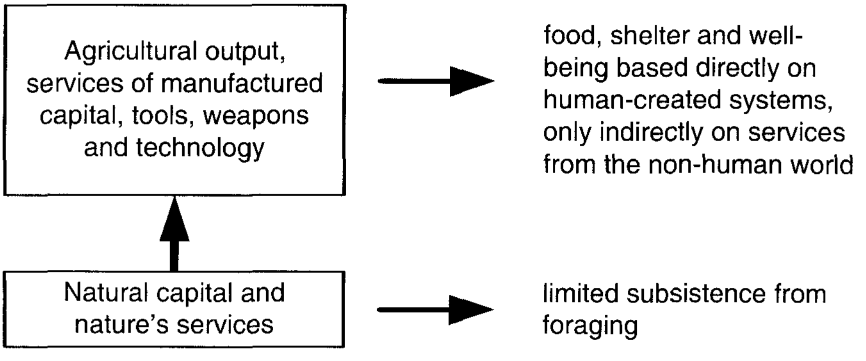

Figure 7.2 Switch to dependence on manufactured capital in agricultural societies.

As depicted in Figure 7.2, the adoption of agriculture led to an increasing dependence on manufactured capital and material technology. This meant that, although humans as biological organisms have always depended on the services of nature to survive, these services became more and more indirect and roundabout. Humans were increasingly able to live under the illusion that they were separate from the natural world.

7.2.2.2 **Intensification of Production and Environmental Decline: Easter Island**

The human occupation of Easter Island, like the Tehuacán example above, also shows a pattern of temporary emancipation from resource constraints, rapid population growth, and eventual collapse as technology became increasingly specialized and more and more vulnerable to exogenous disturbance (Erickson and Gowdy, 2000). Research on Easter Island suggests that island forest resources began to decline shortly after human arrival around 400 AD. Soil erosion was also rapid, accelerated by the destruction of forest cover. Archeological evidence indicates that the human population continued to increase for several hundred years after near depletion of the forest and accompanying environmental degradation. The population peaked at perhaps 10 000 individuals in 1600 AD and had crashed to about 3000 by the time Dutch explorers arrived in 1722. If the population continued to increase in spite of severe resource degradation, something must have substituted for the natural resources in order to maintain population growth following resource degradation. It appears that the lag in population decline after land degradation was due to the ingenuity of Easter Islanders in finding substitutes for natural resources, at least in the short run. For instance, as forest resources were converted to tools and boats, the island's ocean and wildlife resources were harvested more intensively and replaced forest and soil resources.

Limits existed, however, to this substitution of manufactured for natural capital, and Easter Island's population level could not be maintained and eventually crashed. Once the natural resource base had been irrevocably degraded beyond a certain point, the replenishment of manufactured capital depreciation was no longer possible. Despite innovation and substitution, collapse was inevitable. The natural resource base need not be completely consumed in order to instigate its irreversible decline. Moreover, marginal exploitation of ecological systems may lead to sudden, unexpected consequences where the next fish caught, the next species lost, the next acre developed could lead to a downward spiral of resource degradation and social disintegration. The social institutions of Easter Islanders were unable to change quickly enough to smoothly adjust to increasing natural resource scarcity. Instead, archaeological evidence shows severe societal collapse following resource degradation. Warfare, starvation, and cannibalism eventually followed widespread plant and animal extinction (Bahn and Flenley, 1992; van Tilberg, 1994; Diamond, 1995).

7.2.3 The Second Divide: The Rise of Industrial Society

The transformation of the human economy from an agricultural society to an industrial one began only about 250 years ago (Metcalfe, 1988; Mokyr, 1990). Several important technological breakthroughs in the Middle Ages (500–1500 AD), including the wheeled plow, the water wheel, and the horse collar (Mokyr, 1990, chapter 3) and improvements in the organization of agriculture during the Renaissance paved the way for the truly remarkable flowering of commerce and technology from 1750 to the present (Mokyr, 1990; Hohenberg and Lees, 1996). The consequences of the industrial revolution for the human condition and for the natural world have been at least as profound as those following the adoption of agriculture. During the past 2.5 centuries the human population has increased from 1 billion to 6 billion. The growing domination of the market economy has created a civilization of haves and have-nots, with the bulk of an ever-increasing output of economic goods and services going to a smaller and smaller percentage of the world's population. Increasing income stratification is apparently accelerating and occurring within almost every geographic, economic, and sociological category. According to World Bank estimates, the world's poorest countries are getting absolutely poorer and the growth rate of per capita income in the richest countries is accelerating.

The human impact on the natural world is also increasing. Two of the most important negative impacts are biodiversity loss and global climate change. Economic activity, particularly burning fossil fuels and deforestation, has pushed atmospheric CO_2 to its highest level since a period of global warming some 125 000 years ago. Manabe and Stouffer (1993) estimate that atmospheric CO_2 will increase from its preindustrial level of about 270 ppm to over 600 ppm within the next 100 years. This could raise global temperatures by 3.5 to 7 °C and raise sea levels by several meters. The evidence is increasingly clear that the unprecedented change in global temperature is anthropogenic. Crowley (2000, p. 270) writes:

> The combination of a unique level of temperature increase in the late 20th century and improved constraints on the role of natural variability provides further evidence that the greenhouse effect has already established itself above the level of natural variability in the climate system. A 21st century global warming projection far exceeds the natural variability of the past 1000 years and is greater than the best estimate of global temperature change for the last interglacial.

Human activity is also directly and indirectly causing a massive loss of biodiversity, perhaps as great as the losses during the five major extinction episodes of the half-billion years of complex life on earth (E. O. Wilson, 1992). According to calculations by Vitousek et al. (1986), human activity, directly and indirectly, modifies about 40% of the potential terrestrial products of photosynthesis. Human activity now stretches around the globe and is having numerous unintended effects such as the introduction of alien species, disruption of water and nutrient cycles, and

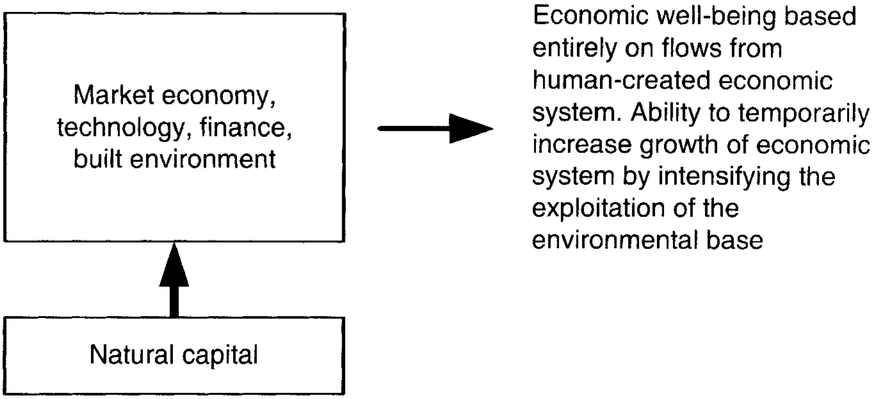

Figure 7.3 Economic use of the environment is indirect in industrial societies.

changes in the composition of atmospheric gases. The entire planet has now become a collection of human-dominated ecosystems. Our material culture has reached the point where nature's contribution to the human economy is almost entirely indirect. As depicted in Figure 7.3, economic well-being for most of the world's population is entirely separated from direct flows from the environment.

The industrial revolution has not only drastically altered relationships between humans and between humans and nature, it also set in motion an ongoing process of economic change with an inner logic of its own (Metcalfe, 1988). It is important to keep in mind, however, that the pattern established since the invention of agriculture – input substitution and intensification of production through technological advance in the face of diminishing resources – continues to be the path followed in the evolution of the industrial economy. The underlying belief system which supports the industrial revolution has its origins in the agricultural revolution – beliefs still enshrined in the world's major religions. These beliefs have in the last few hundred years been refined and honed into a cultural mythology unique in the history of our species. These core beliefs include the inevitability of progress, continual economic expansion, and salvation through technology. This belief system is supported by the discipline of contemporary economics whose theories of the dynamics of market exchange form an ideological core that embodies the most important cultural myths that arose with the adoption of agriculture and that gave birth to the industrial revolution.

The consequences for human cultures of the communication revolution of the 20th century have been so profound that it may be called a 'third divide' in human history. Within the lifetime of a person born early in the 20th century the world has been transformed from one in which each major geographical region had its own unique collection of cultural identities to one where the majority of humans on the planet buy the same commodities, listen to the same music, and through the urging of advertising adopt the same cultural values. Because the globalization of the market culture has occurred so rapidly and so completely, there is a real danger that we might see the triumph of the market as a natural occurrence; as the inevitable victory of rationality over barbarism. This view is not only based on an ideology of efficiency (Bromley, 1990) but also on a belief that Western society is somehow devoid of the 'exotic' customs and beliefs that characterize less developed societies. Sahlins (1993, p. 12) writes:

> Western capitalism in its totality is a truly exotic cultural scheme, as bizarre as any other, marked by the subsumption of material rationality in a vast order of symbolic relationships. We are too much misled by the apparent pragmatism of production and commerce. The whole cultural organization of our economy remains invisible, mystified as the pecuniary rationality by which its arbitrary values are realized. All the idiocies of modern life from Walkmans and Reeboks to mink coats and seven-million-dollar-a-year baseball players, and on to McDonald's and Madonnas and other weapons of mass destruction – this whole curious scheme nonetheless appears to economists as the transparent effects of a universal practical wisdom.

In spite of the claim by many economists that market decisions are based on 'positive' (objective and scientific) not 'normative' (value-laden) criteria, we should not be blind to the fact that the current market system that has evolved over the past few millennia is neither more nor less culturally specific than any other of the enormous variety of ways of making a living created by human societies.

7.2.3.1 Intensification of Production and Environmental Decline: Nauru

The island of Nauru in the South Pacific illustrates the process of intensification of production and environmental degradation in a modern market economy (Gowdy and McDaniel, 1999; McDaniel and Gowdy, 2000). Little is known about Nauru's prehistory, but the island was apparently settled by several groups of Melanesian and Polynesian peoples over a period of several thousand years. Traditionally the small island supported a population of about 1000 people living on fish and a large variety of native and domesticated plants and animals. Because of its geographical isolation, Nauru experienced little contact with Western cultures until the late 1800s. In 1900 it was discovered that the island was composed primarily of one of the highest grades of phosphate rock, an essential requirement for plant growth and an ingredient in fertilizer. Under various colonial administrations, including German, British, Japanese, and Australian, and under independent rule beginning in 1968, most of the island of Nauru has been severely degraded by phosphate mining. Today, most of the island is uninhabitable except for a narrow strip of land around the coastal perimeter.

As the natural resources of Nauru were degraded, the inhabitants came to rely more and more on trade with the outside world for necessities that were once plentiful locally. A diet of fresh fruit, coconuts, vegetables, and fish has been replaced with imported canned goods. Even water now has to be imported from the mainland. The once vibrant and self-sufficient culture, living within the constraints of a local ecosystem, has been transformed into one totally dependent on imports from the world market economy. Not only the cultural traditions of Nauru have suffered; the increased consumption of highly processed foods has given Nauruans one of the worst health profiles in the world. The rate of diabetes is the highest in the world, and very high rates of hypertension and heart disease are also present.

In return for selling their island the people of Nauru, in spite of gross injustices perpetuated by colonial powers, received substantial monetary rewards. A trust fund was established to provide for the day the phosphate would be exhausted. In spite of some bad investments, the value of the trust fund was estimated to be over US $ 1 billion in the early 1990s. Unfortunately, most of the trust fund disappeared because of a combination of bad investments and the Asian financial meltdown of the mid 1990s. Today the people of Nauru are left with few environmental resources and a dwindling income flow from the remnants of the depleted phosphate reserves to provide for their livelihoods. The Nauru experience can be interpreted as an isolated case or as another, modern, example of the pattern of intensification of production and overshoot and collapse that has prevailed in complex societies for the past several thousand years.

7.3
Theories of the Evolution of the Industrial Economy

Karl Marx was the first economist to develop a systematic theory of the evolution of the human economy. Marx's theory of economic evolution is historical materialism, the view that the bases for human social structure and social evolution are the relations of production, that is, the social relations established to reproduce people's material lives. The social relations of production can change quantitatively without modifying the basic structure or can change qualitatively through social upheaval (Mandel, 1988). The goal of his monumental work *Das Kapital* was to describe the inner workings and evolution of the capitalist system. To do this Marx first constructed, in a rigorous way, a model of a pure capitalist system which, in modern terminology, was characterized by competition with no market failures. The driving force in the system was production for profit which came from extracting surplus value from labor. Marx saw economic change as resulting from a struggle between labor, the creator of surplus value, and capitalists, who owned the farms and factories (the means of production).

An important evolutionary law in Marx's system is the falling rate of profit. Under perfect competition, the means of production sell at the value of what they can be expected to produce. If a new machine can be expected to produce $ 100 000 worth of output (properly discounted) over its productive life, then it will sell at that price. Only living labor can be expected to be paid less than the value of its output, because of the unequal power relationship between workers and owners. The problem is that capitalists are under constant pressure to use better and better, and more expensive, machinery to keep pace with competitors. But in doing so, capitalists replace profit-creating labor with non-profit-creating machines. The result is inevitable crisis. In Heilbroner's words (1992, p. 161):

> As his profits shrink, each capitalist will redouble his efforts to put new laborsaving, cost-cutting machinery in his factory. It is only by getting a step ahead of the parade that he can hope to make a profit. But since everyone is doing precisely the same thing, the ratio of living labor (and hence surplus value) to total output shrinks still further. The rate of profit falls and falls. And now doom lies ahead. Profits are cut to the point at which production is no longer profitable at all. Consumption dwindles as machines replace men and the number of employed fails to keep pace with output. Bankruptcies ensue. There is a scramble to dump goods on the market, and in the process smaller firms go under. A capitalist crisis is at hand.

The crisis is not the end of the process. As the economy turns down, unemployment increases, wages fall, machinery is sold at bargain prices, and eventually surplus value returns, and the process repeats itself. Marx argued, however, that each successive crisis is worse than the preceding one, a prediction that held true until the Keynesian policies of the second half of the 20th century damped capitalism's boom and bust cycles.

Marx was greatly influenced by theories of evolution, including Darwin's, that were in the air in the middle of the 19th century. The rigor of his evolutionary approach is still unique in the history of economic science. Marx not only provided a stylized and systematic description of a modern capitalist economy, he stepped outside the arena of positive explanation and provided an evolutionary critique of that system. His work foreshadowed that of many of the ideas of the great economists of the 20th century, including Keynes, Myrdal, and Schumpeter.

In contrast to the great, broad insights into human activities and wide-ranging critiques of industrial society made by Adam Smith, John Stuart Mill, and Karl Marx, by the late 19th and early 20th century economics had become pedantic, cautious, and apologetic for the existing social order. The gilded age of the latter part of the 19th century is seen today as a period of gross excess. It was an age of robber barons and cycles of economic booms and depressions. Yet the works of the great economists of that period, Marshall, Taussig, and J. B. Clark, for example, give no hint of the real society behind their economic analyses. An exception was Thorstein Veblen, who was greatly influenced by the evolutionist Herbert Spencer and was a strong advocate of an evolutionary approach to economics. In his well known essay "Why is economics not an evolutionary science?" (Veblen, 1898) and other writings, he stressed that social institutions evolve and adapt to changing environments. He also believed that human habits were based on instincts that had evolved to take advantage of environmental conditions. But he parted company with the social Darwinists like Spencer and argued that institutions could become lethargic and act as a drag on the progressive evolution of society. He was particularly critical of neoclassical economics (a term he coined to describe the economics of Alfred Marshall), which he saw as narrow and confined to the most uninteresting questions about economic life. For Veblen, economic activity was shaped not by the logic of productive efficiency but rather by its social and institutional context. Veblen drew heavily on the anthropological writings of his day to examine the place and the function of the leisure class in modern society. In contrast to Marx, Veblen saw class distinctions as the glue that held society together. The lower classes did not want to overthrow their superiors, they wanted to emulate them.

Veblen was not only a precursor of contemporary evolutionary economics (Hodgson, 1992) he was a central figure in the emergence of the American School of Institutional Economics. Institutions for Veblen were not formal organizations, but 'settled habits of thought'. Veblen's influence can be seen in the work of C. E. Ayres, John Commons, and now Richard Nelson who follows Veblen's lead in stressing the interplay between habits of thought and technological progress. In a recent paper Nelson and Pack (1999) examined the positive (enhancing) and negative (restraining) roles of institutions in the development of the Korean automobile industry. Frank (1988, 1998) has also resurrected many of Veblen's ideas in popular books on the role of emotions in consumer behavior and conspicuous consumption. Unfortunately, much of the so-called new institutional economics is merely an elaboration of the 'survival of the fittest' metaphor of standard economics so as to include institutions and cultural evolution. With some important exceptions (Hodgson, Nelson, and Warren Samuels to name a few), institutional economics still follows the ultra-Darwinian path of marginalism, radical adaptationism, and methodological individualism (see, for example, Vromen, 1995).

