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# HYPERCELL ORGANISMS

A new perspective of man in evolution

*Dedicated to*

*Charles Darwin*



Translated from the German by Michael Stachowitsch

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## Introduction

In the course of diving expeditions to tropical seas in order to study coral reefs and their inhabitants I was able to make a wealth of observations that suggested parallels to processes in large cities, in the business world and in affairs of state. As a biologist, I was confronted with the thought that certain fundamental views about man's position in evolution might need reconsideration. Could it perhaps be that the many facets of the human condition, as different in every respect as they may appear to us, are governed by laws similar to or even identical with those behind the evolution of plants and animals? I asked myself whether the development of organs, which determines the physical capabilities of all organisms, is really as fundamentally different from man's production of tools, weapons, buildings and machines as first impressions might lead us to believe. I also asked myself whether our innate instincts, with their undeniable affinities to animal behavior, might have intrinsically influenced or even *determined* the development of our technology, economy and culture.

These observations and considerations prompted me to end my research activities in the marine environment in 1960 and motivated me to spend the following decades analyzing business management and economy, politics and other realms of human activity and organization as integral components of the evolutionary process. To further this approach, I also turned my sights to comparative ethology. I beg the reader's forgiveness for including these biographical notes, but they are meant to underline the fact that the theories presented in this book are not the product of hastily drawn conclusions.



In the course of my research in marine biology, I developed a series of underwater cameras and produced many films. The idea struck me that special film techniques might perhaps contribute to the present effort as well. I constructed a lens with a built-in mirror that enabled me to film people without their knowledge; at the same time, I altered the normal speed of events with time-lapse (2 to 6 frames per second) in wide-angle views and, in close-ups, with slow-motion techniques. This approach forces the brain to evaluate even everyday scenes from a new perspective. The first sequences in Vienna, on Somoa and in Benares (1962) yielded promising results. This led me to film human activities on all five continents, in most cases accompanied by my friend Irenäus Eibl-Eibesfeldt. The range of subjects included indigenous peoples, advanced civilizations and industrial society. This method has since proven to be a valuable research tool in human ethology as well.

These film sequences led me to clearly recognize the degree to which humans and their artificially produced tools and machines merge into units that enable new, specialized capabilities. A visitor from outer space observing evolution on our planet would no doubt be particularly intrigued by humans: they are the only organisms capable of boosting, virtually at will, the capabilities of their bodies by using tools and other artificially produced aids. We use them to move faster, cross oceans, fly, visit other heavenly bodies, and engage in a host of other activities that our "natural" bodies would never permit.

Up until Darwin's time, humans considered themselves to be something entirely separate from other organisms. We also considered it self-evident that each species was a creation unto its own. Darwin's contribution was to demonstrate that all organisms, including man, are interrelated and stem from common ancestors. The originally highly controversial theory of evolution has since been overwhelmingly confirmed by successive generations of natural scientists. According to modern science, life originated approximately four billion years ago in shallow seas. Initially, structures in the molecular size range gave rise to unicellular organisms; about 1.8 billion years ago, these in turn gave rise to multicellular organisms. An ever more highly organized succession of forms inhabited the sea and other aquatic habitats. Four hundred million years ago, the first organisms - initially plants, then animals - successfully conquered dry land. Life exploded into a spectrum of species that rapidly spread across the continents.

Humans arose from the ranks of the vertebrates and have, up until this point, been recognized as a species within the order of the primates. We owe our superiority over other organisms to our highly developed brain. Based on this enhanced intellectual capacity we are able to improve our capability by artificial means. Initially, these were weapons and tools. Since they are separate from the body and are not composed of living cells, we humans tend to view them as something fundamentally different from the organs of our body. This interpretation has remained largely unchallenged until this day.

The fact remains that, in the struggle for survival, those organisms that exhibit the optimal capabilities gain the upper hand. Darwin termed this virtually inevitable process "natural selection". Species with more capable organs displace their competition.



All organs of multicellular organisms are composed of cells. The artificial aids produced by humans are "additional organs" in the sense that they also boost the body’s capability or even help it achieve entirely new abilities. The word "organ" stems from the Greek word for tool ("organon"), which - from the dawn of scientific thought - points to the close affinity between organs consisting of cells and the additional organs we produce. Externally, the differences between an ax and a lung are substantial indeed, as are the differences between a cooking pot and a red blood cell. Nonetheless, whether the units that are vital to or even boost our survivability are made of single cells, of cellular organs, or of units that our bodies additionally form from environmental materials is secondary. The key criterion is the overall capability that organisms - and we humans clearly belong in this category - display. This alone decides whether individuals and species persevere, whether they can, in effect, reproduce their own three-dimensional structure.

In the transition from unicellular to multicellular organisms, vital capabilities were transferred from cell organs (organelles) to multicellular organs. The theory I present here contends that man and his intellectual capabilities have, for a second time, led to a shift of capabilities to even more effective organs. A good example of this is the throwing spear, which helped early man dominate the animals. In competitive interactions between humans, those individuals with the more capable additional organs had the decisive advantage. I term the capable unit formed by man, along with the supporting structures that serve him, a "hypercell organism". My contention is that these larger and more capable units - rather than the naked human being as such - represent the continuation of the evolution of uni- and multicellular organisms. From this perspective, humans are by no means the epitome of evolution, but rather an additional germ cell that forms even more powerful living bodies. In the succession of ever-larger structures, humans become an increasingly diminutive, exchangeable organ.

Darwin's theory of evolution explains the early history that led to the origin of man. The theory of the hypercell organisms continues where Darwin's theory left off and deals with the course of evolution beyond humans themselves. Just as certain unicellular organisms ushered in the prodigious development of plants and animals nearly 1.8 billion years ago, a no less astounding development of new life forms, i.e. that of the hypercell organisms, was ushered in by early man. Their additional organs are all formed by man, just like all organs of multicellular animals and plants continue to derive from a single cell (the germ cell). This book is my attempt to demonstrate the underlying continuity in the transition to hypercell organisms and that, despite the altered external appearance, the same fundamental principles remain valid for them as well. This perspective allows interesting conclusions to be drawn about our image of humankind.

Darwin's theory served in our search for truth, but did little to change the course of history. The theory of the hypercell organisms may well suffer the same fate. Nonetheless, today’s ever accelerating technological advances, the population explosion, and unbridled economic growth confronts us with an entirely new set of problems and threats. Perhaps an evolutionary approach to the overall process could help us master this situation.

# 1 Capability as a selection criterion

The theory of hypercell organisms is a direct extension of Darwin's theory of evolution and builds on his concept of natural selection. This calls for briefly recapitulating some of the key thoughts of this pioneering scientist. Darwin's book "On the origin of species", published in 1859, maintains that all organisms, including humans, stem from common ancestors; he bases this thesis on three premises which he supports with an impressive array of examples. Some of his arguments and conclusions may appear banal or even self-evident today, but this was certainly not the case at the time. As emphasized by the German naturalist Ernst Haeckel, a particularly energetic proponent of the new theory, traditional ideas that have been handed down through the generations are exceptionally tenacious. The generally held belief at the time was that the various species of plants and animals were separate creations: according to religious interpretation they were put on Earth by gods or, according to Aristotle, by a directed force which he termed "entelechy".

Darwin's first premise was the assertion that reproduction in both plants and animals leads to offspring whose hereditary features differ from the norm. This was common knowledge to animal and plant breeders, whose experience provided Darwin with convincing evidence.

Darwin's second premise stated that, under favorable conditions, both plants and animals can produce many more progeny than the respective area can support. The evidence for this premise was as strong as that for the first. Insects, for example, often produce thousands or even many tens of thousands of progeny, while fishes frequently produce hundreds of thousands or even millions of offspring in the course of their lives. The logical conclusion is that not all offspring can survive. They fall prey to predators or are killed by a wide range of environmental impacts. In the omnipresent and very tough "struggle for existence", only the best suited or "fittest" can succeed and reproduce. As Darwin clearly stated, the struggle for existence should not be taken too literally. The respective foe need not necessarily always be an organism or involve direct physical contact. Heat and cold can decimate the offspring, as can a wave, insufficient light or a range of other adverse conditions. Darwin unequivocally demonstrated that members of the same species were surprisingly among the most dangerous opponents. After all, they rely on the very same food sources and are adapted to the same environmental conditions. Were all the offspring of a species to survive, so his argument, then the planet Earth would soon be unable to provide for them. Only a tiny fraction are actually successful, on average not more than two individuals per parental pair. Darwin's painstaking studies revealed that the number of individuals of a species remained quite constant in a particular region. If more capable species arise and displace others, then they can reproduce unhindered for a certain period of time. Eventually, however, they come up against natural limits and are forced to adjust to the conditions in the respective habitat.



This leads to the third premise, namely that "natural selection" yields the most suitable species for the particular habitat. Based on the variability of individuals, such species can adapt to the environmental conditions in a series of continuous small steps. The adaptive improvement of plants and animals - the displacement of less well-adapted species by superior forms - is therefore by no means the result of conscious acts of will effected by supernatural forces. Rather, higher development is a slow yet entirely lawful process. The more closely Darwin examined causes and effects, the more he recognized that it was rarely if ever possible to determine precisely why individuals of one species were superior to those of another species or to conspecifics in this struggle for space and food and against predators and the forces of nature. Natural selection acts on its own to better adapt organisms to the environmental conditions, enabling them to tap new resources, occupy new niches, radiate into new, differentiated species, to make the transition from sea to land and even the air, and to produce the most extraordinary specialists (culminating in parasites of other organisms).

The formative power behind this process, which took place over extremely long periods of time, was not and indeed could not be a directed will. Regardless of what a creator created: if this deity did not change the underlying laws of nature or the local conditions, then it would have had no influence on what survived and what perished. This is the inescapable conclusion, even if Darwin did not explicitly put it into words. The formative power behind the innumerable different species was therefore a "natural selection" of the best adapted. Here, Darwin clearly stated how complex the interactions behind this selection were and how difficult, if not impossible, it was to define them in numbers and words.

Over the last few decades, the business world has been abuzz about the newly discovered "interlinkage" of processes that ultimately lead to success in this field; economics has only now recognized how naive traditional "linear thought" is. In nature, more specifically in the realm of populations of organisms, Darwin long ago pointed out and amply illustrated precisely this interlinkage.



Darwin considered it futile to determine why a particular plant species was superior to another or what features enabled one animal species to gradually displace another in the natural habitat. In Staffonshire, he investigated "a large and extremely barren heath, which had never been touched by the hand of man; but several hundred acres of exactly the same nature had been enclosed twenty-five years previously and planted with Scotch fir". He was amazed at the difference between the vegetation in the fenced off area as opposed to the remaining heathland; this difference was greater "than is generally seen in passing from one quite different soil to another". Not only were the proportions of the heath flora entirely different here, but twelve additional species (excluding reed and other grasses) that were absent in the heath grew in the fenced area. The influence on the diversity of the resident insect population was so great that he recorded six species of insectivorous birds that were nowhere to be seen in the adjoining heath; on the other hand, three species were unique to the heathland. This enabled Darwin to recognize how great the impact of introducing a single tree species was in this area, "nothing whatever else having been done, with the exception that the land had been enclosed, so that cattle could not enter".

Another observation that Darwin cited was that when a forest was felled, in Central America for example, an entirely different flora appeared. He wrote: "but it has been observed that ancient Indian ruins in the Southern United States, which must formerly have been cleared of trees, now display the same beautiful diversity and proportion of kinds as in the surrounding virgin forests. What a struggle between the several kinds of trees must here have gone on during long centuries, each annually scattering its seeds by the thousand; what war between insect and insect - between insects, snails, and other animals with birds and beasts of prey - all striving to increase, and all feeding on each other or on the trees or their seeds and seedlings, or on the other plants which first clothed the ground and thus checked the growth of trees!" To this he added: "Throw up a handful of feathers, and all must fall to the ground according to definite laws; but how simple is the problem where each shall fall compared to that of the action and reaction of the innumerable plants and animals which have determined, in the course of centuries, the proportional numbers and kinds of trees now growing on the old Indian ruins!"

Biology has made eminent progress since Darwin's pioneering book was published. Ever better technical aids enabled scientists to probe down to the molecular level of life's structure, with the discovery and partial deciphering of the genetic code representing the climax in research into life's building blocks. New insights were also gained into the interrelationships driving the evolutionary process: Mendel's laws of heredity, the mechanics of mutation, the recombination of genetic factors through sexual reproduction, the definition of the species as a gene pool, the effect of population size, of isolation and genetic drift and, more broadly, adaptive processes and the factors promoting or limiting speciation. The selection process and the optimal adaptations in nature that it explains are irrefutable fact for the modern biologist. No evidence whatsoever exists for metaphysical acts of creation in plant and animal evolution. No miracles have been reported here. On the contrary, evidence abounds that progress has often involved quite astounding detours, while a "helping hand" pointing in the right direction would have accomplished this much more quickly and efficiently. I have referred to this in one of my earlier books and will provide examples here as well. Since Darwin's time, little practical progress has been made in determining which structural features and attributes make one species better and allow it to gradually displace another. Rather, biology's advances on all fronts have led to an inevitable fragmentation into an ever greater number of subdisciplines, a development that is in no way conducive to simplifying our overview of the phenomenon of life.



**The intransparency of natural selection**

Those who tackle the question of how natural selection influences speciation or who seek to determine the structural and behavioral features on which selection acts are most likely to obtain answers by investigating species adapted to life in extreme habitats. Habitats that are particularly hot, particularly cold, particularly dry, or where it is extremely difficult to pinpoint a food source (endoparasites, for example) yield the best clues as to which new attribute or ability provides the critical selective advantage and can be increasingly reinforced in a series of small steps. The morphological and physiological capabilities that enable bacteria to tolerate temperatures of -80 °C (no doubt a significant selective advantage in polar regions) have been analyzed in detail. In the case of the desert rat *Dipodomys merriami*, which can survive in extremely arid habitats and therefore outcompetes its rivals in some regions, we know that high production of a pituitary gland hormone enables the rodent to very successfully recover water from urine. The larva of the oil beetle *Meloe* climbs to the top of flowers, attaches itself to the hairy surface of the bees that land there, and is then transported into the hive (where it devours the bee's larvae and food reserves). In this case one can at least infer which ethological and morphological adaptations were required for this "fitness", i.e. what ultimately enabled natural selection to provide a green light for the further development of this beetle based on the special adaptations of its larva.

Nonetheless, insights from extreme scenarios are of only limited value in providing a general answer to the mechanism behind natural selection. Why? Because life obviously primarily developed in regions with favorable rather than extreme conditions. The functional network of interrelationships in such favorable environments, however, is usually so complex that - as Darwin so vividly illustrated with his example of feathers tossed up into the air - analyzing the relevant factors is difficult if not impossible. This is compounded by additional, significant stumbling blocks.

Organs typically have more than one function. In such cases, mutation-induced changes that improve one function can adversely impact another. The vertebrate lung is a good example. Its primary function (gas exchange) was supplemented by a secondary task, namely to provide the airflow necessary to produce sounds. The result in humans is that we cannot eat and speak at the same time. Here, the disadvantage is so minimal that it did not dampen evolutionary development. In other cases, however, we are justified in asking whether functional progress at one level has been offset by disadvantages at an entirely different level. The topic of multifunctionality in organs (expanded functions) and its consequences will be dealt with in detail in Chapter 6.



Conversely, certain functions require the coordinated efforts of numerous organs. In the blood circulatory system of vertebrates, the branching capillaries and the course of the veins and arteries through the body are no less important than the heart which drives the system or the pacemakers that control the rate of heartbeat depending on demand. Any number of improvements could be made to this system. Similarly, successful reproduction in a cherry tree depends equally on the internal structure of the flower as it does on the features of the cherry pit, whose hard shell prevents the digestive fluids in the stomach of birds, which transport pits in their stomachs, from destroying the seed within. Virtually every new function is characterized by complex correlations that can influence the selective value of mutations.

In all actively motile animals, the efficiency of the locomotory organs is highly dependent on the efficiency of the structures controlling these organs and vice-versa. To this day, however, the relationship between physical body and behavior is often depicted as if the temporal structure of behavior is fundamentally different from the spatial structure of the organs. While this may be plausible, it is only a half-truth: each innate behavior is based on control mechanisms that represent material structures just as any organ does. Their size, however, may be many times smaller, potentially in the realm of molecular "switching circuits". This means that mutations affecting mechanical control mechanisms (both their "hardware" and "software", to borrow terms from computer technology) can be equally as important as those affecting the executing organs. As emphasized by the evolutionary scientist Ernst Mayr and the philosopher Karl Popper, hereditary changes in behavior can trigger the evolution of morphological structures (pacemaker principle, spearhead theory). This important insight is supported by a wealth of evidence. On the other hand, there is ample evidence for a reverse causality, namely that improving an executing organ can initiate a large number of new, ever more perfect behavioral programs. A case in point is the human hand, with its opposable thumb, which we inherited from the climbing habit of our animal ancestors. This perfect grasping organ already enabled apes and monkeys to carry out numerous useful activities (wiping the corners of their eyes or cleaning their noses, removing fleas, picking fruit, etc.). In humans, which are by far more intelligent, the number of functions whose control programs are formed in the brain, particularly by learning processes in professional life, is legion.

Evaluating natural selection involves another difficulty: the distinction between the terms "function" and "capability". They are often used synonymously in that a "good function" means an equally "good capability". The fallacy of equating the two in the evolution of organisms becomes clear when environmental conditions change or when species occupy new niches. Even if organs subsequently lose their purpose, their functionality often remains intact for quite some time. Indeed, the degeneration of organs is an extremely slow process. During this time, such organs provide no *capability* required by the organism. Moreover, they can even become a genetic burden, a selective *disadvantage*. At the same time, the rudiments of reduced organs whose function has been lost can very well serve as the starting point for new capabilities. When vertebrates adapted to life on land, their gills lost their function and were gradually reduced. The primary jaw articulation was replaced by a new one and lost its purpose as well. Embryonically, these long-superfluous organs are still formed in vertebrates, and it is proven fact that their rudiments gave rise to entirely different, highly capable organs. The dorsal part of the first gill arch developed into the auditory ossicle termed the stirrup, while the rudiments of the primary jaw articulation gave rise to the other two ossicles, the hammer and incus. In this manner, functionless structures can provide new capabilities and gain high selective value. Natural selection changes its judgement accordingly.



### The meaning of measurable success

During my research on coral reefs, my attention was drawn to a phenomenon that, although well known in itself, has to my knowledge never been enlisted to improve our understanding of natural selection and its underlying mechanisms.

As habitats, small reefs in particular can be clearly viewed from all sides by SCUBA diving and are much easier to study than a forest, a meadow or a river. Here, I was able to document the wide range of different strategies used by small and medium-sized fish species to fend off larger fish predators.

Certain species have developed spines on various parts of their bodies, some even being equipped with poison glands. The behavior of larger predators clearly shows that these features caused them to avoid such spiny fishes. Other fishes have developed a behavioral mechanism enabling them to make a lightning quick retreat into the sand bottom between the coral structures; this action is so perfect that, after the cloud of sand settles, no mound or other irregularity betrays the spot where the fish has disappeared. A totally different method is used by fishes whose patterns and coloration are so similar to the that of the corals or underlying sand as to render them virtually invisible. When threatened, these species actively seek such sites. Sole and squid have improved upon this strategy by their striking ability to adapt the colors and patterns of their skin to a wide range of different bottoms and coral structures. The skin of a sole that straddles a patch of light sand and mottled cobbles is sand-colored on one side and mottled on the other.

In the case of sharks, for which I had a particular interest, I was able to observe how remoras (*Echeneis*) used these top predators as a shield. They swim close up against the shark's body, a behavior that affords two advantages. On one hand, the remora feeds on small reef fishes, which are not large enough for the shark; the shark therefore presents no threat to these fishes, and when it approaches, they retreat only a short distance, if at all. This puts them within easy striking distance of the remoras. On the other hand, those predators for whom the remoras would make a good meal do not venture close to the sharks. This affords *Echeneis* with optimal protection; the remora itself is apparently too small and agile for the shark. Remoras may also be tolerated because they feed on ectoparasites attached to the shark's skin. In their long phylogenetic development, remoras have modified their dorsal fins into a sucker; when they are tired or satiated they can attach themselves to the skin of the shark and save energy. This animal has created an absolutely optimal situation - an example for the occupation of a niche that provides both food as well as protection and to which this fish species is perfectly adapted both morphologically and in its innate behavior.

Comparing the above four predator-avoiding strategies reveals their underlying dissimilarity on all levels. The cell differentiation required to develop spines and poison glands is quite different from that involved in developing a behavior program that enables a fish to disappear without a trace into the sand. Totally different mutations are required in order to produce appropriate skin patterns and colors along with the corresponding sensory and cerebral capabilities that enable the fish to accurately determine the quality of the bottom and the immediate surroundings. Finally, an entirely different set of behavioral and structural adaptations is necessary to transform a large predator such as a shark into a personal protective shield.



Nonetheless, there is one element common to all strategies: *the result*. Despite their differences, all four adaptations were ultimately designed for a capability vital to all animals, i.e. to avoid landing in the stomach of another animal. In my opinion, this observation in the coral reef provided me with an important insight into the essence of natural selection.

The diffuse multitude of factors that directs the course of speciation and therefore the course of evolution is, in itself, not of primary interest. *Success is the sole criterion that is assessed*. If a fish species can successfully ward off predators - regardless of the strategy - then this is a valuable plus for its survival and further development. Moreover, an additional selective advantage is gained if the defense mechanism leads to lower losses than in competitors that feed on approximately the same prey. On the average, this species will be statistically more capable and will therefore more successfully assert itself against the environment and its competitors. In other words: unique cell differentiations enable it to better face natural selection. Step by step it displaces or even entirely eliminates competing species from this struggle for existence.

The fishes in waters adjoining the coral reef exhibited a wealth of additional predator-avoidance strategies. In a flash, members of very different species flee directly into caves or crevices that they have chosen as their protective organ as soon as predators appear. Or they retreat into hiding places that they have excavated themselves under stones or in the sand. Flying fish (Exocoetidae) break through the water surface to lose their pursuers. Their pectoral fins have expanded into wing-like structures and the lower half of their tail fins is extended. These adaptations enable flying fish to lift off and successively glide for distances totaling 100 meters as a method of escaping predators. Certain harmless fishes are the spitting images of dangerous fish species (mimicry) and are therefore rarely attacked. Others live in schools, where the confusion effect protects them against attackers. In this case, predators can easily overtake the school, but are distracted by its many hectically criss-crossing members and have difficulty concentrating on a single individual. Their meal is guaranteed only if they succeed in isolating individual fish from the school. Still others are perfectly streamlined, extremely fast swimmers, which provides a clear advantage both in pursuing prey and in escaping predation. Clownfishes (*Amphiprion*) seek shelter at the very site where other fishes are engulfed and digested: between the arms and in the digestive cavity of large sea anemones. The consensus is that the anemones recognize the fish based on a chemical substance in the mucus layer of the skin, and that the symbiosis developed because the fish rid the anemone of parasites and unwanted scraps. Finally, many other fishes defend themselves when threatened by biting or with a powerful whack of the tail.

Each of these methods can aptly be termed a "strategy", "technique" or "method", and all involve both structural elements as well as innate behavior patterns. The bottom line, however, is the result or the success achieved. The ultimate criterion is the *effectiveness* of the respective method, which can be quantified based on the proportion of successful versus unsuccessful defensive acts.



The validity of the above conclusion extends beyond predator avoidance and coral reef fishes to cover virtually all organisms and most of their vital activities. Any number of examples prove that "many roads lead to Rome". Thus, the eye enables visual orientation in the environment; its structure in arthropods (compound eye), however, is entirely different from that in vertebrates and molluscs (where important features of the eyes also differ considerably from group to group). The wings of butterflies have an entirely different structure than those of birds and bats, yet are not completely identical to those of the more closely related dragonflies. The cells of insects are supplied with oxygen by a system of tubules (trachea) traversing the body, while in vertebrates this function is fulfilled by the blood circulatory system (which also functions to distribute food). Here, the lungs are responsible for drawing air into the body and providing oxygen to the bloodstream for further distribution. As any biologist knows, there are no end to examples for vital capabilities being delivered by a range of very different approaches. Capabilities that are principally provided by only a single structure or a single behavior pattern are the exception.

Thus, many different components usually contribute to a particular capability; beyond physical structures and behavioral mechanisms, this may also include utilizable factors in the environment (as the remora example illustrates).

This insight inevitably leads to the question whether the traditional definition of "body" in fact encompasses all the material units that constitute the vitality and survivability of organisms. In other words, can one use the term organ to refer to structures that are *not* permanently attached to the bodies they serve? This raises the next question: what concrete capabilities must organisms, independent of their external appearance, exhibit in order to face natural selection? Can such capabilities be clearly formulated and do generally valid guidelines exist?

Both questions lead to a perspective that differs considerably from the traditional manner in which biology approaches the phenomenon of life.

### Fundamental capabilities and supplementary capabilities

From the earliest times, humans have gauged other organisms mainly by the impression they make on our senses and by the behavior they display. Our assessments therefore tended to emphasize the material aspect, much in the same way we evaluated our overall environment. This changed only little with the emergence of scientific thought and directed scientific inquiry: this criterion was adopted and served as the basis for further investigation, as if its validity was beyond a shadow of a doubt. Ongoing technological advances allowed us to study the bodies of organisms and their components in ever more detail: the activity and interplay of organs; the behavior of species towards one another and their adaptations to the environment; their body plans and their phylogenetic relationships; their geographic distribution; and their reproductive mechanisms, to name a few. Then, Darwin demonstrated that natural selection decides which organisms survive and reproduce. If, as outlined above, natural selection acts not primarily on material structures and behavioral repertoires, but on the *selective value of demonstrated capabilities* (i.e. *success*), then the essential capabilities of a particular organism's body become more important than its structure and function per se.



The distinction raised here may initially be difficult to discern. Nonetheless, I hope to conclusively show that a clear difference does exist and that a *capability*-oriented approach leads to a much simpler and better understanding of the phenomenon of life.

The first step is to determine which capabilities *all* organisms must demonstrate in order to survive and reproduce, and which additional capabilities merely play a supporting role. I term the former "fundamental capabilities", the remainder "supplementary capabilities". As is the case in all terminological differentiations designed to bring a measure of order into the diversity of forms, this one is also an artificial construct: it makes no claim to providing razor sharp delimitations. Nevertheless, at least the fundamental capabilities *inherent to all organisms* can be defined quite clearly. They arise as a consequence of necessities, but can also be derived by logical deduction. The following overview lists them in abbreviated form.

The *first fundamental capability* is *energy gain*. No movement, no process, no development is possible without useful, productive energy. Just as no automobile can run without gas, no living process can proceed without energy input. Since modern science holds that energy can neither be created nor destroyed, but merely transformed from one form into another, every organism must gain the energy it needs for all of its activities and processes from environmental sources. Two fundamentally different methods can be distinguished:

The energy source for virtually all *plants* is sunlight. The photosynthetic process allows them to use solar radiation to convert inorganic building blocks into organic molecules (assimilation). Here, electromagnetic energy is converted into the energy of chemical bonds. The plant then releases this energy when it needs to fuel growth, reproduction or other processes (dissimilation).

The energy source for *animals*, on the other hand, consists of animal and plant tissue. Their form of nourishment is therefore based on consumption. They eat and digest other organisms or parts thereof and use oxidation or fermentation processes to extract the bond energy contained in the molecules. This is analogous to the process plants use in breaking down the molecules they themselves formed. Animals use the released energy to support body growth and to power all their processes and activities.

The primacy of this first fundamental capability is underlined by the fact that it largely determines the structure of plants and animals. In plants, specific organelles (plastids) are responsible for capturing and harnessing sunlight. They are distributed along the leaf surface, which is turned to face the sun. In terrestrial plants, the water necessary for photosynthesis is delivered by the roots and through canals in the trunk and branches. *This basic body plan is therefore determined by the energy-gaining process*. The same holds true for animals. The predatory nature of their feeding typically requires them to actively seek out and hunt prey. For this purpose they need locomotory organs. They must be able to recognize and find their prey: this requires sensory organs. They must consume and digest the prey: this calls for a mouth and digestive tract. A control program is necessary to coordinate the sensory perceptions and movements: this task is fulfilled by a central nervous system with specialized centers. Those animals that are unsuccessful in extracting enough energy from the environment are doomed. *The basic animal body plan is therefore also clearly determined by the modalities of energy gain*.



The *second fundamental capability* that every organism must demonstrate is the *acquisition of substances it needs* to form and maintain organs as well as to grow and reproduce. While animals acquire both energy and useful substances with their food, plants obtain most of the substances they need directly from the environment, i.e. from the water, soil and air.

The *third fundamental capability* is to *counteract adverse environmental factors*, whereby three categories can be distinguished. The first is defense against inorganic impacts such as cold, wave action, storms, etc. The second category involves organic influences, particularly predators and parasites, while the third is the conflict with competitors that seek to exploit the same energy and material resources. A particular feature of the latter struggle is that many competitors never directly encounter one another. It is hard to imagine an organism that doesn't need to protect itself against adverse environmental influences. At the same time, many different negative impacts can often be countered with the same defense strategy, for example with armor.

The *fourth fundamental capability* is the *utilization of favorable environmental factors*. This includes taking advantage of external capabilities that help save (one's own) energy. This is the case in partnerships and group formation. Inorganic forces such as those generated by water currents and wind can also be exploited. Favorable environmental conditions also influence the size of the distribution ranges of all plant and animals species.

The *fifth fundamental capability* is *reproduction*, without which evolution would never have taken place. Although individual members of a species can survive without offspring, the prerequisite for the overall quantitative and qualitative development of life is that more offspring are produced than organisms die. This fundamental capability requires particularly complex regulatory programs. In unicellular and multicellular organisms the genome - the hereditary factors contained in the chromosomes - is the responsible unit. It regulates growth and maintains all functional structures. In the hypercell organisms formed by humans, which will be the topic of the subsequent chapters, same-species (*conspecific*) reproduction is transcended. Here, members of one "species" can give rise to members of other "species".

The *sixth* and *final fundamental capability* is *structural improvement*, without which life would never have made any advances. The most important mechanism behind this capability in plants and animals is separate sexes. The sexual process, which involves the fusion of male and female gametes, leads to a mixing of the respective genes. This process guarantees that occasionally occurring changes (mutations) in the genetic material appear in ever new combinations (recombination). This significantly increases the probability that more capable structures will arise. Multicellular organisms evolved a distinctive dissimilarity between female and male individuals. In hypercell organisms the capability for improvement has largely been transferred to other, more efficient mechanisms that simplify and accelerate advances.