In contrast to the evolutionary economics of Marx and Veblen, the use of biological metaphors by mainstream economists took a very different turn toward the end of the 19th century. The conception of evolution held by most economists since Alfred Marshall is analogous to the ultra-Darwinian position in evolutionary biology. In the standard view, economic change occurs through the accumulation of myriad successful innovations, driven by profit maximization through increased efficiency. Individual firms must adopt new, more efficient techniques or they will be replaced by firms that do so. Extensive use of the calculus of constrained maximization insures that this process is seen as gradual and continuous. It is well known that Marshall placed Darwin's phrase 'natura non facit saltum' (nature does not make leaps) on the frontispiece of his *Principles of Economics*. In spite of repeated statements about the limitations of the methods of physical dynamics, Marshall stood by his principle of continuity and defended the view that economic evolution is gradual (Levine, 1983).

The alternative to Marshall's gradualism in the early 20th century was Schumpeter's theory of creative destruction. Schumpeter followed Marx in viewing the economy as an evolving out-of-equilibrium system. Unlike Marx, he put a positive cast on the crisis phase of the economic cycle, with the Darwinian view that crises open up niches in the economic system that are quickly filled by the most innovative and vigorous new firms. 'Destruction' is a necessary ingredient to the 'creative' process of capitalism. In contrast to the gradual Darwinism of Marshall, Schumpeter was less interested in marginal change than in sweeping new innovations radically different from any precursors. Schumpeter had little sympathy for biological analogies in economics because of the insistence in his day that biological evolution follows a uniform unilinear development (Schumpeter, 1934, pp. 57–58). It may be true that Schumpeter misunderstood Darwin (Hodgson, 1997, p. 135), but so did most biologists of his time (Mesner and Gowdy, 1999). Recently, interest in Schumpeter's work has increased markedly. One group of neo-Schumpeterians focuses on the nature of innovation diffusion, and several elaborately modeled simulations have shed some light on this topic (see for example the articles in England, 1994; and Shionya and Perlman, 1994). Georgescu-Roegen (1989) saw a vindication of Schumpeter's insistence on discontinuous change in the punctuated equilibrium revolution in evolutionary biology.

For over 100 years a division has existed in economic theory between those who would limit the scope of economics to explanations of the behavior of consumers and firms in well organized markets and those who insist that economics is a social science, embedded within nature, human culture, and human psychology. Perhaps *the* key issue dividing neoclassical and heterodox explanations of economic evolution is the issue of methodological individualism and the degree of representativeness of economic man. Is economic man an accurate characterization of universal human nature or is there a need to supplement *Homo economicus* with other species describing other human types?

7.4
Economic Man and Economic Change

Contemporary texts define the field of economics as the science of the allocation of scarce resources among alternative ends (R. L Miller, 1998, p. G-4). Individual consumers allocate limited budgets among the unlimited objects of desire in such a way as to maximize utility. Individual firms allocate limited budgets to acquire productive inputs so as to maximize output. The economic problem has been defined as one of constrained optimization, making the best of the generalized scarcity the world confronts us with – a world of unlimited wants and limited means of satisfying those wants. The other important part of the story is that the most efficient way of solving the economic problem is through organized markets. Most economic theory today revolves around the study of how well organized markets operate to allocate resources most efficiently. In this framework, efficiency is the manifestation of progress and the driving force behind economic evolution. And the heart of this theory is economic man. Economic man is naturally acquisitive, with an insatiable appetite for economic goods, is rationally calculating, and is devoid of social and environmental context. Many economists would agree with Margaret Thatcher's claim that there is no such thing as society, only individuals and families (D. S. Wilson, 1999).

The cultural myth of economic man is characterized by a set of axioms based on both utilitarian philosophy and the need for mathematical tractability. The axioms of consumer choice include completeness (consumers can categorize any consumption bundle as more preferred, less preferred, or indifferent to any other bundle), transitivity (the consumer is consistent in ranking commodity bundles from most to least preferred), and nonsatiation (the bundle with more of at least one good is preferred). For a more complete treatment of consumer choice, see any microeconomics textbook including Jehle (1991), Mas-Colell et al. (1995), and Varian (1992). The axioms of consumer choice are a stylized description of consumer behavior in organized markets and are based on a belief system compatible with the kind of impersonal market exchange practiced by western urban people (Georgescu-Roegen, 1960).

Economic man is constructed to describe how individual consumers make choices in organized markets. Some basic beliefs underpinning the construction of economic man are (1) methodological individualism, that is, the belief that the starting point for economic analysis should be an isolated individual acting at a particular point in time; (2) the commensurability of wants, that is, the belief that all things can be compared through a common metric of valuation; and (3) the making of choices on the basis of marginal valuation. As Winter (1988, p. 617) points out, economic man is a first approximation that sometimes works as a description of human behavior and sometimes does not. It is clear, however, that real-world human behavior is a complex combination of immediate self-interest, social cooperation, and genetic predispositions (Gintis, 1998; Winter, 1988, p. 617).

7.4.1 Methodological Individualism

A characteristic of the evolution of the Western-style market economy is the increasing emphasis on the individual to the exclusion of social and ecological context. Over the centuries, markets have become increasingly impersonal, a characteristic seen as a virtue by standard economists. Market outcomes are driven by individual decisions made at a particular point in time. The radical individualism of the market economy is mirrored in economic theory. The neoclassical view is that individual preferences should be taken as the starting point for economic analysis and that these preferences can be accurately revealed in market outcomes. In this view, individuals are rational and are the best judge of what is good for them, the choices that give individuals the greatest amount of utility are those revealed in the market, and these market outcomes are sacrosanct. According to the standard approach, the principle of consumer sovereignty compels us to accept people's tastes including their intertemporal preferences. Methodological individualism in economics is reductionism in the extreme. Its goal is to reduce explanation to the lowest level possible, to the exclusion of higher-order processes. In Shackle's (1989, p. 51) words "economics is about choice as a first cause".

As Hodgson (1993b) argues, the problem with methodological individualism is not reductionism per se but rather the exclusion of other levels of explanation for economic behavior and economic change. Hodgson asserts that the microfoundations project, that is, the attempt to explain all economic processes based on the behavior of individual firms and consumers, has foundered for a number of reasons. Among these are (1) work in theoretical game theory has undermined the economic notion of rationality (see below); (2) related work in the economics of imperfect information and bounded rationality (Tisdell, 1996) has undermined standard rational choice theory; (3) complex system analysis has revealed the sensitivity of realistic nonlinear economic models to initial conditions; and (4) the work of Arrow and Debreu has implied that the existence and uniqueness of equilibrium depends on very strong and extremely unrealistic assumptions. The theory of the firm requires such narrow and unrealistic conditions that its use in describing individual consumer and firm behavior is problematic (Radner, 1968). Using the theory of the firm as a foundation for describing the macroeconomy is even more problematic (van den Bergh and Gowdy, 2003).

Economic man and the approach of methodological individualism may be a reasonable description of impersonal market exchange. Furthermore, the behavior of many individuals, perhaps as many as 25% of the population, corresponds to the neoclassical characterization of human behavior (Gintis, 1998). Much human behavior, even economic behavior, however, falls outside the scope of the narrow focus of the basic neoclassical model. Perhaps the major problem with methodological individualism is its policy implications. Neoclassical theory provides an elaborate justification for the superiority of market choices. Fundamental differences exist, however, between the choices individuals make in the context of markets and the choices they make in a larger context as members of a community of other humans (Sagoff, 1988; Gowdy, 1997, 1999). The individual-at-a-point-in-time perspective of neoclassical economics (and the market economies that that theory describes) is particularly problematic in decisions about the use of exhaustible natural resources and the generation of irreducible pollution (Georgescu-Roegen, 1975; Daly, 1991; Bromley, 1998; Gowdy and Mayumi, 2001).

The belief in the supremacy of markets to make decisions about resource allocation is the one idea that unites most economists. Sometimes this idea is pushed to extremes, as in the claim by Friedman (1963) that the more decisions that can be handled by the market and taken away from the 'irrational' political process the better off (the more democratic) society will be. The argument is that markets are democratic because they are based on the 'dollar votes' of individuals whose collective wishes determine that optimal mix of commodities. The methodological reasoning behind this view has been undermined by advances in economic theory. Arrow's (1963) impossibility theorem essentially states that it is impossible to construct a consistent aggregation rule (a social utility function) based on individual preferences. In other words, it is impossible that social preferences could be rational in the sense that society behaves as a single individual would (Mas-Colellet al., 1995, p. 789). Yet market-based policies, including the 'weak sustainability' criterion for natural resource use (Solow, 1974; Hartwick, 1978), emissions trading to counter global warming (Smith, 1999), and cost–benefit analysis in general (Hanley, 1999), depend on the strong rationality assumptions that are part of methodological individualism and the axioms of consumer choice.

7.4.2 Commensurability of Wants

'Commensurability of wants' is an awkward term referring to the fact that, in neoclassical analysis, all the attributes of a good are reduced to a single metric. The implicit assumption is that all things that humans value can be reduced to some common denominator – utility, or to take it a step further, money. Once the objects of utility are reduced to a common valuation metric, then substitution, marginal tradeoffs, and discounting seem logical and natural. Again, this may be reasonable for many market goods. The relative quality or desirability of clothing items at a department store, for example, may be accurately reflected in their relative prices. When applied to features of the natural world, however, the assumption of commensurability may not be justified. Can one imagine a single measure that could be used to make meaningful comparisons of the values of species or ecosystems anywhere on the planet at any time?

Once the idea of a common denominator of value is accepted, it is a small step to the standard economic notion of sustainability, called weak sustainability, which means sustaining the output of market goods and services. Weak sustainability assumes that manufactured capital and natural resources are substitutable. To ensure that economic growth is nondeclining in the future, society need only maintain the total stock of 'capital', not the individual components. Suppose that the discounted present value of the stream of income from the sustainable use of a rainforest is $ 10 million. Suppose further that you can cut down the forest, sell the timber, invest the money (in anything) and obtain a properly discounted income stream of $ 11 million. From the point of view of traditional cost–benefit economics, the decision is clear: cut down the forest.

7.4.3 Marginal Valuation

Central to economic theory is the concept of marginal value, that is, the change in value that results from a small increase or decrease in the item being valued. Marginal valuation is a concept so ingrained in how economists think about markets and value that it is difficult for many to appreciate its limits. Many sources of human welfare, however, are not reducible to a market context and are not properly subject to marginal valuation. For example, when we consider the value of a species or an ecosystem, the concept of marginal value is problematic. Removing or adding one species will affect all the others in the system in largely unpredictable ways. Biodiversity is characterized by functional transparency (Vatn and Bromley, 1994), that is, the contribution of one feature of an ecosystem cannot be known until it is added to or subtracted from the system. Furthermore, the effect is likely to be different each time a change is made. Unresolved issues in neoclassical utility theory call into question the universal applicability of the notion of marginal value. Widely used tools of neoclassical analysis, such as the marginal rate of substitution, are called into question by the fact that some goods and services are considered to be absolutely essential and not subject to trade (Georgescu-Roegen, 1936, 1950). This is called lexicographic preference and has been empirically verified in several studies of consumer attitudes (for example, Spash and Hanley, 1995).

The question of marginal value is fraught with conceptual as well as informational difficulties. Georgescu-Roegen (1968) pointed out that diminishing marginal utility has no meaning without some notion of cardinality. It is not enough to be able to merely rank goods according to their utility. To construct a complete preference ordering we need to be able to rank not only commodity bundles but also the differences between them.

7.4.4
Consumer Sovereignty and International Trade

An interesting twist in the evolution of economic theory and policy is the emerging conflict between the notion of 'consumer sovereignty' as the starting point for economic analysis and the goal of efficiency in production. Randall (1988, p. 217) gives a lucid statement of the neoclassical view of consumer sovereignty: "The mainstream economic approach is doggedly nonjudgmental about people's preferences: what the individual wants is presumed to be good for that individual." Traditionally economic man and his preferences, however they are formed, have been the starting point for economic analysis (Stigler and Becker, 1977). Recent occurrences have revealed inconsistencies and tensions within economic theory and policy. Concerning bovine growth hormone and genetically modified crops, economists are coming down on the side of efficiency, not consumer sovereignty (Bromley, 1998). Free market based trade agreements such as GATT (General Agreement on Tariffs and Trade) also reveal the conflict between economic man and social reality. GATT rulings, such as the decision not to permit 'dolphin friendly' labels on tuna cans, take the position that giving consumers information about how something is produced is somehow outside the bounds of what market choices should be about. What matters in the standard view are only the physical characteristics of the final product and its price. The driving ideology behind this view is, I believe, a notion of economic (and social) progress through survival of the fittest defined as survival of the most economically efficient. In the context of methodological individualism, commensurability or wants, and marginal valuation, the only things that should matter to the survival of a product through time are the demand for that product and the costs of its production. If one believes in the Spencer–Marshall interpretation of economic evolution through survival of the most efficient, any attempt to judge a product through any quality other than its own physical characteristics and its price is bound to interfere with the 'natural' workings of the market economy.

Barham (1997) discusses the distinction surfacing in trade disputes between labeling based on product-related qualities and those based on characteristics of the producer such as processing and production methods or location of the producer. Giving consumers more information about product-related qualities is consistent with neoliberal economic theory and free-trade ideology. Labels considering the characteristics of the production process, however, are based on very different and broader concepts of economy and society. Barham (1997, p. 2) argues that the 'social value' ecolabeling is indicative of a larger movement which aims to humanize the market mechanism and which can be seen as a microcosm of the future evolution of economic behavior.

New economic theories are evolving based on increasingly realistic models of how social beings, human and otherwise, organize themselves and how they make decisions. Sah and Stiglitz (1986) have constructed a model of an economic system that incorporates hierarchical and polyarchical information and communication systems. The economics of altruism has been explored from neoclassical (Becker, 1976, 1981; Samuelson, 1993) and heterodox (Bergstrom and Stark, 1993; Simon, 1993; Bowles and Gintis, 1999b) perspectives. New work in anthropology and economics stresses the evolutionary importance of social constraints on individual behavior (McClennen, 1990; Hawkes, 1993; Boehm, 1997) and the evolution of social cognition (Caporael, 1997; Richerson et al., 1999; Bowles and Gintis, 1999a). It is only a matter of time until the field of economics is transformed by these scientific advances in other disciplines. Although economics has been influenced by other disciplines in the past, and it is true that neoclassical theory has shown an uncanny ability to absorb criticism, the current challenge is different because it calls into question the core of standard theory. The axioms of consumer choice, upon which welfare economics is based, lead to false predictions about human behavior.

7.4.5
The Evolutionary Roots of Economic Man

There is a growing concern about the increasing depersonalization of modern society and the increasing 'rationalization' of everyday life. Humans today seem to be being rapidly transformed into economic persons. We should not lose sight of the fact, however, that economic man has a long lineage in the cosmology of western civilization. Sahlins argues that the roots of economic man lie deep within Christian cosmology. Man was put on earth destined to a life of misery trying to satisfy desires that even when fulfilled only led to further misery. But as Sahlins (1996, p. 397) points out:

> Still, God was merciful. He gave us Economics. By Adam Smith's time, human misery had been transformed into the positive science of how we make the best of our eternal insufficiencies, the most possible satisfaction from means that are always less than our wants. It was the same miserable condition envisioned in Christian cosmology, only bourgeoisified, an elevation of free will into rational choice, which afforded a more cheerful view of the material opportunities afforded by human suffering. The genesis of Economics was the economics of Genesis.

The characteristics of the economic way of thinking listed above, including the commensurability of wants and methodological individualism, go back many centuries before the commodification of everyday life. In 1440 Nicholas of Cusa argued that it was God's will for humans to place value on His creation:

> For although the human intellect does not give being to value (i.e., does not create the things valued), there would nevertheless be no distinctions in value without it ... Wherewith we see how precious is the mind, for without it, everything in creation would be without value (Quoted in Sahlins, 1996, p. 399).

Methodological individualism also has a history going back long before organized markets. Sahlins (1996, p. 398) writes:

> Again a long line of academic ancestors – stretching back to Vico and Machiavelli through the Enlightenment philosophes to the English utilitarians and their latest incarnations in the Chicago School of (the) Economics (of Everything) – have all argued that individual self-interest in the fundamental bond of society ... Out of the Sin came Society. Men congregate in groups and develop social relations either because it is to their respective advantage to do so or because they discover that other men can serve as means to their own ends.

The notion that suffering is necessary for salvation is another ancient idea solidly ensconced in economic theory. The idea defining contemporary economics is scarcity, unlimited wants confronting limited means of satisfying those wants. Suffering is also necessary on the production side of the economy. Survival of the fittest means extinction of the weak. As John D. Rockefeller wrote with apparent relish:

> The growth of a large business is merely a survival of the fittest ... The American Beauty Rose can be produced in the splendor and fragrance which brings cheer to its beholder only by sacrificing the early buds which grow up around it (Quoted in Penrose, 1952, p. 809).

Schumpeter's 'creative destruction' interpretation of the business cycle is an idea whose origins lie in the beginnings of agricultural society. The seasonal death and resurrection of crops probably gave birth to the idea that we have to sacrifice and suffer to make ourselves better, an idea enshrined in world religions and in the institution of capitalism.

7.5 Contemporary Evolutionary Economics

It is not much of an exaggeration to say that modern evolutionary economics began with the publication in 1982 of Nelson and Winter's book *An Evolutionary Theory of Economic Change*. The book is something of an enigma, in that is has been claimed both by essentially neoclassical economists and by those who argue for a nonequilibrium, nonmarginalist approach. Vromen (1995, Chapter 4), for example, argues that Nelson and Winter's work represents "an extension of the basic beliefs of 'orthodox' theorists such as Alchian and Friedman". If one believes

Nelson and Winter's own words, however, their intellectual debt is to Schumpeter and Herbert Simon. Regarding Simon they write (Nelson and Winter, 1982, p. ix): "His work encouraged us in the view that there is much more to be said on the problem of rational behavior in the world of reality than can be adequately stated in the language of orthodox economic theory."