Each of the above-mentioned fundamental capabilities comprises hierarchical systems of *supplementary capabilities* that help determine which structural features an organism must have in a particular habitat. This translates into a very high number and diversity of such supplementary capabilities. From the perspective of natural selection, organisms are capable entities. The decisive element is capability, which clearly can only be provided by suitably formed organs.

Wilhelm Ostwald, the founder of physical chemistry, studied the phenomenon of life and the evolutionary development of organisms in great detail. In his book "Die energetischen Grundlagen der Kulturwissenschaft", which was published in 1909, he already pointed out that not only do machines function as energy transformers, but also all of mankind's tools along with all the organs of animals and plants. The motor in an automobile converts the molecular bond energy stored in fossil fuel into kinetic energy, specifically into a *capability* desired by humans (comfortable and rapid locomotion). When someone chops down a tree with an ax, the chemical energy in the muscle cells is converted into the kinetic energy of the ax and therefore into a capability useful to that person. Equally, every organ in an organism converts "raw" energy that has been extracted from the environment into the "useful" energy of many different capabilities. How this conversion takes place and what structures are involved in the individual steps is only partially known and of secondary importance. The key issue is the result - the quality of the required capability. An important facet in competitive interactions is also how quickly and reliably these capabilities are attained and the energetic costs involved.

Up until one hundred years ago we knew very little about the nature of energy and its characteristics; biological research therefore concentrated its efforts more on the structural features of organisms and the function of their parts. As I indicated above, however, the basic structure of animals and plants itself clearly reflects the importance of energy gain for all organisms. This is equally true for the conversion of energy into differentiated capabilities, a topic that all later chapters will discuss. Although Ostwald's book was published in the same year in which he received the Nobel Prize for his contributions to physics and chemistry, the book received scant attention. His definition of organs as energy transformers remains virtually unknown until this day.

Traditional frameworks of thought and assessment make it difficult to imagine organisms as capability entities. On the other hand, certain biologists (Mittelstaedt, v. Holst, the Nobel Prize winner Tinbergen and others) have applied the term "Wirkungsgefüge" (effectivity structure) to capable organic structures.

The English philosopher Herbert Spencer, one of the forerunners of Darwin's theory of selection, advised Darwin to replace the rather vague term "natural selection" with the term "survival of the fittest". Darwin proceeded to use the term on several occasions. This supports my contention that confrontations between an organism and its environment or its competitors are less a matter of body structures or behavior patterns than of demonstrated capability. As I will show later, the effectiveness of such capabilities can be quantified based on generally valid criteria.



The objection was raised that Spencer's formulation led to a tautology. After all, the answer to the question "fittest for what?" is "for survival". And the only possible answer to the subsequent question "and what survives?" is "the fittest". This objection, however, is misleading and unjustified because the full answer to the second question is "the fittest *for the required capability*". And, as I indicated above, the necessary capabilities can be quite precisely defined. My argumentation here more closely follows that of the technical practitioner Spencer (he was a railroad engineer by profession) than that of Darwin, with whom I am otherwise in complete agreement.

## 2 Organs that are separate from the body

We can now turn to the second question raised by our new, capability-oriented approach. Must organs – units that deliver a capability – be permanently attached to the organism that they serve?

As long as organisms are viewed as physical phenomena whose special features differentiate them from inanimate objects, it is perfectly understandable why we consider unattached elements as not being bodily components. On the other hand, one can view organisms as entities whose physical structure is not an end in itself, but merely a means or precondition for certain capabilities that enable a steadily expanding process, namely life. In this case, there is no reason why organs that are separate from the body should not exist. If they deliver a required capability then they are part of the body, whether attached or not. It is common knowledge that human progress is largely built upon units that are separate from the cellular body. Does this necessarily mean that the organs of organisms are fundamentally different from man-made technical, economic, governmental and cultural structures?

In the animal kingdom, many species use secretions or environmental material to form "additional organs" that are not fused to the body. Before we evaluate humans and their products from the evolutionary perspective, it is perhaps appropriate to more closely examine such "predecessors". The examples I list are well known to science, but are viewed here for the first time in an evolutionary context in which natural selection acts on the entire capable entity rather than merely on the material structure of the organism itself. An impressive example of an additional organ is the web produced by many species of spider. The web represents a trap which helps these animals decisively improve the first two important capabilities of all living organisms, namely the gain of energy and vital substances.



Today, many spider species still hunt in the original manner without a web. Their prey, mostly insects, is overpowered by a rapid lunge or leap forward. In the course of evolution, species arose that were able to secrete threads from silk glands and construct webs. This development peaks in the round-web spiders, of which the cross spider is a member. They possess six different gland types located in paired spinnerets on the abdomen; the latter are supplied by no less than 800 individual glands. The different techniques used to construct the webs are innate.

The cross spider begins the process by stretching its abdomen upward at an angle and producing a thread bearing a fan-shaped terminal expansion. This allows the thread to be wafted away like a loose sail in the wind. Should the loose end stick to a solid object such as a branch, then this establishes a bridge which is the fundament for a future web. The renowned biologist and Nobel Prize winner Karl von Frisch wrote: " If the thread fails to attach itself to a solid object, then the spider reels it in and devours it in order not to waste the silk material. The spider then tries its luck again".

The technique used by the spider, whose eyesight is not well developed, has been studied down to the finest detail in many hours of patient observation. It initially involves a basic scaffolding attached to solid surfaces, followed by the production of the framework and spokes. The process is a rigid, innate behavior, but may be somewhat modified by local conditions. In the center of the web, the spider builds a platform (the so-called hub), from which it will later operate. While the initial phase involves non-adhesive threads, across which the spider can run with impunity, the final phase involves adhesive threads: the spiral threads running across the spokes represent the actual trap. The spider then lies in wait at the hub, with one leg touching a spoke at all times. If an insect flies into the web, the spider can determine its location based on the type of vibrations emitted by the hapless prey. The next step is to reach the prey as quickly as possible without, however, itself touching the adhesive threads and thus becoming a victim of its own trap. The prey is then immediately sprayed with a bundle of very fine threads ejected from additional glands, bitten with poison gland-containing fangs, and rapidly twirled around to wrap it in non-adhesive threads. The prey is then encased in silk and this food packet is cut from the net and transported to the hub, where it is suspended by a short filament. The spider extracts the substances and energy contained in the packet by injecting digestive juices with its mouthparts and later sucking up the dissolved nutrients. In this sense, it uses the insect's own armor as a digestive tract. During the night or in rainy weather, the spider seeks shelter at the margin of the net, where it remains informed about events in the web by vibrations of the silk threads.

Since the threads are not sticky for long, the web must be frequently renewed. The spider accomplishes this by consuming the threads and using the recycled material to build the next web. Whenever a male spider approaches a female’s web, he sends species-specific signals by plucking at the web; this allows the female to distinguish a potential mate from struggling prey.



I have gone into such detail here in order to point out just how many advantageous mutations were necessary for the innate programs behind such a complex device and such differentiated behavior. Before any change in the genome by mutation and sexual recombination of the genes becomes permanent, it must be accepted as progress by natural selection. The inescapable conclusion is that such a large number of innate program steps could never have developed if the web had not represented a decisive advantage for the spider. Even though the web is not firmly attached to the body, it is by no means far-fetched to view this complex device – whose production is, after all, coded in the genotype – as equal to any of the spider’s other organs.

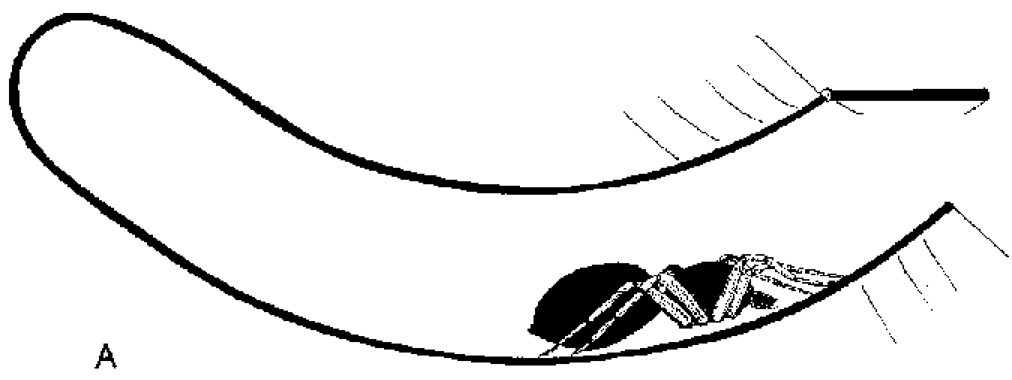
An even stronger argument, one that cannot be easily brushed off, is the indisputable fact that a permanently attached web would be useless to the spider. This would thwart the prey-capturing process: the spider would neither be able to build the web nor use it to ensnare insects. Although it is too early at this stage to draw parallels to mankind and its artificially produced technical aids, it is worth mentioning that the above is equally true for all of our tools. If an ax, a pair of pliers, a pitchfork or a ladder were permanently attached to our bodies, they would surely do more harm than good.

A decisive advantage of functional extensions that do not inherently belong to the body is that they neither burden nor hinder the animal when not in use.

I would like to introduce a third argument here. The spider's trap serves a particularly important task, namely energy gain. As mentioned above, no life process is possible without energy. For this reason, no organ composed of cells can fulfill its tasks without energy input. This applies equally to the spider's organs. Thus, it is difficult to understand why the term "organ" should be rejected for the very unit that is the precondition for the function of all others. If one hinders round-web spiders from building their nets or repeatedly destroys these, then the spiders are doomed. Even if they manage to obtain food by other means for a while, they are at a clear disadvantage to free-foraging spiders and other competitors. These species cannot survive without their webs.

We may initially resist accepting such external units, which are not attached to the spider's cellular body, as additionally formed organs; nonetheless, natural selection clearly argues against any such narrow interpretation based on subjective impressions.

Other tropical and subtropical spider species construct even more technically elaborate trapping devices that help shed light on our topic. The trap-door spiders (Ctenizidae, Actinopodidae and Barychelidae, Fig. 1A) coat holes that they either find or dig themselves with very thin, strong threads; they also use these threads to form a cushion-like lid which fits the conical entrance so tightly that it fully shuts out light and water. It is attached to the burrow with a hinge made of silk. Some species span threads in all directions from the opening: these tip the spider off about approaching prey (insects, millipedes and other small animals). Most of them, however, make do without such trip-threads and rely solely on their highly developed sensory organs to pick up telltale vibrations.



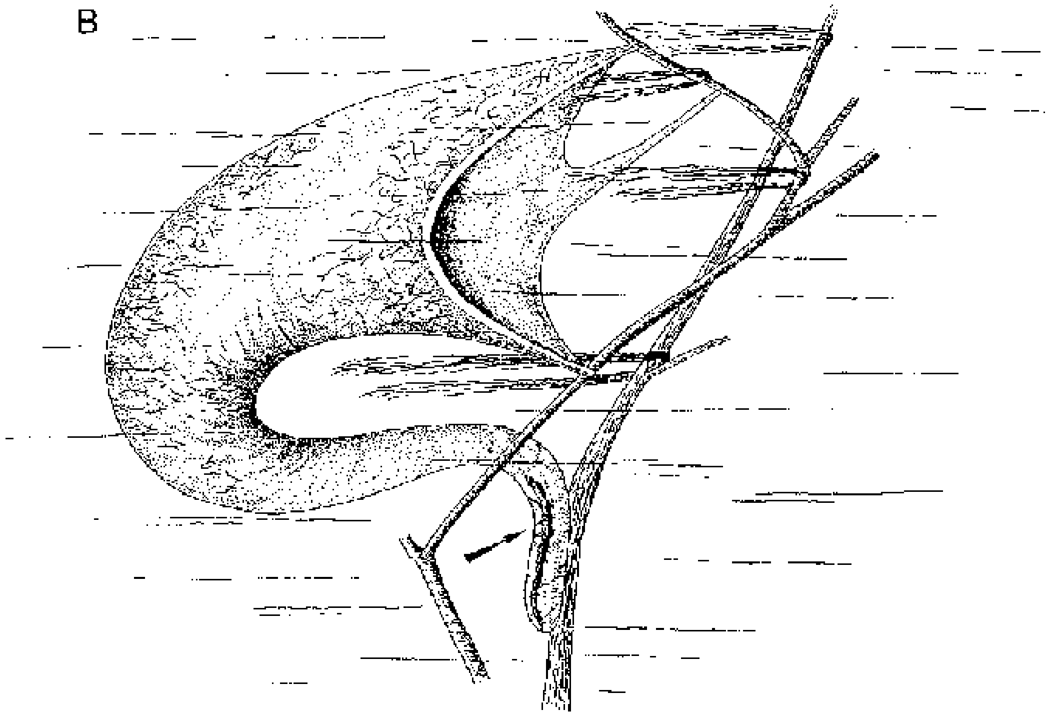


*Fig. 1: Two examples of additional organs that animals form based on innate behavior control mechanisms. Both serve in prey capture.*

*A shows a trap-door spider, which uses silk threads to build a rigid tube inside holes. Only the males leave these structures to mate. The tube has a round opening with a lid that is also fashioned from silk. The spider lies in wait behind the lid, which it holds slightly ajar. If a small insect approaches, the spider flips the lid open in a flash, grasps the prey and drags it back into the tube, closes the lid, and devours the animal.*

*B shows the larva of a caddis fly (see arrow), which lives in streams and constructs a net-like trap with silk threads. This is anchored on aquatic plants and twigs; water currents hold it open and carry food into the funnel. The larva takes up its position at the bottom end of the funnel, where it is well protected against fish predators. From time to time it wanders across the net and feeds on items trapped in the mesh; after v. Frisch, 1974.*



During the day, the spider holds the lid tightly shut with its palps and front legs. At dusk, the lid is opened slightly. If prey approaches, the spider flips the lid up in a flash and lunges forward, whereby the claws on its hind legs usually anchor it at the tube opening. It grasps, bites and drags the prey into the hole, shutting the lid as quickly as it was opened.

Interestingly, trap-door spiders spend their entire lives (some species live to be 10 years old) in these pitch-black burrows. The aranologist Wolfgang Crome reported that *Conothele arboricola*, which inhabits treeholes in the Bismarck Archipelago, shapes the size of its hole to fit the maximum size it can reach. As the spider grows, it never needs to change or enlarge its burrow. Only the males leave their hiding places to mate; they seek the burrow of a female, which proceeds to devour the male after copulation. The young remain with the mother for up to three years.

In these species, the separation between the trapping organ and body is less distinct than in web-building spiders. Their burrow represents additional armor, the perfectly functioning lid a highly efficient "body part" designed for camouflage and deceit. When it sheds its skin, the spider hermetically seals the burrow until the new cuticle has hardened.

The aranologist Harro Buchli studied the behavior of trap-door spiders in the Mediterranean region in 1969 with an automatic recording system. He set his equipment up next to a wall whose crevices contained a burrow of *Nemesia caementaria*: it recorded the spider's every activity over a full year. During this time, the animal hunted on 252 nights, whereby it opened the lid a crack shortly after sunset, assumed an attack stance, and remained frozen in this position until dawn. The average time spent hunting per day was 8 hours and 37 minutes, with the spider taking 5 breaks lasting a total of 2 hours and 45 minutes. On very cloudy days, the spider started earlier and extended its hunting activity by up to 4 hours in the morning as well. The longest uninterrupted lie-in-wait measured 12 hours and 57 minutes on an October night. From a total of 724 attack events, just above 10% were successful. *Nemesia caementaria* deposits the indigestible remains of its prey at the rear end of the burrow and covers them with silk. Other species form such remnants into balls, cover them with silk as well, and eject them from the tube opening.



In this animal, it is somewhat easier to view the additional organs formed by the cell body as being something that is not separate or different. Capability is increased through additional units; the fact that these were produced on instruction of the central nervous system rather than by cell differentiation hardly represents an insurmountable conceptual barrier, especially since natural selection clearly evaluates *the capability of the entity as a whole*.

Some trap-door spiders use small stones, twigs and leaves, i.e. environmental material, to camouflage their tubes if these are exposed. Suitable organic and inorganic objects from the immediate surroundings are spun around the tube and thus transformed into functional components of the capable entity. This also maintains the impression of unity that appears to be so important for our conventional categorization. In my opinion it is therefore incorrect to view these structures - which are not attached to the body - as being something principally different from organs that develop by way of cell differentiation.

Up to now, the use of the term "organ" in the biological sciences has been restricted to units formed of or by cells. According to the cell theory of Schleiden and Schwann (1839) the cell is defined as the "basic unit of living systems". In multicellular organisms it represents the "basic building block of animals and plants". Even if we should have to modify this dogma in the future, it may not be advisable to redefine or question an established term like "organ" without a compelling reason.

On the other hand, the two cases described above (to which I shall add more examples later) clearly show that cellular organs are by no means the sole or ultimate criterion *for natural selection*. We have failed to recognize that the formation of units of capability in animals is not restricted to *one*, but to *two* methods. Such units can arise by means of cell differentiation or by a more complex, indirect pathway. In the latter, the genome instructs the multicellular brain not only to develop programs for innate behavior, but also programs with which the animal forms additional functional units that are not firmly linked to the body. Simply put: in the first method the genome of the cells induces these to form organs *directly*, while in the second method it induces the highly specialized brain, consisting of billions of cells, to form *additional organs* from inorganic material.

In earlier publications (1969, 1970 and 1978) I used the term "artificial organs" to describe the latter because rather than arising by the "natural" process of cell differentiation, they are "artificially" formed products of the overall body. Experience showed that this term was suboptimal and prone to misunderstanding. After all, these additional structures are no less "natural" than organs arising via cell differentiation. Just like the latter, they are also based on instructions coded in the genome. In the first case, the building blocks are consumed as food and then used to build up organs. In the second case, the brain is given an additional task beyond controlling the body, namely to use secretions or environmental materials to form vital tools (Greek: "organa") that are separate from the body. We have already noted that this separateness enables capabilities that cellular organs could never deliver. An additional advantage, which we will deal with later, is that they need not be nourished by the bloodstream, nor need they be linked to nerve cells.



In my opinion, the term "additional organs" more aptly describes the essence of this key step in evolution. The fact that this second method is relatively rare and first appeared in more highly developed organisms is easy to explain: the mechanism involved is considerably more tedious. Specifically, it requires a two-fold transfer of information: first, from the genome to the behavioral programs stored in the brain, second from these programs to the executing organ. Furthermore, the first method produces only a single specialization, not a series of simultaneous, exchangeable specializations as in the case of humans. This will be discussed in more detail in later chapters. The bottom line, however, is that the product of this second method of organ formation in animals is as natural as the first. Such additional organs increase capability and improve fitness in the natural selection process. Thus, they promote the vitality of the life process just as efficient cell organs do.

These two examples allow one more conclusion to be drawn. The trap-door spiders, in particular, spend their entire lives in their additional organ (which has a protective, feeding, and reproductive function) and clearly demonstrate one point: a distinction must be made between the *cellular* (somatic) *body* and the *capable entity* itself. Our senses perceive and our brain categorizes the cellular body as the very organism itself. The key criterion for natural selection, however, is the capable entity. In all organisms that lack additional organs, this entity is identical with the cellular body. In those that enhance the capability of their cellular body with additional organs, this entity consists of the cellular body plus additional organs.

This unaccustomed perspective requires rethinking accepted tenets. Additional examples of animal species that form such separate organs may help promote this reorientation. Most of these examples are well-known. Nonetheless, they have to date been viewed in the context of behavior patterns and their consequences, without recognizing that they demonstrate a second, important principle of organ formation in individuals. Each example drives home the point that the essential unit is not the distinct cellular body registered by our senses, but rather the capable entity, which is the sum of all elements substantially contributing to overall capability.

**The use of favorable environmental factors**

We can begin by comparing two trapping devices formed by various insect larvae. The traps are quite different externally, yet comparing them sheds light on additional organs and their structure.

The first type of trap is formed by larvae of certain caddis flies (for example *Hydropsyche*) that inhabit slow-running streams. Much like spiders, they also secrete silk threads, although they use modified salivary glands opening at the mouth rather than at the hind end of the body. They construct funnel-like traps of fine-meshed threads that are anchored to aquatic plants and twigs. The water current keeps the trap opened and carries small organisms into the funnel, whose walls are periodically grazed by the worm-shaped larva. During the remainder of the time, the larva positions itself in the narrow funnel tip, where it is well protected against fishes and other predators (Fig. 1B).



The second trap that we can compare with that of caddis flies is well known to most children. This type is constructed along the forest edge or on embankments by the much more powerfully built larva of the ant lion (*Myrmeleonidae*). It digs funnel-shaped pits in flat, fine-grained sand surfaces. It lies in wait for ants at the bottom of the pit, with two-thirds of its body buried in the sand. Ants that venture too close to the funnel margin slide down into the conical pit. The larva foils their escape by bombarding them with sand grains that trigger miniature landslides which bring the prey within reach of its powerful jaws. The ant lion seizes, kills, and sucks out the victim, flinging the indigestible remains from the funnel.

Due to its oversized jaws, which make up one-third of the entire animal, the ant lion can only walk backwards. Accordingly, the bristles coating its body are directed forward. In building the funnel, the ant lion seeks a suitable site and proceeds to form a circular trench by walking backward. This involves wriggling into the sand and slinging sand in all directions with back-and-forth movements of its head and the anterior trunk segments. The gradually deepening circular trench defines the circumference of the funnel; the animal gradually removes the cone-shaped sand heap in the middle by turning ever-tighter circles and flinging the sand out. At the center of the circle (the deepest point of the funnel), the ant lion comes to rest and begins to lie in wait for prey. The same jerky movements that cast the sand out are now used to target ants attempting to flee from the funnel; this movement also serves to remove ant remains from the funnel. In the third year, the ant lion forms a spherical, sand-encrusted cocoon from which the delicate adult, which has a wingspan of 3 to 5 centimeters, emerges.

Viewing this sand funnel as an integral component of the ant lion – as *its additional organ* – no doubt presents considerable difficulty. While the caddis fly larvae along with the round-net and trap-door spiders construct their traps from material their bodies produce, the ant lion's funnel is built of environmental material: we may initially be inclined to consider this as merely a useful environmental modification.

This represents an example of the fundamental capability we can term "*use of favorable environmental factors*". The common denominator of the sand funnel and the caddis fly trap is that environmental forces are harnessed to serve the species. The trap is kept open by water pressure, which also channels in microscopic organisms. The Earth's gravity spells doom for ants in the sand funnel. Both animals use *natural forces* to reduce their own energy expenditure. More importantly, both cases functionally involve funnel-shaped structures into which outside forces direct food items. The caddis fly constructs its device with its own means, i.e. with thread production and innate behavior programs. The ant lion takes advantage of another favorable environmental condition: soil consisting of flat, very fine sand. It merely needs to form this sand, much like a potter would form a jug. Functionally, the key criterion is the required shape and a building material that prevents the prey from escaping. Sand has the ideal features. Thus, a second favorable environmental factor helps the ant lion build its trap, making it unnecessary for the organism to produce its own building materials.

In both species, the behavior programs behind these activities were achieved through mutation, recombination and natural selection. After all, the ant lion saves energy on two fronts. Viewed from this perspective, the sand funnel is very clearly an organ additionally formed by the animal to obtain food. It is an integral component of the capable entity we term ant lion, like the exposed stones that early man picked up and used as "ready-made" projectiles to subdue prey.



Favorable environmental conditions that can be used in their natural state include any kind of crevasse or cave that provides suitable shelter for animals and humans. Since they need not be reworked like the ant lion's sandy substrate, we find it more difficult to view them as protective units that enhance the body's capabilities. In this connection we should bear in mind that innate behavior is necessary in order to recognize such units as suitable protective organs. A case in point is the remora, which, as mentioned earlier, makes the shark into its protective organ. Humans, who rely on intelligence, may not immediately understand that for animals, even something as simple as recognizing a hiding place is not self-evident. Rather, it requires the corresponding programs, whether they be innate, instilled, or formed by previous experience.

As long as we consider organisms to be purely material phenomena (the prevalent view today) it is in fact difficult to accept a sand funnel or a natural cave as an integral part of an organism for the duration of its use. The decisive factor for natural selection, however, is *competitive overall performance* rather than physical shape or behavior patterns. This performance can be achieved by very different methods and body forms.

**The great variability of additional organs**

The best way to grasp the concept of additional organs and its validity is to examine a broad range of examples from this perspective. In all species, the ability to utilize favorable environmental factors is equally important in *reproduction* (a fundamental capability) as it is in repelling disturbing or hostile influences. In cases where the young are not fully developed at birth, protective structures that are not attached to the body become essential. Since cell differentiation alone rarely gives rise to such structures, additional organs formed by the cell body must assume this role.

Although many classes of animals contain viviparous species, these remain the exception rather than the rule. In the vast majority of species, the germ cell – provided with the appropriate nutrition and enclosed in a protective envelope – is discharged from the mother's body as an egg and left to its fate. This is the case in most arthropods and most vertebrates, i.e. the fishes. In those cases where the progeny enjoy additional provisioning – from the mother, the parents, the pack, or from "states" (insects) – the number of brood care strategies are virtually unlimited.

From the functional perspective, the technically so ingenious honeycombs of bees and wasps are small, artificially formed protective units for embryos growing outside the mother's body. The bees typically construct these from wax, which they secrete from special wax glands; other species use resin that oozes from trees. The combs of wasps, on the other hand, are built of wood fibers glued together with a cement produced by the body. The wall thickness of some of these combs measures a mere 0.0073 millimeters. The solitary pill wasp *Eumenes* forms delicate urn-shaped structures of clay. If the clay is too dry, the wasp tanks water in its stomach, spits it on the clay, and scrapes off enough to make a pill. This is then carried to the construction site and drawn out into a strip using the jaws and legs. A series of such strips is molded into a hollow sphere that is constricted distally to form the urn. Paralyzed larvae or caterpillars are squeezed through the opening as food for the larva. Before sealing the urn, the wasp forms a final pill from which it suspends an egg on a short thread. The freshly hatched larva can begin to feed immediately. The tropical South American oven bird also uses clay to form spherical containers with a side entrance. In the words of v. Frisch, they create "a chamber where none is provided by nature". Both the female and male work together to produce the structure. The task requires several weeks, as nearly two thousand small balls of clay must be transported to the nest as building material. Finally, the brood chamber, which is partitioned off by a wall, is cushioned with thin blades of grass.



The above examples all clearly show that it is principally irrelevant whether the additional organs are constructed entirely of material produced by the body (the bee's honeycomb), only partially so (the wasp's nest), or of foreign substances (the clay urns of the pill wasp). The decisive factor for natural selection or "the survival of the fittest" is an adequate brood protection function. This line of argumentation is cemented by the honeycomb toad (*Pipa pipa*), which forms similar protective units for its embryos on its back: these units consist of the toad's own cells and are firmly attached to its body. In my opinion this is firm evidence that it is unjustified to interpret these protective units as components of the animal, and the others not.

In many cases, organs of other organisms serve as independent protective organs for progeny. Most bird nests, for example, are built of dead twigs and grasses. Living plant organs are also known to serve a similar function. The feces of other animals, environmental forces, and ultimately even the services of other animals can be utilized for this purpose. The tailorbird (*Orthotomus sutorius*) of southern China and India sews together large tree leaves using blades of grass which it pulls through holes it has punctured. The result is an open cone, which is subsequently filled with soft nesting material. The bird's long, pointed bill functions as a needle for this complex task. The thread consists of silk filaments, bast, and cotton fibers that are twined into a thicker thread. A knot on both sides prevents the thread from slipping out. The beak and one leg work skillfully together to accomplish this feat.

A no less amazing counterpart is known in ants. In tropical South Asia, representatives of the genus *Oecophylla* form spherical or oval nests that are also made of living leaves joined together by a dense, silk-like tissue. The mechanism behind this nest building was initially unclear because only the larvae possess silk glands (in order to cocoon themselves after completing the growth phase). The riddle was solved when groups of workers were observed pulling together adjoining leaves. If the leaves were too far apart, these females formed chains, with one ant climbing over the other, its abdomen then being firmly held by the ant it crawled over. Other workers then bring a larva, which they hold in their jaws, and press them mouth-first against the leaf margins when these have been drawn close enough together. Jaw pressure induces the larvae to discharge their glandular secretion. The larvae therefore serve a two-fold additional function, once to produce thread and once as a weaver's shuttle.



The weaver birds (*Ploceidae*) of Africa and Southeast Asia use their legs and beaks to construct particularly elaborate nests. The male grabs the margins of leaves and blades of grass, tearing off long strips as he flies away. These strips and other threads are then combined to form spherical nests that hang from trees like large fruits. The entrance is located on the lower side and often bears a tubular extension. Much like a basket weaver, the bird attaches its thread with a knot, forms it into loops, sticks the thread into the network, and pulls it out again at another position. The final product is a very durable home for the bird and its brood, one that also affords optimal protection. Once the nest is finished, the female is left to decide whether it meets her approval. If it stands the test, she will help complete the interior. If she rejects the nest, the male will destroy it after about a week: he undoes the knots and begins anew to construct an even better home for himself and his family.

The flying frog *Rhacophorus reinwardti* on Java builds an entirely different type of nest, although it uses living leaves as building material just like the weaver birds and tree ants. During the mating season, the males and females seek a large leaf along the shore of a river or lake, or choose a site between several smaller leaves. The eggs are deposited here and fertilized by the male. During this process, the female secretes a slimy fluid. After each egg is laid, the males and females stomp their feet in unison, whereby they dip their feet into the mucus and pat them together. After 30 to 60 minutes, 60 to 90 eggs lie in a foam mass measuring 5 to 7 centimeters in diameter. The female then proceeds to press the leaves against the foam heap, whose surface hardens and becomes glued to the leaves. Thereafter, the parents pay no further attention to their brood. During embryonic development, part of the foam becomes fluid, forming a small aquarium within the foam nest. The freshly hatched tadpoles can swim about here for several days until a stronger rainfall softens the outer layer of the foam nest and releases the young into the water.