A deficiency in Friedman's 'survival of the fittest' argument for the existing array of firms in a capitalist economy is the lack of a gene-equivalent in economic evolution. Friedman's position has been pointedly criticized on this point by Penrose (1952), Winter (1964, 1971, 1975), and Hodgson (1993a, 1994). Nelson and Winter (1982) argue that the carrier of economic information is production is the 'routine'. Routines range from well specified technical procedures to business strategies, and they play the role genes do in evolutionary biology. Nelson and Winter (1982) present a series of simulation models to examine a variety of assumptions about firm behavior. Although their simulations are limited to marginal changes, not Schumpeterian quantitative leaps, Nelson and Winter show clearly that in an evolutionary system, convergence to equilibrium is a special case requiring numerous restrictive assumptions. A good analysis of economic evolution should provide relevant and meaningful policy recommendations. And according to Nelson and Winter (1982, p. 413): "Orthodox theory cannot adequately provide that analysis and understanding because, fundamentally, it is about an ahistorical world in which genuine novelties do not arise."

The lack of a specific unit of inheritance – a gene-equivalent – is a problem that has plagued theories of economic evolution for decades. In the early 1950s several economists applied the metaphor of natural selection to the theory of the firm. Alchian (1950) argued that, because of the natural selection operating on firms, they need not be conscious maximizers. Like Friedman (1953) he asserts that evolutionary processes, namely survival of the fittest (most efficient) firms, will insure that profit maximizers survive whether or not they overtly try to maximize profit. Alchian's position was criticized by Penrose (1952) because of the lack of a gene-equivalent in the economic world. Interestingly, as Hodgson (1994) pointed out, in a later work Penrose (1959) at least implicitly proposed a theory of economic evolution and transmission of knowledge through routines, foreshadowing the work of Nelson and Winter. Penrose parted company with neoclassical economists on several other points (Best and Garnsey, 1999). First she recognized the importance of contingency and moving equilibria (see her 1995 preface to the reissued *The Theory of the Growth of the Firm*). Second, she argued that firms are not passive agents responding like optimizing automatons to changing external conditions, but rather consciously shape their economic environments. Finally, she recognized the importance of increasing returns to the economic development of the 20th century.

Enke (1951) also argued that, because of survival of the fittest, in the long run only optimizers survive. The article that has perhaps had a greater impact than any other on economics is Friedman's 1953 paper "The methodology of positive economics", an uncompromising defense of methodological individualism, the separation of 'positive' from 'normative' economics, and a survival-of-the-fittest justification for market outcomes. In an oft-quoted paragraph Friedman (1953, p. 22) wrote:

> Let the apparent immediate determinant of business behavior be anything at all – habitual reaction, random chance, or whatnot. Whenever this determinant happens to lead to behavior consistent with rational and informed maximization of returns, the business will prosper and acquire resources with which to expand; whenever it does not, the business will tend to lose resources and can be kept in existence only by the addition of resources from the outside. The process of 'natural selection' thus helps to validate the hypothesis – or, rather, given natural selection, acceptance of the hypothesis can be based largely on the judgment that it summarizes appropriately the conditions for survival.

Winter (1964) made a telling criticism of Friedman's maximization hypothesis. For selection to work there must be some superior quality or characteristic of a surviving firm that is passed on from generation to generation. Unless there are characteristics that can be identified and traced through time, Friedman's survival of the fittest argument is a mere tautology. Profit maximizers survive and if a firm survives that means it is a profit maximizer. Although it is not necessary to have a firm 'gene' that determines fitness, there must be some identifiable underlying characteristic that works on the firm 'phenotype' (Hodgson, 1994). According to Winter (1988, p. 616),

> Evolutionary economics thus attaches central importance to a question that is not merely unanswered, but unasked in the context of orthodox economic theory: what are the social processes by which productive knowledge is *stored*?

Identifying such processes is critical in understanding economic evolution. Even if specific routines could be identified there are several objections to applying the survival of the fittest argument to firms:

1. There must be some mechanism for radical innovations (mutations) to enter the existing mix of routines. Schumpeter's cycle of creative destruction provides the environment for innovation but not the mechanism through which mutations are created.
2. The economic environment is not exogenous to the firm. Firm behavior actively shapes its environment and its success or failure alters that environment (Penrose, 1959; Nelson and Winter, 1982; Hodgson, 1994).
3. Accidents of history may favor less efficient firms or technology. Examples include the adoption of the QWERTY typewriter keyboard and the survival of the VHS video recording system over the apparently superior Beta technology (Gould and Lewontin, 1979; David, 1985).
4. Increasing returns to scale may favor first, but less efficient, entrants in the market over superior later entrants (Arthur, 1989).

7.6
Beyond Methodological Individualism in Biology and Economics

The philosophical debates in economics and evolutionary biology are remarkably similar. Furthermore, the resolution of these debates is heading toward similar outcomes in both fields of inquiry. We have seen that the cornerstone of orthodox economic theory is the notion of economic man, existing at an isolated point in space and time devoid of cultural and environmental context. For most of this 20th century orthodox evolutionary theory in biology also focused on individual units and generally eschewed a holistic approach. The 'virtue of selfishness' has been a major theme in biology as well as in economics. Ghiselin (1974, p. 247, quoted in Sober and Wilson, 1998) wrote:

> The economy of nature is competitive from beginning to end ... The impulses that lead one animal to sacrifice himself for another turn out to have their ultimate rationale in gaining advantage over a third ... Where it is in his own interest, every organism may reasonably be expected to aid his fellows ... Yet given a full chance to act in his own interest, nothing but expediency will restrain him from brutalizing, from maiming, from murdering – his brother, his mate, his parent, or his child. Scratch an 'altruist', and watch a 'hypocrite' bleed.

Such sentiments would warm the cockles of many an economist's heart. This view of the biological world mirrors the orthodox view of the economy. Nature and the market economy are both filled with utility-maximizing individuals with no room for cooperation except for one individual to gain an advantage over others.

7.6.1
Beyond the Selfish Gene

The 'economic man' of biology is the 'selfish gene'. And like its economic counterpart, it has also come under attack. For one thing, recent research indicates that the genotype/phenotype distinction is not as clear as it once seemed. Apparently, genetic information is contained in other than germ cells. For example, if *Paramecium* cilia are removed and put back in the reversed position, this induced cilia reversal is inherited by subsequent generations (Margulis, 1998). Experiments like this indicate that organisms are more than mere carriers of genes. There is apparently a lot of interplay upward and downward in the hierarchy of life processes. It has also been discovered that simple organisms actually exchange genetic material with each other (R. V. Miller, 1998). More remarkably, although the idea is still controversial, it is increasingly accepted that a key process in the evolution of higher organisms is endosymbiosis, the creation of new tissues, organs, or species through the symbiotic joining of separate organisms. Mitochondria, for example, are respiratory organelles ubiquitous in cells, which apparently evolved separately then entered eukaryotic cells in a symbiotic relationship (Sapp, 1994). The separate evolutionary origin of mitochondria is confirmed by the fact that they contain bacteria-like DNA distinct from that found in the nuclei of the cells they inhabit. What we consider to be groups of 'individuals' are actually groups of organisms symbiotically cooperating. Margulis (1998, p. 11) gave this example:

> *Ophrydium*, a pond water scum that, upon close inspection, seems to be countable green 'jelly ball' bodies is an example of emergent individuality that we recently discovered in Massachusetts and redescribed. Our films show these water balls with exquisite clarity. The larger 'individual' green jelly ball is composed of smaller cone-shaped actively contractile 'individuals'. These in turn are composite: green *Chlorella* dwell inside ciliates, all packed into rows. Inside each upside-down cone are hundreds of spherical symbionts, cells of *Chlorella*. *Chlorella* is a common green alga; the algae of *Ophrydium* are trapped into service for the jelly ball community. Each 'individual organism' in this 'species' is really a group, a membrane-bounded packet of microbes that looks like and acts as a single individual.

Organisms in mature ecosystems such as old-growth forests, undisturbed deserts, and coral reefs are bound together in a complex web of mutually beneficial relationships. Fungi in old-growth forests act as conduits for nutrients that link diverse species together in one huge symbiotic relationship. Trees routinely share water with neighboring plants during the night when transpiration is low (Yoon, 1993b). This keeps nearby plants thriving and thus helps hold moisture and soil. When forests are attacked by insects, trees send out chemical warnings to neighboring tress, which then release other chemicals to protect themselves from the impending insect invasion. All these examples could probably be forced into the 'pure selfishness' model but at what intellectual cost?

Corning (1997, p. 382) pointed out that E. O. Wilson, considered to be one of the premier genetic determinists, wrote in the critical second chapter of *Sociobiology*, "The higher properties of life are emergent". Wilson is even more emphatic in his recent work *Consilience* (Wilson, 1998, p. 137): "The accepted explanation of causality from genes to culture, as from genes to any other product of life, is not heredity alone. It is not environment alone. It is interaction between the two." Dawkins himself wrote in *The Blind Watchmaker* (Dawkins, 1986, pp. 170–171):

> In a sense, the whole process of embryonic development can be looked upon as a cooperative venture, jointly run by thousands of genes together. Embryos are put together by all the working genes in the developing organism, in collaboration with one another ... We have a picture of teams of genes all evolving toward cooperative solutions to problems ... It is the 'team' that evolves.

These and other examples from ecology do not deny that competition exists and do not imply that the world is one happy community joined together in an exclusively cooperative arrangement. Competition exists, but it is of a much more complicated sort than that assumed by the selfish gene of biology or the economic man of the market. Competition is more complicated than isolated individuals transparently competing for immediate gain. It takes place between groups as well as between individuals. And cooperation is more complicated than a simple tit-for-tat strategy and goes beyond reciprocal altruism and kin selection.

7.6.2
The Evolution of Cooperation and Multilevel Selection

One of the most hotly debated topics in evolutionary biology is group selection, a concept whose definition has become increasingly slippery. As Corning (1997) pointed out, natural selection above the level of the individual was a quite acceptable idea to Darwin, Wallace, and Spencer, who all believed in the differential survival of groups. Even Sewall Wright, one of the key founders of the modern synthesis of genetic and morphological biology, used the term 'interdemic selection' to characterize selection among discrete breeding groups or 'demes' (Corning, 1997, p. 364). During the 20th century, however, explanations of evolutionary change became more and more reductionist, culminating in Richard Dawkins' influential book *The Selfish Gene* (1976). This trend was to some extent a reaction to metaphysical theories of the evolution of a higher consciousness, such as Theilhard de Chardin's noosphere. Any attempt to stray beyond the straight and narrow path of methodological individualism was met with skepticism, if not outright hostility.

As recounted by Corning (1997), the first real skirmish between group selectionists and ultra-Darwinians occurred in the 1960s with the publication of Wynne-Edwards' (1962) book *Animal Dispersion in Relation to Social Behavior* and the strong adverse reaction to it by Hamilton (1964a, b), Williams (1966), and to a lesser extent, E. O. Wilson (1975). Two theoretical extensions of Dawkin's selfish gene theory were used to attack Wynne-Edward's formulation of group selection. One was kin selection (Alexander, 1987), which argued that apparently altruistic behavior is genetically based, because altruists are actually protecting their own genes by helping close relatives survive. The other was reciprocal altruism (Trivers, 1985), which argued that apparent altruism was based on the expectation that favors would be returned.

For a few years after these exchanges, any notion of group selection as a factor in evolution was considered to be unscientific. G. C. William's book *Adaptation and Natural Selection* was especially influential in debunking group selection. Sober and Wilson (1998, p. 5) wrote, "For the next decade [after the publication of William's book,] group selection theory was widely regarded as not just false but as off-limits, as far as serious evolutionary thought was concerned." In the 1980s and 1990s, for a number of reasons, there was a resurgence of interest in group or 'multilevel' selection (Boyd and Richerson, 1985; Wilson, 1997; White, 1998). Group selection means that the fitness of every member of the group depends on a group characteristic that is not isolated in an individual. There is mounting evidence that groups characterized by non-kin and nonreciprocal altruism may outcompete groups composed of selfish individuals or individuals showing only kin and reciprocal altruism. The existence of group selection has important implications for the neo-Darwinian view (in biology and economics) that all evolutionary change is driven by individual characteristics alone (Depew and Weber, 1997; Wynne-Edwards, 1991).

D. S. Wilson (1975, 1980) uses the phrase 'trait group selection' to refer to linkages between two or more individuals which themselves become a mechanism of differential survival rates (Corning, 1996, 1997, 1998). Maynard Smith (1982) made a similar case for what he termed synergistic selection. Examples of non-kin-based cooperation include food sharing among vampire bats (Wilkinson, 1990), cooperative raising of young among unrelated Florida scrub jays, and group hunting among female African lions (Scheel and Packer, 1991). Cooperation may also take the form of 'superorganisms' (Corning, 1997), including social insects (Wilson, 1974) and social mammals such as the naked mole rat (Sherman et al., 1991).

7.6.3 Social Cognition and Economic Theory

A large body of evidence suggests that human groups engage in a cognitive division of labor. When groups are assigned specific tasks in experimental studies, such as assembling radios, individual members specialized in remembering different aspects of the assembly process, thus enhancing group performance (Liang et al., 1995). Caporael (1997) wrote:

> Group coordination implies that individuals may be 'units' of larger functional entities that cannot be reduced to mere aggregates of autonomously behaving individuals. Accordingly, human cognition could be viewed, at least under some circumstances, as truly social, interdependent with social context and not just 'in the head' of the individual organizer. To make temporary and limited use of the information-processing metaphor, humans would be part of a 'network', participating in 'truly social' (i.e., irreducible to individual level) groups. This is not to say that there is a transcendental 'group mind'. Rather, it identifies the problem of coordination as the 'central problem' for human evolutionary analysis.

Human societies are characterized by top-down and bottom-up hierarchical control. Individual behavior may be constrained by upper level rulers or by customs and mores imposed at the lower level by all members of the group. Humans are capable of a wide range of behavior, and any trait or combination of traits may be emphasized by particular cultures. Studies of nonmarket societies have provided a wealth of information about the incredible variety of human behaviors and about the peculiarity of the notion that greed and selfishness is always a dominant human characteristic (Gowdy, 1999). During most of our existence as a species, we lived in small bands of hunter–gatherers. Among these groups a highly stable egalitarianism arose as a survival mechanism. Boehm (1997) argues that cooperative human institutions had a great impact on our physical evolution. Competition among males was reduced (see Lee, 1993; Gowdy, 1998), as was the intensity of selection within the group, thereby reducing variation among phenotypes (Boehm, 1997, p. S100).

In economics, the phenomenon of group selection has been recognized among product groups, industries, and even countries (Gowdy and Seidl, 2004). Tisdell

(1998) argues that there is a strong advantage for diversity and cooperation within industrial organizations and that this can make it inefficient to be on the neoclassical production frontier. To have a diverse array of firms within an industry can give a competitive advantage, in part due to that industry having more potential avenues to take advantage of new innovations. An entire industry can have an evolutionary advantage by keeping options open, especially in periods of rapid change. Tisdell gives the example of the very successful economic transition of China, which was driven by diverse village enterprises, as opposed to the unsuccessful transitions of Vietnam and the former Soviet Union, which lacked such diversity in their industrial structures.

The work of Bowles and Gintis (1999a, b) also brings a modern evolutionary perspective to economics. In examinations of the economics of egalitarianism, they focus on the evolution of group selection and what they term 'strong reciprocity'. Using data from a variety of human societies, they argue convincingly that *Homo reciprocans* is as distinctively human as *Homo economicus*. As D. S. Wilson (1999) points out, evolutionary models predict that a single population contains a variety of behavioral patterns. In a commentary on Bowles and Gintis' (1999a) paper, Wilson writes:

> Economic models also frequently predict mixed outcomes, but the image of human populations as a community of interacting behavioral strategies has not emerged as strongly from economic theory as from evolutionary theory. It is therefore gratifying that Bowles and Gintis emphasize the possibility of more than one human nature; human populations may consist of a spectrum from extreme altruists to extreme sociopaths. In addition to this theoretical plausibility, there is growing empirical evidence that a propensity to cooperate or exploit forms an important axis of human behavioral variation. Seeing human groups as both communities of interacting strategies and (partially) adaptive units deserves to become a major theme in the future.

Most of the literature on the altruism–cooperation–selfishness debate focuses on the consumer. Perhaps this is because the profit motive that drives production seems transparently individualistic. A closer look at the structure of production, however, shows a complex web of competition, cooperation, and mutualism. Most industries are examples of mutually reinforcing symbiotic relationships. The theory on regional economics in particular contains a variety of concepts recognizing interdependence and mutual advantage. 'Agglomeration', for example, refers to the mutual economic advantage of several firms being located together. Increasing returns to scale through economic growth is also a phenomenon through which all firms mutually benefit. Growth of several enterprises lets all of them increase the scale of operation and potentially produce goods more cheaply. Increasing returns may be the driving force behind the phenomenal rate of economic growth in the 20th century (Arthur, 1989). The basis of input–output analysis is the recognition of mutual interdependence in a modern economy. In general, firms rise and fall together with the prevailing business climate. Division of risks is also present in a complex economy. Some parts of the economy are highly competitive, with high rates of return and a high rate of technological change. Other parts of the economy are less volatile, with lower but steady profits and less risk.