During my "Xarifa" expedition to the Indian Ocean in 1958, our ship lay at anchor for nearly one month in an inlet of Grand Nikobar Island in the Bay of Bengal. We were the first to dive in these interesting waters and were able to observe a number of new phenomena. Directly under the boat, where our garbage began to collect on a flat, sandy bottom at 15 meters depth, I discovered a slightly gaping, upright cockle from which two eyes peered out. These eyes were much too highly developed for a bivalve. I brought the cockle to the surface and placed it in an a large aquarium, where it was soon surrounded by the many hermit crabs and other crabs living in the aquarium. It turned out that the cockle contained a female octopus (*Octopus aegina*), which had laid her eggs between the empty valves. She firmly attached herself to the inner surface of both valves with the suckers on her arms and was able to open and close the shell much like the living cockle had been able to do. Thus, the female octopus had transformed the unoccupied shell into her additional, brood-protecting organ.

In mouth-breeding fishes (for example certain catfish and cichlids), yet another strategy is used to protect the young. Rather than producing or using a structure that is separate from the body, an anatomical organ temporarily assumes a completely different role. In this case it is the mouth. Among the catfish, this method of brooding is done exclusively by the males. They safekeep the eggs deposited by the female in their mouths until the young hatch. The male Brazilian catfish *Arius commersoni* , for example, can accommodate between 30 and 40 eggs – each measuring 10 to 15 millimeters – in its mouth, forcing it to go without food for the entire brooding period. During this time they take no bait and their gut shows signs of degeneration. In mouth-breeding cichlids, the females provide the additional protective organ for the eggs; here, the freshly hatched fry dart into the mother's mouth at the slightest threat. According to Eibl-Eibesfeldt they have developed an innate releasing mechanism to recognize this shelter, with the mother's eyes playing a decisive role. "They attempt to gain entrance even into simple decoys of the mother's head, orienting themselves according to the position of her eyes and heading toward a point between the two. Decoys whose eyespots are positioned on a horizontal plane are much more effective than when one eye is located on top, the other on the bottom".



In the Chilean bell frog (*Rhinoderma darwini*) the male takes the 10-14 yolk-rich eggs deposited by the female into his mouth and shifts them into the vocal sac, which opens into the floor of the buccal cavity. With this load of eggs, the bulging sac extends all the way to the back of the head. Inside this pouch, the eggs are arranged in two layers, one lying up against the dorsal wall, the other against the ventral wall. From there, they receive oxygen and apparently even food. The young remain here until after they have completed metamorphosis, leaving the sac as fully developed froglets. At this point, the brooding male has been reduced to skin and bones. von Frisch writes: "This is surely one of the most unique kindergartens in the animal kingdom. The father frog need not construct it – the kindergarten has already been provided as a gift of nature". In this example the protective function for the young is temporarily assumed by a natural organ formed of cells rather than by an additional organ. In marine turtles, on the other hand, the eggs deposited by the female are "entrusted" to the hot sand for brooding. Since these reptiles stem from terrestrial ancestors, their instinct drives them to return to land to lay their eggs. They arduously crawl up the beach, dig a pit with their hind flippers, and deposit their eggs in an egg chamber which is then covered up again with sand. Sand and sun are the factors that take over the protective function and control the brooding process. The energy savings afforded by this inorganic "foster mother" have a considerable effect on the turtle's overall energy budget – a vital factor in all animals.

The scrub fowl (*Megapodiidae*) of the Malay-Australian tropics exploit yet another energy source. They construct up to 5 m high "brood heaps" made of plant material: the heat of fermentation within this pile is sufficient to brood the eggs. The birds spend up to 11 months of the year maintaining the internal temperature of the structure at a constant 34° Celsius for the eggs inside. The temperature is controlled almost daily and fluctuations are generally kept within a range of 1° Celsius. The strategy is adapted to the season. In spring, they merely need to draw off excessive fermentation heat through air shafts and to close the openings on time. In summer, fermentation is slower, but the sun plays an increasingly important role. The birds counteract potential overheating by increasing the thickness of the sand layer covering the heap. As the sun's heat gradually penetrates deeper into the structure, they implement an astonishing yet effective counter-strategy: in the cool of the morning they remove the upper dome, dig a deep crater right down to the top of the eggs, and spread out the sand. After the sand has cooled, they kick it back into the hole again and top it with a thick layer of the old plant material in order to regulate the temperature. It takes the bird 2-3 hours to complete this process each time. The Australian ornithologist Harold J. Frith inserted a remote-controlled heating device into such a nest. The scrub hens initially reacted correctly. In spring they tended to open the nest every 2-3 days. As soon as the temperature was artificially raised, they began to open it every day in order to keep the temperature under control. When the heat was turned on in summer, however, they failed to recognize that the heat was coming from below. Taking their cue from the season, they directed their activity toward preventing excessive heat build-up by the sun. The result was that the heap grew higher and higher; had a defective generator not ended the experiment, the heap may well have grown even taller.

The scrub fowl's capabilities are strongly reminiscent of how mankind technically manipulates the forces of nature. The more commonly known cuckoo bird, however, demonstrates that – beyond using leaves, sand, sun and heat of fermentation – other animals can also be enlisted to support the brooding process. The females begin by carefully observing the nest-building activity of other bird species. As soon as these birds have laid their eggs, the cuckoo female as inconspicuously as possible deposits one of her own eggs into the nest, often taking one of the original eggs with her. The affected birds typically show no reaction and assume the role of foster parents, brooding the foreign egg together with their own. Four hours after the young cuckoo hatches, an innate drive kicks in: the blind and helpless chick proceeds to evict other eggs and freshly hatched nestlings. It wedges itself under the other occupants and uses its head and feet to leverage them up over the rim of the nest. Its particularly large and conspicuous super-gape triggers a much stronger adult provisioning response than does that of the original young, should any of these manage to have remained in the nest. The foster parents are busy from dawn to dusk bringing food and even follow the young cuckoo for up to several weeks after it has left the nest in order to keep feeding it. This strategy is based on innate behavior programs in both the mother and the young: its success in inducing other birds to take on the task of brooding, i.e. in transforming these birds into additional organs of a capable entity (the cuckoo), is immediately apparent. The cuckoo bird family comprises over 140 species and is distributed over most of the world; more than 50 species are such brood parasites.

In my opinion, these case studies, to which many more could be added, clearly demonstrate that separate organs are by no means the prerogative of human inventiveness. A whole range of animal species has already developed such additional functional units which considerably amplify the capability of their bodies. They may be composed either of the body's own secretions (the spider's web) or of environmental materials (like the bird's nest, the pill wasp's clay urn, and the ant lion's sand funnel). Our perception would lead us to believe that these objects are distinctly separate from the cell body: functionally, however, they clearly form a unit.

None of these additional organs can be formed without investing a corresponding amount of energy, just as in organs arising through cell differentiation. Similarly, the benefit that each such organ provides the organism must outweigh any costs involved in producing and maintaining it: additional organs must be controlled, upkept, repaired, and replaced as the need arises, just like organs composed of cells. Moreover, the above-mentioned examples show that virtually every additional organ would be unable to unfold its capability were it permanently fixed to the body that produced it. In most cases the body would not even be capable of forming them.



I have gone into considerable detail in presenting the above examples because this highlights that very many advantageous mutations and sexual recombinations of genes were required to produce such a variety of body structures and behavior programs. Moreover, each intermediate stage in such an evolutionary chain, which took place over millions of years, was subject to natural selection, i.e. had to have a positive selective value! In my opinion, this is further strong evidence that additional organs were critical for the survival and development of the respective species – it would be totally unjustified to view them as something entirely separate from the cellular body, as something apart from them.

# 3 The origin of hypercell organisms

The first two chapters structures of organisms than on the capabilities they display in order to survive were devoted to showing that natural selection acts less on the physical and further evolve. My thesis is that most of these capabilities can be achieved by a wide range of different body plans and behavior patterns. If this is correct, then specific body shapes or behaviors are clearly not decisive. Rather, the key criterion is the capability achieved, the result attained, i.e. success. I will demonstrate later in the book that this is a measurable entity.

I presented numerous examples showing that organs which fulfill vital tasks need not necessarily be firmly attached to the body of the organism they serve. The organ’s degree of integration has no bearing on natural selection, which decides what organisms ultimately survive and reproduce; the material making up these organs and their specific genesis is also irrelevant. Successful capability remains the ultimate measure. From this perspective, organisms are capable entities more than mere physical phenomena.

As a rule, the organs of most organisms are composed of cells. There is, however, another approach to enhancing capability. Here, innate behavior leads the fully developed cellular body to form additional organs which are not firmly attached to it and that consist either of the body's own secretions or of material from the surrounding environment. Such capability-enhancing structures – the spider's web or the ant lion’s sand funnel – are generally viewed as a "product" rather than as a part of the organism. Nonetheless, such structures promote capability and increase selective value much as cellular organs do. This role in natural selection is the basis for my assertion that they are *integral components* of the organism as a capable entity.



This second avenue of organ formation is relatively rare in evolution. Why? Perhaps because it requires rather complex behavioral control mechanisms, mechanisms that can only develop via mutation and recombination under very advantageous conditions. This strategy has led to marked progress in only a handful of animal groups, which explains why it has never received full recognition or why the underlying processes have never been viewed as organ formation.

The more advanced vertebrates have developed *individual* behavior control mechanisms through learning. This ability culminated in organisms whose exceptional mental capabilities enabled additional organs to be formed to fit particular needs. Furthermore, language enables these organisms to communicate to each other instructions on how to produce and use these additional organs. Decoupling this process from innate behavior patterns and from the genome accelerated the speed at which such independent organs could be obtained. This unfettered mode of organ formation boosted performance to previously unknown levels. Since we humans are the organisms at this evolutionary crossroad, we find it difficult to analyze this transition objectively.

A key aspect here is that man is not merely one of many mammal species. Rather, human beings are functionally most comparable with those unicellular organisms that gave rise to multicellular organisms. Just as every multicellular organism continues to originate from a unicell (the germ cell), every larger capable entity that man has produced from additional organs always has a human being in the "control room". I term these larger living units hypercell organisms and contend that they represent the direct continuation of uni- and multicellular evolution.

**The turning point**

Learned representatives from virtually every school of thought have dealt exhaustively with man's position in life, which has remained one of the key philosophical issues over the centuries. We will examine some of these approaches in more detail here. A particularly important question is what makes our mental capabilities so very superior to those of our closest relatives. No investigation has shed more light on this topic than Wolfgang Köhler's experiments with chimpanzees, which were already conducted in 1921.

The bait in these experiments was a banana suspended from the roof of a tall cage. The objects necessary to reach the banana included empty crates that were strewn about the cage and that could be stacked on top of each other, along with stick sections that could be inserted into one another to produce a long stick. The intelligence of the chimpanzees (which are very close to humans on the evolutionary ladder) was tested by examining whether they were capable of obtaining the desired fruit under these circumstances.



Some particularly intelligent individuals were actually successful. After a series of failed attempts, outbursts of anger, "thinking pauses", and renewed attempts, they managed to grasp the situation and solve the problem. However, when Köhler scattered the crates and stick sections in a number of cages connected by passageways, none of the experimental animals was able to reach the banana. Why? Apparently because the crates and sticks were no longer *simultaneously* present in their field of view. One particular advance of human intelligence over highly intelligent animals, whether they be our close relatives the chimpanzees or members of other groups such as octopuses, is that we are able to link experiences - even when we perceive them with a spatial or temporal delay - by using our brain, our powers of imagination, our fantasy. This enables us to recall and combine "in our minds" impressions and experiences that we gain in different places and at different times. Then, to the extent our memory allows, we can compare and weigh these events, much like on a film screen. We objectively incorporate ourselves into this interplay of images and thoughts, a process that we experience as self-awareness. We can hatch any number of plans, deliberate the consequences of specific actions, and use our combination skill and planning ability to discover mistakes in a potential implementation phase without having to carry out the scenario in real life. Humankind has the opportunity to do precisely what evolution has done through countless mutations and recombinations - only we can test the chances of success in advance. The only prerequisite is the necessary intellectual tools, i.e. the impressions and experience relevant to the problem at hand. We can then call upon these to promote our inner examination of causalities and their effects.

It is questionable whether science will ever succeed in precisely determining the where and how of this new capability in the highly interlinked network of ganglia in our cerebral cortex. There can be no doubt, however, that the brain is at work here. After all, various levels of competence exist and this ability can decrease significantly or be lost altogether when we are tired, sick or suffer brain damage.

The successive development of learning and combination skills has certain parallels in bridge construction. In building a bridge, the last few meters are decisive, regardless of the bridge's total length, because they ultimately make the connection to the opposite shore and open the new path. Equally, the above learning skills, which can be traced back to unicellular organisms, may have merely required a tiny last step to "reach the other shore", where novel opportunities arose.

This process is directly applicable to improved *capability*: the competence for one decisive ability, namely the ability to form new, capability-enhancing organs, has been transferred in humans from the genome into the realm of the cerebral cortex, which is responsible for thought processes. In one fell swoop it is shifted from one unit (the DNA strands of the genome) to a completely different one (the ganglion cells of the cerebral cortex). This transition to another unit was the springboard for an incalculable number of further capability enhancements. No specific "macromutations" were necessary for this step, an issue we will discuss later in this book. Nonetheless, this *capability shift* would have had little repercussion had not a second shift taken place at the same time. Specifically, the differentiated language communication between human beings enabled us to directly impart the ongoing progress to others. It was no longer necessary to code the instructions for additional organs and their use into the DNA strands of the genome.



This second shift also involved transferring an important function from one physical structure to a completely different one, namely from the genome to the cerebral cortex (more precisely, from the region of the genes responsible for reproduction to the regions of the cerebral cortex responsible for language). This shift also represents a major leap forward, because the first functional unit in no way *directly* influenced the second. Here, one organ complex (the cerebral cortex) did, however, interfere in the traditional competence of another. It took over the other's tasks in the body's division of labor and, moreover, it did the job better. This enabled progress far beyond the capabilities of the original unit. I call this process a *shift*, a term which further underlines the difference to mutations. In the case of favorable mutations, a change in the physical structure of the genome leads to *improved capabilities*. In the case of a shift, capabilities are transferred from one organ complex to another (and entirely different selection pressures are at work at the two levels). Thus, there is no direct causal relationship between the formation of the former and the origin of the latter. As in mutations, chance rather than directed intent underlies this process.

In using the term shift for such capability transfers, we must keep one thing in mind: although shifts can open astounding new opportunities, it may take considerable time to translate these opportunities into reality. As far as mankind’s additional organs are concerned, their actual formation and the language communication on how to construct and use them was initially very slow and hesitant. For over one million years, primitive man used suitably formed stones or their fragments to improve the capability of his hand (pebble culture). It took another million years for these largely unworked hand axes and their flakes to be modified into scrapers, knives, drills, and the like. Over this long period of time, our ancestors had no doubt already used quite a number of additional organs made of plant and animal material, material that left no traces (digging tools, throwing spears, animal skins, leather shoes, ropes, nets, traps, etc.). Only in the last 10 000 years have we taken full advantage of these eminent advances. Inventions that improved mobility, transmitted information and exploited energy created a positive feedback loop and were instrumental in accelerating this process.

Beyond these two shifts - if we agree to continue using this term for transfers of capabilities from one functional unit to another - a *third* shift was equally important for the "emergence" of man. After all, none of the advances characterizing the hypercell organisms formed by humans would ever have occurred had our ancestors not been equipped with suitable anatomical features at this critical junction; these features enabled them to translate enhanced capability into action. Specifically, our hands, with their opposable thumbs, were ideally suited to use and build tools. It is common knowledge that we owe this to the arboreal habits of our ancestors in primeval forests. This third functional unit, with its somewhat more prosaic history, had to be added in order not only to reach the "far shore" but to be able to take concrete action once there. The key role our hands played in making us what we are (and in allowing us to create what we have created) is often neglected in the light of our intellectual progress. At any rate, value judgements are superfluous in evaluating key evolutionary capabilities. This can perhaps best be illustrated with a practical example.



Let us examine dolphins for example. Training experiments in oceanaria and dolphin brain structure reveal that these animals - terrestrial mammals that have returned to the sea - are particularly intelligent and are capable of highly differentiated acoustic communication. Nonetheless, even in millions of years, dolphins will never be able to embark on an evolutionary pathway rivaling that of mankind. Why? Because they lack suitable grasping organs to build and successfully apply tools. Take *one* chain of developments as an example: they will never be able to produce or much less use a pencil; nor will they be able to construct a mailbox or develop a postal service. At the same time, the embryogenesis of these toothed whales is still characterized by anterior extremities with segmented fingers. These relicts, however, are incorporated into stiff flippers and can no longer be reactivated. Equally, mutation and recombination will never be able to convert these flippers into efficient grasping organs.

This example demonstrates how a combination of quite different capabilities was often necessary to promote the development of life. Although some capabilities require more highly differentiated physical structures than others, evolution relies on capabilities with very different qualities. We humans tend to view the intellectual level as something entirely separate and unique. As far as capability is concerned, however, no development is principally more valuable than the other. Our prehensile hand, which we owe to climbing activity in primeval trees, is a case in point. Conversely, even strenuous intellectual endeavor can lead to disastrous failures, while coincidence has often sparked significant inventions and successes.

What capability shift took place in the simian hand? In this case the environment changed rather than the organ. Approximately 3 million years ago, primeval forests became less dense due to climate changes and the savannas expanded. According to modern theory, this explains why certain apes moved into such steppe regions and adapted to the conditions there. The process involved taking on an erect body posture and a bipedal stride using the hind limbs; the anterior extremities and grasping hands were thus freed for other tasks. This was the prerequisite for actually using additional organs: the initial use of branches and stones as digging tools and throwing spears was followed by hand axes, scrapers, and an ever-greater array of additional capabilities.

Thus, a particular capability is not shifted to another functional unit. Rather, an organ originally designed for one function (climbing in trees) unexpectedly enables a significantly enhanced capability in another functional realm. This additional opportunity for sudden progress will be discussed in more detail later,

### The specialist in versatile specialization

From the evolutionary perspective, how can we evaluate humans – these unusual multicellular organisms – who continue to enhance the capability of their genetic bodies with an increasing number of additional organs? The organisms treated in previous chapters, those whose additional organs are based on *innate* behavior, can hardly be compared with humankind. Their additional organ formation typically enhances only a single capability (for example feeding, defense, reproduction), as a rule making them into extreme specialists. Humans, on the other hand, have reached a stage where they can use additional organs to improve both vital capabilities inherent to all organisms and a wide range of "lesser" activities. This enables us to *alternately* specialize in *very different activities*. As Teilhard de Chardin said so poignantly "one and the same individual can at the same time be mole, bird or fish". Among all animals, "man has the ability to bring variety into his work, without ultimately becoming its slave".



At this point, it would be opportune to briefly recall the general advantages and disadvantages of *specialists*. The more an organism specializes itself for a particular task, the greater its superiority over its competition in biotopes and niches where this task is critical. In fact, numerous extremely specialized species monopolize their role in the system. On the other hand, this opportunity represents a trade-off with correspondingly greater risk: altered environmental conditions, for example food items, greatly diminish their chances for survival. Blood-sucking mosquitoes depend on specific prey from which they draw blood with their modified mouthparts. Mistletoe, which has spared itself the costly formation of trunks and roots, loses its special status and the privileges that go with it under conditions that negate the underlying strategy. Should the bird species responsible for disseminating the plant become extinct, for example, then the mistletoe is doomed.

Human employment is no different. In today's ever more complex economy, every fresh demand becomes a new niche that can be occupied by a specialist supplier. Monopolies are rapidly established when only one supplier can fill the vacuum.

Konrad Lorenz characterized man as "the specialist in non-specialization". He based this judgement on the fact that humans, as *generalists*, have a highly diverse repertoire of capabilities. It would be nothing unusual for a human being - in a single day - to walk 35 kilometers, climb a 5 meter rope, dive 4 meters and then swim underwater 15 meters, picking objects up along the way, something that "no other mammal could do". This characterization of man is no doubt correct if one adheres to the traditional view that additional organs need not be considered. These very organs, however, provide the basis for man's superiority and selective value. A naked human being, growing up in isolation, has virtually no chances of survival in this day and age. The traditional perspective denies man's uniqueness as the only organism capable of continuously changing its body.

A native hunting a gazelle with his throwing spear is more highly specialized than most predators. By stowing the spear in his hut and taking to the water in a boat, which allows him to cross a river without getting wet, he becomes an entirely different specialist. Evolution has never brought forth the likes of this on our planet: an organism that can change its capabilities at will. From this perspective, man can better be described as a *specialist in versatile specialization*.

As humans, we find nothing more difficult than freeing ourselves from our own subjective self-assessment. No one would argue with the fact that tools, weapons, machines, buildings and other technical aids significantly increase our capabilities, and most people would put up a good fight should someone try to steal such an additional organ. Since our nerves and blood vessels do not extend into these units, we consider them to be something separate; we give no thought to the fact that such units would be of no real use to us if they were attached to our bodies.



In his system of living organisms, Carl von Linné classified man as the species *Homo sapiens*. The term *Homo habilis*, subsequently chosen by Louis Leakey to designate one of our ancestors, indicates that the key feature was less man's intellectual capability than the tasks he applied these capabilities to. According to my theory, our early ancestor represents both the last *multicellular organism* in an evolutionary line encompassing the apes, as well as the first *hypercellorganism*: the first organism capable of indefinitely increasing the capability of its body by using intellectual prowess to form additional organs. Forever changing, humans can *alternately* specialize in any number of tasks. The prerequisite is that these additional organs can be *put aside*, i.e. their *separateness-from-the-body*. When we pick up a pencil to write a letter, we are specialized for an entirely different task than when we subsequently juggle with pots and pans to cook a meal in the kitchen. This first representative of a new era in evolution – the hypercell organism – warrants a new name. I have chosen *Homo proteus*, a term stemming from Greek mythology: Proteus was a cave-dwelling giant capable of changing his appearance at will. Like a magician, humans are capable of artificially supplementing and improving upon their bodies. This is the essential feature.

In my travels around the world, I filmed people carrying out a wide range of tasks. In order to minimize my influence on their activities, I used a lens with a built-in mirror, leading the people to believe that I was filming in the other direction. At the same time, I altered the normal speed of events with time lapse and, in close-ups, with slow motion techniques. I recognized that this type of filming forces our brain to view people from an unaccustomed perspective, leading to interesting insights. On the island of Bali, I used this method to film a brick-maker at work. The "accelerated" film later clearly revealed the mechanical coordination of his movements. Using consistently the same movements, he filled a simple wood form with clay, wiped the surface smooth, and lifted the frame: 12 new bricks lay on the ground to dry. He then placed the wood form on the ground next to this row and refilled the dozen compartments with clay. Several months later I filmed the movements of autoworkers on an assembly line in Germany. One segment involved two men working on a special-purpose machine whose operation required approximately 80 precise hand movements. One of the men was a beginner, and the film analysis clearly showed the difficulties he had with correctly carrying out these movements and completing the sequence in an economic manner. The second man had two years of experience on the machine and his movements were optimally coordinated. Although the machine was clearly a separate entity, it nevertheless seemed to form a unit with his body. It had become an integral component of his capable entity, even if its metallic frame was not infused with his nerves and blood vessels.

This analysis gave me an important and unexpected insight. Every such coordination between a human being and a machine or tool is accompanied by the formation of special control "software" in the brain of the operator. Its structure probably resembles the innate programs controlling instinct behavior in animals. As experiments with brain probes show, these programs represent complex "wiring" between numerous ganglion cells. In humans and all animals with learning ability, such control programs develop through learning and become functional units much like the machine or tool they control. They clearly also represent additional, capability-enhancing units, even though they are not separate from the body, but arise in the brain due to modified ganglion structure. Simply put: additional organs *need not necessarily be separate from the body*. The decisive factor is that their production and control is not coded in the genome and cannot be passed on by cell division.



In all "learning animals" that are unable to pass their experience and achievements on to their progeny or other conspecifics, this information is lost with the death of the individual. They therefore contribute nothing to the higher development of the respective species. Humans, on the other hand, can pass this information on to others in the form of gestures, language or writing. They "reproduce" themselves and increase the capability within the population, independent of their genome.

It should be stressed that virtually every additional organ formed by *Homo proteus* requires still other organs, namely altered, organic body structures. From the onset, *two very different types* of additional organs were therefore equally important for this versatile specialist, who ushered in the era of the hypercell organism. The first are consciously built of material from the surrounding environment and are subjectively not considered to be components of the human body (extracorporal) because they are separate from the body and are not composed of cells. The second arise via the learning process and become so ingrained in the ganglionic mass that we never consider them to be true organs even though they deliver vital capabilities much like the heart or lungs. Moreover, since one type cannot function without the other, both influence the selective value of the capable entity. Both are also essential to measure selective values, which will be discussed later in this book.

The formation of additional organs enabled *Homo proteus* and all subsequent hypercell organisms to improve practically all fundamental and most supplementary capabilities that characterize virtually every living organism. Clearly, the emphasis was originally on additional defense organs and organs that helped procure food. No life process (and no reproduction) is possible without energy and matter. In humans, as in all other animals, feeding is a predatory act controlled by an innate drive. It must be emphasized that our ancestors' novel intellectual capabilities, their self-awareness and new behavior control mechanisms (attained consciously by learning), never stood in opposition to innate predatory instincts. On the contrary, intelligence and instinct went hand in hand to achieve optimal results: intelligence became a tool for efficient hunting and gathering and skilled defensive action.

Using artificially produced weapons, hypercell organisms were more successful than the competition in bagging prey and fighting off predators. They were better able to withstand natural selection, to conquer and occupy new habitats. The cultivation of plants and the domestication of animals were the next two major feats of human intelligence. In the case of farming, the intellectual act lies in recognizing that fruits and seeds - if they are placed in suitable soil rather than eaten - can after months or even years multiply the food supply many times over. The insight in animal domestication is similar: it is more advantageous not to kill and eat the captured animals (as our instincts would dictate), but to care for, feed and protect them until they reproduce. The result is that - months or years later - meat can be put on the table with much less effort than by hunting or setting traps. Both new approaches require additional organs, namely those for clearing the land and tilling the soil, for cages, fences and stables for the animals. Above all, they require mental effort and powers of imagination to combine cause and effect (even if the latter is much delayed) and thus to arrive at new, directed behavior control mechanisms.



From the evolutionary standpoint this constellation undeniably allowed *Homo proteus* to become a particularly efficient and successful predator. He was able to form settlements, induce the soil to satisfy his needs, and spare himself unnecessary risk and long migrations. Directed breeding efforts even enabled him to create new breeds of animals and plants that were more useful than the original species. This process later led Darwin to recognize an analogous selection driven by environmental factors: over the course of evolution this automatically allowed the fittest individual to succeed in the "struggle for existence". The resulting natural selection led to ever better adapted, more efficient and more highly differentiated species. This, in turn, allowed new species specialized for other environmental conditions to branch off.

We often tend to overlook the fact that members of the same species (conspecifics) are inevitably dangerous competitors or even bitter enemies. Their common structural features and innate behavior make them strong competitors for the same sources of energy and substances and thus the foremost rivals for food resources. This is already evident in plants. Since sunlight is generally available in abundant supply, intraspecific competition in plants mainly involves suitable sites and soils as well as water resources, which may be difficult to tap on land. Nonetheless, the fact that undergrowth and trees tend to lift their leaves above those of the competition clearly shows that an intense struggle is also underway for the available light. In animals, this competition is clearly directed at food or prey, which provides both energy and substances.

This situation is aggravated in social species that live in packs or other groups. Such associations are hierarchically higher living units; for them, packs of other conspecifics inevitably pose the greatest threat because they compete for the same food resources. This explains why natural selection in pack-forming animals promotes innate behaviors that more closely bind its members to the group, that favor a division of labor, and that ultimately make this larger unit more competitive. This gives rise to social instincts such as a readiness to support group members, to submit to the command of alpha animals, or even to give one's life for the group. It is also expressed in the innate readiness to fight competing packs, even though these are composed of members of the same species.

The same holds true for *Homo proteus*. He lived in smaller social groups, much like his ancestors and modern primates. As soon as he began to improve his somatic body with additional organs, however, his behavior toward conspecifics entered a new era. As mentioned above, additional organs yield decisive advantages: they do not burden humans when not in use, they are exchangeable, and they permit versatile specialization. Within groups, several members can join together to form larger communal organs that no one individual could create. These can benefit all members of the group and help increase their capability. Examples might include larger structures such as a bridges, fortifications or aqueducts. The vital role played by such communal organs will be the topic of later chapters. On the other hand, additional organs that are separate from the cellular body have a serious, inherent problem: the fact that they can be used by others makes it tempting to steal or otherwise annex them for one’s own capable entity.



In this connection, bear in mind that throughout the course of evolution virtually no organism was ever in a position to steal a cellular organ from another organism. When one animal eats another, it breaks down the organ's matrix and uses the energy and matter contained therein to build up its own body. Unfortunately, on average 90% of the original energy is lost in this process. The theft of an additional organ, however, entails no such loss. When hypercell organism A steals a knife from hypercell organism B, the knife fulfils its function without restriction or loss of value (as long as A knows how to handle this tool).

Within associations, the inclination to thievery is counteracted by laws, religion and social mores, an issue we will return to later. On the other hand, human intelligence was also clearly applied with great success in such illegal activity.

This supports the argument that the hypercell organisms formed by humans have more cause to encounter each other with hostility than pack-forming animals. Enemy territory itself was no longer the most valuable booty for organized groups of *Homo proteus*; rather, the productive fields and animal herds, above all the many weapons, tools, clothes, buildings and other additional organs (all of the foreign community’s possessions that can be directly appended to the new owners' capable entities) became a much more profitable target.

The great advantages that additional organs provided to hypercell organisms were burdened from the onset with a serious handicap: they invited forcible acquisition. A philosopher living at the time of the first additional organs might well have predicted that hypercell organisms would wage wars fiercer than anything known in the animal kingdom, even when logic and emotional considerations clearly argued against such hostilities. This, however, was the price that the specialist in versatile specialization had to pay for the privilege of ushering in a new era in the evolutive process.

### Exchange of capabilities and the function of money

Just as the first multicellular organisms arose from unicells nearly 1.8 billion years ago, *Homo proteus* ushered in the era of hypercell organisms approximately 2 million years ago. In both cases, the transitions shifted capabilities to new, more efficient units. In multicellular organisms, multicelled organs took over the function of the unicells' organelles. In hypercell organisms, *additional organs* (directly formed of material from the surrounding environment) increased the capabilities of multicellular organs or replaced them with something better. Our overview of the development of hypercell organisms should begin with a closer examination of some of the more important evolutionary advances that they initiated.