7.6.4
Evolutionary Game Theory

Game theory was once a bastion of orthodoxy in economics and is still roundly criticized by many heterodox economists who see it as being just another variation in the selfishness-can-explain-all school of economics. Blaug (1998, p. 18) is particularly harsh in his verdict on game theory:

> But game theory has turned out to be an even more seductive technique for economists than general equilibrium theory, encouraging once again the persistent tendency of modern economists to look away from the world and engage instead in armchair deductive theorizing.

In contrast, Corning (1997, p. 370) argues that game theory, seen in its proper light, can provide great insights into a realistic, holistic view of economic evolution. He also argues that traditional game theoretic models such as the Prisoner's Dilemma are in effect rigged to favor selfish behavior that duplicates market outcomes. Players are not allowed to communicate, defectors are rewarded for cheating, and cooperators have no power to punish cheating. In nature and in the economy, none of these assumptions typically hold. In recent applications of game theory, these restrictive assumptions are relaxed and, as in iterative games, cooperation becomes the preferred strategy. A case in point are the ultimatum and dictator games which, in a variety of cultural settings, have shown a strong predilection for altruistic behavior among humans (Gowdy et al., 2004).

Gintis (2000) makes a case for game theory as a universal language for the sciences of biology, anthropology, sociology, political science, psychology, and economics. Gintis (2000) says that games theory's bad name comes from its wholesale adoption of *Homo economicus* from traditional economic theory:

> *Homo economicus* is great when people are faced with anonymous market-like conditions, but not otherwise. Experimental techniques have a lot to teach us about choice and strategic interaction, and it's up to us to develop rigorous, testable models of real human behavior.

Bowles and Gintis (1999b) use a game theoretic approach to demonstrate the evolutionary feasibility of strong reciprocity, that is, cooperative behavior not based on reciprocal altruism (weak reciprocity). They use their experimental results, as well as case studies of hunting and gathering societies, to argue that sharing is as much 'normal' human behavior as is selfishness.

Gintis (2000, Chapter 11) summarizes a number of findings by psychologists about how people make decisions (Tversky and Kahneman, 1974; Kahneman et al., 1982; Shafir and Tversky, 1992, 1995). For example, people are about twice as averse to losses as to accepting the same amount of gain. This is partly due to the 'endowment effect', by which people place higher values on things they already possess than on the same things they do not have. Bringing more realistic models of human behavior into economic theory has important policy implications, particularly for the kinds of cost–benefit analysis widely used to value environmental goods. Findings from game theory and psychology help to explain the apparent anomaly from 'contingent valuation' surveys showing that people place much high values on environmental goods evaluated on willingness to accept a loss (WTA) as compared to willingness to pay for a gain (WTP). It also implies that policies for environmental protection should be based on higher WTA estimates even though lower WTP estimates are usually used. Of potentially immense importance to choice theory is the finding from neurological research that decisions are made in the human brain by reconciling various structurally distinct and spatially separated areas that probably evolved at different evolutionary stages (Gintis, 2000). Again, these findings question the validity of the model of human behavior that lies at the core of neoclassical theory. Models based on true altruism, social cognition, cooperation, and learning by doing are proving to be better predictors of behavior than the selfish model of economic man.

7.6.5
Cooperation as Evolutionary Progress

Another contentious issue in evolutionary biology is the notion of progress. The general view is that progress can be equated with increasing complexity and that life has progressed from simple organisms to more complex ones, culminating in nature's greatest achievement, the human species. Even if most biologists reject such an obviously culturally conditioned interpretation of evolution, the trend toward increasing complexity seems obvious. Or is it? Attempts to test specific examples of the evolution of complexity are inconclusive. One study examining the evolution of mammalian backbones concluded that the overall course of evolution shows no trend toward complexity (Thomas and Reif, 1993). Neither does the evolution of shells of marine animals show a trend toward increasing complexity. Yoon (1993a) summaries these studies:

The outer limit of complexity may increase over time, as an occasional lineage of organisms becomes more complex. But at the same time other species may be growing less complex. Thus over all, within a given assemblage of species, there is no evident evolutionary drive toward greater complexity.

And of course, the 'lower' animals, bacteria, and other simple organisms, including forms of early life on earth, are still with us and have thus proven to be just as 'successful' and 'modern' as we are. These findings have prompted Gould (1988) to write: "Progress is a noxious, culturally embedded, untestable, nonoperational, intractable idea that must be replaced if we wished to understand the patterns of history."

Notions of progress are deeply embodied in economic theory. In the standard view, market economies progress through the competition-induced drive toward efficiency. Economic growth itself is seen as a sign of progress. In a widely used microeconomics text, Mansfield (1991, p. 9) wrote, "The goal of economic growth is a relatively new oe; most past societies have had economies that were unprogressive." The neoclassical model of perfect competition invites a progressivist interpretation. Even some of the alternatives to the unlimited-growth assumptions of neoclassical economists still argue for continual progress, for example, the green alternative to the Gross Domestic Product, the 'Genuine Progress Indicator'.

Stewart (1997) resurrected the notion of progress by arguing that evolution is characterized by an increasing level of cooperation among living processes. He argues (Stewart 1997, p. 340) that life itself originated through the formation of cooperative hierarchical structures:

> A key step in the evolution of life is the emergence of relatively large, stable molecules (or groups of molecules, as in an autocatalytic set) which use their capacity to control and manage the activities of smaller-scale atoms and molecules to maintain themselves and to produce replicas of themselves. Again, the essence of this evolution is the discovery by managing entities of ways of controlling and coordinating other entities so as to enhance the evolutionary interests of the managing entities and the assemblage as a whole. The result is the formation of hierarchical organizations such as the autocatalytic sets which manage proto metabolisms, as described by Bagley and Farmer (1991).

Stewart (1997, p. 342) sees three key steps in the history of life on earth, each of which involved the evolution of cooperative organizations. The first step was the formation of macromolecules to form a reproducing assemblage. The second was the management of these assemblages by RNA to form prokaryotic cells. The third was the management by DNA to form eukaryotic cells (Cavalier-Smith, 1981). Complex organisms can be seen as cooperative associations of different organ systems (Margulis, 1998).

The traditional view of progress in economics is the continual improvement in efficiency in production, that is, a technological or managerial advance that allows the production of a given level of output with fewer inputs. For an individual firm, an increase in efficiency is an unambiguous improvement if something can be produced more cheaply. What meaning does this have, however, for the macroeconomy? The standard argument is that increases in efficiency free up scarce resources that can then be used to produce more economic goods and that more economic goods increases the total welfare of human society. The view of efficiency as progress, then, hinges on one of the basic assumptions of economic man, more is always preferred to less. Likewise, the belief that the specific array of goods produced is 'optimal' depends on the rationality of each individual consumer's choices.

7.7 Coevolution, Evolutionary Theory, and Economic Policy

Coevolution applied to human society refers to the fact that not only are humans shaped by their environment, they are in turn profoundly affected by that environment. About 50 million years ago the climate of the earth began to change dramatically as temperatures fell and climatic fluctuations increased. These changes affected mammalian evolution in still poorly understood but intriguing ways. For example, during this period of climatic instability the brain size increased in many species (Jerison, 1973), perhaps because intelligence became a new evolutionary advantage in dealing with rapidly changing conditions. The evolution of our species was shaped by changing environmental conditions in East Africa. Richerson and Boyd (2000) argue that a destabilized, unpredictable climate gave an evolutionary advantage to increased cognitive complexity that outweighed the costs of a greater metabolic requirement. Climate deterioration in the Pleistocene was particularly rapid, and this is the period in which brain size increased most dramatically. According to Vrba's (1985) turnover pulse hypothesis, the major punctuations in human brain evolution that occurred about 1.8 millions years ago (*Australopithecus* to *Homo erectus*), and about 200 000 years ago (the appearance of *Homo sapiens*) were driven by extreme climate events. As discussed above, perhaps the most profound cultural and technological shift in the history of our species, the adoption of agriculture, was likely spurred by the unprecedented climate stability of the Holocene. Potts (1996, p. 121) argues that lithic tool making gave humans the ability to switch from one type of prey to another as the others became scarce or extinct due to climate change. Humans gained an advantage over other species in terms of adaptability because of their reliance on exosomatic (outside the body) rather than endosomatic (part of the body) tools (Lotka, 1924; Georgescu-Roegen, 1977). The invention of tools freed our ancestors from an exclusive reliance on evolved part-of-the-body 'tools', such as sharper fangs or longer legs. The unique characteristics of our species were shaped by biological and cultural adaptations to climate changes.

Not only has a changing environment driven human evolution, humans have also profoundly affected the ecosystems we live in. For about 99% of our existence, humans lived as hunter–gatherers within the limits of particular ecosystems. Even such technologically simple societies, however, had profound effects on the landscape. Selective hunting and gathering patterns favor some species over others. In many parts of the world humans modified the land through the selective use of fire. Humans are not unique in this respect. The environment-modifying impacts of such animals as elephants and beavers are well known, but even small, less intrusive animals can have large effects.

With the advent of agriculture, the human impact on the natural world increased by several orders of magnitude. No only were animals and plants selectively harvested, but competitors for human food were systematically eliminated. As with the adoption of tool making by hunter–gatherers, so with the widespread use of agriculture humans substituted technology for environmental adaptation. As human hunter–gatherers we did not evolve physical adaptations to exploit specific environmental resources but rather opted for a more generalized and flexible approach using tools. As agriculturalists we gave up cultural adaptations to specific ecosystems in favor of a more general technique (agriculture) that could be applied to a wider variety of ecosystems.

In the industrial age we have come to dominate the planet as never before. McKibbin (1989) argues that the late 20th century witnessed the 'end of nature'. By this he means that no place on earth is unaffected by human presence. The modern irony is that we have broken out of the limits imposed on us by local ecosystems only to enter once again an era of ecosystem limits; limits imposed by the finiteness of earth itself. Eldredge (1995) wrote:

> For 10 000 years, all but a remnant handful of hunting–gathering societies have been living outside the normal, local-ecosystem confines of nature. That is why our cultural heritage proclaims us to be something apart from, even over and above, the beasts of the field ... We need an updated story, one that acknowledges that we did not so much leave the natural world as redefine our position in it. It is simply not true that our future is in any real sense independent of the future of the rest of the global system.

The market economy is organized to use resources for economic growth and to substitute one resource for another as the first becomes relatively scarce. This strategy has been remarkably successful in producing a dizzying array of consumer goods for a sizable minority of the world's population. As discussed above, this economic system originates with a set of ethical beliefs probably going back to the beginnings of agriculture. Numerous past societies have had similar beliefs, only to disintegrate when they came up against the limits imposed by local ecosystems. Our world market economy may, of course, really be different. Unlike earlier societies that lacked our science and technology, we may be able to plan, substitute, and mitigate the negative impacts we are now having on the planet.

On the other hand, it may already be too late. The warning signs are ominous. The loss of biological diversity is reaching the level of the great extinction episodes of the past 600 million years of complex life on earth. Climate change seems to be accelerating and may have already led to destabilizing the earth's climate. A recent study discovered that, in recent years, the Arctic ice mass has been thawing at a rate of about 15% per decade and that that rate is probably increasing. Since 1970 the total volume of Arctic ice has decreased by about 40% (Kerr, 1999). When such rapid melting has occurred in the past, the ocean circulation system has been altered and this has led, paradoxically, to a period of rapid cooling. In the past, cooling of Europe and North America occurred abruptly during warming trends as the great North Atlantic current, which brings warm water from the tropics northward, slowed or even reversed. This reversal was caused by the inundation of fresh water from polar melting which prevented the heavier, saltier water from sinking and driving the climate conveyor belt. Should this current reversal happen again, it will have unknown but probably severe effects on world agriculture. Researchers predict that the rate of sea-ice melting will increase if emissions of heat-trapping greenhouse gases continue at the present rate (Vinnikov et al., 1999). The damage we have done may have already sealed our fate if the world agricultural system that now feeds over 6 billion people is crippled by volatile and unpredictable weather.

The economy is a complex hierarchical system that depends on social institutions, physical inputs from the natural world, and competing and cooperating collections of agents and ethical beliefs. Like past civilizations, ours has opportunistically exploited natural resources and overcome the resulting scarcity of particular resources with technological advances. Unlike past cultures that overshot their environmental base, we do not have the option of moving to a new area and starting over. A defining feature of our species is flexibility. As hunter–gatherers our larger brains gave us the ability to use tools to adapt to rapidly changing climates when other species were driven to extinction. Likewise, agriculture enabled humans to move beyond the limits of specific ecosystems and reshape and exploit a variety of environments. The latest human engine of adaptability, the market economy, has enabled us to take substitution to a new level. Markets have made it possible for humans to exhaust natural resources, eliminate species and entire ecosystems, and even change worldwide atmospheric conditions without affecting the expansion of our economies or our population. As outlined above, however, there are good reasons to believe that the process of intensified exploitation through substitution and adaptability will once again come to an end. And the collapse next time will be worldwide, not confined to a small region of the planet. It may well be that, paradoxically, our adaptability is itself an overspecialization which will lead to the extinction of our species.

On the other hand, applying an evolutionary approach may help us to understand the power of the market to both allocate resources and to systematically destroy the social and biological basis for human existence. The field of economics is currently undergoing a radical change that is making it more dynamic, more interdisciplinary, more scientific, and more relevant to the problems we face in this new century. The new evolutionary approach has the potential to move economic policy in a direction that will take into account the complexities of human decision making and the complexities of the interactions between economy, society, and environment. Perhaps our flexibility and adaptability will allow us to make the drastic changes necessary to insure our survival.

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8
The Evolution of Scientific Method

Erhard Oeser

8.1
Introduction

The term 'evolutionary epistemology' refers to the phenomenon of prescientific common-sense knowledge as well as to the phenomenon of science itself. Both evolutionary views emerged independently during the 20th century. Both had forerunners in the 19th century, even before the time of Darwin. Moreover, both forms of evolutionary epistemology are closely related to other evolutionary views that deal not only with human knowledge but also with certain human activities as well, whether in an ethical–moralistic, social, or cultural sense. The framework for these evolutionary views is made up partly of general cosmological evolutionary philosophical systems, which from a historical point of view, although they enabled the theory of evolution to be formulated, have nevertheless been disproved by it (Oeser, 1974). At least this holds true for Darwin's theory of evolution, which removed any kind of the teleology that dominated not only earlier evolutionary philosophical systems but also the theory of Lamarck. Nevertheless, even Darwin himself did not exclude the possibility of such a comprehensive and universal theory of evolution for the time to come; he hoped that "the principle of life will be recognized as part or sequel of a universal law" (Bresch, 1977). In the course of the 20th century many biologists and philosophers have adopted this idea. This chapter does not deal with the various, frequently overlapping, at times even contradictory, universal evolutionary conceptions, but concentrates on the attempt to establish a relation between the two views of evolutionary epistemology, using an elementary terminology, that is, the theory of individual, subjective, common-sense reason, and the theory of collective, trans-subjective scientific reason. People in all fields of evolutionary research, such as molecular genetics, ethology, and evolutionary epistemology, are well acquainted with this terminology. It rests on the term 'information'. First, however, we have to consider the historical background to this question (because it has been a matter of controversy for some time), that is, whether the basic assumption of the human ability to know also applies to higher forms of reason, i.e., to 'scientific knowledge'.

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8.2 Historical Background

Darwin himself (1896) stated that man with his "god-like intellect which has penetrated into the movements and constitution of the solar system ... still bears in his bodily frame the indelible stamp of his lowly origin". But, in what manner the mental powers were first developed in the lowest organisms, remained for him "as hopeless an enquiry as how life itself first originated". He considered both questions as problems to be solved in the distant future. His contemporary, Herbert Spencer (1862), on the other hand, had postulated a general-development hypothesis even before Darwin's main works were published. This stated that the entire perceptible reality constitutes a transition process that leads from an indefinite unconnected homology to a definite connected heterogeny.

Thus, Darwin was able to refer, in his introductory historical outline of *The Origin of Species*, to Spencer's *Development Hypothesis* of 1852, as well as to the fact that Spencer in his *Principles of Psychology* had already extended this hypothesis to the gradual acquisition of all mental powers and abilities. The application of the general-development hypothesis to science itself was therefore taken for granted by Spencer. For scientific progress, too, gradually evolves from the simple and concrete to the more complex and abstract relations:

> The law of the scales was known before the general law of the lever was known; the law of the lever was known before the laws of composition and resolution of forces were known; and these were known before the laws of motion under their universal forms were known. From the ancient doctrine that the curve in which the sun, the moon, and each of the planets move is a circle (a perfectly simple and constant figure); to the doctrine taught by Kepler, that each member of the planetary system describes an ellipse (a much less simple and constant figure); and afterwards to the doctrine taught by Newton, that the curve described by every heavenly body is some conic section (a still less simple and constant figure); the advance in generality, in complexity, in abstractness, is manifest. Numerous like illustrations are furnished by physics, by chemistry, by physiology: all of them showing, in common with the foregoing ones, that the advance has been gradual, and that each more general relation has become known through the experience of relations a degree less general (Spencer, 1870).

This conception was adopted by Mach. In his inaugural speech as chancellor of the University of Prague in 1883 he characterized the development of science as a special case of a common biological process, entirely corresponding with Darwin's theory of evolution in both its basic factors of mutation and selection:

> We observe how scientific views are being transformed, how they are spreading to other areas, struggling with rival ideas and conquering those which are less efficient. Every person involved in the process of learning can observe such processes in his own head (Mach, 1911).

Similar ideas were advocated by Candolle. He too, referring to Spencer and Darwin, saw the evolution of man in the age of science as a struggle for existence, that was currently proceeding favorably for the educated, whereas in former times it was decidedly in favor of the barbarous and most violent (Candolle, 1911).

Since Darwin it was clear, also, that here a base can be found for establishing in a natural scientific way the evolutionary dynamics of scientific method. It was not the biologists, but physicists like Mach and Boltzmann, who consequently expanded the evolutionary approach to the epistemology of their own discipline.

Boltzmann had an ambivalent relation towards philosophy. On one hand he was fascinated by this enormous area of knowledge, and the other hand he harbored a healthy mistrust of certain philosophers such as Hegel and Schopenhauer and even voiced explicit disgust for philosophy as such. It was a difficult decision for him, when in 1903 he was asked to replace Mach, who had become too sick to carry on his lectures on the philosophy of nature and the methodology of the natural sciences. When he finally accepted, it was because he believed that real progress in the fundamentals of both natural sciences and philosophy could only be achieved when both disciplines cooperated. Boltzmann believed that the time was right for such cooperation between epistemology and physics, because he had witnessed the progress made in physical theory (mechanics), which to him was due to a parallel development in epistemology. Mach had been of the same opinion, when in his history of mechanics he aimed at demonstrating the progress made by human cognition. But whereas Mach, in accordance with his principle of economy, viewed hypotheses and theories instrumentalistically, Boltzmann from the very beginning was convinced that our hypotheses and theories bear resemblance to reality. They are nor only instruments of thought, but possible expositions of reality.

To justify this hypothetical realism, Boltzmann needed a theory of the perceiving apparatus that surpassed Mach's theory of sensations. Boltzmann looked towards brain physiology as an empirical support for his epistemological ideas and not as much towards sense physiology, as Mach had done. Both agreed that Darwin's theory of evolution laid the ground for all epistemology; yet, whereas Mach applied Darwin's theory to a theory of sense organs, Boltzmann (1905, p. 179) considered the brain to be the central computation unit and the bearer of human cognitive faculties – he wrote explicitly of a 'mechanism inside the human head', whose organ is the brain:

> We consider the brain as a world-perceiving apparatus, which, since it proved useful to the survival of the human species, has achieved near perfection. According to Darwin's theory this apparatus has developed an especial perfection like the extremely long neck of the giraffe or the beak of the stork.

This phylogenetically and ontogenetically extremely developed organ, the brain, manages to "accord even better to knowledge". His manuscript of 1903/1904 for his lectures clearly states this point. It was a new idea even for Mach, because it surpassed the concept of innate structures of thought, which Mach had evolved in his interpretation of Kant's a priori categories. Boltzmann emphasized that these innate structures can be modified.

If one compares Boltzmann's statement with contemporary statements relating to brain physiology it becomes clear that Boltzmann was not only fully informed about the state of the art but even went further. The most prominent brain scientist in Vienna at that time was Meynert, whose popular lectures on the brain were certainly known to Boltzmann. Meynert believed that all scientific regularity of appearances stems from the atomistic world view. The atomistic world, however, consists merely of mathematical points, because atoms posses no qualities that can be sensed. Starting from these points, quantifiable forces trigger appearances in our conscience. Such atomistic universes consisting of mathematical points do not form a view of the world, which is integrated into our consciousness ready-made, but this world view is constructed with the help of the brain mechanism, which also accords with mechanical laws (Meynert, 1892, p. 20).

The cerebrum can take in perceptions from the peripheral sense organs and stimulate the muscles. Sense receptors and motor effectors are projected on the cerebrum. Between these, associative fibers maintain a connection, and if amassed, form 'fields of association' in which thinking takes place. The anatomical structure and the function of the brain clearly correspond: "The organ's structure contains the precondition of its function" (Meynert, 1892, p. 11).

A comparison between these statements and Boltzmann's concept of a mechanism within the human head shows at once the fundamental agreement between Boltzmann's epistemology and contemporary brain research even as regards terminology. Boltzmann's realism rests on the insight that there are no psychic events that do not correspond with brain processes. This is shown empirically when disturbances of the mechanical processes in the brain cause corresponding disturbances in performance. They are conditioned not only by phylogenesis but also by ontogenesis, as Boltzmann pointed out 1905 in accordance with neuronal theory. Anticipating Hebb's synapse theory, Boltzmann (1905) noted that different conceptions

> at moments where different images correspond, the respective neurons build up fibers between each other. When a child starts connecting sight and sound sensations, fibers between the two corresponding centers in the brain are established, such as between the centers of sight and touch and the motor nerves, as soon as the child starts to grasp at things.

Such modifications lead to necessary correctives, ameliorations, and expansions of our innate habits of thought. These modifications must be carried out actively and consciously. Our innate laws of thinking are prerequisites for our complex experiences; but this is not true of lower organisms, where these innate laws developed slowly as a result of simple experiences and then were passed on to higher organisms, i.e., such laws of thinking were acquired by our ancestors, but they are innate to us, and that Boltzmann equates with a priori.

Their being innate conditions their psychological rigour, but not their logical-epistemological infallibility. Boltzmann believed that Kant had been convinced of the infallibility of the laws of thinking and considered this conviction a logical mistake due to Kant's ignorance of the identity of innate and a priori laws of thought, which Darwin discovered. How far Kant was really ignorant in this aspect is still discussed by his interpreters He himself criticized the use of categories in metaphysics. His a priori structures of cognition acquire content and truth only when applied in reality. Darwin's theory explains why the laws of thinking appear to be infallible: only thoughts proved useful to survival are passed on. What proved wrong and did not serve the survival of the individual and the species was lost. This adaptation of our laws of thinking to the important problems of everyday existence by far surpasses its air, but for the solution of abstract problems of cognition that do not affect survival, they are imperfect.

This imperfection can be overcome step by step. Boltzmann prophetically defined the task of a philosophy of the future: to formulate fundamental concepts so as to enable their user to give precise directives for useful action.

Boltzmann drew up three rules for this purpose:

1. Laws of thinking have to be modified if they produce contradictions when applied.
2. Empirically, laws of thinking must lead us to actions that correspond to our aims.
3. The urge to apply the laws of thinking to areas where they do not apply must be resisted until it disappears.

These three points together form a theory of scientific method, which as Boltzmann puts it, make up the skeleton that supports the progress of all science.

In the 20th century the renewal of this evolutionary approach emerged from Popper's fundamental objection that the really interesting dynamic aspects of evolution and variation in science escape the mere logical analysis of evidential systems. For a long time Popper was reluctant to accept the theory of evolution as a natural scientific theory and accused it of having a circular character. He considered Darwinism to be a medium of battle against Carnap's inductivism, putting forward an analogy between Darwinism and Lamarckism, as well as selection and instruction (instruction through repetition), on the one hand, and deductivism and inductivism, as well as critical elimination of mistakes and positive justification, on the other. To characterize his own position, Popper added that his logic of research contains a theory of knowledge – growth through trial and error – that is, through the elimination of mistakes. This means selection instead of Lamarckian instruction. Popper (1994, p. 33) elaborated this analogy into a four-phase scheme of the dynamic of theories:

1. Problem (not observation).
2. Attempts at solution = hypotheses.
3. Elimination = refutation of hypotheses or theories.
4. New and more sharply defined problem that develops out of the critical discussion.

As Popper noted himself, this scheme was supported by Lorenz at the deeper level of comparative behavioral research. Thus it can be said that the old ideas of the evolution of science (as anticipated by Mach and Boltzmann) were not only renewed by Popper but that modern behavioral science, too, has delivered a natural scientific base which is far more than a mere analogy. The evolutionary philosophy of science as a second phase of evolutionary epistemology, however, is not merely a metaphorical view of the dynamics of theories in evolutionary disguise, but a further development of the basic trial-and-error mechanism related to scientific methods of cognition. Therefore its object is not the evolution of theories (as recognized clearly by Boltzmann), but the evolution of the scientific method as a goal-oriented activity of cognition that hastens the scientific theories.

The fundamental deficiency of the earlier conception of the evolution of science (Mach and Boltzmann), however, lies in the fact that all its references are only analogies, pointing out by the help of a vivid metaphorical language similarities to the process of the evolution of organisms, without being able to explain them. Moreover, Spencer, who regarded the evolution of science, within the framework of his general-development hypothesis, as a direct sequel of biological evolution, failed to observe differences between biological and socio-cultural evolution. Not only is scientific development much faster and more complex: it also shows definite breaks with the past.

8.3
Objective Scientific Knowledge as a Break with the Ratiomorphic Past

Humanity's common-sense knowledge can be understood as a continuation of the ratiomorphic 'reasonable behavior' of animals, as it serves the preservation of life. The scientific method, however, surpasses life- and species-preserving functions, by serving objective knowledge. This causes a great change in the phylogenetically developed perceiving apparatus. This apparatus is constructed in such a way that it functions reliably only in the field of life-preservation. It does not function reliably in other fields – it may even turn out to be an impediment to knowledge or a source of error. Scientific method, therefore, has to surpass this general aim of live-preservation by reversing the phylogenetically conditioned innate perceiving apparatus that developed in the biological evolution.

This change in direction taking place within the evolution of human knowledge had been perceived already at the beginning of theoretically based science in ancient Greece. Thus the philosophers of the ancient world, especially Plato, described the permanently recurring process of reversal and transgression of one's own perceiving apparatus as a 'second voyage'. Galileo transferred this distinction to the methods of modern physics, separating the primo aspetto of common-sense knowledge from the secondo aspetto of scientific knowledge. That is, for the direct, theoretically unconsidered perceiver, the sun still orbits the earth and determines the rhythm of day and night. The secondo aspetto of scientific reason, which constructs a theory of the solar system, shows, contrary to the immediate perception, that the sun's apparent movement is a direct result of the rotation of the earth. This very process of a reversal of the direct sense-perception is increasingly noticeable in other scientific theories, too, including the relativity of space and time in modern physics.

As a consequence of this change of direction to the emergence of science initiates a new stage of evolution. This stage transcends not only the biological evolution of plants and animals but even the sociocultural evolution of man, with consequences that cannot be foretold as yet.

The main characteristic of this last stage of evolution, which started only at the very last minute, so to speak, of this process, lasting billions of years, is manifest in the fact that the human perceiving apparatus does not follow a natural adaptation process but rather places itself outside this process. This leads to successfully passing beyond the originally life-preservation-oriented perceptive functions. This 'going beyond' of the adaptation process manifests itself visibly in those drastic changes in human environment that result from the technical application of theoretical science, enabling man to adapt the world to his needs and conceptions.

The decisive fact, however, is that this process of reversing and going beyond the innate perceiving apparatus is not a unique incident, but a process continually repeated during the development of every individual. Thus we can say, following Haeckel's biogenetic law, that the individual studying a science repeats, in a condensed way, the entire history of the development of this science. The decisive factor is, not a repetition of the occurrence of various theories one succeeding another during the history of science, but the development of scientific method. The application of the scientific method constitutes in the life of a scientist, a permanent process of going beyond the self, repeated for every act of knowledge.

This results in an essential discrepancy that has not been given sufficient consideration by modem philosophers of science: the difference between the dynamics of theory and the dynamics of method. Insufficient consideration of this discrepancy had led the philosophy of science to a confrontation between two seemingly contradictory models: the revolutionary and evolutionary models of science.

The revolutionary model, particularly advocated by Kuhn (1962), is based on a process that has been observed several times during the history of science: a fundamental change occurs in scientific theories, that is, in their basic concept and axioms. But when the new theory is compared with the corresponding old theory, it turns out that the old theory (even if the new theory is drastically different) was, at least in certain respects, an approximation of the new theory. This becomes even more apparent when the various intermediate hypotheses that bridge the gap between revolutionarily different theories are considered. The existence of intermediate hypotheses, by which the overall understanding gradually proceeds through various stages, may better be compared to biological evolution. However, if we confine ourselves to a mere consideration of similarities, we may not be able to decide if a change in theory is evolutionary or revolutionary. According to one's intention to emphasize continuity or change, one gives priority to the evolutionary or revolutionary model. If the theory change is regarded, from the viewpoint of the sociology of science, as a process that has actual effects on scientists, scientific communities, and institutions, every fundamental paradigm change can be called a revolution. From a methodological viewpoint, however, there are no changes or even crises or breakdowns in science. On the contrary, when a standstill occurs in scientific theory formation, during which none of the existing alternative theories is accepted generally, the methodology of a discipline constitutes the stablest generally accepted basis for that discipline. This means that the function of science itself is maintained, although certain structural breakdowns within science, concerning first of all theoretical concepts, may occur. This, however, is the exact characteristic of an evolutionary process (Eigen and Winkler, 1975). In Kuhn's theory (Kuhn, 1962), too, we are able to discern, in certain processes during changes in theory, dynamics that certainly may be described as revolutionary from a sociological standpoint but are easily compatible with an evolutionary conception of the dynamics of method. Later (Kuhn, 1970), he even clearly emphasized the priority of the evolutionary approach, explicitly stating that his view of scientific development is evolutionary: "For me, therefore, scientific development is, like biological evolution, directional and irreversible."

The adequate continuation of evolutionary epistemology in the field of scientific knowledge may thus be called an 'evolutionary methodology'. This evolution of scientific method is based, however, on a specific ability of consciousness, inherent only in humans, in whom, unlike in all other organisms, subjective knowledge as an adaptation process transforms itself into objective knowledge devoid of all life-preserving function. This means, however, that an evolutionary view of scientific methodology is based on an analysis of the human ability to perceive, to the extent that it has deviated from its phylogenetically conditioned foundations. In contradistinction to the empirico-biological approach, this#Q13# question has always, from Plato and Aristotle through Kant's *Critique of Pure Reason,* been posed in a meta-empirical fashion, which is characteristic of a pure epistemology. Therefore, the concept of a pure epistemology has to be considered before dealing with an evolutionary methodology of scientific knowledge. This concept should describe, in an elementary fashion, the structure of those cognitive processes that actually render it possible for human reason to detach itself from its phylogenetically acquired basis. Such a pure epistemology is not only the adequate equivalent of an evolutionary epistemology that deals with the phylogenetically acquired basis of human knowledge and constitutes a connection with the pre-human world; it is also its negation and deliberate reversal.

This means that pure epistemology, in the sense of Kant, starts exactly at the point where evolutionary epistemology ends. Pure epistemology is a priori, because it neither empirically describes the individual human cognitive activities, nor aims at theoretically explaining them in accordance with the theory of evolution. Instead, pure epistemology prescribes how the acquisition of knowledge should proceed in order to arrive at objective truth. This prescriptive or normative function of the a priori was Kant's basic idea. In his doctrine of Reason as the legislator of nature, Kant did not want to propagate any kind of 'idealism', but to provide constructive criticism of the human capacity to know.

8.4
The Systematic Relationship of Empirical–Evolutionary Epistemology and Meta-Empirical or Pure 'Transcendental' Epistemology

Supposing that evolutionary epistemology and philosophical epistemology do not constitute mutually exclusive alternatives, we basically have at our disposition two possibilities for describing the systematic relationship between these two theories. The first possibility may be characterized as follows: Evolutionary epistemology is a general biologically-based theory from which the phenomenon of human knowledge in all its forms can be deduced. Philosophical epistemology is then nothing but a system of deduced concepts and theorems, affirmable within the framework of evolutionary epistemology. The ancient mystery of knowledge, which Kant most radically formulated as the question of why subjective structures of knowledge can be applied to the real world a priori, would thus be resolved. As Popper pointed out in his preliminary studies on the logic of scientific discovery (1930–1933; Popper, 1994), when the term 'evolutionary epistemology' was not yet used to denote a separate discipline, Kant's attitude towards this solution was in no way entirely negative. He was only lacking a category of 'necessity', which a priori forms would consequently lack. An empirical theory may indeed explain the origin of a priori forms, but it cannot justify them as indispensable preconditions of the possibility of knowledge. This holds true even for Darwin's theory of evolution, which in its explanatory scheme already blends chance (mutation) and necessity (selection). For Kant, however, a priori forms are in the category of pure necessity, because they simultaneously possess a normative or prescriptive nature. Hence, empirical evolutionary epistemology and pure (transcendental) epistemology are two theories on different levels and cannot be deduced from one another.

The second possibility is that the empirical evolutionary epistemology, just like other forms of empirical theories that deal with the phenomenon of knowledge, such as Piaget's (1973) genetic epistemology, constitutes processes of argumentation parallel to philosophical epistemology, which is located on a different level.

Figure 8.1 shows what consequences can be drawn from this parallelism of pure-philosophical and empirical-evolutionary epistemology regarding the function and position of formal logic in the analysis of scientific knowledge. Formal logic is reduced to a syntactic and/or semantic analysis of the products of human cognition, whereas pure epistemology provides the gradual foundation (motivation) for the scientific method, endeavoring to define normative rules for the cognitive process. Evolutionary epistemology, as a primarily biological discipline, on the other hand provides an underlying basis for all empirical scientific research, dealing with scientists themselves and their individual psychological and social–institutional conditioning. Regarding the relation between empirical-evolutionary and pure-philosophical epistemology, it follows that, as parallel processes, they are by definition not competing programs, which mutually exclude each other or provide reduction. This parallelism, however, implies that evolutionary epistemology, against the background of classical philosophical epistemology, in no way represents a revolution, replacing or superseding classical epistemology as an obsolete theory.