A human being is always at the core of each hypercell organism: he or she increases the capabilities of his or her body with additional organs. In higher-level hypercell organisms such as business enterprises, *groups* of specialized humans can form the central core. Man‘s cellular body - the constructive basis and control center - remains largely unchanged and reproduces itself as usual. The decisive factor for natural selection, however, is the additional, artificially produced organs. They promote ever-new special capabilities and are reproduced independently by an entirely different mechanism. The first question we should examine is: who produces them?



*Homo proteus*, who sparked this new development, initially produced additional organs for himself and his family. Today this is still the case in certain indigenous tribes living in remote areas. As in other more highly developed mammals, early man developed a division of labor. The woman was mainly responsible for children and household, while the man‘s most important task was to defend the group, which initially consisted of only a few families. Both partners helped put food on the table: the male hunted and trapped, the female along with her children collected fruit, edible roots and small animals. Both partners were also involved in producing additional organs: the male primarily tools, weapons and dwellings, the female clothing, nets, carrying bags, jewelry, etc.

From the functional perspective, the first major advance in the development of hypercell organisms was virtually preprogrammed: individuals within the small associations specialized in producing particularly important additional organs. This led to improved products and more rationalized production - a decisive advantage against rival and hostile groups. Of course, these specialized producers had to be freed from their remaining duties, especially their hunting and defensive roles. This presented no real problem as long as the association remained relatively small. The leader was entrusted with organizing this group structure. Since all members profited from a well-developed division of labor, there was little reason to change this winning formula. The leadership was often handed down from father to son.

As the communities grew, however, serious problems became inevitable. On one hand, a greater number of people was advantageous in clashes with other groups because larger communities allowed for ever greater differentiation and specialization. On the other hand, it became increasingly difficult to retain an overview of the many specialists and their needs. At some point it became more opportune for these first tradesmen to themselves provide for their own and their family's interests by barter.

This book makes no attempt to reconstruct the historical process. Research in the fields of prehistory and early history show that it was by no means uniform everywhere. My concern is to show that the production of such essential additional organs put the development of hypercell organisms on a *predetermined track*. We have clearly viewed ourselves and our development much too subjectively. This book pursues the question of how to interpret our explosive development if we refrain from viewing ourselves as something separate from the remainder of evolutionary history. What if we accept ourselves as integral components in a development that gave rise to man and that continues today via larger units of our own making? From this perspective, our radiation is in no way as autonomous and free as previously thought. Rather, it is subject to the conditions underlying evolutionary history as a whole. Natural selection remains the formative force behind species radiation even in this third phase of evolution (where speciation has shifted to generating established professions. Even at the level of hypercell organisms, natural selection decides which units are successful in the struggle for existence. From the evolutionary viewpoint, our cellular body – with which our ego identifies - is by no means the decisive element. Rather, the forces of natural selection work on the capable entities we have formed, entities I term hypercell organisms. The crucial element here is the *fundamental capabilities* basic to all organisms.



The subsequent development of hypercell organisms eventually came up against a seemingly banal yet critical barrier: the producers of additional organs had difficulty trading the product of their work for goods they needed to live. This can best be illustrated with a trivial but convincing example. If a craftsman makes a pair of shoes and his wife needs three eggs, then a barter transaction is impracticable because of the great difference in value. A mediating entity that would remedy this functional dilemma was sorely missing. The optimal solution was a further additional organ: *money*. This universal mediating factor made capabilities *arbitrarily divisible* and *convertible* into the products of the capabilities of others. The shoemaker could procure the three eggs mentioned above without incurring any loss. The divisibility of money enabled a trouble-free exchange of entirely different objects. The concrete value of any product automatically resulted from the effort involved in producing it and from the relationship between supply and demand. From an evolutionary viewpoint, money is a tool to transform one product of human labor into any other product of human labor.

As demonstrated earlier, the advent of man went hand in hand with significantly enhanced capability. This involved a transfer of functions much like when one cell association takes over the duties of an entirely different one. I introduced the term *shift* for this phenomenon and provided an example in which the genome's task of forming and reproducing new organs was transferred to the much more efficient cerebral cortex. A similar shift took place when the grasping hand we inherited from our simian ancestors suddenly became a perfect tool for *building* and *using organs*.

Let us return to the function of money and re-analyze the shoemaker's situation. He specializes in producing the footwear we use daily. Learning processes have instilled the corresponding control mechanisms for the most skillful and competent production of these products in his brain. Shoemaking has survived as a profession to this day. It is in no way related to procuring food or producing other additional organs such as pliers, bicycles or vacuum cleaners. Yet by receiving money for his shoes, his wife can easily purchase three eggs or a pair of pliers; and if he pools the money earned from the sale of several pairs of shoes, he can buy a bicycle or vacuum cleaner. This is by no means as self-evident and simple as it sounds. Never in evolution has one organism gained access to the labor of numerous others by specializing in a particular task. Symbioses, which will be discussed later, also essentially involve an exchange of capabilities: each partner benefits because the other requires a crucial capability. This can also be designated as a shift. Nonetheless, functionally, such a partnership bears no relation to taking advantage of many capabilities of many organisms based on a single type of specialization. This functionally characterizes the full implication of money, which has become the cornerstone of the entire economy. For the first time in evolutionary history, this "magic wand" (no exaggeration when referring to money) enables life forms (hypercell organisms) to supplement their capable entities with an unlimited number of others merely by specializing in a *single* capability.



A prerequisite for this development is a larger, well-organized community. The additional organ money, however, remains the common denominator fueling the process. It should come as no surprise that money, like virtually every other organ, requires specific conditions to function properly. These include divisibility into sufficiently small units, acceptance within a community, and a value that can be maintained at stable levels. On the other hand, the advantage of being able to enjoy the labors of others at will is so great, that the advent of money can be termed a "*mega-shift*": nothing comparable existed in the entire history of life. It is responsible for the ever-accelerating progress of hypercell organs and therefore of mankind. It also shows how greatly hypercell organisms rely on each other, how little the humans at their core remain "individuals", and the extent to which they have generated an immense, incredibly complex organization that simultaneously strives to attain a thousand different goals while being internally linked by an enormous number of interactions.

Quite a few biologists felt (and many still do) that the known mechanisms behind improvements (mutation, recombination, selection) must be supplemented by others to satisfactorily explain evolution. A time span of four billion years is considerable, yet still appears to be very short to accommodate the development of highly advanced animals and their many capabilities. This problem would have been solved by Jean-Baptiste de Lamarck's postulated mechanism involving the "inheritance of acquired characters", but no proof for this has ever been provided. Such a mechanism first became reality in *Homo proteus*, namely when the reproduction of additional organs shifted to language and writing.

The main argument against the often expressed assumption that "macromutations" were responsible for the relatively rapid progress of evolution and for the origin of new species was formulated by the English biologist Richard Dawkins: the equally banal yet convincing reason for rejecting all such theories is "that should a new species arise in this manner, then members of that species would have difficulty finding a mate". Reproduction in almost all higher animals is based on the prior union of the DNA strands of the male and female parent genomes; it is therefore truly difficult to image how macromutations, which would involve considerable changes in these long strands, could give rise to viable progeny. The union of such a "macromutated" genome with a normal one could never yield viable phenotypes (organisms). A prerequisite for successful reproduction would be the *same* macromutation in both a male and female gamete. Furthermore, precisely these two gametes – among the entire gene pool of the species - would have to encounter each other during copulation. The probability for this is so minimal that this mechanism can be immediately eliminated as a plausible explanation for evolutionary phenomena.

Dawkin's objection, which I wholeheartedly support, is in no way compromised by my thesis that shifts enable quantum leaps in capability. Rather than involving radical *changes in physical structures* (i.e. DNA strands), these involve major capability shifts to *other*, already existing *physical structures*.

I can well imagine that these transfers of function (my "shifts") do, in fact, represent a mechanism that significantly accelerates evolution and therefore basically correspond to what certain proponents of "saltatory evolution" have had in mind.



I will present additional examples of shifts in unicellular, multicellular, as well as in the development of hypercell organisms; this book will examine a few relevant examples in more detail. If my thesis is correct, then evolution is truly characterized by major leaps forward. These are then followed by periods of incremental improvements in which the potential applications of the respective shift (as in the case of all human inventions) are sounded out and implemented.

**Obtaining goods by "two-fold exchange" and the origin of specialized types of hypercell organisms**

A further opportunity for hypercell organisms to earn money was to sell "services" to others. This form of employment is much older still: it existed long before money was invented. Every symbiosis between plant and animal in effect involves one partner gaining the services of another by providing a service of its own. Numerous forms of exchanged services can be observed in social animals, for example in apes and monkeys, where one individual removes the lice from another individual, followed by a switch of roles. Long before money ever changed hands, laborers and servants in communities of hypercell organisms worked for others for room and board (a practice that continues to this day in many countries). The same no doubt also holds true for the "oldest trade in the world", prostitution. Subsequently, through the services sector, money also opened entirely new perspectives for all forms of energy gain.

Nonetheless, I do not believe that the exchange of services itself led to the discovery of money for the simple reason that services, as opposed to products, can be *arbitrarily subdivided*.

While filming human behavior on Samoa with my mirror-lens, a European-born resident explained to me how Samoans conducted business. "If an islander wants to buy a new shirt, he first asks how much it costs, then inquires as to what type of work he could do in order to obtain this sum. He then completes this work, buys the shirt, and sets forth on his care-free life". In modern, industrialized society, work for pay has become routine, although quite a few people still adhere to principles similar to those of the Samoans. When outside services can be obtained by providing one's own services, then money becomes superfluous. The services can then be directly matched based on their value and duration. Agreements along the lines of "scratch my back and I'll scratch yours" no doubt cropped up as soon as *Homo proteus* was able to communicate verbally. Such arrangements have lost none of their importance in either private life or modern business. I am devoting more time to this topic because the above scenario makes one thing clear: the complications involved in exchanging products no doubt gave rise to the selective pressure that inevitably led to the introduction of money. The remarkable fact here is that money (by buying services) enables much greater increases in capability than could be gained by producing additional organs.

Namely, anyone who acquires an additional organ has actually obtained only one element of the sought capability. The person who purchases a spear must then learn how to wield it. This requires creating the wiring in the brain that enables the owner to hit prey or enemies with the new instrument. If, on the other hand, this person hires a hunter or a warrior skilled in spear-throwing, then this additional effort becomes superfluous. Beyond merely providing the necessary tool, this strategy also ensures its professional operation. This holds true for any type of service purchased. For the duration of the contract, anyone with sufficient funds to hire the services of a doctor or lawyer supplements his/her capable entity with special skills that they themselves could never provide. The consequence of this is that by hiring services, a hypercell organism can gain virtually any type of special capability that others are willing to provide for money. While purchasing a tool or machines can improve the person's own capable entity, these units *themselves* must be properly applied to the task. Beyond this, they must be maintained in working order, protected against theft, and repaired or replaced as necessary. All these activities become largely or entirely superfluous when skilled services are enlisted. Engaging a doctor or lawyer automatically provides the patient or victim with the full range of experience gained by such highly specialized types of hypercell organisms.



This is an example of the indirect path that evolution can take to arrive at improved capability. Purchasing a product toward this end required money as a universal mediator. This mediator is most effective when used to hire services. The customer gains not only the means for the task at hand, but the entire capability relevant to that task.

Two main groups of people - those who sell products and those who sell services - are accompanied by a third profession, namely tradesmen. These hypercell organisms specialize in mediating between supply and demand. Theirs is a two-pronged effort: at one end, they locate the required goods, at the other end they help ensure that produced goods are sold.

From the functional perspective, this form of energy gain is presaged in the animal kingdom. One example is an African bird of the genus *Indicator*, commonly known as the honey guide. In a complex sequence of innate behaviors, it first determines the location of a bee hive; once a hive is spotted, it searches for a honey badger (*Mellivora capensis*) and attracts its attention with conspicuous movements and sounds. The badger understands the signal and follows the bird, which leads the way by flying ahead and repeatedly returning to the badger. Once at the hive, the badger tears it apart with its powerful forelegs and devours its contents. The bird receives a "commission" for its mediation, much like a trader or agent. In this case the reward is food: the badger is only interested in the honey and leaves the wax of the honeycomb untouched. The bird, however, can break this wax down for food with the help of symbionts living in its digestive tract. Without the badger, the bird would be unable to tap this source of food and energy, much as a trader can never hope to make a profit if markets are nonexistent. Curiously, honey guides have learned that humans are also interested in honey, just like the humans living here have learned to interpret the bird's signals. They also let the bird guide them to bee hives, which they then dismantle. The humans are only peripherally interested in the wax, leaving enough for the bird to get its reward.

As we all know, the animal and plant kingdoms have given rise to an incredible number of species: the insects alone encompass more than 1 million described species. Every one of these species is capable of utilizing a food resource and gaining energy as well as matter with which it builds up its own body structure and reproduces via offspring. This is no different in hypercell organisms. Those who produce required goods, who provide services, and who mediate the transactions - all have specialized in ever-new occupations, have conquered ever-new niches, and taken advantage of the ever new opportunities that life offers. In both cases, species have been displaced (and ultimately driven to extinction) by others who were better adapted and therefore more efficient. In both realms, strong competition developed between members of the same species, while members of other species were treated indifferently because no conflicts of interest arose. Both realms were characterized by the formation of interest groups and by a web of interdependencies. Although hypercell organs differ considerably from animals and plants in their external appearance and behavior, the manner in which they form new species is quite analogous.



The above-mentioned professions include a number of activities that enrich hypercell organisms by circumventing the rules and laws of the community. These can also be viewed as true occupations, even if they are illegal and disreputable. They allow a person's capable entity to acquire additional organs with only negligible loss of value, and these additional organs can also be made into money (the universal mediator) by selling them on the market. These features no doubt contributed significantly to promoting such illegal occupations. Thievery, extortion, drug dealing and fraud are often associated with considerable profits, although the risks are commensurately high. Larger groups collectively finance security forces to safeguard personal property, a development we will discuss at a later stage.

How does the hypercell organism’s method of gaining energy, which is so tightly bound to money, fit into the overall concept of evolution? Most plants, for example, rely on freely available sunlight as an energy source. The plant's structure enables it to use the energy of the sun's rays to convert inorganic matter into organic structures, namely into molecules whose configuration retains part of the energy extracted from the sunlight as bond forces. Plants therefore capture energy and put it to use. Most animals, on the other hand, gain the energy they need by consuming other organisms, whether they be plants or animals, and subsequently breaking down their molecules and utilizing the energy of the chemical bonds contained therein. Animals "steal" energy. The very same technique is in effect in the humans that form and control hypercell organisms. Humans operate even larger capable entities with muscle power, i.e. with energy gained from the food they consume. The next step - utilizing energy sources available in the environment, for example to power machines – will be discussed in a later chapter. Hypercell organisms are in fact characterized by an entirely different type of energy gain involving two-fold exchange.

The first exchange process involves earning money by selling products or services that others need. The second, which is typically much simpler, involves using this money to buy food and other necessary items. In this strategy, the major effort is shifted to the first transaction. The buyer, the customer, the target group, the market become the actual energy source. The fact that money can be used to purchase food and other fuels (coal, crude oil, electricity) from other individuals is only one side of the coin. More importantly, money can be used to transfer the specialized skills of other persons to one's own capable entity.

It should be stressed here that money is not a state of energy, i.e. it cannot be directly converted into units of energy. Rather, within organized communities, money represents a generally accepted proxy for energy or for the result of energy expended by others. The value of money, very much like that of any other goods, depends on supply and demand (unless regulations within the communities hinder this). Nonetheless, the act of earning money in hypercell organisms is ultimately directed at gaining energy, whether it be energy incorporated in the body and its organs or energy needed by others to produce necessary goods or to deliver specialized services.



**Man and the hypercell organism**

My theory has met with difficulty not for lack of convincing evidence, but rather because it forces us to fundamentally re-evaluate ourselves and our position in the flow of life.

The terms "man" and "hypercell organism" are by no means interchangeable. If a coal merchant goes bankrupt or if the demand for some other profession dries up, this in no way implies the death of the people involved. They continue to live, earn their money by other means, and one day form entirely new hypercell organisms. The demise of a business or profession may cause people to lose their jobs and their source of income, but they can subsequently give rise to an entirely new breed of hypercell organism. Some may take this as striking evidence supporting the belief that the sociocultural evolution of man is fundamentally different from biological evolution. I maintain, however, that this transition was a continuous process when viewed from the perspective of developing capabilities, regardless of how much external appearances and certain functional operations have changed.

At the core of every hypercell organism is a human being who has improved his/her own capable entity with additional organs. Everyone will agree that the decisive element in natural selection is not the naked human body, but rather the body along with the array of additional organs that help enhance its capability.

A number of animal species have already developed functional units that are separate from their bodies, units with which they clearly increase their selective value. The formation of such structures is extremely slow because it involves innate behavior that, in turn, relies on changes in the genetic makeup. Reproduction in these animal species is also bound to genetic mechanisms, which further limits their developmental potential. This situation suddenly changed upon the emergence of man, a long evolutionary process that is still evidenced in the vertebrates inhabiting our planet today. Specifically, this quantum leap occurred when man's mental capacity increased to the point where our brains (our powers of imagination) enabled us to associate and combine cause and effect, even if these were temporally and spatially distant events. This organism was now in a position to form additional organs by learning and then to test and improve these organs. Such progress would have been of little avail to the organism had its transmission remained bound to genetic mechanisms: the advances would have inevitably been lost upon the death of the respective individual. With the advent of the human capacity for oral and written communication, individually acquired advances could be directly imparted to others. The fetters to coding in the genome were broken.



The new situation in many ways paralleled what we know about technological advances: a final small step led to immeasurable new opportunities. For the first time, evolution gave rise to an organism that was able to transmit individually acquired advances to conspecifics on a broad basis. *Homo proteus* became a specialist in versatile specialization; biologically, he can be regarded as a cosmopolitan species whose great adaptability makes him far superior to plants and animals. Much like his ancestors, this remarkable organism lived in small groups that battled each other for food and space and had thus already become *higher-level organisms*. Every improvement in their particular community was an advantage in natural selection. An additional advantage was that certain individuals specialized in producing extremely important additional *extracorporal* organs that were not permanently attached to the body. From this moment on, this cosmopolitan species radiated (in the traditional biological sense of the word) into a great number of individual species. Every working person who achieved success based on a special accomplishment inevitably led others to emulate him/her, thus becoming the founder of a *new species*.

The traditional species concept, which functioned so well for all uni- and multicellular organisms, is coupled to the gene pool. Since the reproduction of the vital additional organs shifted from the genome to language and writing, this species concept is no longer applicable to the larger capable entities (hypercell organisms) formed by man. Clearly, modern biologists will find it difficult to question or even reject the familiar, traditional classification. The fact remains, however, that the formation of organs which are not bound to the cellular body – a strategy first successfully employed by animals - ushered in a new era of organ genesis and evolution in man. Although humans influenced natural selection by changing their environment, this influence was no greater than that exerted by spontaneous environmental change. Anthropogenic activity merely supplemented and modified the selective factors, an ongoing process up to this day. Thus, selective factors continue to control and determine which products of human ingenuity are successful and which are not.

It should be abundantly clear that the decisive element here is not the human, cellular body, but rather the capable entity that man creates. Since we do not perceive the latter directly, we have difficulty accepting that the true self is represented not by our physical body, but by an amorphous unit defined by capabilities and forces. In my opinion, however, we should have no difficulty accepting this identity shift. After all, daily life demonstrates time and time again how much our successes or failures depend on units other than those that are formed of cells and attached to our bodies. The business world has long recognized the importance of immaterial values that rarely appear on balance sheets yet are often critical for success. Examples include: reputation, standing, customer satisfaction, well-established business connections, faith in the reliability of coworkers and suppliers, the commitment within one's own team, and the loyalty of the regular clientele. All the above are important elements that decisively influence the capable entity of individuals and of the larger units formed by many individuals.

Chapter 5 will deal in greater detail with those business enterprises formed by hypercell organisms in which humans become entirely exchangeable and replaceable units. These mainly involve major corporations, but also include predatory mega-organizations such as the Mafia. I will also show that certain forms of state fall under this definition.

The hypercell organisms formed by humans can enormously boost their potential by acquiring new capabilities. We tend to shy away from viewing the services rendered by others as integral parts of the capable entities that are subject to natural selection. Our senses perceive the two as entirely separate entities. Those who wish to follow my line of thinking will have to put aside these prejudices. The view of life envisioned by my theory differs considerably from the traditional one. Although it may only minimally impact our daily routine, it could very well help us to tackle certain barriers that seem insurmountable today.

# 4 Organ formation and material components

The reason why we have such great difficulty acknowledging that additionally formed organs are inseparable from our bodies goes beyond the physical distance between us and these units. Two further considerations play a role here: the mismatch in building materials and the entirely different genesis. Every organ in the human body – and in all other organisms – consists of variously differentiated cells or, as in the case of our fingernails, of products these cells secrete. Tools and machines, however, are made largely of metal, buildings typically of natural stone or concrete. Moreover, rather than being built by the organism itself, most of the additional organs of hypercell organisms are purchased from others. Perhaps *these* differences do in fact justify a principle distinction between additional organs and their cellular counterparts. In order to resolve this issue, it is again useful to take a look at the materials making up the organs of a broad range of organisms and to examine their genesis.

Even the lowly unicellular organisms have representatives that use both building blocks of their own manufacture and environmental material to form organs. The closely related species *Amoeba euglypha* and *Amoeba difflugia* are an instructive example. Both inhabit moist soils, often even in the same area (for example Sphagnum moss in moors). Most amoebas "flow around" the organic particles that make up their food and incorporate them into their bodies. *A. euglypha* and *A. difflugia*, however, which belong to the thecamoebas, form an urn-shaped case into which they can retract almost completely when they sense danger. They crawl around the bottom by stretching their thread-like "feet" or filopodia out from their case; they also use these projections to grasp food items, which they draw back into the case and incorporate into their bodies. Case formation in the two species, however, differs considerably. *S. euglypha* produces tiny silica platelets from metabolic products of digestion and transports these to its outer layer. Here, they are firmly cemented to one another by a sticky secretion termed pseudochitin. The result is a rigid case wall formed of relatively uniformly sized plates. *A. difflugia*, on the other hand, takes suitably sized sand grains up with its food; these are also shifted to the outside and glued together with pseudochitin to form a rigid case. Externally, these two very dissimilar protective structures closely resemble one another (Fig. 2A). Their rigidity is no doubt also comparable: the only difference is that one is composed of self-made platelets (*A. euglypha*), the other of freely available environmental material of approximately the same size (*A. difflugia*). Does this make the armor of *A. difflugia* any less an organ of this animal, merely because it isn't composed of self-produced units?

Multicellular organisms provide the next few examples, specifically the larvae of caddis flies that abound in our streams. We have already examined one representative of this group, namely the species that uses filaments to construct funnel-shaped traps.

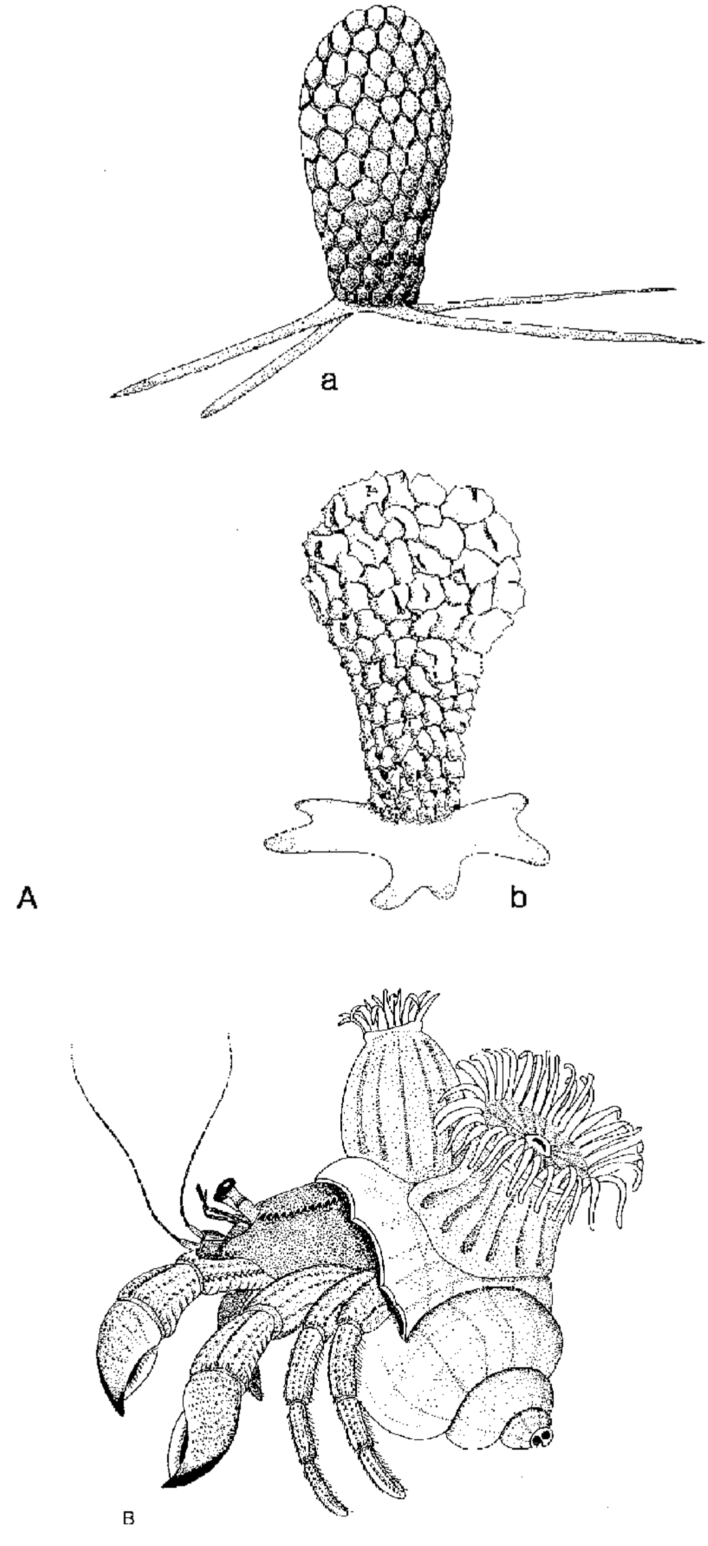



*Fig. 2: Two examples of how fundamentally different material components of additional organs can be.* ***A*** *shows two amoeba species that produce protective cases into which they retract when threatened. Amoeba euglypha (a) uses silica platelets for its house: these are formed within its own body, transported to the outside, and firmly cemented together with a sticky secretion it produces itself. Amoeba difflugia (b) produces a very similar armor by using its pseudopodia to take up suitably sized sand particles with its food; it also transports these*

*to its outer surface and then rigidly cements them together with a self-produced cement. The fact that both species often inhabit the same biotope is proof that both types of case are equally effective. Even at the level of unicellular organisms it is clearly inconsequential whether organs consist of the body's own building blocks or of environmental materials.*

***B**: Hermit crabs use empty snail shells as a protective organ for the hind part of their body. Some species even transplant sea anemones onto their shells for additional protection against sea stars. The snail shell, which serves as a protective organ for the crab, was produced by another animal; the sea anemones - as protective organs - are entirely separate living organisms. Both examples clearly show that the material and genesis of organs is irrelevant: the ability to fulfil necessary functions is the key criterion.*

Most caddis fly larvae, however, use their silk threads to fabricate protective tubes into which they retreat when threatened, much like the amoeba species retract into their cases. In order to strengthen the delicate yet sturdy tubes that they carry about with them, they fortify the silk network with sand grains, small stones, plant debris, tiny snail shells, small twigs and other environmental materials. All of these elements are attached to the tube with threads. Specialists who collect such tubes can often assign them to a particular species based on their composition. The larvae therefore demonstrate *innate preferences* in their tube-building activity. Some species that use plant stems cut these into equally long strips with their jaws; these strips fit more snugly up against the silk tube and form a more tightly-knit protective sheath. This once more raises the question: do these types of armor, which tightly enclose the body but are not fused to it, represent organs of the animal or not? In snails, which secrete calcium to form the protective shells into which they retreat, no biologist has ever questioned this. The shell is an integral part of the snail's body and a very important organ indeed. The caddis fly's tube, however, is largely formed by adding layers of environmental material. In many ways they already foreshadow the clothes that humans fashion of natural materials.



### The cell as a material component

At this point we need to discuss the inherent advantages and disadvantages of cells at the transition from uni- to multicellular organisms, when they relinquished their individual freedom as separate organisms and became building blocks of larger life forms. Bear in mind that when the cell assumed this new role, it already had a more than 2-billion-year-old history and had achieved an extraordinary level of efficiency and differentiation.

With only a single exception, which we will return to later, no building material other than the cell offers so many advantages and is capable of taking on such a wide range of tasks. We only need to recall that, in the multicellular body, practically the very same unit forms both the muscle and bone tissue, both nerves and kidneys, sensory organs and red blood cells. As white blood cells they still largely retain their independence, roaming through the body and disposing of wastes; after loading themselves up with toxins or pathogens that have breached the body's defenses, they can even "commit suicide" for the good of the overall organisms by leaving the body as pus. Furthermore, building material, the cell is largely self-maintaining; in the event of damage, it even assumes a self-repairing function. When the need arises, cells can often re-differentiate themselves. This is the case when muscle cells transform themselves into bone cells or when connective tissue cells develop into cells that form blood vessels. A salamander can fully regenerate a limb lost due to injury. Even if all the bone has been lost, the remaining tissues give rise to new bony tissue through re-differentiation. Science has largely clarified the mechanisms that enable cells to transform themselves into such widely divergent structures and to take on such disparate roles. There is no need to delve into this matter here. We merely need to note that, as material components of larger living organisms, cells develop a diversity that borders on the miraculous.