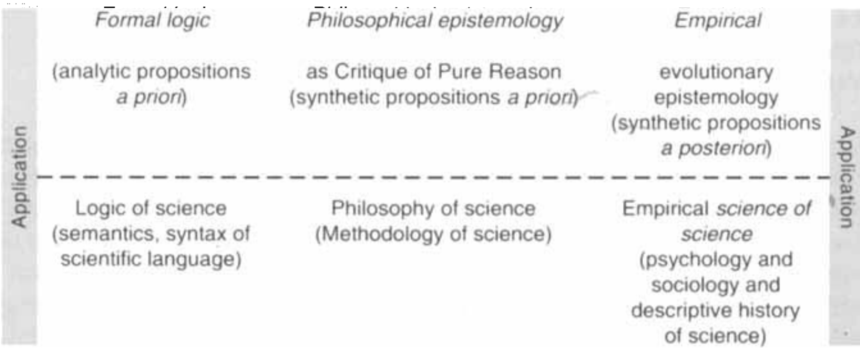

Figure 8.1: Parallelism between formal logic, philosophical epistemology, and empirical–evolutionary epistemology.

Strings of argumentation can conform only when parallel. If so, they are able to support each other and advance heuristically in a catalytic process. These processes may even diverge without causing a refutation, just as the conformity of a certain epistemological position, for example the so-called hypothetical realism, with evolutionary epistemology would not automatically imply any confirmation or corroboration of this position. The fact that internal or philosophical discussion among holders of the various epistemological positions has not brought about any variations since the appearance of evolutionary epistemology provides effective proof of this.

There is, however, a direct possibility of verification and falsification of pure epistemology. Here, epistemology is considered not only as pure meta-empirical discipline but also as a normative prototheory for real scientific knowledge manifesting itself in actual historical development. This means that all epistemological conjectures have to be transformed into methodological rules. Thus meta-science, the philosophy of science, provides direct, pragmatic, effective, control of pure epistemology, which was absent in the context of philosophical systems.

Simultaneously, another close relation of philosophy of science to evolutionary epistemology is established. Already in Darwin's time, progress in science was regarded not only as a phenomenon of development but also as a phenomenon of evolution, with numerous analogies to biological evolution. Evolutionary epistemology now offers the possibility of conceiving these analogies as structures of a manifest historical context. Thus the indispensability of classical epistemology becomes apparent to modern philosophy of science, which tended to restrict itself to the syntax and semantics of modern scientific language. For evolutionary epistemology is nothing but the biological interpretation of Kant's idea of the a priori (Lorenz, 1973; Campbell, 1974). Spencer called attention to this fact – he had by that time (Spencer, 1872) expressed the classical formula of evolutionary epistemology by means of Kant's terminology, namely, by regarding the data of intelligence as "a priori for the individual, but as a posteriori for that entire series of individuals of which he forms the last term". The discrepancy between Spencer's reflections and current views in evolutionary epistemology lies in that fact that, as Lorenz (1973) put it, the continuum of evolution shows stages and levels, in which new system properties appear. Whereas Spencer (1872) considered "the ability of reasoning of children not better than that of a dog", and the difference between the way of thinking of a Hottentot and Laplace equal to the difference between higher forms of animal intelligence and lower forms of human intelligence, Lorenz labeled the emergence of human consciousness with a much stronger term as a higher system-property: 'fulguration' (Lorenz, 1973).

Lorenz's view is not only adopted and rendered more precise by distinguishing between a genetically and physiologically determined concept of information and a concept of cognitive information, but it is also broadened by introducing the concept of scientific information. The concept of scientific information defines within the so-called second evolution, that is, sociocultural evolution, a relatively autonomous field whose development can be considered analogous to Popper's 'world 3 of objective knowledge' – a third evolution. Whereas evolutionary epistemology in the sense of Lorenz is concerned with the development of ratiomorphic structures inherent in living organisms and their historical phylogenetic relation to individual, creative, rational, human acquisition of knowledge with all its advantages and disadvantages, in this chapter I describe the evolution of scientific method. The evolution of method constitutes the transformation of individual subjective and intersubjective knowledge into the transsubjective objective knowledge of science. Thus a connection is established between both evolutionary views, largely independently developed. One view was concerned with the phenomenon of man (Lorenz, 1973), the other with the phenomenon of science (Popper).

8.5 Information and Knowledge

There is only one way to find a common terminological basis for both evolutionary epistemology, which deals with the phylogenetic preconditions of the human ability to perceive, and pure philosophical epistemology: the concept of 'information'.

A difficulty, however, arises from the fact that the concept of information is presently dominated by the pragmatic–technical aspects of information, i.e., information processing, in a way that leads to near-complete disregard of its original meaning (which is still present in everyday language, where the term 'information' always implies an increase in individual subjective knowledge, whether by communication with others or directly by representation). But whereas information processing only permits transmission or transformation of information (or signals) according to algorithmic rules, human processes, as well as all other processes of information within living systems, show processes of self-organization, which generate something totally new.

This change is brought about by processing already-existing information. Aristotle recognized that the processing of information during cognition is different from the processing of matter and energy: "The stone is not within the mind." To process information does not imply that something is 'annihilated', but only that something is devalued. Information that is already known, already processed by the system, is no longer information to that system. It has fulfilled its function, in establishing a higher structural order. On the elementary level of self-organization, the concept of information permits equating the terms 'life' and 'cognition'. Both are information-gaining processes according to structurally identical rules and laws, but on different levels. These levels can be distinguished by specifying information processing more accurately.

The most elementary kind of information processing is found in the self-organizational stage of evolution, which already existed on the molecular level when life began. This is genetic information, which already exhibits the main characteristics of genuine information processing, i.e., processing and evaluation of information to achieve higher patterns of order.

Between the living organism and its environment there exists a partial isomorphism, for, by adapting to its environment, the organism becomes a representation of it. The living organism extracts from its environment information about the external world, such as 'the eye is attuned to the sun', the motion of a fin is attuned to the undulation of the sea, as Lorenz (1973) has shown, and so on. This information is handed down as genetic information. This is true for every individual structure, from body shape and its structural parts to the positions of molecules, and from the simplest to the most complex structures of behavior. Those principles of environment that are essential for life preservation are rebuilt by trial and error and coded into the hereditary material, so as to be reproducible later (pattern matching). Campbell wrote in his essay "Evolutionary epistemology" (1974) that this pattern-matching process "can be generalized to other epistemic activities, as learning, thought and science". This view of knowledge as an adaptation process was regarded as the basic model of evolutionary epistemology and submitted to a critique. The main counter-argument is that

> man is distinguished from all animals by his faculty of developing new perceiving abilities, i.e., new methods of knowledge, without changing his physiological organization, and moreover, actually had done so (Frey, 1980).

According to the basic model of evolutionary epistemology, our thinking should be determined by the evolutionarily developed organic perceiving apparatus in such a way as to constitute "a pair of spectacles that can never be taken off" (Frey, 1980). Moreover, the model of knowledge as an adaptation process would be valid only in a more-or-less unchanging environment. This critique of evolutionary epistemology, however, ignores one important fact (Vollmer, 1975). In addition to adaptation, Lorenz distinguishes another type of information processing, which is entirely different. This is not a process of adaptation, but rather a function of nervous sensory and bodily structures that are already adapted. These functions apply to short-term information processing, that is, to information that cannot be stored, as it refers to rapidly changing environmental circumstances. Such information is not permitted to leave any trace in the physiological apparatus, because the main function of this mechanism is to maintain the permanent ability to recall a newly-received signal and to replace it by another, frequently even the opposite one (Lorenz, 1973). This functional structure of short-term information processing, which necessarily has to exist before any experience and also to be emptied of any experience, is the only one actually equated by Lorenz with Kant's a priori. The difference between such short-term information processing and the process of human cognition lies in the fact that these responses, such as homeostasis, amoeboid reactions, etc., are restricted to the processing of a specific kind of information, especially in lower organisms. The result is a very narrow and strictly closed program. On the other hand, the a priori of the process of human cognition, especially when we look at the differentiation and graduation that was made by Kant, is basically not specific to a certain kind of information, but has universal character.

On the organogenic level this successive change in direction is characterized by an increasing encephalization of perception, and consequently of all other behaviorist components. That is, the original tendency of evolution was directed toward the multiplication and perfection of various sensory channels; with the emergence of the brain, however, especially in man, it was redirected towards improved processing and evaluation of sensory data (Seitelberger, 1980). From that moment on, organically considered, the fitness of perceiving structures is no longer decisive. What counts is the ability to design constructive models of reality that are later checked against the empirical data of perception. These empirical data go far beyond the natural range of our sense organs, because they are obtained by theoretically constructed observation instruments. Kant's epistemology, vis-a-vis these biological evolutionary empirical epistemologies, represents the transcendental meta-empirical path of self-awareness, which simultaneously implies the normative function of transcendentalism.

We may thus distinguish at least three levels of information:

The *first* level is genetic information, which governs the development of organisms. Information processing from the genome is always valid for whole populations, because this information can be transmitted to the next generation only genetically, by way of inheritance. We are concerned here with the adaptation processes in species and populations, lasting over generations.

The *second* level of information requires the existence of an information-processing system, i.e., a central nervous system. At first on this level does a kind of information processing occur that shows a certain similarity to the human cognition, because it constitutes a process that resembles individual learning. The neurodynamic information system is distinguished from the genetic information system by the fact that it enables the individual organism to acquire and to store information about certain individual situations in its environment. This acquisition of new information, which depends on the existence of a central nervous system, must be distinguished from strictly genetic systems, which are ready-made adaptations to individual situations in plants and other 'primitive' organisms and are genetically fixed. It would be misleading to consider, as does Bresch (1977), that individually acquired neurodynamic information on the subhuman level is 'intellectual information', because the term intellectual should be restricted to human consciousness.

> The organic level of neuronal information processing deals, in contrast to the molecular–genetic level of information, with phenomena that form the basis of all conscious cognition. However, contrary to the conscious processes of knowledge, this kind of information is not detached from its material basis. Being materially conditioned information, it remains dependent on specific material conditions of certain neurodynamic systems and occurs only in that form. Like genetic information, it has the character of a 'signal', represented by certain physicochemical manifestations. In this sense, a signal is the property of physicochemical states that occur in the brain as an information processing system. Information itself, however, is the property of sets of signals; epistemologically seen it is the property of properties, or a meta-predicate. The meta-predicate 'information' must also be attributed to the subconscious brain states of subhuman organisms, because the behavioral patterns of animals have to be understood as informational reactions to the environment. These cannot, however, be regarded as intellectual or rational information.
>
> Unconscious operations, functionally similar to reasonable calculation and conclusions, may very well be labeled 'ratiomorphic', the term that was coined by Brunswik (1955) and adopted by Lorenz (1977). Ratiomorphic information is located at the level of subconscious behavior that does not constitute 'rational knowledge' or conscious acting: "It is undoubtedly not only a prerequisite, ontogenetically and phylogenetically, for the development of abstract thought, but also remains an indispensable part of it."

Only at the *third* level of information do we encounter human knowledge and conscious acting: here we may speak of 'rational' or 'intellectual' information. Within the actual subjective knowledge of an individual human, 'rational' or 'intellectual' information represents a certain state of consciousness that has its material equivalent in the neurodynamic system. If we use the symbol *O* for the mental phenomenon of consciousness and the symbol *X* for its neurodynamic equivalent, we may say with Dubrovsky (1978) "that this *O–X* connection is a special kind of functional connection, which characterizes the relationship between information and its bearer". *O* is 'contained' in *X* in the same sense that information is 'contained' in a signal. This conscious act of knowledge, however, is not the information coded as a signal in the neurodynamic system, but 'pure information', whose material basis was eliminated. For the subject of cognition has no direct or conscious experience of the material bases of information, that is, the neurodynamic states of the brain while perceiving an object or thinking.

> In this sense Kant had stated, as a matter of principle, that the subject of consciousness may regard itself as only a 'spectator', who must leave it to nature to take action, as he does not know neurons or fibers or how to manage them for his intentions. Thus, information as knowledge is 'pure information', original information devoid of its material basis. It emerges as abstract information independent of any specific 'bearer'. In the field of

> epistemology, ever since Aristotle, only this 'pure information' has been identified with the concept of human knowledge. In modern times this distinction has been clearly realized both in empiricism and rationalism. According to Locke's essay concerning human understanding (1788), the process of knowledge is based on the senses that inform the mind.
>
> In the same way Descartes clearly distinguished between material information processing, in which the objects of the outer world leave their impressions mediated through the senses, and that process from which ideas of a purely spiritual nature arise as genuine and certain knowledge. Descartes regarded these ideas as forms of our thoughts when they inform our mind by turning it towards the brain, but not when they are impressed in a material organic sense in our brains. Kant himself, in fact, in accordance with contemporary terminology, no longer employed the concept of information in its original epistemological meaning. His differentiation, following the Aristotelian scholastic terminology of form and content (matter), between a priori and a posteriori has been, however, referred to the concept of information in the 19th century (Whewell, 1860) as well as in the 20th century.
>
> MacKay (1950) provided, by coordinating structural information content with Kant's concept of a priori, a modern approach to an information-theory-based reconstruction of Kant's transcendental philosophy. This informational approach to human cognition (Oeser, 1976) helps explain the relation as well as the difference between pure philosophical and empirical evolutionary epistemology. The a priori structural information content represents the subjective function of consciousness in human knowledge. It constitutes the a priori disposition of that information process, which starts by illuminating some spots of the 'infinite field' of subconscious 'obscure images' by way of reason. This process corresponds exactly to the above-mentioned process of detaching 'pure information' from its material basis in chemophysicophysiological brain processes.

Even though no further processing of free abstract information can occur without the underlying brain processes, we have now reached another level of representation of information with a new process pattern. This sequel structure is directed by the logical laws of a priori forms of thinking. It represents, therefore, the purely logical level of information processing.

Kant (1781) explicitly called his epistemology 'transcendental logic' and thus distinguished it from all empirical-sensory, brain-physiological, and empirical-psychological investigations. Moreover, he defined transcendental logic against a formal propositional logic, or, as he called it, 'general logic', by distinguishing two basic principles:

1. The law of prohibited contradiction is the basic law of formal logic.
2. The law of sufficient reason is the basic law of epistemology. It must not be confused with the formal principle of knowledge, that every statement must

have a reason, which can be deduced from the law of contradiction. It is rather, as the first synthetic principle, a priori the material principle of knowledge. It states, according to Kant, that "every object must have its cause".

The law of sufficient reason in this generalized formulation is not identical to the principle of causality in natural knowledge. It is rather to be placed above this special principle, because it refers to the causal structure of the real process of knowledge in its dynamic sequence. A process having neither material nor energetic character, but nevertheless showing a causal structure, is called, in accordance with current terminology, a 'process of information'. Thus, Kant's vaguely formulated law of sufficient reason can be defined more precisely as the principle of information.

The principle of information states, in the classical terminology of the law of reason as formulated by Leibniz, that the process of proving the 'truth' of a statement must have the same causal structure as the process that establishes (causes) the 'existence of a fact'. This structural identity of material causal processes and informational processes is, although implying a synthetic statement on the structure of the world, a purely a priori axiom of epistemology, as it necessarily results from the definition of 'knowledge'. The concept of knowledge, being a rational concept, always implies a connection between a knowing subject and a known object; the connection itself is a process between those two components. No knowledge can occur if there is either no difference at all between those two components or a very significant difference, leaving them completely independent of each other. In both instances, every connection is eliminated. Complete identity or complete independence between the subject and the object of knowledge does not allow any processing of information to take place, and such states of 'knowledge' can be described only negatively:

- Complete identity means absolutely certain knowledge. Absolutely certain knowledge, however, can be achieved only in tautological analytical connections. Tautological insights, however, do not yield any evidence of the world. Such postulates are therefore trivial knowledge, because they do not contain any information.
- Complete independence means absolutely uncertain knowledge. It implies the ultimate impossibility of perceiving the world by knowledge. Such a situation would occur only for a completely unstructured world. Such postulates are absurd knowledge, because they do not contain any information.

Knowledge can occur only if both relation components, i.e., the subject and the object of knowledge, are simultaneously homogeneous and heterogeneous. Only thus are they able to constitute a system in which a process can occur. In traditional epistemology this basic insight was made into a formula by Aristotle. He regarded knowledge as a process, through which something different in species, but identical in genus, affects something else in such a way that the ones different by species start to resemble each other. Aristotle distinguished this process from a material process that destroys the opposite, like incorporation of nourishment, which is a material causal process; Aristotle termed the former an informational process, in which a transformation of what had been existing potentially as a form occurs and results in its becoming real as an abstract form.

In other words, in Aristotle's theory of knowledge the processing of information means an activation of the invariant substantial forms of real objects that have always been potentially present in the subject of knowledge. This process is accomplished when the form of the subjective image corresponds to the substantial form of the real object. The concept of knowledge as a process of realizing forms that potentially already exist within the subject of knowledge is a basically static structural concept of a world with a constant amount of invariant forms.

The contemporary concept of information, however, does not include this ontological precondition regarding the existence of invariant substantial forms. It refers only to the process of change itself, which is defined by the relation between 'condition' and 'effect'. For knowledge is not rendered possible by certain unchangeable forms of things-in-themselves, but by the causal structure or regularity of processes of change, determining the structures of being as well as the structures of knowledge. Here, knowledge no longer stands for an ideal correspondence between invariable substantial forms of things and their mental images, but for the correspondence of two structurally homogeneous processes, caused by an attributive relation between process elements.

One process takes place within the subject of knowledge, requiring, however, another process to take place in the subject's environment. The connection between these two processes is established actively and spontaneously by the subject. As a result, the ambiguity of the term 'information', unavoidable in any epistemological subject–object relation, is rendered comprehensible:

- When referring to the subject, information has a structural a priori content.
- When referring to the object, information has an empirical a posteriori content.

The structural information content is an achievement of the subject itself. There are stipulated conditions under which a thing may actually become an object of knowledge. Expressed in a realistic interpretation of Kantian terminology, this structural a priori content constitutes a species-specific potential of brain performance.

The most-elementary structural conditions, those of time and space, make up the basic pattern by which the world of objects is made accessible to the epistemological subject, and by which categories are established that enable the epistemological subject to structure the world relationally.

The empirical information content refers to conditions and events that occur repeatedly, or not at all, independent of the subject, that is, of the subject's perception of them. The existence of such elementary effects, independent of consciousness, has throughout the history of epistemology, from Aristotle to Kant, been regarded as the only certain guarantee of reality. They not only constitute the point of departure, but if repeatedly occurring, continual verifications of the truth of knowledge.

Knowledge is, therefore, a never-ending, irreversible processing of information, with a constantly changing ratio of empirical and structural information content. Even those conditions of the processing of information that seem not to change, and which are consequently regarded as the end or the completion of the cognition process, are nothing other than stabilized (steady-state) phases in which the cognition process has adapted itself to the processes occurring within the reality and the environment of the subject. Both processes have a certain discrete phase-structure that remains basically unchanged:

- Within the environment, a process starts from a state that constitutes the condition for an event, which in turn creates a new state that constitutes the condition for another event.
- Within the subject, a process starts with information about the environment, which creates a new state of knowledge, which is transformed via additional information into other states, and so on.

Nevertheless, the attributive relation may vary – it can be practical or theoretical. Either way, it is actively established by the subject of knowledge and may take the following forms:

- A passive information-gaining relation that does not alter the environmental conditions, for example:
  - perception
  - observation
  - measurement (macrophysical)
- An active information-gaining relation that does change the state of the environment, such as experimental preparation so as to create a certain state or an action that leads to a change in conditions by causing an event to occur.
- A theoretical relation, representing a certain state of knowledge or information, that permits prediction of an event or planning of an action that will cause an event.

In each case, a phase shift between the two processes occurring within the subject and its environment takes place. On the one hand, information about a real event can be obtained only after the event has occurred. On the other hand, the subject is capable of receiving information only while it remains in existence: "Hence, the eye strides, but does not glide" (see Holst, 1969/70).

The formal symbolic apparatus that represents this process structure may be very simple, but it has to always maintain the relation between the subject and object of knowledge, in order to serve as a 'correspondence theory' of truth within epistemology. Thus, we may distinguish two kinds of information distribution (Figure 8.2):

1. The information process within the subject, i.e., the transport or processing of information within the system. Symbolically represented by a horizontal arrow.
2. The input from the environment of the subject, resulting in pure information as a change in the system. Although certainly no passive reception process, but an active encounter of the subject with the environment, this process can nev-

ertheless occur only because the environment actually exists. Symbolically it is represented by a vertical line.

Even if these processes have an identical structure, two process elements must be distinguished:

1. The states of the subject and the environment, being an informational state of knowledge on the one hand and a factual situation on the other hand. Symbolically this is represented by a circle.
2. These states are conditions for changes to occur, either as structural changes in the informational state of knowledge by new information or as real events. Symbolically represented by a square.

This representation by four symbols may be more complicated than the topological figures of 'process logic' or 'temporal logic', as conceived for example by Wright (1971), which consist only of 'states' (circles) and horizontal lines representing the 'history' of the state. Yet they allow a more precise description of cognition processes, decisions, and actions, without having to presume the logical-atomistic structure of the world as a fundamental metaphysical conception. The structural theory of information processing that is presented here is not a logical but an epistemological atomism. In contrast to those who hold ontological concepts, I make no statements on the logic setup of possible worlds. All I aim at is to analyze the informational processes within and above the real and factually knowable world, the only presupposition being that the world has process character, i.e., that it can exist only in space and time. This presupposition, however, is nothing but the condition of the possibility of its perception. The cognition process itself, as a process of information, is based on an underlying process in the real world in which the recognizable phase of this reality process has always already taken place.

Thus, a graphical representation of the basic forms of information processes can be provided, allotting distinct places to information, observation, prediction, event, condition, etc. (Figure 8.2). This representation also clearly demonstrates the genetic priority of knowledge over action. Before a consciously planned interference in the environment can be made, information-gathering and predictive

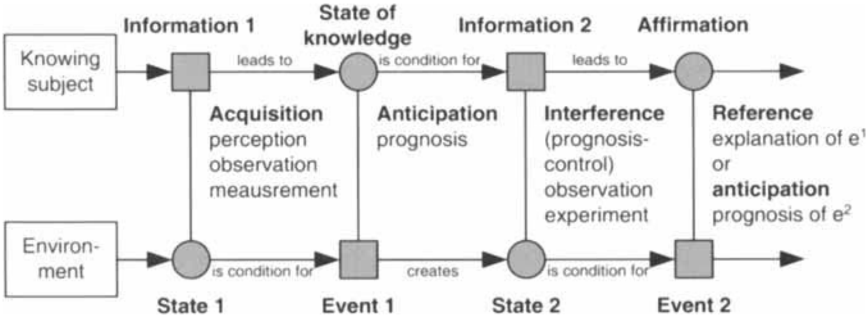

Figure 8.2: Basic forms of information processing See the text for an explanation of the symbols.

anticipation of the subject's environment are necessary. The immediate relation between knowledge and action is given systematically by the concept of 'change'. When the process of gaining knowledge is merely contemplative or passive, the concept of change refers to the subject itself. Passive information-gathering does not and cannot change the observable environment at all; an example is non-experimental astronomical observations, because of the great distance to the observed object. There 'change' means an 'adaptation' or 'assimilation' of the subject's cognitive condition to the environment. In this sense the concept of information also refers to the subject. The concept of information is a systems-relative concept, expressing nothing but the change within the subject's system caused by environmental influences. This, however, does not imply that the environment is an unchangeable part of the whole system. On the contrary, the changeability of the objective world through activities on the part of the subject is an essential precondition of its recognition. All our knowledge is originally experimental knowledge, that is, it interferes with the environment, thereby launching real observable processes.

Kant, in contrast to Aristotle and Leibniz, emphasized this component of spontaneity in human cognition. He did not want to establish an idealistic epistemology, but an activist one. Thus, the law of reason, formulated more precisely as the principle of information, gains its fundamental meaning as the principle of causation of knowledge. This means, in Kant's words, "that within the occurrence there is always to be found the condition, from which this process (necessarily) follows at any time". In other words, the a priori forms of consciousness form the structural conditions of the process of knowledge in its causal temporal structure and are necessary because without them, no cognition – information processing – can occur. These a priori forms are also of general validity, representing not individual coincidental preconditions of an empirical subject, but the general homogeneous constitution of the human cognitive ability. From an evolutionary point of view, this universal constitution of the human cognitive ability equals a species-specific potential of brain activity, which Lorenz (1977) explicitly calls 'fulguration': "The evolution of man is a 'creative flash' of accumulated tradition and the cerebrum is its organ."

Epistemologically speaking, the empirical fact of brain development has its equivalent in the hierarchical organization of the cognitive ability, as described by Kant. Hence it follows that it is not sensory experience, but scientific theory, that decides what is real. Thus the subjectivity of perception, conditioned by the brain, is transcended by an equally conditioned higher potential of human brain activity. So the brain is represented, very much in the sense of Kant, as a system of systems, continually increasing its information content by systematically expending a certain amount of sensory energy or by suppressing it and 'illuminating' only those parts of the consciousness that have previously been decided on by the 'obscure' system of preconscious processing of sensory stimuli. The 'chaos of sensory perceptions' mentioned by Kant (1781), receives, in exact accordance with his doctrine of categories, a preconscious but nevertheless a priori formation. A modern probabilistic interpretation of signal processing by nerve cells, by von Neumann (1956), allows the Kantian conception of chaos, from which order arises by spontaneous cognitive ability, to be formulated more precisely. Von Neumann demonstrated how to build reliable systems from unreliable elements. Such possibilities are realized within certain neural networks, counterbalancing the statistical uncertainties of changeable chemical processes. Thus, the material presented to conscious cognition is already processed and arranged according to certain structures. However, even this material of conscious sensory knowledge is further processed according to higher selective principles, in a process repeating itself from a structural point of view. Consequently, also in this sense, the rational supersystem supersedes understanding, which is a subsystem. This complies with the following fact of brain physiology: that as sense-organ signals undergo more and more neural representational processes, the greater the degree of independence of the neural stimulation pattern from the environmental trigger (Grüsser and Henn, 1970).

On this logical level of information processing, it is essential that the empirico–causal material processes within the sense organs and the brain, that is, within the peripheral and central nervous system, are rearranged and directed by a second process. Although these forms of consciousness have their phylogenetic roots in preconscious or ratiomorphic structures of subhuman organisms, they possess a different character on this level. They are determining components of a process, which consciousness identifies in all its parts as its own acts. Using an image William James borrowed from Kant, conscious human knowledge resembles, in contrast to causal–energetic processes on a material–empirical level, a game of billiards in which the elastic balls are not only able to move, but are also conscious of it. The first ball would thus transmit not only its motion but also its consciousness to a second ball, which after receiving it would transmit motion and consciousness to a third ball, and on and on until the last ball would contain everything. In this way a vivid description of the fundamental structure of every conscious process of knowledge, from the most primitive formation of concepts to the highest form of constructing scientific hypotheses and theories is presented, all of which are processes of information condensation.

From this perspective, the process of acquiring knowledge consists of a chain of mental states, having their material equivalents in the dynamic organization of the brain. Nevertheless, only achieved states of consciousness are perceivable, not the transitions and transient parts of the stream of consciousness, which are always completely obscured by the achieved goal of the movement. To record these transitory motions is impossible, as it would mean their destruction. It resembles, as William James puts it, the futile effort to switch on the light to see what the darkness looks like.

Nevertheless, the continuity of consciousness, the 'I think, accompanying my imaginations', is maintained; because every state of consciousness, every substantial point of rest, contains the previous one. Moreover, this does not take place in a random way, but according to certain unchangeable structural synthetic a priori laws that provide the ultimate guarantee for the unity of consciousness. From this it becomes obvious that information within the human cognitive process is not developed by mere addition, but aims towards an increasingly constructive rational-

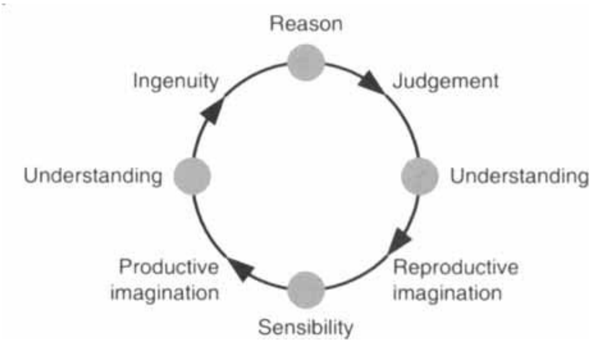

Figure 8.3: Kant's relationships between powers of the mind.

ity. This rationality is constructed by a certain mechanism, which Kant already precisely described in his transcendental epistemology (Oeser, 1982) (Figure 8.3).

Figure 8.3 shows that the well-known circular arrangement of sensory input, understanding, and reason, each containing certain levels of a priori form (space and time, categories, and ideas), does not make up a static structure, but has a dynamic functional relation. This functional relation is set up by knowledge potentials, precisely determined in the sense of logical operation, that are closely linked with each other, forming a topological system having a quasicircular character.

Differing from the conventional interpretation of Kant, but in accordance with evolutionary epistemology, I can demonstrate, by reconstructing Kant's pragmatic anthropological ideas, that his system of synthetic a priori forms provided not only a topology of human perceptive ability, but also a topology of error. The basic idea behind this negative topology of human cognition is that even error can be explained epistemologically. Or, as Shakespeare put it: "Though this be madness; yet there's method in it." Figure 8.4 shows the methodical structure of error as a pathological exaggeration of cognitive abilities and forces on the productive heuristic side, whereas on the reproductive stabilizing side, deficiencies and attenuations are seen. This topology of error, which is of course totally realized within a real individual, constitutes the foundation of individual–private, as well as of collective–systematic disinformation, which occurs even within science.

The functional unity of all perceiving abilities and their connecting cognitive forces are exactly what Kant calls the epistemological subject, or self-consciousness. This unity is the a priori precondition for the possibility of knowledge, which itself appears only during the process of experience. Thus, the reality of consciousness may be comprehended as an informational reality that exists only within this constantly repeated functional relation. Moreover, this functional relation is the key to an evolutionary methodology of science that is capable of explaining the development of those mechanisms of knowledge that serve to transcend the phylogenetically conditioned foundations of human cognitive ability.

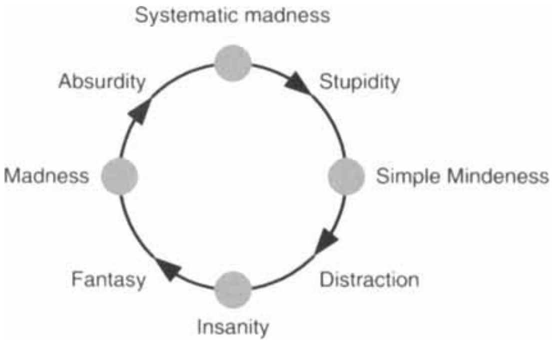

Figure 8.4: Kant's topology of error.

8.6 Science as an Evolutionary Information System

Scientific knowledge can be regarded as a reversal of common-sense knowledge, because it does not primarily serve to preserve life, but to acquire 'objective knowledge'. All the same, our innate cognitive apparatus can be transcended only by aid of the apparatus itself, by a repetition of the original procedure. This means that scientific method has the same circular structure as the elementary mechanism of trial and error-elimination that is observable also in the lower animals. Scientific method, however, is distinguished by being a consciously developed supra-individual mechanism for self-correction, that not only eliminates incorrect information but also stores correct information, or more precisely, condenses it in an abstract manner. This process can be illustrated by the epistemological model in Figure 8.5.

Although this model resembles the three-worlds model of Popper and Eccles, it is different in that it is a purely epistemological model (not an ontological model, which distinguishes diverse levels of being or different relatively independent worlds). In contrast, in an epistemological model, stratification of being or separation of worlds occurs as abstract differentiation of the object area of scientific knowl-

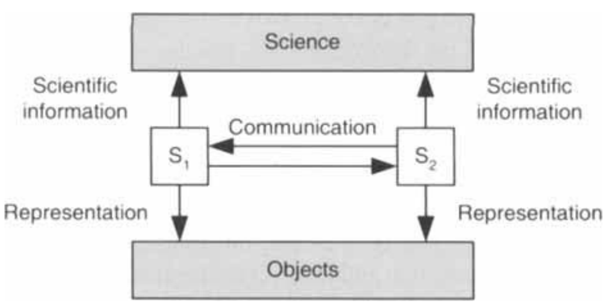

Figure 8.5: Diagram of the process of scientific method.

edge. The model demonstrates cognitive processes and the conditions by which the subjects of cognition represent the central active parts or bearers of the scientific process. Representation is the most elementary form of an information process that, on the cognitive human level, may be termed 'knowledge'. My model shows representation as a direct connection between an epistemological subject and an object area. The adequacy of this representation corresponds to what has, in classical correspondence theory, been called the 'correspondence' of subject and object. This correspondence can now be identified as the result of an information process, by transforming the Kantian principle of the possibility of experience, that is, the law of sufficient reason, into the information principle. In this process, information is not transmitted, but is produced by the human consciousness. Human consciousness (or, as Kant put it, the originally synthetic unity of transcendental apperception) separates itself, as well as its material bearer (the organism), from the external world by setting up a subjective model of this external world as a phenomenological world within itself. Here, the Kantian a priori forms of sensibility (Anschauung) and Reason result in a model of knowledge operations, which, as a general principle, can no longer be questioned. They are, however, in no way an absolute guarantee of the truth of knowledge. Not even Kant ever claimed this. They are merely a guarantee of the 'impossibility of absolute error'. In every individual cognitive process, knowledge and error are inseparably blended, because the subjective model of the external world does not consist only of information, but also of disinformation.

Disinformation can be identified as such only after a corrective process is applied. It is, so to speak, a topological distortion of the external world integrated into this model along with undistorted information. Hence, the model of the external world, set up by a cognition process, resembles a map on which the various places actually exist, but their relative positions are shifted. This displacement does not make the map completely incorrect, as we can still reach these places by following the paths on the map.

But the subjective model of the external world can also be lifted to the higher level of intersubjectivity by the individual concrete subject's communication with other subjects, which results in a specific social construct of reality. The perceiving individual may thus escape from the prison of his own brain-conditioned subjectivity.