These eminent advantages, however, are balanced by quite considerable disadvantages that have received much less attention in light of the cell's stature as a living wonder. The first minus is that each cell – each individual building block – must be supplied with energy and substances, necessitating a highly intricate blood circulatory system. This requires countless, ever-branching tubular ducts along with one or more pumps to power circulation. A shot through the heart kills a human being almost instantaneously because this material component can no longer fulfil its task. At the same time, all the waste products formed during cell metabolism must be removed because they impair the cell's abilities. In the human body, as in all higher vertebrates, this task is also largely left to the circulatory system; the process does, however, require further supporting organs such as the kidneys and the excretory ducts for the toxic substances. While the cell may be an exceptionally versatile building block, it very clearly does place considerable demands and entails commensurately high costs. This also means that cells cannot form organs that are not served by the circulatory system, and clearly none that are separate from the body either.



Organs whose function relies on *not* being permanently attached to the body – such as the spider's web and most additional organs of humans – cannot be built of cells. This raises the inevitable question: is the process we refer to as "life" by definition tied to specific material components – even if other materials significantly boost capability? In my opinion this is an untenable position.

The cell as an efficient building material suffers from a further, no less grave disadvantage: this highly differentiated unit cannot tolerate higher temperatures. This helps explain why both uni- and multicellular organisms never developed organs or organ parts composed of metal, which would have required high smelting temperatures. On the other hand, *additionally formed* units that are separate from the body, like a forge or a blast furnace, do enable metals to be worked. This very process led to the development of those capable entities – human beings – that have so extraordinarily boosted the evolutionary process. The major industrial production and transportation systems are a case in point. None of these organs of hypercell organisms and their organizations could ever have developed via cell differentiation. We are once again confronted with the question of whether our definition of "life" need necessarily be restricted to cells and their products or whether perhaps less importance should be attached to this efficient building material.

In the case of crystals, growth is in fact dependent on the steady accretion of certain building blocks. Organisms, however, are physical structures that must exhibit certain *capabilities* in order to survive and reproduce. From this perspective it is difficult to understand why they should be conceptually bound to specific material components. Should other materials enable even greater capabilities, then natural selection, which can only evaluate *results*, will certainly not reject them.

These divergent strategies are already foreshadowed in the two above-mentioned amoeba species and the caddis fly larvae. From a functional standpoint, *A. euglypha* leads to all those organisms whose material components are restricted to cells. The other path leads via *A. difflugia* to all those organisms that also use foreign elements to build their organs and that, ultimately, either form or otherwise procure organs that are separate from the body. The list of weighty drawbacks that cells have as building blocks for larger units will be extended later in the book by a number of other examples. The two mentioned above suffice for the time being.

### The procurement of organs

During the course of my film activities in coral reefs, I often had the opportunity to observe the delicate longnose butterflyfish (*Forciper longirostris*). I followed this fish over great distances and used time-lapse techniques to show how they used their elongate, tube-like snout to probe the spaces between coral branches and pick at the small snails, crustaceans and other tiny invertebrates hidden there. This species, which is related to forms with short, pointed mouths, very clearly demonstrated to me the evolutionary pathway of this unusual feature. In foraging for food, one group had a decisive competitive advantage: those individuals who – through genetic variability due to mutation and recombination – had a longer and more pointed mouth. They were able to extract prey from cracks that were inaccessible to conspecifics and other competitors. Over millions of years, this selective advantage, as unspectacular as it may seem (and promoted by other changes in the genetic makeup) led to an increasingly elongated mouth. In the true Darwinian sense, a series of small steps yielded highly adapted forms. Thanks to this selective advantage they successfully reproduced and gradually gave rise to a new species. Similar trends can be observed in certain bird species. The very long, thin beak of the wall creeper (*Trichodroma muraria*) and sword-billed hummingbird (*Ensifera ensifera*), for example, helps them to extract small prey items hidden in rock cracks or to suck nectar from flower cups . This mode of feeding is difficult if not impossible for other species. On the other hand, these birds – much like the longnose butterflyfish – are at an advantage only when such special food niches actually exist. Were such highly adapted birds driven into the desert by winds, or such specialized fishes carried off to flat, sandy bottoms by currents, then their chances of survival would be limited. A further disadvantage is that the beaks of the former and the jaws of the latter are poorly suited defense organs against predators.

During his 5-year voyage on the research vessel "Beagle", Charles Darwin devoted particular attention to the finches of the Galapagos Islands. However, the eminent naturalist apparently failed to notice a particular trait of one of the finks he observed. This species developed an innate behavior pattern – no doubt through gradual changes in its genetic makeup – that enabled it to reach prey hidden in cracks in wood without any morphological change to its beak. After removing the bark with its beak, the bird breaks off long cactus needles and uses them to prod insects and other animals from their hiding places. Today, this woodpecker finch (*Cactospiza pallida*) serves as a classical example for tool use in the animal kingdom. One particular feature, however, usually receives no mention: the bird, which can also feed without using cactus needles, has gained an additional advantage due to its behavior. Cacti are abundant on these islands. The bird has no problem finding a suitable needle whenever it needs to extend its beak. After use, the needle is discarded and a new one found as the need arises. This bird's feeding success would not be severely compromised if it were suddenly carried off to a region that lacked cactus needles: it is by no means dependent on the advantage that the needles afford. When these are unavailable, the bird is perfectly capable of capturing prey with its unmodified beak.

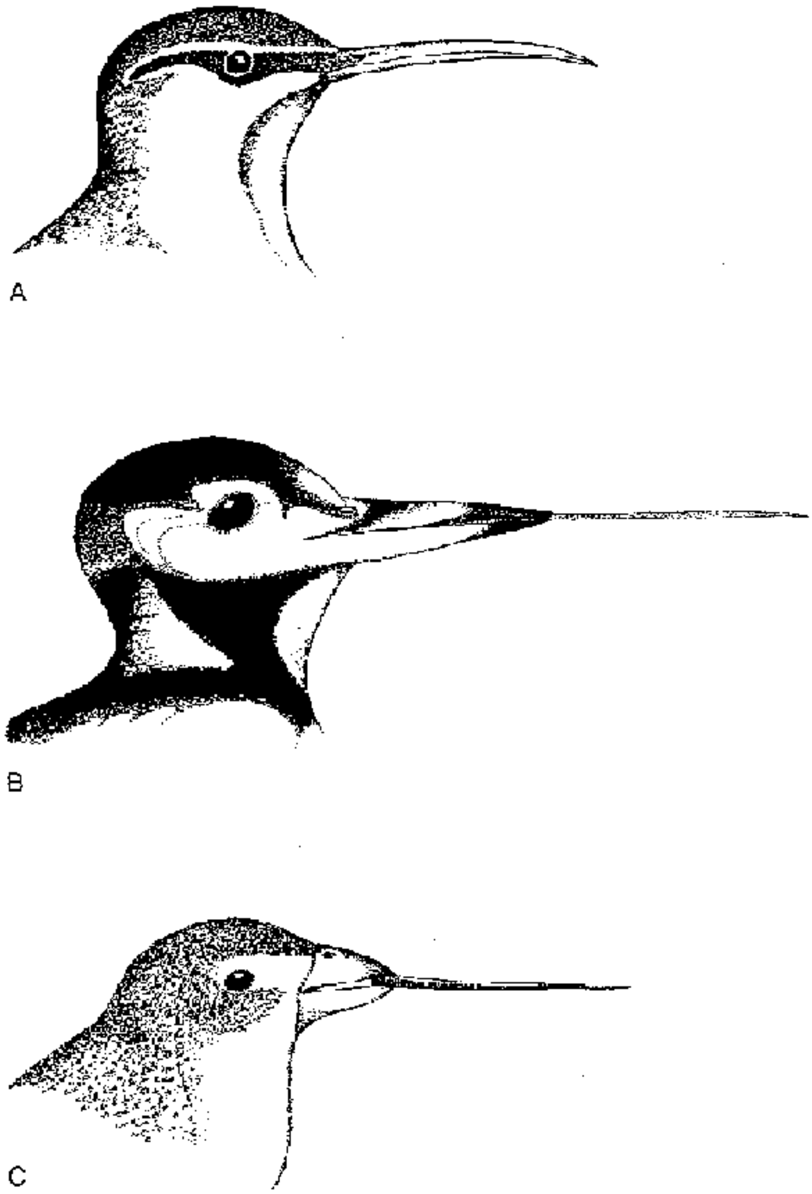



*Fig. 3: Exploiting similar food niches in three bird species*

*A: The wall creeper (Tichodroma muraria) uses its particularly long, thin bill to extract insects from cracks in rocks. Its ancestors had shorter beaks, but mutants with longer beaks were able to reach prey that was inaccessible to the competition; this success led to the establishment of a new species.*

*B: The same evolutionary pathway enabled the great spotted woodpecker (Dendocopos major) to develop a long, powerful beak to hammer through the bark of rotting trees and reach insect larvae in their burrows. Mutations also led to an extremely long tongue with a sticky tip, with which the birds can probe even further into the burrows.*

*C: The woodpecker finch (Cactospiza pallida), a native of the Galapagos Islands, gained an analogous advantage: here, in a series of mutative steps, the bird developed an innate behavior pattern in which it breaks off cactus needles and uses these to prod insects from their hiding places. Based on its behavior, this bird belongs to a group of animals that have increased their capability with additional organs that are not fused to the body, organs whose advantage is that they can be put aside. As opposed to the above two species, the woodpecker finch can use its powerful beak to peck open seeds. If it needs a cactus needle to get into cracks, then it breaks off a suitable needle, much like a human would grab a tool to improve the capability of his/her hands.*



Early man improved his hunting success by using suitable stones as projectiles. In areas where such stones were abundantly available, humans probably discarded these additional organs after each use. Later, when specially shaped hand axes were used as universal tools to dig, cut branches, and produce hunting spears, humans no doubt held on to them and protected them from theft. The great advantage of additional organs is evident both here and in the case of the woodpecker finch. Early man was also not necessarily dependent upon the advantages afforded by the hand axe and other additional organs. The material itself was of no consequence in either the projectile or the cactus needle: virtually unlimited supplies of both were available. From the standpoint of natural selection, both units represent additional organs even though they are not produced by the organism itself. The woodpecker finch's needle is much like early man's stone projectile and, subsequently, his hand axe, hatchet, hunting spear, noose, fall traps, and other artifacts: all serve to obtain food and therefore provide two decisive fundamental capabilities, namely *energy gain* and *gain of vital substances*. There is no reason why these artifacts should not be viewed as organs exactly like the extended mouth of the longnose butterflyfish or the beaks of the wall creeper and sword-billed hummingbird. The material making up the additional organs is irrelevant, as long as they function satisfactorily. *Amoeba difflugia* and *Amoeba euglypha* are a case in point. The same holds true for the great variety of mussels and clams as well as for the caddis fly larvae. The longnose butterflyfish and the woodpecker finch are further evidence. Many additional examples could be cited. I have restricted myself to these because I find them to be particularly illustrative.

One group that drives this point home is the hermit crabs. Numerous genera and species are widely distributed all over the world and provide convincing evidence for the selective advantage that their strategy offers against predators and other threats. The abdomen of most crabs is protected by a hard outer skeleton (exoskeleton), just like the remainder of the body. In hermit crabs the abdomen is soft. They use "prefabricated" units, i.e. the shells that snails leave behind when they die, to protect the hind part of their bodies. Originally, ancestors of these crabs may have merely improved the protective function of their armor by inserting their tails into empty snail shells. Over the course of time – in a series of many small evolutionary steps – they gradually reduced the armor of their tail, which had become a superfluous effort to produce. Today, hermit crabs can only live in areas that have a sufficient supply of snail shells. Marine snails are found worldwide and the shells they leave behind are very sturdy. This is the ideal prerequisite for the hermit crab's success throughout the world's oceans, particularly along tropical and subtropical coasts.

On the other hand, crabs (like all arthropods) must periodically shed their old exoskeleton and grow new, larger one as they become larger. During this phase they often retreat into cracks to hide from predators until the newly formed exoskeleton becomes hard enough. Even hermit crabs shed their exoskeleton from time to time. When the occupied snail shell becomes too small, the crab must seek and move into the next larger size. Hermit crabs have developed a series of further innate behaviors for this critical process, during which they are open to attack by predatory fishes. They manipulate and test potential new housings, checking each for appropriate size and fit. Once they have selected a suitable candidate, the actual change takes place very rapidly.



The evolution of hermit crabs is also characterized by morphological adaptations to the special situation of being able to acquire a vital organ rather than having to develop the organ itself. The unprotected abdomen of all modern hermit crabs is wound just like the whorls of the snail shell, yielding a perfect fit. This is accompanied by modified claw shape: when the crab is threatened it retracts its entire body into the shell along with all its walking legs. It then uses its claws – which snugly fit the shell opening – to hermetically seal its home like a safe door. This is reminiscent of technical constructions. The difference is that humans achieved this capability through intelligence, animals via the much longer evolutionary pathway involving advantageous changes in the genome.

The question we need to ask here is the following: is the acquired and functionally adapted snail shell an additional organ of the hermit crab or not? In the living snail, which produced the shell, we have no problem recognizing the shell as a bodily organ. When occupied by the crab, however, the very same shell is interpreted differently because it was produced by another organism. For natural selection, which decides which organism will survive and which won't, this difference is inconsequential. The decisive criterion here is efficient protection – something that both animals require. Any number of different strategies can be used to achieve this end.

From the evolutionary perspective, I can see no adequate grounds, much less compelling arguments, for rejecting capability-enhancing units as true organs of an organism merely because they were produced by another organism. In fact, the adaptation of the hermit crab's abdomen, which consists of cells, to the shape of the snail shell is strong evidence that the crab's genome "recognizes" this unit (acquired from the environment) as an integral part of the organism.

This new, expanded organ definition therefore maintains that organs need by no means be composed of self-produced building elements. Most organs in animals and plants are, in fact, normally produced by the respective organism, making this the rule in evolutionary history. Nonetheless, other avenues of organ genesis exist. One method is to acquire freely available building material from the environment (such as in *Amoeba difflugia* and the ant lion) or to take up ready-made organs (as hermit crabs do). However, the full potential of this technique was first reached when humans consciously formed additional organs.

Some animals, for example, are also known to steal complex cellular substructures termed organelles from their prey and convert them into their own capability-enhancing structures. The most astounding example is the purloining of stinging capsules (nematocysts) produced by coral polyps. These capsules are exquisitely designed dartguns. Touching the spine-like trigger of this organelle discharges a tiny, tethered dart into a prey organism or enemy. In a fraction of a second, its tip folds out into a ring of stiletto-like structures, which enlarges the wound. Then, a tube is introduced and paralytic poison injected into the wound. Despite this defense, certain sea slugs (*Aeolidiacea*) and a comb-jelly (*Euchlora rubra*) feed on coral polyps – without triggering the polyps' stinging capsules. Instead these capsules are transported through the body into special appendages, which thus become the new owner's own protective organs. One can hardly argue that such *stolen organelles* (cleptocnids), whose origin has been known for some time, are organs while they are in the epithelium of the coral polyps, but not in the epithelium of the sea slugs. Whether they were produced by the snail or by a foreign genome, they deliver the required capability in both one and the other. In animals and plants such organ theft is an exceptional phenomenon. This situation changes radically in hypercell organisms. While organs consisting of cellular tissue can only rarely be transferred from one organ complex to another, the additional organs of humans can very well be stolen and incorporated into the capable entities of other hypercell organisms. Whether organs are partially or entirely produced by the body's own cellular activity or obtained from other organisms is secondary, just as it was inconsequential whether *Homo proteus* produced a necessary additional organ him-/herself or stole, exchanged or purchased it from others. In the struggle for existence (a phrase that Darwin frequently used), and particularly when conflicts with competitors are involved, there is one and only one set of criteria: the organism must have capability-providing units when it needs them and it must integrate these units into its overall structural complex (cellular plus additional organs), whereby each component must support rather than hinder the function of the others.



### Transforming other organisms into the body's own organs

My studies in far-flung seas provided me with ample opportunity to observe the activities of many individual animals. I was able to witness how some marine organisms resolutely and ruthlessly converted others into integral components of their own capable entities. The wool crab (*Dromia vulgaris*) is a case in point. It uses sponges to more effectively camouflage itself. The crab selects a sponge, detaches it from the substrate, and uses its claws to cut and form the sponge so that it fits perfectly atop the crab's carapace. Although one is tempted to interpret this meticulous procedure as a feat of intelligence, it remains an innate behavior program: like any morphological structure, it arose via a long succession of mutations and recombinations of the controlling genes, gradually becoming ever more improved. The crab turns the sponge from side to side, inspects it, and evaluates the work in progress until the sponge takes on the exact intended shape and fit. It then sets the sponge atop its arched carapace, holding it firmly in the back with the last pair of legs and anchoring it with hooks in the front. This camouflage renders the crab virtually invisible in its biotope, thereby considerably reducing its risk of being eaten by predators and – in the same measure – significantly improving its own feeding success. The sponge lives on despite its mutilation, and the association is in many ways reminiscent of people who "cut others down to size" and draft them into functional components of their own capable entities. As long as organisms, including humans and their material structures, are viewed solely from an external, material vantage point (as is the rule today), then every such comparison appears to be mere analogy. If, on the other hand, capability is the key to survival, and the underlying material structures and processes are treated as secondary, then the *result* is decisive, i.e. to what degree has capability been enhanced in one system and the other. If one human so successfully molds another that the latter ultimately subordinates his/her own will and goals to those of the former, then the originally independent organism will increasingly be reduced to an organ that serves to enhance the dominant entity's power. Although individual freedom and individuality per se may not be transformed as dramatically or radically as the wool crab *Dromia* remodels its sponge, in both cases a particular behavior pattern can – under the appropriate circumstances – make independent organisms into completely dependent, subservient tools.



Symbiosis is an even more elegant example of how the capability of individuals can be enhanced by a *mutually beneficial* partnership. Hermit crabs, whose behavior I examined in detail, can again be cited as a well-known case of such ubiquitous and well-studied symbioses. Some species do more than merely transform the organ of one organism (i.e. the shell of a dead snail) into their own organ: they actually improve the effectiveness of the protective units they have acquired by making a further, living organism into an additional organ.

Sea stars are among the chief predators of hermit crabs. Although the crabs can retreat deep into the very sturdy shells when threatened, the sea stars can still get at their prey. They anchor themselves on the bottom with all five arms, attach their suckers to the crab's claw, and pull the struggling victim out of the shell. Some crabs have developed additional behavioral programs that help them to thwart this predator. Using a complex sequence of stroking movements with their claws, they dislodge sea anemones that have firmly attached themselves to the rocky substrate. The hermit crab then transplants the anemone onto its shell, whereby the anemone actively attaches itself and accepts the shell as its new home. *Its* advantage is that it has transformed itself from a sessile to a mobile animal at virtually no cost. The anemone is carried about – a considerable advantage over the competition because of the vastly improved opportunity to always enjoy optimal living conditions. The hermit crab gains an additional defense mechanism in this exchange and therefore improves its own selective value; the anemone gains a locomotory organ that provides for all its needs. Each partner therefore makes another organism with an entirely different genome into its own additional organ.

This mechanism of gaining new organs is so important because it enables veritable leaps in capability. More closely examining the anemone's situation in the hermit crab symbiosis reveals why. Anemones that are firmly attached to a rock substrate have only a very limited radius of activity. The symbiosis with the hermit crab, however, provides it with the services of well-developed legs that it could not have evolved itself even in hundreds of thousands of generations. Indeed, selection pressure to develop legs never existed because the food particles it needed floated right by its tentacles with the water currents. The fact remains that the anemone gained the advantage of these highly developed limbs with a moderate number of mutations and recombinations – a significant *shift* in the sense I introduced above. Its capability is enhanced by leaps and bounds, and in exchange for this, it provides one of its capabilities to the new partner. While the advantage of mobility may be modest to the anemone, it is clearly great enough to have given rise to this association with the crab. Under certain environmental conditions, however, such mobility may well provide a critical advantage. This underlines the evolutionary opportunities that symbioses have to offer: the partners gain new capabilities without themselves having to bear the development costs. This is the very principle that enables the universal mediator "money" to so dramatically boost the capability of hypercell organisms. Such shifts – in which organs with an entirely different developmental history are incorporated into an unrelated capable entity – are already evident in symbioses. And, in the course of evolution, each such shift can either prove to be only moderately significant or can lead to entirely new selective advantages. The latter was the case in *Homo proteus*, where the hand axe and hunting spear gradually gave rise to all manner of tools and to every industry founded by hypercell organisms.



The above strategy of acquiring and incorporating foreign organs into one's own capable entity is already evident in animal and plant symbioses. It leads to a second evolutionary pathway that can briefly be introduced at this stage. Specifically, I am referring to the partnership arising from the presence of two sexes in more highly developed multicellular organisms: it is the most important mechanism for *improvement* as a fundamental capability. In brood-caring animal species in which the parents actively protect, feed or even "teach" their young, this type of interaction can be viewed as being functionally related to symbiosis. Although brood care involves an association of individuals of the same species, each partner becomes an additional organ of the other. This culminates in marriage, friendship and other forms of human partnership.

If we return to the hermit crab symbiosis, and if we accept that capabilities rather than bodily structures are the key feature in evolution, then we can legitimately ask whether this partnership does not in fact constitute an organism at a higher level of integration. This question is even amenable to experimental study. If the partners' chances of survival as a team are generally greater than if each were to live alone, then we are dealing with a higher-level organism: a new, more complex living unit that must face natural selection. This can lead to an increasingly differentiated division of labor, such as in insect colonies. Using powers of intelligence, it can also lead to the governments founded by hypercell organisms (see Chapter 5).

Certain unicellular organisms already exhibit a remarkable transition from free-living individuals to temporary, cohesive units. After a period of independent life, thousands of individual slime molds (myxomycetes) aggregate to form a spore capsule; this grows from the substrate on a long stalk and serves the fundamental capabilities of *reproduction* and *improvement*. Here, the genome compels these unicellular organisms to aggregate and to undergo a cell differentiation rivaling that of multicellular organisms. On the other hand, the genome of each germ cell in multicellular organisms represents a cohesive unit; should cell division give rise to new individuals and members bearing this genome be dispersed in all directions, then it still retains the common organization that we define under the term "species".

In every cohesive organizational unit, as well as in all those whose components are not firmly connected, each organ is not merely an organ of a greater, common entity, but also serves as an additional organ for every other subunit. This is equally true in multicellular organisms and in the associations, business organizations and governments formed by hypercell organisms.

Termites demonstrate how insignificant the size-relationship between symbiotic partners is. These highly specialized organisms feed on the cellulose contained in wood, but are themselves unable to digest this material. This means they are unable to release and utilize the bond energy contained in the cellulose molecules for their own metabolism. A symbiosis with protozoans (flagellates of the order *Polymastigina*) than can break down cellulose has become the cornerstone of the termite's existence. They live as "digestive helpers" in the termite's gut, breaking down the consumed cellulose, covering both their own metabolic needs and passing the greater portion of the yield on to the thousand-fold larger termite. One advantage for the digestive helpers is the perfect protection afforded by the termite's body. Also, they need expend no energy in looking for food: the termite provides them with a never-ending supply. If the gut of a termite is experimentally sterilized and the flagellates all killed, then the insect will starve regardless of how much wood it eats. Here, we are entirely justified in asking: can the *endosymbionts* be regarded as organs of the termite or not? According to current thinking the answer is no, they are not organs. First, because they are separate organisms with their own genetic makeup, and second because they do not originate from the termite's genome: their production is not coded in the termite's genetic makeup.



Termites are not the only organisms that rely on such digestive helpers. Many other insects and ultimately even cows would be unable to survive without such symbionts. In plant-sap sucking insects such as the jumping plant louse *Psylla buxi*, special organs (mycetomes) in the abdomen house the symbionts. This development reaches its epitome in other species, such as the weevil *Cleonus piger*, that have developed complex organs to spray their digestive helpers (in this case bacteria) onto their eggs. When the larvae emerge, they infect themselves with these bacteria or, from our perspective, procure the vital additional organs they need to survive. The symbiotic weevil also assumes a supporting role in enabling the fundamental capability of *reproduction* in the bacterial partner.

I reiterate the question: Is it justified to consider these extensive and complex multicellular mycetomes to be organs of the insect's body, as has been taken for granted in the past, merely because they are produced by the body's own genome, while at the same time denying this designation for those entities (bacteria) that actually enable the fundamental capability (energy gain)? After all, the entire role of the mycetomes is to support the bacteria. If the termites were in a position – via cell differentiation – to develop glands that secrete cellulose-splitting enzymes, then no one would hesitate to consider these glands as the body's own organs. Such a cellular differentiation was apparently not possible through mutation and recombination, or perhaps the endosymbiosis provided a simpler means to the same end; this strategy was even supported by supplementary structures like the mycetomes, whose development was automatically promoted by natural selection. The decisive fundamental capability of *energy gain* was therefore achieved by an entirely different pathway. In my opinion, the termite's digestive helpers are a prime example of how a different species can be transformed into an organ of one' own capable entity. I discussed this condition in detail in an earlier work (1970).

Other endosymbionts enter into an even more intimate relationship with the cellular body of their much larger partners. The incredible reef structures that coral polyps build require the ability to extract the necessary building material (calcium carbonate) from seawater. This task consumes much more oxygen than is available in dissolved form in the water. Nonetheless, in this case symbiotic *plants* (unicellular algae) enable the process to go ahead. They live in the cell tissue of the polyps and can only be recognized under a microscope based on their different color. As plants, they produce oxygen, which the polyps can take up directly. Conversely, the algae in this partnership benefit from the fact that the polyp's cells – like the cells of all animals – emit carbon dioxide. This is an important building block for the algae. Those who would maintain that the unicellular algae within the polyp's tissue are not an integral component of the coral body (because they were not produced by differentiation of the coral's own cells) will have to face the critique that they have long been misled by the uniform appearance of corals and by the false conclusions drawn from this. Again, a rigorous distinction between the true polyp and more "foreign" components can hardly be upheld. Natural selection is only concerned with capability, with success. More than one road leads to Rome.



In defining each unit that fulfills at least one task in the organism's division of labor as an organ, we are fully justified in viewing symbionts as *organs*; this holds true even if they are not produced by that organism's genome and are therefore designated as additional rather than natural organs.

**Temporarily "renting" necessary organs**

This section deals with another strategy of using additionally acquired organs to improve the selective value of the organism's own capable entity. In the hypercell organisms formed by human beings, additional organs clearly do not need to become permanent fixtures of the capable entity. A visitor who needs a room for the night by no means needs to purchase that room; someone who flies to Rio de Janeiro rents a seat on the flight rather than buying the airplane. As indicated above, the situation is much the same when we hire the services of another hypercell organism, such as that of a secretary, a cook or a shipping agency. This is referred to as a short-term obligation rather than "renting", but functionally both are the same.

In both cases, a required additional organ (which can either be an inorganic structure or another organism) is bound to a capable entity for some defined period rather than becoming a permanent fixture. The price is a charge or fee of some kind.

Early stages of such associations abound in organisms, particularly in the plant kingdom. The task facing plants, however, is radically different from that facing animals: their source of energy – the sunlight falling on the Earth – is anything but scarce. Scientists have calculated that plants can at best capture 1% of the solar radiation reaching the planet. On the other hand, in Earth's early history when evolution was restricted to the underwater realm, plants had to develop structures that prevented them from sinking down into the dark depths. In the case of planktonic algae, fat or gas pockets provide buoyancy. Unicellular algae, much like unicellular animals, also have organs that allow active locomotion. The flagellate *Euglena viridis*, which is both plant and animal, uses its flagellum for both life strategies. If it behaves like an animal, the flagellum serves in seeking prey; if it behaves like a plant, the flagellum helps it to return to sunlit waters if it has sunk into darkness.

On land, the main problem became to obtain sufficient water for photosynthesis. Locomotory organs, on the other hand, became superfluous. Terrestrial plants are therefore bound to a particular site, while most animals need locomotory organs to reach their source of energy (other animals). Of the six fundamental capabilities that I believe all organisms must have, two became a particular problem for all land plants, namely *reproduction* and *improvement*.



When plants produce seeds, these can be distributed by currents in the water and by wind on land. Virtually all aquatic plants and, at least initially, all terrestrial plants took advantage of these *favorable environmental factors*. Later, some succeeded in turning other organisms into their additional organs by enclosing their seedlings in sugar-rich pulp, which animals enjoyed as food. The animals ate these auxiliary reproductive organs, which we term fruits. The seedlings passed undigested through their guts and were excreted at a new location along with the remaining feces. Clearly, this exploitative strategy can only function if the seedling is so well encased that it cannot be digested by the transporting animal. This is why seedlings hidden in fruit are enclosed in such sturdy protective casings (seeds). The return service that the transporting animal – usually a bird or mammal – receives for its unwitting role is, as mentioned above, the energy-rich, sugary fruit. A mutual exchange, about which both partners are "ignorant", takes place here. This holds true for all symbioses that have not been instigated by man. Again, natural selection is concerned only with the result. Whether this is achieved by conscious or unconscious strategies is irrelevant.

The second difficulty all land plants face is the sexual union of the gametes of different individuals – the most important evolution-promoting mechanism in multicellular organisms. Due to well-known reasons that need not be dealt with here, this mechanism functions optimally when gametes from widely separated regions cross; inbreeding – the crossing of closely related gametes – can involve considerable disadvantages. How can plants that are firmly anchored in the soil, however, arrange for their gametes to cross with those from individuals that are as remote as possible. Again, favorable environmental factors such as water currents or wind can play a supporting role. Higher plants, however, developed an even more effective solution: other organisms, in this case almost exclusively insects, were drafted as additional organs to fulfil this fundamental capability. The plants developed special organs, namely flowers, to promote this service. Flowers consist of units that secrete sugary nectar, additional units that attract the respective insects (conspicuous flower petals), and finally other units that help attach pollen that contains male gametes onto insects. These are then carried by insects to other flowers of the same species, where they fuse with the female gametes to form functional seedlings. The fruits and flowers are distinctively colored in order to draw the attention of and attract the desired symbiosis partner. In flowers, odor substances also play the same role.

Before proceeding further, we need to discuss a banality that turns out to be less banal than one would think. It revolves around the question why I have chosen to discuss the formation of fruit before going into that of the flowers. After all, everyone knows that fruits typically develop from flowers. Or, formulated more generally, why did I list the fundamental capability *improvement* as the last item after *reproduction*, although reproduction regularly follows mating in both plants and animals.