Hence, communication is the second process of human knowledge processing, which is permanently superimposed on the information process of representation, and which, at least as far as intersubjectivity is concerned, provides an additional guarantee of reality. The original medium of direct personal communication is natural language, which originated under selective pressure for communication among subjects. As Berger and Luckmann (1966) told it so vividly, the everyday life of man resembles the rattling of a conversational apparatus, which constantly guarantees, modifies, and reconstructs his reality. We have, however, to distinguish between direct interpersonal communication and indirect communication, which arose with the invention of writing. A written document not only creates the opportunity for a new kind of indirect communication, independent of time and place, but simultaneously provides a novel source of information. A written document not only serves, at least in the area of science, to spread knowledge, but, moreover, contains the demand for further information processing within the framework of a comprehensive transsubjective process, in which each document represents but a minute part.

Scientific knowledge is indeed based on processes of information and representation, which are also well known in common-sense knowledge. But, as a matter of principle, scientific knowledge must be distinguished from common sense by the fact that – from the beginning – 'scientific knowledge' refers to the transsubjective system of science, which is endowed with relative independence. This abstract system of science, however, cannot be directly identified with the whole of papers, books, and documents (including electronic documentation), because for the most part, these documents contain devalued information that is no longer used. The state of science is in fact represented only by those documents actually used by scientists. This conception of science as a system of information can, with reference to Bolzano, be labeled an 'actualistic' conception. It contends that only what corresponds to the current state of scientific communication can be regarded as 'science'. Everything that is not part of the current information process of the widely branched interpersonal communication system of science, either no longer belongs or does not yet belong to science. Without adding criteria for this 'actuality', however, this theory would indeed be trivial. Statistics on author citations or keywords may provide an outward reference, but by no means an undisputed foundation. The logical epistemological criterion determined by the concept of 'truth' is no better qualified for this purpose, because current science includes current truth as well as current error, which is constantly present in the system of science, as a collective disinformation. As a basic criterion, as well as a real entrance condition and selection mechanism, we should therefore regard only the scientific method of a discipline, because it decides the foundation and justification of new knowledge, just as it decides the processing and devaluation of former knowledge. The totality of all methods of a discipline represents the mechanism of knowledge accepted by the scientists in that field. It functions even when alternative theories within a discipline conflict, because such disputes are decided in accordance with methodological principles. Controversies between various methods do not arise solely within the overall system of all sciences, but also within the limits of specific sciences. However, this controversy between methods refers after all only to a shift of emphasis within the system of methods used by a discipline. It does not concern the functional relation itself, which basically connects all possible methods of knowledge, including reduction, induction, construction, and deduction. This functional relation is established within the human cognitive faculty as an a priori basic structure. At the level of scientific knowledge this cyclic or quasi-circular structure proves to be a methodologically regulated corrective process. The basic pattern of this constantly ascending self-corrective process can be described most adequately as a spiral iteration that gradually approaches an unknown aim without ever actually reaching it. This corrective procedure is, like common-sense knowledge, a product of evolution – of an evolution, however, that has already changed its direction from subjective knowledge, which aims at the preservation of life, to objective knowledge.

8.7
The 'Law of Three Stages' of the Evolution of Method

A functional relation between methods, serving the purpose of acquisition, systematization, and justification of scientific knowledge, is established today within many empirical sciences. Actually it is nothing but an iteration of the subjective individual mechanism of common-sense knowledge, originally serving the maintenance of life. We could say that this elementary mechanism, epistemologically proven even in the behavioral patterns of lower organisms, forms a kind of prototype of the mechanism of scientific knowledge, in which every methodologically regulated step has to be retraceable. This is demonstrated in Figure 8.6 (Oeser, 1976) which completely corresponds with Kant's model of the functional relation between cognitive faculty and cognitive forces. The reconstruction of the historical development of this model depicts the evolution of scientific method.

This evolution constitutes a process, which, as Spencer already assumed, is determined by an evolutionary law. Even before Spencer and Darwin, Comte had demonstrated the development of simple, concrete relations into complicated, abstract relations, by positing a law of three stages. This law maintains that different sciences, depending on whether their field of study is simple or complex, attain different stages of development at different times. Although Comte considered these stages of development – in tune with his positivist ideal – as a process liberating science from theological and metaphysical influences, the history of science assumes a vastly different character when seen against the background of the evolution of methods. It then no longer represents a process, leading phylogenetically as well as ontogenetically from a theological through a metaphysical to a positive scientific stage, but rather a process, developing in its first stage an empirical inductive method, in its second stage a constructive systematic method, and in its third stage a deductive formal method. These methods do not supersede or replace

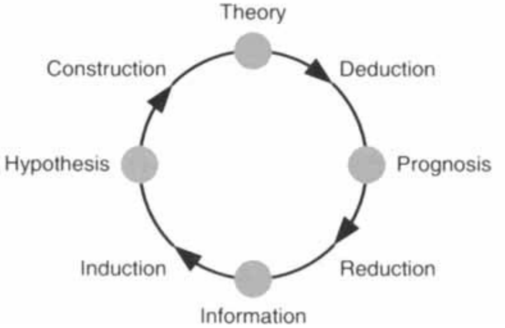

Figure 8.6: The functional relation between scientific methods.

one another, but unite into an increasingly compact functional relation. This approach corresponds to Spencer's amendment of the Comtian law of three stages. Contrary to Comte, Spencer points out that there are not three antagonistic methods of knowledge acquisition, but a single method that basically remains the same. Unlike Spencer, we are not compelled to abandon the law of three stages in our model, because the various stages of science can be regarded as periods in the development of a single increasingly complex method relation. Thus, Comte's idea of different sciences attaining these stages at different times or remaining in these stages for different periods of time is retained. It may even occur that certain sciences, having a complex content, never reach the axiomatic deductive phase. In the model this means that the separate sectors of the quasicircular process form not only a logical systematical sequence, but also a historical genetic one. Thus the evolution of method may be demonstrated as follows.

The first phase in the development of science is characterized methodologically as a pretheoretical phase. During this phase the inductive method is developed in its simplest enumerative form. At this stage of scientific progress, science is merely descriptive, for example the classical natural history. Yet, even on this level of pretheoretical science, it is possible to make predictions about future effects. A prerequisite for such a prediction (i.e., a prognosis without theory) is the uniformity or permanent repetition of effects. A general principle of induction is thus justified by the uniformity of the world, and a prediction is just the extrapolation of a uniformity series of observations into the future. An example (Figure 8.7) is provided by Babylonian astronomy.

The second stage of scientific knowledge is marked by a period of theory construction. During this period a jump from inductively enumeratively obtained statements to general statements (laws) occurs. This typological jump is not justifiable by pure logic and consequently requires a new kind of induction, going beyond mere enumeration. Whewell (1860) called it a 'superinduction', always containing a mysterious, creative element that cannot be rationalized by formal logic. Historically, this leap in the field of empirical science was made possible by the development of Euclidean geometry. It created a scope of empirically independent regularities that could, however, be transferred to the area of experience. A brilliant example for such a general analogy, in which mathematical laws were translated into reality, is the Ptolemaic astronomy of ancient Greece.

Thus the Comtian classification of science, which represents a series of developments from a historical genetic point of view starting with mathematics and lead-

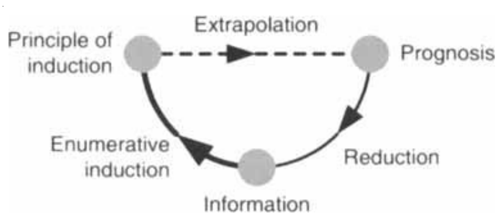

Figure 8.7: The pretheoretical phase of scientific method.

ing via astronomy to physics, chemistry, biology, and finally to sociology is confirmed. In observing the actual evolutionary history of science, we realize that, indeed, physics was the next science to reach the constructive theoretical stage. Although, within the dynamics of astronomical theory, a change from the geocentric to the heliocentric system was effected by Kepler and Copernicus, the development of method in this field remained perfectly continuous. A decisive change occurred however when, along with Galileo's nuova scienza, physics as terrestrial mechanics passed into its second methodological phase. Galileo, and later Newton and Huygens, explicitly named the basic structure of this methodological step the method of opposed operations – metodo risolutivo and metodo compositivo – the method of analysis and the method of synthesis. This means that, when analyzing a homogeneous phenomenon of motion, for example, in the motion of a free-falling sphere, the primitive enumerative induction is retained. It serves, however, a higher purpose, namely the deduction of general laws, which succeeds only by way of superinduction, provided by geometry. The discovery of these laws exactly illustrates the process of development from simple concrete laws to complicated higher laws; e.g., from the primitive law of scales and levers to the complex laws of free fall.

The constructive synthetic setup of a theory thus follows a law of development, in which, by varying the experimental conditions, increasingly complex relations can be realized. This process can be considered a constructive one, because previous steps can be employed for further procedure. The more abstract and comprehensive a law, the more complex and broad its context, because it integrates previous regularities as structural conditions. The classical example of such integrative growth is Newton's theory of gravitation, which contains the laws of terrestrial as well as of celestial mechanics. Classical (inductive synthetic) theories meet their limits in the unwieldy mathematical apparatus of Euclidean geometry, which sets bounds to any further development towards more comprehensive principles, no longer graphically presentable. In the model, this means that emphasis on the inductive constructive part coincides with deficiency on the deductive part (Figure 8.8).

Being axiomatic deductive theories, classical synthetic theories are logically incomplete. No concept is ultimately defined, in the sense of mathematical logical exactitude so as to exclude emendation. No axiom is formulated so as to exclude correction; no theorem is self-evident to such an extent that it would not require additional proof for its deductibility from axioms.

Only in the third stage, methodologically characterized by the development of a formal analytic method of deduction, does science attain the degree of systematical perfection that permits prediction and explanation of individual phenomena within a certain area and in a constant manner, in the sense of an algorithmic method. Thus, a major shift in emphasis from observing, measuring, and experimental procedure to theoretical calculation occurs. This holds true at least for 'normal' problems, for which algorithms are available in the form of algebraic equations. The prime example of this, unmatched to this day, is the analytical mechanics of Langrange and Laplace. It is, as Mach (1921) stated, a purely formal development

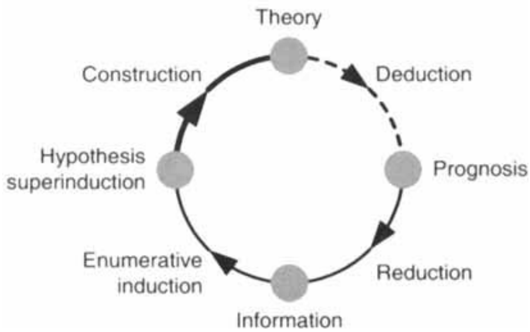

Figure 8.8: The constructive synthetic phase of scientific method.

of Newton's original constructive synthetic theory into a formal axiomatic deductive system. In terms of the model, this means that emphasis on the deductive part coincides with abandonment of the inductive constructive method (Figure 8.9).

Not even heuristic developments or fundamental changes in the axiomatic deductive theory in its basic concepts and axioms, such as, for example, Einstein's theory of relativity in relation to classical mechanics, has had such an effect on the basic structure of previously valid scientific method. The inductive constructive procedure of heuristic logic, which is closely tied to sensory experience, is supplanted by a speculative constructive procedure, which is far from realistic experience and creates concepts that, as Einstein (1956) said, are free inventions of the human mind.

For this reason, Einstein (1956) characterizes the movement from axioms to a highly developed theory of principles as a 'jump', no longer justifiable by the traditional procedure of gradual induction (Oeser, 1979). This view, however, should not be identified with anti-inductivism, as advocated by Popper in his radicalization of Einstein's reflections on method. As a matter of fact, this discontinuous procedure was characteristic also of classical induction. There, the jumps had of course been shorter and fewer, because they usually occurred in the same way as those in

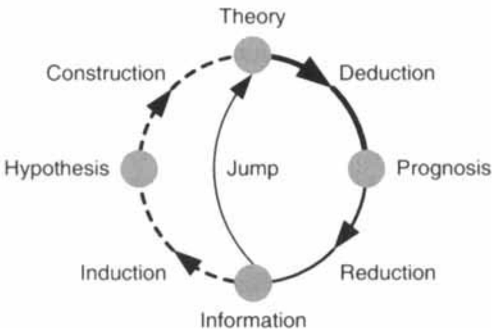

Figure 8.9: The axiomatic-deductive phase of scientific method.

Euclidean geometry, that is, within a defined area. Deductive systematization was therefore considered merely an additional effect that often manifested itself only generations later.

A somewhat different situation is encountered in the abstract theories of principles of modern physics. Precisely because their basic concepts are inaccessible to experience, deductive systematization has to be performed directly and with ultimate consistency, to make the free play of thought a scientifically relevant, i.e., systems-relative, process of knowledge. How strictly even Einstein followed this 'logical path' of deductive systematization is evident from his scientific papers, in which he employs the purely logical aspect of thought economy to an extent that highlights the limitations of creative intuition in scientific procedure more clearly than ever. The distinction between hypothesis and theory is visible on this level of deductive systematization. Isolated hypotheses are unimportant at this stage. Only within a system of axioms do they gain a certain significance. Subsequent inductive support of such abstract hypotheses before the establishment of a theory is therefore superfluous, regardless of the fact that, in general, there are no such possibilities. Hypotheses, forming the top of a highly abstract system of axioms, mutually support each other. Einstein (1956) endeavoured to substantiate this 'criterion of inner perfection' that "is not concerned with the relation to the observed material" not only from a logical, but also from a pragmatic and aesthetic point of view.

According to the comprehensive formula of Comte, not only mathematics, astronomy, and physics have attained the stage of positive science, but in succession also chemistry, biology, and sociology. This development has its equivalent in the model of the evolution of method. For example, chemistry reached, at the latest when Dalton's theory of atoms became known, the last stage of axiomatic theory formation. At this stage it is possible to predict, within the framework of Mendeleev's periodic table of the elements, the discovery of new elements. Here, however, chemistry, in the sense of homogenous reduction, overlaps physics, since the basic theory of both disciplines has become identical. In the field of biology we encounter a slightly different situation: already Darwin pointed out that, compared to physical laws, the relations between biological phenomena are far more complicated. An even higher level of intricacy occurs in the laws in the field of human society. Here an entirely new factor is added, namely the fact that theoretical concepts cause some changes in the field of study

Being phylogenetically firmly established in the human perceiving apparatus, the quasicircular fundamental structure of functional relations among methods in retained throughout. An example in the field of humanities is the so-called hermeneutic circle, which, in applied sciences is the action-circle or applicative circle. As Schleiermacher and Dilthey stated, this circle of human knowledge is based on the functional relation between induction and deduction. Therefore, it does not in general display any structural difference from the feedback loop of inductive experience and deductive theory customary in natural sciences. The difference lies not in the structure of the cognitive mechanism, but in the peculiarity of the object area which contains different kinds of order. For example, in the field of biology, contrary to physicochemical laws of repetitive and universal character, a new kind of order appears, which only distantly originates in thermodynamic equilibria (Prigogine and Stengers, 1981).

Of this kind of order of living systems, new structures of order appear in the human sphere which will probably never be understood by means of axiomatic deductive theories. These new open structures correspond to another type of theory that, although not having fixed determinations or axioms, is no less scientific. It is based on a methodologically justifiable fundamental structure of a self-controlling process of knowledge.

This methodological fundamental structure, although formed in the course of the history of science, is merely an idealized abstraction, not pertaining to any individual scientist but only to the system of science. This means that the individual scientist is free to choose his or her method and even to come up with absurdities. The constitution of human cognitive ability, however, proves Kant's statement of the impossibility of total error. A positive formulation of this idea, corroborated by evolutionary epistemology, appeared in "Allgemeine Naturgeschichte und Theorie des Himmels" (Kant, 1755) and could be made the guiding principle of the entire history of human knowledge and science: "Even in the most absurd views that have found approbation by man, there will always be found a grain of truth." Methodologically, this means that scientific research cannot be mastered in an ideal way, i.e., completely harmonized in its functional elements. The functional connection, phylogenetically developed in the course of the history of science, has its ontological equivalent within the human individual. Here, too, shifts in emphasis are observable. It may develop into stationary conditions that cannot be escaped individually. In the history of science, there will always be radical inductivists or deductivists contributing their share to the general development of science.

The actual selective mechanism, however, is not affected (in the sense of a primitive social Darwinism) by disputes and discussions among scientists, but by the system of science itself. This selective mechanism treats the individual mercilessly but with absolute justice. In science, no structure of order is ever lost. Discoveries made too early, like the Mendelian laws of heredity, are rediscovered later. For the individual, however, this justice is usually administered too late, because the selective forces are not attuned to the individual person. To the contrary, they cut right through personal ideas and scientific efforts, where truth and error, sense and nonsense, constitute a uniform system.

This selective agency, for example, separates the Galileo who founded physics from the Galileo who established abstruse theories on high and low tides; it separates the Newton who founded a fundamental uniform astronomical/physical theory from the Newton who dabbled in pyramids, theology, and alchemy; it separates the Cuvier who founded comparative anatomy and paleontology from the Cuvier who was an irrational and furious opponent of the theory of evolution.

The advantage of such an impersonal justice, which does not have to be invoked by the individual, because it will be provided anyway, is contrasted with its disadvantage, that science indeed no longer needs the creative human individual and thus acquires an inhuman dimension that has already begun to frighten us.

8.8
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