Foremost, all the fundamental capabilities I listed have no given natural sequence. The reason for putting energy gain first was merely because no other fundamental capabilities could have been realized without energy being available. On the other hand, energy gain would not be possible without most of the other fundamental capabilities and many supplementary capabilities. When I list reproduction in fifth position and place improvement last, it is because reproduction was the prerequisite for the evolution of organisms from the onset. Although mechanisms for structural improvement were equally important for evolution, they clearly only arose later. For billions of years, the most important mechanism was sexuality – the fusion of genomes of different individuals of the same species. During cell division, this enabled the random changes (mutations) in the genetic material to be recombined in a highly variable manner. The fact that this process can, if only rarely, lead to structural improvements is the functional basis for a mechanism that is both efficient yet very slow to yield progress. In my opinion, the so-called *shifts* that I introduced in this book are an additional mechanism behind major improvements. At this point, however, such shifts are merely a hypothesis I have forwarded and will not be treated in this section.



My putting reproduction *before* improvement (the sequence is actually reversed in both animals and plants) is simple to explain. Logically, mating *after* successful reproduction would be ineffective from several standpoints. According to Spencer, the reversed order is more suitable in every respect, and Darwin considers it to be more advantageous with regard to natural selection. The closer mating is to the reproductive process, the better the potential result. This also helps eliminate superfluous exertion and damaging influences. Even today, most people consider mating and reproduction as two acts in the same functional process. They fail to see that it in fact involves the inevitable linkage of *two contrary functions*. The task of reproduction is to achieve the most precise intraspecific replication, one that guarantees that no improvements made by the species are lost. Mating, on the other hand, also serves to yield altered and in this sense species-atypical progeny: without such individuals, no evolutionary development would ever have taken place at all.

To little, if any, emphasis has been placed on this *functional conflict*, which has played a key role in hindering and checking evolution. Put even more succinctly: on one hand, life could not have developed without reproduction (the error-free transfer of information to the offspring); the crucial aspect here was that once made, no progress should be lost. On the other hand, offspring that were mere mirror-images of each other would never have enabled new developments or improved capability. How could the one aspect become linked with the other? Up until *Homo proteus*, the direct coupling of mating and reproduction was the only solution. Mating had to immediately precede reproduction in order to ensure progeny of the same species, but also to improve the chances that some of these new variants developed traits that subsequently gave rise to better or new cellular organs or additional organs.

In numerous species of land plants, insects became the effective intermediaries in the first of these two such contrary processes, the fusion of male and female gametes. Flowers served as the requisite auxiliary structures. The insects innately recognize that energy-rich food is available here, and the flower's shape enables it to attach pollen to the visiting insect. This pollen reaches the female flower quite naturally in the course of the insects' activities. Some pollen grains invariably fall onto the stigma of the pistil; the male gametes contained therein reach the egg cells via the projecting pollen tube and the style. Later, the fertilized seeds that arise from this fusion are distributed by a second symbiosis, this one primarily involving birds and mammals. The auxiliary structures here are the conspicuous fruits. Their sugary, energy-rich pulp conceals the functional seeds. The latter are usually further enclosed in a hard shell to prevent them from being digested in the animal's gut (in cherries, for example, this is the cherry seed). The seed itself is then transported over shorter or longer distances by the bird or mammal that ate the fruit; ultimately it is excreted along with the feces, which fertilize the seedling and therefore provide the plant with a good head start.



Note that both processes involve a temporary symbiosis in which the respective insect, bird, mammal or other animal temporarily becomes a component of the plant's capable entity. They are "paid" for their services with energy and useful material, much like humans reimburse those whose services they contract. "Business" is conducted along the same principles in both cases. Plants were the first to take broad advantage of such temporary symbioses, i.e. "renting services" to obtain additional organs. In hypercell organisms, this strategy triggered an explosion of mutual capability enhancements.

In summary, the type of material used in organs and the production mechanisms are as irrelevant as whether the resulting organs are firmly attached to the cellular body or not. Cells are tremendously versatile, transformable and efficient material components, yet also very costly and burdened with serious deficiencies. They must be fed with energy and material and need to be hooked up to the appropriate supply lines, preventing them from forming organs outside the body. They cannot tolerate high temperatures and therefore cannot use metals as structural components. Additional organs, however, suffer no such limitations and can be made of virtually any material capable of delivering the required service. Organs of other organisms or even entire organisms themselves can be transformed into organs of one's own capable entity, either forcibly or by exchange, either permanently or for a limited period of time.

In uni- and multicellular organisms, this method of acquiring additional organs is limited, as is their ability to acquire foreign organs or transform other organisms into their own organs. In the human-based hypercell organisms, many of these limitations no longer apply. We built or obtained an ever-larger number of additional organs, which needed upkeep like their cellular counterparts. The difference was that the former could be put aside and exchanged, freeing the capable entity to adapt to a broad range of tasks. The introduction of money made it simple to rent additional organs as needed; this was less costly than personal property. In the services sector, we use the term "employment" to refer to the more long-term obligations that hypercell organisms enter into. Additional commitments here, beyond payment, might include lodging, paid vacations and social security. They help bind the employee to the hypercell organism's capable entity or to the business enterprise. In short-term contracts, such additional obligations are largely unnecessary, making the employer even more flexible and adaptable in the face of competition.

## 5 Businesses and governments

Just as some species of unicellular organisms aggregated to form larger, multicellular organisms more than a billion years ago, hypercell organisms also began to form larger business organizations designed to take on common tasks. Much in the same way that the cells of multicellular bodies form larger, more efficient organs – such as the fins, eyes and bones – the larger bodies formed by thousands of hypercell organisms are also composed of "departments". Each is entrusted with a specific task: in a business enterprise, for example, these include management with its many executive branches, a production department, sales department, etc., all staffed by many hypercell organisms. In state governments, which are even larger, similar departments arose: the ministry responsible for security within the country's borders, the ministry entrusted with national defense, and other ministries charged with finances, transportation, commerce, etc.

Our conventional way of thinking has made it difficult for us to distinguish terminologically between the multicellular organism "man" and the hypercell organisms he builds. The next step – differentiating between hypercell organisms and a larger business enterprises – is no less easy. In fact, no clear borders can be drawn. When a hypercell organism, for example an industrious master tailor, adds new additional organs to his capable entity (whether they be tools and machines or other specialized hypercell organisms that provide services to him, i.e. employees, co-workers), this gives rise to a *capable entity at a higher level of integration*. The result may be a major enterprise in the clothing industry. The entrepreneur who founded the company can remain at the helm of his/her business for a long time. In the normal course of development, however, this function is at some point assumed by a board consisting of several hypercell organisms (management, shareholders). The transition to the next-larger units – states or governments – is equally fluid. It proceeds via kinship groups, hordes, and increasingly differentiated and organized units; these are initially not bound to a particular territory, but eventually become sedentary and arrive at clearly defined borders with neighboring states.



From the evolutionary perspective, even a superficial examination shows that the semantic differentiation between business enterprises and governments is very difficult, even though we consider both to be quite different. A simple example must suffice here. Every state is composed of its citizens, of the hypercell organisms that these residents build, as well as of business enterprises and other organizations. The state ranks above them all: they are collectively under the jurisdiction of the state's legal framework and are dependent on it in many matters. At the same time, the state – in its function as guarantor of life and property – can very well be viewed as a giant *communal organ* of all its citizens, of the hypercell organisms they form, and of business enterprises and other organizations. This large structure is ultimately under the control of each of these subunits and is, in this sense, their servant, their additional organ.

Before going into this knotty problem and its evolutionary implications, another equally important question needs to be ventilated. One feature common to both business enterprises and governments is their reliance on large facilities and machines that are far removed from being powered by the energy that humans gain from food. In the industrial sector, this is clearly reflected in the ever-larger factories with ever more powerful machinery. In states, this is evident in the public transportation sector and, above all, in the cannons, tanks, fighter planes, battleships and rockets on which our national defense is based. What source of energy powers this equipment?

**Environmental energy directly fuels additional organs**

From an economic perspective, the energy gain in all animals including man is rather inefficient. The organic tissue gained through digestion, and the subsequent breakdown of its molecules and energy transformation within the cells, involves a considerable loss of energy to the environment through transformation and frictional losses in the form of heat (law of entropy). Only a small fraction remains available as useful energy to perform vital functions. The typical loss averages 70 to 90%, leaving a mere 30 to 10% (at times much less) for the animal.

The physiologist Werner Nachtigall calculated more precisely how much of energy released by the muscle cells of a breaststroke swimmer actually went toward propelling the swimmer forward in the water. The loss during the transformation of the chemical energy within the muscle cells (molecular bond energy) into mechanical energy (contraction) was approximately 70%. Nearly 40% of the remainder are lost through friction between the bones (despite the cartilage capsules and lubricating synovial fluids), through tissue deformation, as well as through the acceleration and deceleration of the arms and legs. Of the remainder, an additional 50% are lost in transferring hydromechanical energy to the water as well as through the movements of the fluid layers against one another and the turbulent wake that trails off and continues to rotate until its rotational energy is spent. Since the arm and leg strokes are circular movements rather than being perfectly directed from front to back, their resisting forces are also spread in all directions. The result is a further 60% reduction in usable swimming power (effective forward thrust). The overall efficiency is therefore a mere 4% forward thrust. If we also factor in the losses incurred in originally gaining this energy – the swimmer's job, buying and eating food, digesting and transferring the incorporated fuel (molecules and atoms) into the bloodstream and on into the cells – then the useful energy that propels the swimmer forward is reduced to less than 2%. Ultimately, the energy balance is further burdened by the costs of operating and maintaining the body as a whole; these metabolic costs must pay off. In humans, Prof. Nachtigall assured me, less than 1% of the nutritional energy gained is effectively available to carry out necessary tasks. This, however, means that humans and most higher animals must have an extraordinarily positive energy balance. Specifically, they must consume more than one hundred times more energy than their maintenance costs.



Compared with swimming, *Homo proteus* achieved a much greater energetic efficiency by building a dugout canoe and using additional artificial organs (paddles) to transport himself across a river or lake. However, the energy that fueled this mode of transportation still stemmed entirely from the raw energy in our food. Much greater energy savings were achieved by directly harnessing environmental energy to power additional organs. This is precisely what happened when one of our early forefathers came up with the idea of erecting a mast on the boat, sewing a sail, and rigging the unit with ropes. A new source of energy was tamed. This improvement of the additional organ "boat" forced the wind as a natural source of energy to power the boat forward *directly*. Plying the waters no longer required a tedious and inefficient energetic detour via the mouth, digestive tract, bloodstream, cells etc. Rather, the kinetic energy of the wind was transformed into the kinetic energy of the boat with only little frictional loss. Sailing had the added advantage of being much quicker than paddling.

The capability boost achieved by hypercell organisms and their organizations is largely founded on this principle, namely of powering additional organs by harnessing environmental energy with appropriate equipment rather than using muscle power. In the case of the automobile, for example, we need not consume, transform and apply the energy required to turn the wheels ourselves; rather, the chemical energy contained in gasoline is used to power the car *directly* via the motor. The miller operating a water-powered mill doesn't need to first direct the kinetic energy of the streamwater into his own body to grind the grain. The mill wheel and other additional energy-transforming organs *directly* power the rotational motion of the heavy millstone.

A variety of animal and plant species also directly harness environmental energy. This advance is therefore by no means a true divide that would justify the traditional separation of man's sociocultural evolution from the biological evolution of plants and animals. *Erigone dentipalpis*, one of many species of ballooning spiders, is a case in point. *E. dentipalpis* climbs up to a wind-exposed site and produces a thread that is caught by the breeze. As soon as the thread is long enough to provide sufficient drag, the spider lifts off and is wafted over long distances as if driven by a sail. This may not only improve the situation of the individual spider, but also promotes the dispersal of the species as a whole. As mentioned earlier, many species of land plants use wind energy to spread their seeds. In ballooning spiders, the wind powers the entire body (much like gasoline powers the car we sit in) rather than merely a single organ (water turning the millstone in the mill). In plants such as the dandelion, for example, windborne dispersal carries individual organs (the seeds) over many kilometers, a feat that the plant itself could never accomplish. Nonetheless, these plants also require additional structural features such as feathery projections (like the sailboat's mast, sail and rigging) to successfully exploit additional forms of energy (external energy).



In the sea, many species of animals such as coral polyps forgo the effort of developing the locomotory organs needed to capture prey. They position themselves in suitable locations on the seafloor and leave it up to water currents and wave action to bring planktonic food items directly to them. They merely need to develop tentacles and stinging capsules to capture, immobilize and convey the prey into the gastrovascular cavity. The body of sponges, on the other hand, is full of internal cavities lined with ciliated cells that generate a constant water current into the interior. There, other cells capture and digest the incoming plankton. This has prompted many "lodgers" (worms, small crabs, copepods, isopods, etc.) to inhabit the tube systems of these sponges and to exploit the reliable current, which brings a constant stream of food and an ample supply of oxygen-rich water to meet their energy demands. In addition, the sponge's labyrinth of cavities affords protection from larger predators. In the Gulf of Mexico, Arthur S. Pearse counted 17 128 such lodgers (belonging to 22 species) in a single large specimen of *Speciospongia vespara*. In this case we are dealing with a mild case of parasitism: one organism exploits the efforts of another in order to save energy. Overall, every such exploitation of external energy represents the fundamental capability I term the *utilization of favorable environmental factors*, which is equally important for all unicellular, multicellular and hypercell organisms.

One of the most important additional forms of energy that *Homo proteus* pressed into service was fire, which, through oxidation, converts the chemical energy contained in dead organic material into *heat*. Our forefathers used fire to ward off the cold, but more importantly to cook and roast food. The cell walls of organic tissue lose their toughness when heated, so that the energy and matter contained in plant- and animal-based food can be better digested. While our early ancestors were unaware of this, it did make their food more edible and their diets tastier. Note that this important capability of hypercell organisms – and we are in fact dealing with a true enhancement – was only achievable through additional organs that could withstand high temperatures (hearth, oven, pots, pans). We tend to view this crucial activity, which can only be achieved by organs that are separate from the body, as something apart from the life process. This once again shows how we overrate the "cell" as a building block. It also does little justice to the essence of the phenomenon of life.

Humans are warm-blooded animals. This is a considerable selective advantage over poikilothermic vertebrates such as the dinosaurs, who had to curtail their activities during the night when temperatures dropped. Additional organs that augment the effect of warm-bloodedness are the clothes that warm us and, ultimately, ovens that give off heat. Today we take heating units for granted; from the evolutionary standpoint, however, they have expanded the habitat suitable for hypercell organisms two- to three-fold. Even more so: the colder regions, where the struggle for survival was tougher, put human intelligence to the test. The result was progress and inventions that biological evolution may never have attained under more favorable living conditions. An additional factor was the use of fire to melt metals.



Heat is a form of energy known as kinetic energy (energy of motion). Heat is defined as the vibratory movement of atoms and molecules that cause the heated media, for example air or metals, to expand. Since this movement is undirected, only the expansion itself can be exploited as useful energy, as was done by the steam engines that burned coal as a fossil fuel. This was a crucial factor in enabling hypercell organisms to disperse across all continents and seas.

Crude oil is also a fossil organic substance: burning it in the internal combustion engines of automobiles and airplanes greatly promoted the power base of hypercell organisms. At this point it would be appropriate to say a few words about the importance of *communal organs*. The additional organs formed by *Homo proteus* can not only be put aside and require no nourishment via a continuously operating circulatory system, they have the added advantage that they can be produced by a team of people and can alternately or simultaneously serve many masters. Trains, oceanliners, automobiles and airplanes are striking examples. A single hypercell organisms could never have built one by him- or herself. Teamwork, however, enabled them to be produced, and once means of transportation were built and functional, many other persons who were not involved in the manufacturing process were able to enjoy their advantages; short-term rental (purchasing a ticket) also helped cover the costs of production, maintenance and replacement.

Artificial energy sources, such as gunpowder and dynamite, were discovered. The spear that *Homo proteus* used to hunt and that made him so superior to his early enemies and competitors still had to be powered by energy gained from food. The bow and arrow represent progress in that the elastic bow transformed muscle power into the potential energy of deformation, which in turn was again converted in propelling the miniature spear with even greater energy and accuracy. In this case, however, the necessary energy still stemmed from the very uneconomical breakdown of food. The musket, rifle, revolver and canon, on the other hand, represent artificial organs that are powered *directly* by external energy rather than the body's own energy. This development ultimately led to the rockets with which hypercell organisms not only threaten their rivals on other continents, but which also helped some of our fellow human beings to visit the moon.

Electricity was a decisive discovery in the history of exploiting external energy. This form of energy belongs, together with visible and invisible radiation (waves) and magnetism, to the electromagnetic forms of energy. Its particular advantage in boosting the capability of hypercell organisms and their organizations was the rapid, directed transfer of energy from one location to another. Also, it was easily convertible into almost every other form of energy.



Let us examine a practical example. According to conventional thought, rivers run downhill. Since there is no "up" and "down" in space, rivers actually strive to flow toward the center of our planet. The steeper the gradient, the more energy each drop of water in the river contains. The larger the river, the more water drops bear the respective amount of energy. The origin of all this kinetic energy is the Earth's gravity or, more precisely, the attractive forces that one mass of matter exerts upon the other. The kinetic energy of rivers therefore represents converted gravitational energy. The losses in this conversion are minimal; they are limited to the friction of the river flowing over the stones on the underlying riverbed.

If we install turbines under a waterfall and use these to power generators, then these machines convert the kinetic energy of the falling water into electrical energy, which can then be conducted virtually instantaneously through cables to any desired destination. The conversion losses here amount to approximately 15%, with an additional 1-2% being lost per 100 kilometers of power lines. If the final destination is a factory, for example, then the electricity can be converted into any number of different energy forms, e.g. into light emitted by a light bulb (this is a very costly transformation in which 97% of the energy is lost as heat). It can also be converted back into kinetic energy by being used to power electricity-driven machinery (loss: 8-25%), converted into heat by electric ovens (loss: virtually zero), or transformed into bond energy through chemical processes that combine atoms and molecules into new plastics. Finally, it can also be transformed back into gravitational energy if an electric pump is used to pump water into a higher reservoir (i.e. one that is further away from the center of the Earth); in this case, the water is a source of potential energy that is impotent until the tap is opened and the downhill-flowing water can be reconverted into electrical energy through turbines and generators (overall loss in this transaction about 25%). The above example clearly illustrates what the renowned chemist and philosopher Wilhelm Ostwald meant when he termed electricity a "jack-of-all-trades".

There is a remarkable relationship between electricity and money: Just as money can convert one type of service into virtually any other type, electricity can also convert almost every form of energy into any other form. If, as I outlined earlier, money enables shifts of great evolutionary significance, then this is analogous to the conversion between different forms of energy. Such energy transformations enable equally momentous boosts in capability. Just to pick an example, this is the case when electrically operated news services such as radio or television transmit information that averts a global catastrophe.

As modern physics has shown, the greatest energy source on our planet would be the conversion of mass into energy. Einstein was able to define the precise relationship (mass-energy equivalent) with the astonishingly simple formula $E = mc^2$ (energy E equals mass m times the speed of light c squared). This means that every kilogram of a particular substance, i.e. 1 kg hay, 1 kg diamonds, 1 kg oxygen or 1 kg meat, have the same potential energy, namely $9 \times 10^{23}$ erg. This is equivalent to 100x the energy released by the atomic bomb dropped over Hiroshima. Humans and the hypercell organisms they form are currently investing huge sums of money to harness and subjugate this form of external energy to further their own goals. One consequence could well be the self-destruction of the evolutionary process on our planet.



**Business enterprises**

Throughout evolution, increasing size has always turned out to be an selective advantage. Larger fish eat smaller ones; amoebas engulf the much smaller bacteria and convert them into food; larger buffalo drive smaller ones away from the waterhole or, in the mating season, away from the females; the collective unit formed by piranhas or a wolf pack is far superior to the prey they surround and attack from all sides. It would therefore contravene biological laws if the hypercell organisms formed by humans did not show the same tendency: capable entities do, in fact, continuously grow by adding ever greater numbers of employees, tools, machines, buildings and other functional units in order to surpass and eclipse the competition, and to achieve even higher returns.

Note once again that I define a hypercell organism to be every person who increases the capability of their somatic body with additional organs and who, via learning processes, "wires" their brains to better perform some job that secures their existence. Early in human evolution, this was restricted to optimizing foraging and hunting strategies and competing against other humans. As the social groups grew in size, hypercell organisms began to specialize in producing additional organs or in providing services for other members. In return, they received money with which they could purchase food, products, or services from others. This new form of business involves a "two-fold exchange" in which the food (energy) that fueled life was not gained directly. Rather, money served as the mediator. Money is by no means a new manifestation of energy in the physical sense. In the framework of a well-functioning economy, it represents a remittance for tasks fulfilled by others, with one such task being the provision of food. This explains why food items can be much more expensive in one location than in another. There can be no precise key for converting money into energy. A one-hundred-dollar bill is of little use to the traveler who is lost and starving in the desert. On the other hand, money can be variously converted into energy units. Not only can it be used to buy food to power the body directly, but it can also pay for fuels to drive machines. Above all, money can be used to purchase a wide range of products that others produce and sell, i.e. that are the product of specialized energy inputs or of services, which themselves merely represent the result of differentiated energy inputs.

As I have indicated earlier, no clearly defined boundary can be drawn between hypercell organisms, which are geared toward satisfying a wide-range of demands (in a wide-range of markets), and business enterprises, which I will continue to term businesses based on the traditional understanding of the word. Perhaps the main difference is that businesses are *supra-individual* organizations in which virtually every unit (including the owner) is exchangeable. They can develop through steady growth, but another equally common strategy is for several hypercell organisms (business executives) to identify a promising new market and pool their resources, interest financial backers for the project, purchase the necessary real estate, and commission the necessary factory buildings and other means of production. Like Aphrodite's birth from seafoam, within a relatively brief period a new industrial enterprise, a new living entity, arises and quickly enters the fray of the business world.



*Reproduction* is one vital fundamental capability which saddles all organisms with considerable constraints. I have already mentioned that reproduction no longer needs be pursued by hypercell organisms themselves because their genetic makeup no longer requires them to reproduce in a species-specific manner. If the appropriate demand arises, then new members of the "species" appear on the scene all by themselves – financed by nascent competitors. This may appear grotesque at first glance, but it reflects reality and is fully conform with the fact that conspecifics, from the onset of evolution, were the strongest food competitors: they were designed to exploit the very same energy and material resources. This makes for a rather curious situation in which each individual uni- or multicellular organism is *genetically compelled* to apply the fruits of its labor to creating its own competition. Evolution was forced to accept this handicap over most of its course. For us it is self-evident that every frog can only produce spitting images of itself and that each fir tree produces only new fir trees. Hypercell organisms were able to cast off this specific reproduction in one fell swoop thanks to the mental capabilities of *Homo proteus* and to his array of additionally formed organs. Human beings, depending on their talents and their assessment of currently promising markets, can pursue a very broad range of income- (energy-) providing business opportunities. The same holds true for every business enterprise. At least in the market economy, none are forced to spend their hard-earned profits to found additional companies whose products are not in demand and therefore unprofitable. New businesses can therefore arise by any number of means; this type of genesis clearly impacts the evolutive process far less than wastefully investing profits in sectors with no chance of success.

Due to their size, businesses often, but not always, have considerable advantages over hypercell organisms. All those people who invested heavily to raise starting capital have a personal stake in seeing their investment turn a profit. The result is that businesses have a much stronger power base than an individual hypercell organism. Thanks to bigger and better-equipped facilities, mass production allows them to offer their products or services at lower prices than smaller competitors, who must cover their costs with considerably lower turnovers. Above all, large businesses can manufacture products whose capabilities exceed those of even the most successful hypercell organism, namely automobiles, airplanes, major construction projects, space technology and other cost- or labor-intensive projects.

While hypercell organisms remain more or less distinct, functional extensions of individual human beings that have merely boosted the body's capability with additional organs, major businesses clearly represent living entities at a higher integrative level. They are higher-order organisms with a correspondingly strong power base: subjectively, we shy away from acknowledging their affinity to unicellular and multicellular organisms because their physical structure is so radically different. This viewpoint will need extensive reconsideration once we recognize that capabilities rather than external appearance are the characteristic feature of all organisms. Natural selection is the ultimate mediator in deciding what qualifies as an organism. Based on the impact exerted by humans and their hypercell organisms, many additional factors have come into play in the selection process: the legal framework in the various countries, the job market situation, the available means of transportation, the stability of the currency. The traditional criteria, however, have lost none of their importance.



Just like a living plant or animal, every business must chalk up a positive energy balance. In the event of failure, the government or the banks may step in over the short term to help save jobs. In the long run, however, if operating costs remain in the red (the financial balance sheet is the key statistic describing energy and material gains as well as other performance criteria), then the business is doomed just like any plant or ladybug that fails to meet its output target. A company that is unable to withstand predatory practices, unfavorable environmental conditions or competition inevitably suffers the same fate as an earthworm facing the same pressures. Closer scrutiny of these so widely diverging entities reveals astounding parallels.

Whether this body be an earthworm or the Volkswagen concern: the parts that make up the capable entity must *somehow be interconnected*. The earthworm impresses us as being a single, solid unit. Yet when we examine it more closely, we discover that tonofibrils in the cell membranes are responsible for connecting each individual cell to the other highly specialized units; other units such as dermal layers, ligaments and muscles attach other organs and tissues to one another. In the Volkswagen concern, workers and employees are bound to the company by wage agreements and contracts, while machines and facilities are company property based on rights of ownership guaranteed by the government (and paid for through taxes). Here again, many roads lead to Rome. For natural selection, or in Spencer's words for "the survival of the fittest", only the concrete result counts, regardless of how it came about or what it looks like.

Let us examine another vital capability common to the internal structure of both "Volkswagen" as a business and the "earthworm" as an organism: the coordination of internal processes.

Granted: this coordination is less complex in the worm. Nonetheless, when it burrows its way through the soil, the muscle cells must fulfill their task in an orderly sequence, and the sensory organs must convey their signals to the responsible control centers, which must interpret and coordinate them correctly. In the Volkswagen facility, the task is to monitor the activity and coordinate the output of thousands of workers and machines. This bustle would be reduced to cacophonous insignificance and chaos if each task were not performed at the correct location and at the precisely the correct time.

Perhaps a third and final example can make the seemingly impossible possible, namely force our brain - despite all its experience – to recognize that the Volkswagen concern and the earthworm are comparable entities. A vital prerequisite in every living organism is that its organs be neither too large nor too small: they must appropriately dimensioned to meet the demands placed on them by the whole. The Volkswagen concern consists of tens of thousands of functional units (organs), whether they be hypercell organisms, machines or assembly lines. The company would soon succumb to other auto manufacturers if key components were over- or under-sized by a factor of three. This would lead to major unforeseen expenditures and weak points that would cripple competitiveness. Simply put, the components responsible for any organism's overall capability must *match with one another*. Every factor that represents a weak link or entails superfluous expenditures is far more critical in real life than any difference in impression we may have of automobile plants and earthworms.



The list of functional correspondences between the Volkswagen facility and the earthworm – indeed between any business and any multicellular organism – are endless. Every organ in either realm must be maintained, inspected, and repaired or replaced as the need arises. Each must be provided with energy. Each must be rid of waste products. Each organ that operates below full capacity is a potential threat to the output of the whole. Functionless units (regardless of how they came about) are a handicap, a disadvantage in both systems. They take up space, must be detoured, run up additional costs and can trigger disturbances. Here, businesses are at a clear advantage over multicellular organisms: they can simply discard functionless or decrepit units. Should these units still have a market value, they can even be sold. If not, they can at least be removed from the facility. In multicellular organisms, however, it often takes many millions of years to reduce a superfluous organ. In both cases, the lock-and-key analogy best describes the relationship between each organ and its task. The bit of the key represents the required task profile. The tighter the tolerances, the more efficient the process. In both cases, the lock (the required task) thereby controls the necessary shape of the key and bit (task profile). The more we analyze the inherent functionality and interactions of organic bodies and their organs, the clearer this correspondence becomes. This is as true of businesses and multicellular organisms as it is of all unicells and hypercell organisms. It is valid for virtually all vital, life-promoting structures in time and space.

My theory therefore distinguishes four major groups of structural entities that perpetuate evolution, each with many transitional forms and intermediate stages.

*First*: Unicellular organisms. They encompass all early stages in this evolutionary series and ultimately lead to the highly differentiated, extremely efficient unit we refer to as the "cell".

They comprise a broad range of species adapted to various lifestyles, allowing them to conquer the world's oceans and other aquatic systems.

*Second*: Multicellular organisms, a group in which the cell – the highly complex life form that dominated the sea – became a building block of even larger organisms. About 400 million years ago, the increasingly efficient members of this group succeeded in conquering land. They ultimately gave rise to human beings.

*Third*: Hypercell organisms. They originated from humans, whose mental capabilities were particularly well developed. While other organisms had already formed organs that were separate from the body, man did this consciously and purposefully, enabling him to boost his capability many-fold. Each hypercell has a human being at its center, enabling it to produce – by acquiring artificially formed organs – ever larger, more efficient species of hypercell organisms.

*Fourth*: Business organizations. They are composed of numerous hypercell organisms, are capable of tapping new energy sources, and develop an internal momentum that enables them to multiply their power and capability. Today, the wastes they produce and their other negative impacts make them a threat to the entire evolutionary process, including themselves.

At each of these transitions, independent living individuals became organs of larger entities. Conflicts of interest were inevitable.



**The state**

Businesses represent a direct continuation in the developmental series from unicellular organisms, multicellular organisms to hypercell organisms (as far as acquisition, growth, reproduction, competition and increased capability is concerned). States or governments are a more complex phenomenon. In his book "Allgemeine Staatslehre" (1925), the philosopher of law Hans Kelsen underlined that it was possible to discern more than a dozen entirely different meanings of the word "state", even "with an only superficial perusal of the scientific terminology". I believe my theory is in a position to at least show where this definitional Gordian knot lies and how it might be unraveled.

My line of argument is *not* based on a historical perspective. Rather, it begins with the contention that there is a *compulsory*, forthright causal relationship between the underlying structure of *all* successful states – as different as their external appearances may be – and the formation of additional organs by human beings. This bold approach goes beyond superficial similarities, as an analysis from the evolutionary perspective shows.

All additional organs have a clear advantage: they can be set aside, exchanged, need not be nourished by the bloodstream, and need not be produced by the organisms themselves. An inherent feature is that *communal organs* can be produced by a group of hypercell organisms and then used either proportionately or alternately to satisfy individual needs. In *Homo proteus* and his descendents, such additional organs enabled a previously unattainable form of organization based on manifold specialization. These organs ushered in the evolution of hypercell organisms, which then proceeded to take advantage of novel life strategies; this process continues to bring forth new species to this very day. Communal organs also led to the introduction of the mediator "money", which enabled hypercell organisms and business organizations to acquire ever new capabilities. This went hand in hand with the ability to exploit new sources of energy and apply environmental forces in order to power additional organs *directly*. This, in turn, was the prerequisite for developing ever-larger businesses and corporations, culminating in unbridled industrial production.

The long list of significant advantages afforded by man's additional organs is offset by a number of major disadvantages. One disadvantage was particularly grave: organs not firmly attached to the body were *easy to steal*. This raises the acute problem of how to protect them from theft. Their very nature makes them equally suited to serve other humans, other hypercell organisms, or other businesses by boosting the effectiveness of the respective capable entity.

This was a novelty in evolutionary history. While animals can consume other animals, they are unable to utilize their preys' cellular organs for their own purposes. When a lizard devours a dragonfly, it cannot fly with the insect's wings. In order to add new tissue to their bodies, animals must break the organic material they consume down into its smallest components and then exploit the energy and matter contained therein. An average of 90% of the consumed energy is lost in this process. In addition, each animal can develop only those organs whose structure is coded in its genetic makeup. When one human steals a tool from another, however, he or she can use that tool with no loss of value whatsoever. Should the theft involve a bicycle, and the thief have no experience in riding bicycles, then the new owner can receive instruction in the art and learn to use the vehicle. In biological terms, the thief in effect becomes a lizard that *can* fly with the prey's wings. One consequence is that the additional organs of humans exert a strong inherent *attraction* on others to steal them. From their earliest evolution, hypercell organisms attacked one another to gain possession of weapons, tools and other additional organs. They also stole food and took slaves, thus further increasing the power of their capable entities. Later, in wars of conquest between states, the bone of contention was land, i.e. more territory and natural resources. The underlying lure of all such pillaging is the prospect of acquiring additional organs, especially money and valuables with which such organs can be easily obtained. Hypercell organisms also had to protect their goods from thievery by those *within* the group, the settlement, the tribe. How could these goods be protected?



Weapons and other valuables can be hidden or buried. Such hiding places, however, are more often than not discovered and plundered. Additional organs can also be locked in buildings or secured in rooms or containers. Even these barriers do not necessarily thwart the thief. I merely wish to show here that specially made additional organs ushered in a new era in evolution and boosted our power, enormously accelerating progress; at the same time, however, they were heavily burdened by the need to be effectively protected. Their advantages could be fully exploited only when anti-theft measures to safeguard these physically unattached objects were in place. I argue that only one option was available here. Just once, only a single road led to Rome. Only organized groups were in a position to provide the necessary protection – by forming extensive communal organs to counter theft.

Obviously, governments fulfill a wide range of other tasks as well, and we will deal with these at a later stage. Here, I merely contend that a direct and obligatory relationship exists between the additional organs formed by man and the government agencies designed to protect these organs. The development of hypercell organisms could never have taken place without such agencies. One could not have been realized without the other: no state protection, no higher evolution based on additional organs.

It is admittedly a daunting task to causally link a process (formation of additional organs by man) that took place at the dawn of human history with the realities of modern states. However, I continue to maintain that each piece of equipment that serves man and his organizations has costs that go beyond those incurred in its production. Specifically, each contributes to the costs that society must pay for the communal organs that protect these items. Without these security measures, such items could neither be produced nor utilized.

The key elements in the communal strategy to ward off predatory interests are well known and need only be roughly outlined here. Protection against outside enemies (countries) requires a complete national defense system (fortifications, armed forces, fighter planes, warships, rockets). Protection from the enemy *within* calls for a legal framework coupled with a police force, judicial system and jails. The latter, basic government functions are subsumed under the terms legislative, executive and judiciary branches. The forces that protect us from outside threats, as well as those that maintain internal security and protect life and property (i.e. the natural and additional organs of hypercell organisms (citizens) and their organizations) must be financed in one form or another by members of the union, usually by some means of taxation. This calls for yet another organization and entails considerable additional effort. Finally, this gigantic security organ, like any other organ, requires a *control mechanism*.



Herein lies the Achilles' heel of the entire system. If the organ is to be successful, especially when external security is involved, then quick decisions and corresponding authority are crucial. History is full of cases in which the top military leadership used its competence to press the entire communal organ into service for its own personal capable entity. The military usually swears allegiance to the state. Under suitable circumstances, the entire state structure (constitution) can be fully transformed within days or even hours. The result may be an absolute monarchy or a tenacious dictatorship. The internal organization need not necessarily undergo major restructuring. Opponents of the process must be neutralized and strategic changes made to certain laws. Nonetheless – and this is the essential point – the need for external and internal security, along with the necessary funding, remains unchanged. The new strongman can distribute key posts to friends, family members and experts who are willing to provide their services for good pay. The police force is beefed up by additional units charged with protecting the new ruler and enforcing his edicts. This ruler can confiscate whatever he sees fit and enjoys a wealth of other advantages. If the strongman doesn't overstep the mark and rules skillfully, the populace (the hypercell organisms in their entirety, along with their organizations) may even grow to accept the new regime after the initial stir has died down.

Our concern here is the theoretical, evolutionary aspect. A gigantic communal organ changes ownership due to a weak point that is difficult to avoid. A major shift – in the sense of a sudden boost in the capability of one particular individual – takes place. A society with an enormous communal security organ suddenly mutates into a major business enterprise in which, in the extreme case, the "shares" are all in one hand.

A form of state that essentially consists of a single society of hypercell organisms, a clearly defined territory (national borders) and a large communal security organ is said to be extremely liberal (the French astronomer Pierre-Simon de LaPlace termed it a "night watchman" state). Whether such a state actually ever existed in pure form is not the issue here. From our perspective, however, it defines the minimal size of the communal organ necessary to protect all the hypercell organisms in the state, i.e. all human beings and their additional organs, against predatory activity.

In practice, this minimalist state automatically takes on further tasks that the community deems necessary or desirable. Examples include bridge construction and road building, laying of water lines and sewerage systems, public transportation, a postal system, utilities, the formulation of civil law, the opening of schools, the establishment of a national bank charged with printing money and maintaining stable exchange rates, and the erection of public libraries. Embassies in foreign countries become essential. The burgeoning costs require a larger Ministry of Finances. Depending on the priorities of the society, additional social institutions are soon founded: hospitals, homes for senior citizens and nursing homes, unemployment and pension funds, state-owned industries, promotion for trade and commerce, natural catastrophe funds, etc. This leads to a state with a network of public servants and government employees. Democratically run states tend to increasingly resemble a higher-level organism striving to achieve economic growth, progress, justice, peace, and a balanced budget for the common good. The result is a large, independent, living body that Georg Jellinek – from the perspective of political science –described as the "complete state" (1914) and Herbert Krüger as the "modern state" (1964). The hypercell theory maintains that this form of state cannot do without a communal security organ to manage external and internal affairs. While it is difficult to specify the actual cost to the overall budget, the fact remains that the evolution of hypercell organisms and their organizations, particularly businesses, would never have been possible without such security agencies.



We need not go into further detail here. Virtually every conceivable form of state has been attempted in the course of history, and the respective advantages and disadvantages of all have come to light; none has proven to be universally optimal. In times of political, economic and social turmoil, more rigidly led systems are successful, while in peaceful times less authoritative regimes prevail. From an economic standpoint, government organizations are monopolies with all their inherent shortcomings. When competition is missing and government employees have life-time job security, then initiative tends to become stifled, except for those who seek top posts. The inevitable result is a bureaucracy whose members tend to fulfil their tasks with the minimum of effort, to feign problems, and to studiously avoid any risk that could endanger their largely preordained and secure careers. A further problem is the fact that the government – as a gigantic organ (or gigantic enterprise) – is often the main contractor for many branches of industry, and awarding major contracts is automatically associated with bribery. If the state is run by political parties that battle each other for dominance, then these tend to act like commercial enterprises and place more emphasis on their coffers than on state interests, even if they never tire of claiming otherwise. The brief legislation periods between elections further detract from implementing necessary long-term, unpopular measures. When upper classes rule the state, as was the case during feudal times, then the enduring communal organ becomes, as correctly expressed by Karl Marx, a "tool to protect privileges". As clearly demonstrated by John Kenneth Galbraith, in modern times large states tend to allow certain state agencies, particularly those charged with defense and space exploration, to enter into a symbiosis with major industries. As mentioned above, any form of state can quickly flip into virtually any other, whether this be triggered by revolution, coup, legal accession to power, or military conflicts with other countries.

From antiquity, philosophers and thinkers from various schools of thought and scientific disciplines have dealt with the phenomenon of states. Many have compared states to an organism. Plato referred to the state as "a human being enlarged", while Aristotles spoke of "an organism with a soul". The English philosopher Thomas Hobbes saw the origin of human states in fear and termed the state "an all-devouring monster". Johann Gottlieb Fichte considered it to the "organic manifestation of God". Friedrich Wilhelm Joseph von Shelling wrote that the state is not the means to a particular end, but rather the "construction of the absolute organism". In his "Grundlinien einer Philosophie der Technik" (1877), Ernst Knapp characterized the state as an "organism fashioned after the human body". After 1890, the eminent zoologist Oskar Hertwig closely examined the state as a phenomenon and termed it "a higher form of organism, higher than man". In 1924, the Swedish historicist and state theorist Rudolf Kjellén went so far as to place plants, animals and man alongside the state as a form of life. He circumscribed the state as "a true personality with a life of its own", as "an organism in the biological sense".



From the viewpoint of the hypercell theory, some forms of state are, in fact, directly comparable to organisms; after all, in the case of dictatorships and absolute monarchies, states are the extremely extended capable entities of individual hypercell organisms, whereas pirate states and theocratically or ideologically governed states with centralistic economies tend to resemble large corporations. The essential feature common to all, however, is that their core structure is a consequence of the additional organs formed by humans. This core structure is the large communal security organ, without which the third and fourth eras of evolution would never have taken place. This organ also represents a considerable source of energy that hypercell organisms and businesses exploit in numerous ways. Engels’ statement that "the state will not be abolished, it will die off" is highly unlikely from the evolutionary perspective. Without powerful communal security organs, the technical boost of capability that accompanied the advent of man would not have been possible. Should a world government be established at some point in the future – a development that is entirely conceivable considering the environmental issues we face – then external security needs would dwindle, whereas internal security would gain even greater significance.

# 6 Efficiency and its quantification

Before turning to the interesting question of what happens with the considerable profits that hypercell organisms and businesses turn (the subject of Chapter 7), I would like to support my contention that the evolution of unicellular and multicellular organisms is seamlessly continued by that of hypercell organisms and business organizations. To our senses, the difference between plants and animals on one hand and gainfully employed persons and industrial enterprises on the other is so great that I wish to present a particularly important piece of evidence for my theory before broaching the delicate issue of man's position in this process.

As already mentioned at the onset of this book, Darwin considered it impossible to more precisely determine what features of a plant or animal species made that species superior to and ultimately capable of displacing another in the intricate web of ecosystems in nature. As long as we consider the material structures and behavior of living organisms to be the factors determining competitiveness, then it is, in fact, difficult to decide where to begin our investigation and where to set our measuring instruments. The bodies of multicellular organisms, the forms their organs take on and their behavioral repertoires are so complex that it would seem hopeless to search for common criteria that could universally determine selective value. Every biologist after Darwin shared this opinion. This is underlined by my argument that "many roads lead to Rome" as far as most vital capabilities are concerned. At best, examining a particular "road" can provide information on the effectiveness of that road; this, however, loses significance when in the same capability can be delivered better by other organs or behaviors. Perhaps in extreme environments, inhabited by only few species, we can draw conclusions as to which traits make one species superior to the others, much as we obtain certain insights into this problem when we transplant exotic animal and plant species from one part of the globe to another: some species turn out to be extremely successful in the new environment, while others fail miserably. Based on the above considerations, any claim that the competitiveness of all organisms can be measured using the same criteria, or that these quantifiable criteria are equally valid for the structures and organizations formed by humans, would have to be considered highly implausible.



On the other hand, viewing capability rather than the material body or behavior as the crucial trait (as natural selection would suggest) alters the picture. After all, the *efficiency of capabilities* can be measured. Moreover, the relevant criteria are very simple and valid for all phenomena of life.

### The three criteria of efficiency

I subsume these three criteria under the terms "cost", "precision" and "time required". Under cost I understand the average energy required to attain a particular capability. This is quantifiable in energy units or, in the case of hypercell organisms and businesses, with the financial effort required to attain that capability in a specific region. A certain discrepancy arises here due to the floating conversion rate between money and energy. This, however, does not affect competitiveness because every competitor is equally affected by the local conditions. I chose the term precision to define the quality and reliability of a capability: how often per hundred attempts does it deliver the sought-after capability, i.e. how often is it successful. This value can be determined statistically and expressed in percentages. Required time, the third criteria, involves the average time that a particular capability takes, a parameter that can be quantified in units of time.

It is not my intention to present a detailed account of efficiency theory here; this would by far exceed the bounds of this book. I do, however, wish to point out the underlying, inherent affinity of the various expressions of life with a few selected examples. I challenge the reader to take the next step and, depending on his/her knowledge and interests, to pick out additional examples from everyday life and to submit them to the above-mentioned efficiency criteria. Whether these capabilities lie in the realm of unicellular and multicellular organisms, hypercell organisms, or business organizations is of no import.

I will begin here with unicellular organisms and contend that the costs of vital capabilities determine the vitality and selective value of every species. As indicated earlier, energy is the cornerstone of the entire phenomenon of life. When animals feed, most of the consumed "raw" energy is lost in conversion processes, leaving only a minute fraction – as "useful" energy – available for necessary capabilities. This highlights the importance of a positive energy balance, especially in critical phases of the life cycle. If a shortage of food leads to a negative energy balance, then the animal can mobilize reserves and break down body tissue to remain alive; should the balance still remain negative, then the life process slows down and eventually grinds to a halt, resulting in death. This makes it vital for every animal, and more generally every living organism, to achieve its capabilities with the least expenditure of energy. If the capabilities of two competing animal species A and B are equivalent except that A can attain capability x with equal speed and proficiency yet much more inexpensively, i.e. with less energy consumption than B, then A is no doubt at a considerable competitive advantage. In hard times, this can decide over life and death for B.



The situation is no different for hypercell organisms and business organizations. Here, money pays for the necessary foodstuffs and materials, the bills for the work done by employees, and the fuel that powers the machines, whereby the competition is stuck with the same or very similar exchange rates for converting money into energy values. There is no need to dwell on the role of positive financial balances in the economic sector. Hard times separate the wheat from the chaff here as well. During economic downturns, the banks, the government or friends may pitch in with credit; nonetheless, should the balance books of a tradesman or business remain in the red, their commercial activities are bound to grind to a halt. The tradesman must close his shop or business, the business enterprise must file for bankruptcy.

In order to survive in the business world, cost reduction has become the catchword at every phase of operation. Again, if competitors A and B run head to head in every respect except that A has lower expenses than B in exercising an important capability, then A has a distinct advantage over B. Since total cost is the sum of the costs for each business organ and activity, "cost" as an efficiency criterion is valid not only for the hypercell organism or business as a whole, but also for each functional component (organ).

We have thus discovered an innate affinity between all unicellular and multicellular organisms, hypercell organisms and business enterprises; however, this universally acknowledged "economic principle" continues to elude our sensory apparatus. Nonetheless, every organism (a term that we continue to apply here to the capable entity formed by hypercell organisms and businesses), regardless of the how much it may differ in size or structure, is dependent on the efficiency factor "cost". This factor clearly also strongly influences the effectiveness of natural selection. Efficiency and survival at all levels, whether it be competition in animals and plants or in every business founded by man, involves achieving maximum gain while reducing cost to an absolute minimum. In other words, the universal strategy is to attain the same goal with the least expenditures.

Every component of these so very different entities, and the specifications of each component, is important here. Cutting costs at every opportunity without reducing the quality or speed of the overall capability is not only important, but vital. This can be achieved either by improving the organs in one way or another, or by providing the necessary capability by other means, i.e. other organs. Hypercell organisms and businesses have the decisive edge as far as the second strategy is concerned. While such improvements in uni- and multicellular organisms require changes in the genetic makeup and corresponding changes in cell activity and differentiation, our exchangeable additional organs allow suboptimal products to be replaced by those that help deliver equivalent capabilities at lower cost. Employees and hired services can also be replaced by others. These organisms are therefore much more flexible and adaptable.



Furthermore, it is irrelevant whether improvements are achieved by chance or through human intelligence. The *result* is all that matters. Improvements can clearly be accelerated if human intelligence is applied, and additional organs do allow progress beyond anything cell differentiation could yield. On the other hand, the human mind by no means guarantees that our activities actually lead to improvements: while the odds are considerably higher, it is the result rather than the production method that counts.

We can now turn to the second criterion of efficiency: precision. Its definition is much more complex than that of cost, which can be easily determined and compared. Precision as a criterion involves how often a capability is successful and how often attempts miss their mark. The organs and their activities, which work in concert to achieve a particular capability, must often fulfil a wide range of very different requirements. They can be compared to a key, which must have a certain configuration in order to open a particular lock. In the case of a key, the profile of the bit is decisive. It is shaped in such a way as to open the lock mechanism. Should one of the teeth be too long or too wide, then the key cannot turn the lock or open the lock mechanism. In this very sense, every organ must be built to meet every task put to it. Our eye, for example, must deliver an entire set of capabilities before the required overall task, namely providing us with an visual impression of our environment, is fulfilled. The lens must be as intact as the pupil, the light-sensitive eyeground equally functional as the muscles that move the eye. Should only one of these components be defective, then the consequences are the same as when one of the key's teeth are broken off and the lock remains closed: the eye cannot fulfil its function. A hammer turns out to be a much simpler key when viewed from the same perspective. Its task is to enable the human hand to drive in a nail. The flat, metal head and the handle, whose size must be adapted to that of the hand – just as the flat surface of the head must fit the nail – serve this purpose. To use the same analogy, this "key" therefore has much fewer "teeth". Nevertheless, without these few crucial teeth, it would also be unable to "open" its lock (i.e. fulfil the task of hammering in the nail). Let us examine a third case: the production department of a business that manufactures certain goods. It consists of many specialized persons (hypercell organisms), buildings, machines and tools, i.e. it is comparable to a key with many teeth, all of which must be present in order to fulfil the required task. As an efficiency criterion, precision shows how well the "fit" between a particular organism or its organs and the task at hand is. Just as security locks can only be opened with very special keys, there are tasks that can only be completed by very precise skills. Further criteria, such as proneness to breakdown, regenerability after damage, sensitivity to environmental influences, i.e. reliability in the broadest sense, play an additional role in this fit. If a facility produces 4% rejects when manufacturing a particular item, then its precision is 96%. Birds that pick at seeds and miss every second one have a mere 50% feeding efficiency.

Traditional avenues of thought must be modified if we wish to apply the term precision to those forms of energy gain that involve exchange processes. A manufacturer's source of profits is the demand for the products or services that he/she delivers: the lock that must be opened is the wishes of the customer. The closer a product mirrors the desires and needs of the public, the closer the fit, i.e. the more precise the purchase becomes. Any product that meets 80% of the customers' wishes has a competitive advantage over those that only attain a value of 50%. A company that advertises an opening for a new production manager must consider a wide range of skills. Among the many applicants, the person who most closely fills the outlined duties will ultimately be chosen. In the business world, one refers to a job profile that should match a certain performance profile as best as possible. The teeth of such a key can be very different indeed: technical skills, character, family status, distance of commute between home and workplace, etc. When examining any organ of an animal or plant, or in scrutinizing any functional component of a hypercell organism or a business, we must always ask: what demands are placed on these units and what tasks must they carry out? From this we can deduce the features and capabilities that the particular unit must have. In each case, the degree of fit provides information about the degree of precision. This can generally only be determined based on empirical values or quantified a posteriori. The fact remains: the better an organ is adapted to its task, the greater the advantage to the organism it serves. In the business word, a poor fit is known as "internal friction" or "poorly invested capital". Regardless of whether the unit is a unicellular, multicellular or hypercell organism, a business or the government itself: the precision with which it fulfils its task is no less important than the associated costs.



As an efficiency criterion, precision – just like cost – is equally valid for the overall organism and for its individual components. The better a business or a hypercell organism is adapted to its customers' wishes and to the environmental conditions, the greater its selective value, i.e. its ability to persevere in the struggle for survival. The better plants or animals are adapted to energy and material sources and other critical environmental conditions, the greater their precision and the respective selective value.

My primary concern is to use a broad spectrum of examples to draw the reader's attention to the fact that the colorful world of animals and plants on the one hand, and the no less colorful diversity of the human-based hypercell organisms and their organizations on the other hand, have much more in common than first meets the eye. Thus, the two efficiency criteria of precision and cost are equally important in determining the competitiveness of *all* expressions of life. It is ultimately unimportant whether the units under consideration are the tiniest functional component of a cell, the building material of some additional organ, the highly complex ganglion networks in animals and humans, the blueprints of an assembly line in a factory, or ultimately even a government legislature: in all of the above, the criterion "well or less-well adapted" reflects the precision with which the task at hand is accomplished, much like the criterion "highly or less cost-effective" is decisive for a particular capability that is being pursued.

The third criterion of efficiency, time required, is also instrumental in influencing the selective value of the functional units that propagate life, although not always and everywhere. For example, no selective advantage is involved when a particular organ within the animal completes its task at twice the speed that the interplay of the other organs requires. The same holds true for the assembly line worker who completes his or her task much faster than required by the overall production pace. The essential factor is the coordination of all natural and additional organs. This does not only mean that one organ should not block or otherwise disturb another; rather, the temporal coordination, the concerted activity, is crucial. Wherever a particular function lags behind, a bottleneck arises, a weak link in the chain develops. This manifests itself in animals and plants as well as in the human body when we become ill or some organ becomes injured. The repercussions are no less grave in businesses, in industry or in governments when an important organ or key process breaks down. In this respect, the efficiency criterion "time required" is also a factor in the internal processes of living organisms: they should proceed neither too quickly nor too slowly.



As far as gaining energy and repelling enemies is concerned, the criterion time required plays exactly the same role in hypercell organisms and businesses as it does in uni- and multicellular organisms. "The early bird catches the fly" is an old proverb. When plants sprout from the ground in spring, those individuals that grow quick enough to lift their leaves above those of the competition are at an advantage. In the business world, the same advantage is garnered by those who can recognize and satisfy a newly developing market before others do. Animals that move faster than their competitors will not only be better equipped to outrun their prey, but will also be able to flee faster. Throughout the course of history, states whose armies were able to occupy strategically important locations more quickly than those of other states won the upper hand.

Finally, efficiency requires a *balance* between the criteria of cost, precision and time required. The greatest advantage would clearly be gained if a task could be completed quickly, inexpensively and at a high level of precision. This is rarely the case in nature. The *correlations* between the three efficiency criteria are thus all the more crucial.

Wherever speed is the key objective in a particular form of business or function, then this is almost inevitably linked with lower precision and higher costs. The home-builder who wants his or her house to be completed within one year instead of the projected three years can be accommodated; however, he or she must pay considerably more and accept the risk of shoddy workmanship and architectural shortcuts. Those who require greatest precision, such as in military operations or other high-risk projects, cannot afford to cut any costs and must be in a position to patiently wait for the right moment. Whenever the main priority is to keep costs down, then patience is also a virtue and certain flaws will have to be accepted. As in all facets of life, the correct balance is crucial.

In the business world, the term "quality" is often used in the same sense as my definition of the word "precision". While this may be entirely justified in some cases, it remains problematic in the sense of a clear terminological distinction. In business, after all, quality is used to describe optimal customer satisfaction. This often (justifiably) entails making certain that the product is not overly expensive and that delivery and potential maintenance is speedy. In this light, "quality" may in fact encompass all three of the above-mentioned criteria – precision, cost and time required – in effect defining the optimum as the perfect balance between these three. For this reason, and because "quality" is saddled with overtones that are inappropriate for biological organisms, which are not created by an act of will, I continue to prefer the term "precision".

I first published this framework for evaluating selective values and competitiveness, which I hold to be equally applicable and valid in every level of evolution, in 1970, albeit in abbreviated form. Since then I have presented it to the public in university courses, lectures, and business seminars. I cannot recall a single instance in which inconsistencies cropped up or serious objections were raised. If anything, I had the impression that this evaluation scheme, whose components are common knowledge and accepted truths, was regarded as being too simple to help yield new insights. I often get the impression that particularly complex and bewildering diagrammatic representations are gaining favor in management consultancy, and that greater weight is attached to those that skirt comprehensibility. I was thus all the more pleased that Hans-Dieter Seghezzy, professor at the School of Economics at the University of St. Gallen, Switzerland, and prominent expert on quality, introduced the factors quality, money and time as the crucial "triangle of business-related forces" in his book "Qualitätsstrategien". This concept is further expanded upon in the same book by Roland Berger, who stressed the applied level under the title "Time-Cost-Quality-Leadership". In this connection it is perhaps interesting to note that, as of 1975, many very large business enterprises in Japan such as the automobile-maker Toyota have oriented their production according to the target hierarchy of quality, cost and time. This orientation stems from a Japanese philosophy of life termed "kaizen", which places priority on the pursuit of perfection and excellence.

| | | A Growth period | B Function | Active period Quiescence | Dormancy |
|---|---|---|---|---|---|
| a | Cost | 1 Cost of growth | 4 Cost of function | 7 Cost of quiescence | 10 Cost of dormancy |
| b | Precision | 2 Precision of growth | 5 Precision of function | 8 Risk of quiescence | 11 Risk of dormancy |
| c | Time required | 3 Duration of growth | 6 Duration of functional act | 9 Duration of quiescence | 12 Duration of dormancy |

*Fig. 4: Twelve criteria that determine the efficiency of organisms. Since the efficiency of every organism is the product of the capability of its organs, each organ can in principle influence overall selective value. Three main criteria, quantifiable as mean values, determine the capability of each organ: a) the cost of that organ to the organism, b) the precision with which it fulfils its function (how many times out of one hundred is it successful) and c) the time that the function requires. A is the organ's period of growth and B its period of activity, which comprises alternating functional and quiescent phases. This is accompanied by dormant phases in which the organism reduces its organ complex to a minimum. During the growth period and the three phases of the active period, the criteria cost, precision and time required lead to different values that can influence selective value (1-12). Correlations, which must also be taken into consideration, exist between all these values (see text for details).*

*Note that this scheme is valid not only for the organs, but for each organism as a whole (unicellular organism, multicellular organism, hypercell organism, business enterprise). This provides strong evidence for the affinities of all organisms and their organs.*



### The invisible framework of values

My publication of 1970 specifically drew attention to the fact that the selective value of living entities could be quantified more exactly if the efficiency criteria precision, cost and time required are analyzed separately in the various periods of their existence. Logically, each organ can only fulfil its function once that organ has been completed. This holds true for both an automobile tire and the blood vessels in our bodies, for the organelles of unicells and for every production department of an industrial complex. For some organs, the function is an active one, as in the legs of a beetle, our kidneys or the locomotive of a train. In others this function is passive, as in the armor plates of a warship, the skeleton of a vertebrate, or the foundations of a building. The function of the organ we term "book" is to make information available in the form of a handy package. The organ "chimney" is designed to conduct smoke into the air. The organ "actor" has the task of assuming a particular role in film or theater. The organ "President of the United States" functions in governing that nation. Life avails itself of an extremely broad range of organs. The feature common to all of them, however, is that they only become functional once they have become completed and are positioned at the required site. This allows us to distinguish between a build-up period and an active period in every case.

The *build-up period* ends when the independent function kicks in. The subsequent active period can be further subdivided into three phases that are critical for the selective value: first, in the phases of their specific functional activity; second, in quiescent periods in which the organ is not functional; and third, in transitional phases in which the organ becomes dormant or is transformed to assume functions other than the original one. I contend that we can determine the selective value of organs even more exactly when we investigate the efficiency criteria cost, precision, and time required in each of these phases separately (Fig. 4). This looks more complicated than it actually is.

The *cost* of building up an organ is an important factor in determining its selective value. If the two competitors A and B face off, and their capabilities are identical except that A forms or acquires a vital organ with less energy expenditure than B, then A is clearly at an advantage. The same holds true for *precision*. If the losses in building up an organ amount to 15%, then this can translate into a considerable disadvantage vis-á-vis competitors capable of acquiring that organ more efficiently. The *time required* also turns out to be a significant factor. Especially when the energy supply is subject to fluctuations, waiting for the right moment becomes critical. Then, the speed with which an organ becomes available can be decisive. These correlations and a host of others can be demonstrated in all organisms, regardless of how different their shape or how divergent their circumstances.



In the subsequent *active period*, the average costs of the individual functional acts play an important role; they must be viewed separately from the build-up costs. Thus, building up an organ may be inexpensive, its operation more costly, or vice versa. The crucial element for every organism is its energy balance: it represents the sum of the energy balances of all the component organs. Unfavorable conditions often prove to be a limiting factor here. Should the energy balance of a uni- or multicellular organism or the energy/financial balance of a hypercell organism or business organization become negative, then the organisms can mobilize stored reserves, while the hypercell organisms and businesses can rely on credit from banks, friends or the government to remain operational for a certain period. The inevitable consequence of an ongoing negative balance, however, is death or, in the case of hypercell organisms or businesses, bankruptcy, which is an equivalent fate from the evolutionary perspective.

It is beyond the scope of this book to delve further into efficiency theory. Rather, my intent is to demonstrate how certain general laws apply equally to the evolution of plants and animals as they do to the capable entities formed by humans. The efficiency criterion precision, for example, is clearly also at work in the active period of every organism. The better an organ fulfils its functional task, the better it serves the overall entity of which it is a part. The same holds true for the time required.

A great number of correlations that affect selective value exist between the above parameters and other parameters treated later. The critical reader is called upon to come up with further examples from his/her own field of interest or experience and to examine them in the light of my theory. It no doubt comes as a surprise to our set way of thinking that solid comparative measures exist for such an enormous number of entirely divergent organs, but this is precisely the case. Competitiveness and the selective value, rather than being governed by external appearance, are determined by an invisible framework of values; these values decide which functional units come out on top in the "struggle for existence" and ultimately contribute to evolution by bringing forth a steady stream of new species.

The *dormant phases*, which interrupt the functional activity of virtually all organs in more or less regular intervals, become particularly important when they involve ongoing maintenance costs. The shorter these phases, the better. The reason our innate sleep drive forces us to regularly interrupt our activity is based on the specific needs of the ganglia cells in our brain. Machines and tools also require corresponding care and maintenance. In cases where environmental conditions necessitate lengthier dormant phases (seasonal business operations or organisms whose metabolic balance is positive only during certain seasons of the year), two options are available to ensure that reserves are tapped economically: either temporary dormancy or a shift to other tasks. Examples of the former include seasonal trade in the business world; here, employees may be fired in order to reduce operating costs to a minimum. In the animal kingdom, this is illustrated by species that hibernate or form resting stages. The other strategy involves long-term restructuring of functionless organs so they can assume other tasks that help support the organism. Examples here include the coal merchant who sells ice cream in summer or machines that are reprogrammed to carry out other tasks.



The same efficiency scheme is valid not only for all organs, whether they be formed by cell differentiation or directly from environmental materials, but also for every known organism: uni- and multicellular organisms, hypercell organisms and business organizations. Moreover, this "hidden communality" (to use the language of Goethe) behind all these living entities is expressed on a third level as well. Virtually every organ is itself composed of subordinate functional units. Our eye, with its lens, pupil and eyeground – the latter composed of a great number of light-sensitive cells – is a classic example. These cells themselves are again composed of subordinate functional units arranged into a hierarchic structure. The situation is no different in the assembly plant of an industrial complex. Here as well, the machines and the hypercell organisms operating them are subordinate units, which themselves are composed of further subunits. As anyone is free to verify, the same efficiency criteria at work in these and similar units are valid for all independently operating and reproducing living entities along with their manifold organs. Taken together, this is convincing evidence for the thesis that evolution has by no means run its course with the advent of man. Rather, it has found its direct continuation in the capable entities formed by man – hypercell organisms and business organizations.

## Shifting functions

At this point I wish to briefly point out some underlying correlations that provide a wealth of evidence for the tight functional affinity between uni- and multicellular organisms on the one hand and hypercell organisms and business enterprises on the other.

My line of argumentation has been based on the premise that an organ fulfils only a *single* function. Although this may be true in most cases and over considerable periods of time, evolutionary progress involves *changes* in the capabilities exhibited by organs and their interactions. When such changes occur, efficiency must be calculated anew because a spectrum of correlations will be affected. While the previous argumentation remains valid for every individually assessed situation, it fails to consider the overall course of evolution and the altered selective values when structural features or behavior control mechanisms are improved.

My earlier publications have treated shifts in function in detail. I therefore restrict myself here to a brief description of the interrelationships and to presenting clear-cut examples for the affinity of all organisms, including hypercell organisms and business organizations. The reader will immediately recognize that humans, rather than representing the zenith of evolution, are embedded – together with all their achievements – in the overall evolutionary process (see Fig. 5).



A particularly important process in the course of evolution is an organ’s ability to add new capabilities – above and beyond its original task – a process that I have termed *functional expansion* (Fig. 5a). The roots of land plants are a good example. Their primary function was to acquire water and nutrients, but in taller species they must support and anchor the plant and are correspondingly dimensioned. In automobiles, the water in the radiator initially served to cool the motor. Later, it took on the added function of heating the car's interior. The fan-like, feathery gills of tube-worms that live firmly attached to the sea floor also serve in feeding. Much like an expanded net, they capture organic particles suspended in the water and convey them to the mouth with cilia. Today, many tools and machines are designed such that exchanging certain parts or installing different software can allow new functions to be carried out. The circulatory system in vertebrates is a particularly impressive example of extended functionality. Its original task was to supply every cell with the necessary nutrients. In the course of evolution, it assumed the task of removing accumulating metabolic wastes and transporting gases for respiration. It also became the "postal system" for hormones, the transportation route for the white blood cells and antibodies that function as the "internal police", the medium of a "central heating" system that keeps warm-blooded animals alive, and in certain species even serves the erectile tissue of the genital organs. Every new function typically requires an additional structure; the excretion of metabolic wastes, for example, necessitates kidneys, while the delivery and removal of gases requires lungs. This strategy is ultimately much less costly for the organism and can be achieved much more simply via mutation and selection than developing a separate in- and outflow system, i.e. such as that developed for gases by insects (the trachea). A comparable example in hypercell organisms and business enterprises is the powerlines that supply of electricity to factories. Their original function was to provide light and to power machines; once they were installed, however, they took on other duties such as operating loudspeakers, radios, hot plates and electric hair dryers for employees, to name but a few applications. Just as creating a separate duct system to transport hormones or to supply the erectile tissue of the genital organs would have been uneconomical, the employees' hot plates and hair dryers alone would never have justified connecting the factory to the main lines. Once strong selective pressure has led such distribution systems to be installed, however, they became available for additional tasks. Such functional expansions are promoted above all by the development of new behavior control mechanisms, as I explicated earlier in the book. Two prime examples are the human hand in the realm of multicellular organisms, and humans themselves in the realm of hypercell organisms: additional motion control mechanisms in the former enable it to fulfil a thousand different functions, while the latter can probably carry out an even greater number of functions through various trades and businesses.



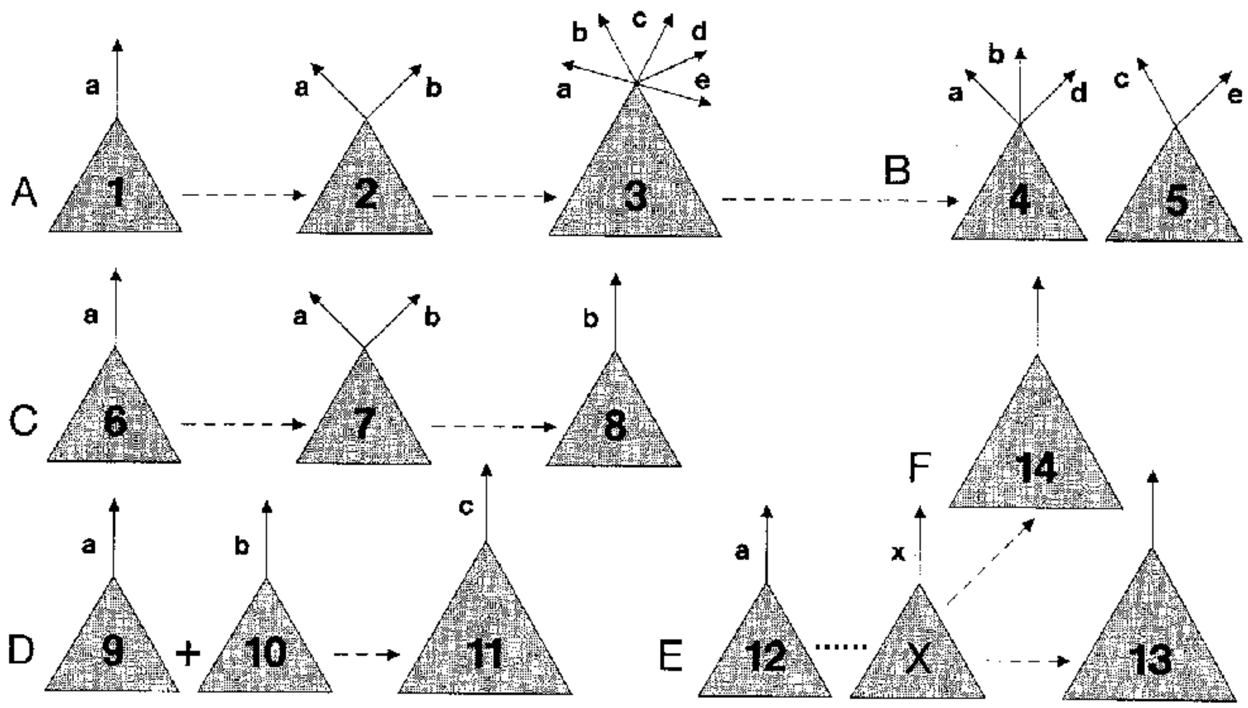



*Fig. 5: The six most important possibilities for functional shifts of organs. The organs (O) are represented as triangles, their functions as arrows originating at the tip (a-x).*

*A: Functional expansion: the organ O1 is capable of only a single function (a), but then also gains further functions (O3a-e).*

*B: Functional partition: By taking on ever more numerous functions, these functions can mutually hinder and disturb one another and lead to functional overload. The solution is functional partition. In the figure, O4 takes over the functions a, b, d, while O5 takes over c and e. This process is identical with the clearly discernible differentiation in all complex organisms, especially multicellular organisms and business organizations. The result is an increasing division of labor.*

*C: Functional shift: As in A, an organ (O6) takes on an additional function (O7b). This then becomes the main function, while the original function often degenerates completely. This indirect route led to new functions in all four groups of organisms (uni- and multicellular organisms, hypercell organisms, businesses), functions that often would have been unattainable through mutation and recombination.*

*D: Functional partnership (symbiosis): The two organs O9 and O10 combine to form a partnership (O11); each gains advantages through the partner.*

*E, F: Several organs (O12 to Ox) combine to form a larger organ. When such combined organs retain the same functions, we term this a functional amalgamation (E); if the original organs had different functions and the new entity has a new function, we term this a functional concentration (F).*
*The key here is that these processes, which are important for evolutionary progress at all levels, are clear evidence for the uniformity of evolution in the living world.*



Functional expansions can, however, lead to *functional overload*, which decreases selective value. The more functions an organ fulfils, the greater the danger that the functions hinder one another or that precision is reduced. In multicellular organisms, as well as in hypercell organisms and business enterprises, this leads to *functional partition*, i.e. an ever increasing differentiation and division of labor (Fig. 5B). This process is common knowledge and need not be illustrated with examples. The essential point is that we are dealing with a further, systematic evolutionary process that is equally valid for natural and additional organs. It considerably improves selective values in all four major organismic levels (unicellular and multicellular organisms, hypercell organisms, businesses).

Functional expansion can lead to yet another significant step forward, namely *functional shifts* (Fig. 5C). In animals and plants as well as in human technologies and organizations, later functions commonly develop into main functions, while the original function degenerates entirely. Thus, the ovipositor of some insects developed into a poisonous sting, while the unpaired pineal eye of reptiles became the pineal gland in mammals, where it helps control the day/night rhythm. What equivalents can we find in humans? Some buttons, for example, have long served to decorate rather than fasten. The differential gears in automobiles were originally invented for the weaving machine. In plants, the leaves gave rise to tendrils and thorns, to the traps of pitcher plants, as well as to the stamens and pistils of flowers. Goethe, who discovered this, wrote to Herder in 1788: "From front to rear, a plant is merely leaf". Primeval fishes were unable to develop a swimbladder – a crucial organ to help control buoyancy – via mutation and recombination. Their descendants conquered land, where their gills dried out and lost their function. Initially, the roof of the palate, which was richly supplied with blood vessels, took over the necessary gas exchange, even if only suboptimally. At this point, mutation and recombination led to folding, which increased the surface area and gave rise to a sac-shaped structure that later became the lung of terrestrial vertebrates. Some early fishes or amphibians – or whatever name we wish to give these transitional stages – returned to the sea with these sac-like structures, which then served as swimbladders. The selective advantage of the newly evolving species with such buoyancy organs (all modern bony fishes) was so great that they displaced the primeval fishes. Only a few groups such as sharks and rays were able to survive until today without a swimbladder. In ancestral sharks, the body scales grew longer around the margins of the mouth and developed, through a functional shift, into teeth. Their descendants that conquered land gradually lost the scales on their bodies, but the teeth remained. In the human embryo, the teeth still develop just like the placoid scales of the shark. The same holds true for the gill slits that characterize primeval fishes: on land, these became useless and were reduced, whereby, as described earlier, the rudiments of the gill arches developed into hearing ossicles.

Still another form of functional shift is the *functional partnership*, which helps cut unnecessary costs and in which each partner gains an advantage through the other (Fig. 5D). When different organs within an organism carry out the same function, then this *functional amalgamation* into a larger common organ can increase competitiveness (Fig. 5E). This is standard procedure in business enterprises and is reflected in central repair shops, common vehicle fleets and other combined facilities. As outlined earlier, this strategy was limited in multicellular organisms because the cell, as a highly organized building material, did not lend itself to such rigorous changes with the modest means of mutation and recombination. On the other hand, some functions are known to profit considerably from decentralization. A further opportunity to boost capability involves merging several organs with different functions into one larger unit, yielding an organ with new capabilities (Fig. 5F). This is no doubt what Konrad Lorenz meant with his term "fulguration". In earlier publications I termed this functional shift a *functional concentration*. Haken's "synergistic effect" probably also fits in here.



Note that, as was the case in the efficiency criteria, the same systematic correlations exist not only for all organs, but also for *every organism*. Two examples suffice. As we saw, symbioses in uni- and multicellular organisms, which are analogous to the functional partnerships mentioned above, play an equally important role as mergers between large businesses and industries do. In a process analogous to functional concentration, *Homo proteus* gave rise to hypercell organisms and to business organizations like the Volkswagen company and the USA.

Finally, virtually every organ requires corresponding control mechanisms to function properly. These must also be developed and exhibit phases of activity, dormancy and potential change. Here as well, the three efficiency criteria (cost, precision, time required) provide input that affects selective value. The fact that these control mechanisms are often separate from the organs that are being controlled is inconsequential. Arms and legs or additional organs are of little use to us if they cannot be effectively controlled. Throughout the living world, all the efficiency criteria that pertain to control mechanisms are also decisive for the selective value and competitive ability. This is further evidence that somatic organs and the "works" of man are ultimately components of one and the same evolutionary stream.

## 7 Innate human drives

Let us first turn to those features that most clearly differentiate us from animals, the organismic realm that gave rise to humans. This difference is perhaps best expressed in the refinement and differentiation of our life habits, namely our culture in the widest sense of the word. This is reflected in the human aspiration toward ethical and aesthetic values, law and order, toward comfort and luxury. In the more highly developed mammals, lions for example, we can already discern how daily life splits into two domains: the first is the acquisitional phase involving hunting for prey, while the second can be subsumed under the somewhat unconventional yet clearly applicable heading "private life". In the latter, the satiated and clearly contented lion family rests at a site that provides a clear view to all sides. After all, even lions must be on guard against potential threats. The young play and scuffle with one another, and the parents are also included in the fun. These, in turn, nudge each other lovingly, nap, and stretch with visible pleasure. All clearly relish themselves and their situation.



At some point, the intellectual development of *Homo proteus* reached a level where past experiences could be summoned up on an internal projection screen, allowing them to be compared with one another and conclusions to be drawn. This was accompanied by the ability to recognize cause and effect in temporally and spatially distant events and to relate them to one another in an interplay of imagination and thought. One result was that we purposefully formed additional organs to boost our capability. At the same time it also led to another trend that significantly impacted our lifestyle: sooner or later, humans must have come to recognize that some of their activities and situations led to pleasant inner experiences while others were associated with unpleasant feelings. In my mind, nothing could be more natural and self-evident that humans – as a species with an unerring drive to improve the body – at some point focused their behavior and organ formation on enhancing pleasant feelings and, as far as possible, minimizing unpleasant ones. After we successfully cemented our superiority over the competition and our surpluses provided time for leisure and reflection, a new era was ushered in: man became the "seeker of happiness" par excellence.

### The innate legacy

Comparative ethology helps provide valuable insight into the innate mechanisms that control instincts. This field has delved deep into the structure of the mechanisms that govern capabilities in animals and it has dealt with the functional significance of pleasant and unpleasant sensations. In everyday life, we consider it self-evident that some experiences trigger pleasant, others unpleasant feelings. And, since most humans find any comparison with animals to be undignified, we are rather unaccustomed to relating our inner experiences with the evolution of our predecessors. Precisely this historical perspective, however, yields important information on the motivations behind how we define and gauge our objectives.

Three quite distinct capabilities of the central nervous system, especially of the brain, are necessary for an animal to obtain its source of energy and matter, i.e. to find food. *First*, the animals must recognize their prey based on certain unmistakable features termed key stimuli. *Second*, after the prey has been detected, innate behavior control mechanisms must issue the necessary orders that enable the musculature to stalk, overwhelm, and partially or entirely consume the prey. *Third*, an additional brain structure must be specialized in motivating the animal, in the absence of a key stimulus, to actively seek that very stimulus. This motivating mechanism, which is known as a drive, functions by continuing to reinforce an unpleasant sensation such as hunger as long as prey remains unavailable. Once the predator has killed and eaten its prey, it experiences pleasant taste sensations and the feeling of satiation.

The situation is very similar in most instinct behaviors. An animal's preservation instinct involves detecting enemies and other dangers in time and avoiding them. Here as well, key stimuli that indicate danger generate unpleasant feelings of fear. If the animal escapes danger and finds protective shelter, it then experiences pleasurable comfort and relief. The sexual drive triggers particularly strong unpleasant sensations when the animal fails to find a suitable partner during the mating season. On the other hand, it experiences intense pleasure if the mating act is consummated. Since we are unable to communicate with animals, we cannot furnish definitive proof that our inner human experiences are similar to those of higher mammals. Nonetheless, their close kinship and the clear parallels in their behavior, which is particularly evident in domestic animals, leave little doubt that this is the case.



In animals, positive and negative sensations are therefore *a means to an end* (without which the motivating instinct mechanism would be unable to function). *Homo proteus* and his successors, however, have almost inevitably reached the stage where they have *elevated the means to an end*. By orienting their lives so that positive feelings are cultivated and, whenever possible, reinforced and combined with other such feelings, they converted *a tool into a goal*. They used additional organs to design their lives for the pursuit of maximum pleasure while at the same time warding off and minimizing unpleasant feelings. The result was a *reversal of polarity* of a magnitude previously unknown in the history of evolution. This reversal determined the future course of evolution and speciation.

### The luxury structures of humans

In unicellular and multicellular organisms, all surpluses are always invested in progeny. This stands in contrast to the hypercell organisms formed by humans. A significant proportion of the profits they reap flows into other channels, namely into those that serve to increase the comfort of the humans that control them. I trust that my use of the term luxury, which bears negative connotations, will not lead to misunderstandings. From the evolutionary perspective, all the additional organ formations and behaviors associated with this phenomenon are a luxury in the sense that they cost energy yet are neither essential nor necessarily promote the organism’s survival or efficiency. Let us examine this development in somewhat greater detail.

Before the advent of man, organisms had little leeway with regard to the surpluses they produced. Beyond being used for somatic growth, which is naturally limited, these surpluses could only be invested in reproduction, more specifically in a *species-specific* reproduction. Pine trees beget pine trees, bees only new bees, and crustaceans only crustaceans of the same species. To my knowledge no other author has ever pointed out the negative aspect of this process, which is straightjacketed by the mechanics of genetics. Our understandable admiration for organisms and their capabilities no doubt stifled such critical thoughts, yet the disadvantages of this reproductive mode for the overall course of evolution are plainly visible. When the conditions for a particular animal or plant species deteriorated, while they may have been favorable for another species, then the original species was still forced to pour its ever more meager resources into reproducing more individuals of its own kind. The reproductive mechanism hindered the production of an entirely different form of life. *Homo proteus* was the first to break these chains. The hypercell organisms he formed, which comprised both a somatic (cellular) body and an increasing number of additional organs, were no longer bound to producing progeny of the same species. While the cellular body continued to reproduce species-specifically through traditional genetic mechanisms, he was *not forced to retain* the complement of additional organs! He was able to form a wide array of hypercell organisms that could build up surpluses by very different means. This pattern formed the basis for all further development. The son of a blacksmith could very well become an engineer, a police officer or a building contractor. He can establish himself as a new individual in a wide range of endeavors; if the hypercell organism he forms proves unsuccessful, then he can change his profession. Hypercell organisms are in a position to change their complement of additional organs, to switch to another line of production or service, and then to enter into competition in that new field. They can even devise and test new species of hypercell organisms. And this process sets itself forth in our children. They can either take over our business or embark upon an entirely new branch of business. Hypercell organisms owe this immense difference to their core entity ( a human) and its capabilities: the creative freedom to direct surpluses where they can best serve life's development. At the same time, another unusual opportunity opened up: the human control center had no need to invest the gained surpluses in further business endeavors. Thanks to our self-awareness, intelligence and versatility we can apply them to increasing our own comfort and to providing a broad range of pleasurable experiences.



When I first became conscious of this circumstance – diving somewhere in a coral reef – my first reaction was to ask the question: how could natural selection tolerate such a deviation from the traditional path? When a lion takes pleasure in rolling about in the grass or a manta ray does acrobatic maneuvers for the pure joy of it, these activities can still be explained as an epi-phenomenon of their normal complement of instincts. When the core of a successful hypercell organism takes million-dollar sums, which represent an enormous energy potential, and funnels them into purchasing a luxury villa, a racing yacht, or valuable jewelry, then this is clearly a major loss for the selective value of that individual. At the time, I sought to allay my unease with the argument that as long as this did not drive the hypercell organism to ruin, then natural selection might well "overlook" this activity. After all, I suddenly perceived humans as some type of parasite bent on exploiting their own pleasure-providing mechanisms. Only much later did I come to realize that even this phenomenon by no means broke the restraints of evolution, but rather considerably boosted its progress. Let us begin by examining a few practical repercussions of this reversed polarity.

It is common knowledge that our innate hunger drive has become a source of pleasure. Cooking, baking, spicing and fancy methods of preparing parts of plants and animals help make food tastier to the palate. This provided a source of income for the hypercell organisms we term chefs and the restaurant business, and also supported all those involved in producing kitchen furnishings, refrigerators and other accessories in the field of gastronomy. Both animals and humans respond positively to sweet foods because sugar is an easily metabolizable source of energy. The strong pleasant feelings that sugary foods elicit have spawned the ubiquitous pastry shops in every city. At the same time, they have led to the demand for methods and products designed to help lose weight, a field in which an entirely different set of hypercell organisms and industries is specialized. The demand for the vital resource water has led to a gigantic industry that produces tasty drinks, to numerous businesses that supply the bottles for these beverages, to enterprises that transport, deliver and sell the product to the thirsty masses. A no less prolific industry supplies alcoholic beverages to humans; these can help raise our spirits and therefore enjoy particular popularity. The air that humans breath is misused to convey nicotine-containing, stimulating toxins into the body; in many countries the state has a monopoly on tobacco sales, which does wonders for government coffers but cannot be said to promote the health of the citizenry.



And what price are humans willing to pay to dissipate feelings of anxiety! For all practical purposes, the innate preservation instinct in animals is no less important than their hunger drive. After all, gaining energy and matter is futile if, moments later, the satiated animal itself becomes the source of energy and matter for another organism. Hypercell organisms protect themselves with weapons, walls and lockable doors rather than by fleeing and hiding. Scores of tradesmen and businesses earn a living producing these protective organs. Ultimately, a country's citizens are protected by the state, which represents an expensive communal organ that must be supported by taxes. Additional protective strategies that impart pleasant feelings of security and reduce anxiety are the insurance agencies budding up all over the world; they protect against losses by covering damages. Similarly, pension funds help overcome the fear of poverty with old age.

The repercussions of our sexual drive on human existence, and the costs that this drive incurs directly or indirectly, are incalculable. In animals this instinct is restricted to a relatively brief rutting season. One explanation for this is that the distracted partners more easily fall prey to predators. The fact that adult humans remain subject to the influences of this drive throughout the year and up into old age has been explained by the strong selective pressure to bind early man to the woman and children that required his care and protection. According to this interpretation, the sexual drive took on the additional function of a *bonding mechanism* that tied the male to the partner with whom he shared sexual pleasure. Today, this drive no longer serves primarily to more firmly bond the couple; on the contrary, more often than not it leads solid marriages to be divorced because the bond has been violated. At any rate, its positive and negative repercussions extort a high price from those in the pursuit of happiness. This is further aggravated by the display behavior that is invariably associated with courtship.

Brood care is another obvious behavior that we share with higher vertebrates (mammals and birds): much of the great effort we invest into our jobs serves to perpetuate our own selves by providing our children with joy and successful futures. Our affluent society, however, tends to exaggerate the effort behind this innate motivation, a topic we will return to later.

In this day and age, all those who doubt the innate behavioral links between us and our closest relatives in the animal kingdom should be converted by the obvious correspondence in the control mechanisms (for pleasure/pain) that so clearly influence our lives. Our clearly hereditary drives have become a key goalpost for human endeavor, for our culture. Although Schopenhauer's statement that the intellect is "the servant of desire" may appear disparaging, we can hardly deny that human intellect was a major vehicle in our search for pleasure and joy. This reversal of polarity may seem odd and costly from the evolutionary perspective. Nevertheless, it is instrumental in steering our aspirations and at the same time a major handicap for hypercell organisms.

This confronts us with a clear gap between traditional assessments of our overall situation and evaluations based on the evolutionary standpoint. The evolution of hypercell organisms and business enterprises is a clear continuation of that undergone by uni- and multicellular organisms: in both one and the other, energy gain is inevitably a crucial if not the most critical function. In both cases, appropriately structured organs convert raw energy into vital capabilities. In both cases the body’s shape and behavior can be explained by fundamental capabilities that need to be fulfilled. In both cases natural selection of the best-adapted organisms governs speciation, whereby organisms whose subunits are not firmly fused to one another can exhibit much greater variability in adapting to environmental conditions; this is also a considerable advantage vis-à-vis natural selection. These parallels add to the list of other similarities and could be supplemented by a string of additional examples.



Although we are dealing here with a clear evolutionary series, our increasing self-indulgence (i.e. the "private lives" of human beings, which have themselves come to represent organs) seems to be a distinct deviation from the evolutionary norm. As I hope to show, this "wrong turn" is in fact nothing of the kind; rather, this path provides evolution with a mighty boost. It suffices here to point out the radical gap between how we evaluate ourselves and our actual status in the evolutionary process. For most people, namely, private life is the top priority, whereas a job or profession is merely a means to an end. Additional organs are not fused to our bodies, giving us the freedom to leave these units behind at the end of the day. This perspective led humans to view the home as the natural hub of their lives, as the point of departure for the workplace. From the evolutionary perspective, however, each human is an integral part of a larger organism, although we can leave that entity because no permanent bond exists. In a nutshell, the organ can leave – for a certain period of time or even permanently – the capable entity it belongs to and for which it carried out specialized tasks. If we humans consider this absence – this private life – as our ultimate goal, then this fundamentally contravenes our natural status as producers and control centers of hypercell organisms, which must be classified as unique entities in evolution.

## Curiosity

In Sankt Christoph am Arlberg I clandestinely filmed skiers – greatly time-lapsed – as they stood in line for the ski lift, were pulled up, skied down the slope, re-entered the line, and soon thereafter skied back down the slope. Upon later viewing the film I asked myself: How would a visitor from outer space interpret this activity? The visitor would probably begin by asking what purpose all this effort served. It most certainly wasn't feeding, because food was nowhere to be seen on the snow-covered mountains. Neither were the enthusiastic skiers, who expended so much energy for their activity, aggregating for mating. I shot similar films of tourist swarms making their way up to the Acropolis and flooding across the colonnade. This would no doubt also have confounded our extraterrestrial vistor. Why this zeal, why this effort? In the case of animals, various behaviors are amenable to careful study and interpretation. In the case of the Acropolis visitors (and even more so in the case of the skiers), we might conclude that the idea was to somehow get rid of superfluous energy, without any recognizable gain.

The particularly strong play and curiosity drives in humans can be derived from those exhibited by the young of all higher vertebrates. These organisms are not born "fully developed", and their motor-instinct control mechanisms are particularly underdeveloped. Active interaction with the environment helps them to "wire" the cerebral behavior controls that they need for their future lives. This involves active testing, learning and practicing (exploratory behavior) and represents evolutionary progress in that these animals act and react less mechanically than insects, for example. This allows them to adapt much better to changing environmental conditions. A clear prerequisite for this, however, is the parallel development of a parental brood care instinct that protects the young against predators while they are helpless and ensures that they are adequately fed, cared for, and stimulated to undertake the trials we term play. The human child is born at a particularly early stage, which can in part be explained by our erect body posture along with the accompanying narrowing of the mother's pelvis and difficulties in giving birth. This necessitates a commensurately long phase of parental care. In animals, the drive that we, for the sake of simplicity, refer to here as curiosity tends to disappear at sexual maturity. In humans, however, the drive to approach novel situations and take on new challenges in a playful manner remains active to a ripe old age. This is a further distinguishing trait of humans. According to my theory it developed hand in hand with our formation of more capable living entities, namely hypercell organisms. With the arrival of *Homo proteus*, humans gained the ability to learn new behavior patterns, to purposefully form additional organs that were separate from the body, and to apply these in a useful manner. Moreover, humans were able to use language to transmit this ability on – not only to their own children but also to the group as a whole. It goes without saying that natural selection supported any genetic progress that promoted this key capability. Evolution was handed an immense opportunity to form new structures, new species, new niches, and to enhance capability, i.e. it received a powerful boost in the broadest sense. In animals there was simply *no selection pressure* to extend the curiosity drive beyond sexual maturity. They developed all the behavior control mechanisms necessary for their survival in a piecemeal manner: a further inclination for exploration had much greater potential for harm than good.

Humans on the other hand – in their role as the "germ cell" of fundamentally new, larger living entities (hypercell organisms) – were subject to strong selection pressure to apply their intellectual powers and experience, which increase with age, in a playful manner rather than viewing all novel opportunities for improvement with waning interest. The play and exploration activity that was originally tailored to the situation of the child (and which, in keeping with Darwin, took place "in small steps") ultimately gave rise to the *research drive* that so characterizes the human race. This, in association with the respective sensations of pleasure and pain, again provided a powerful impetus for the further development of hypercell organisms and business organizations.

From the very beginning, this innate behavior, which prompted ever new experiments and yielded ever new species, clearly also represented a threat to life. Its counterpart or natural antagonist was the preservation instinct, which already expressed itself in animals as mistrust toward everything new and unusual. In the human child, this clearly manifests itself in a fear of strangers and in caution. Our undiminished curiosity is further considerably dampened by communal traditions such as morals and customs. This may help explain why, over the course of history, only few persons, in whom this drive was particularly well developed (hypertrophied), sought to change the course of events with new ideas and inventions.

On the other hand, curiosity – based on the pleasure it conveys – has been factored into our concept of culture; this is entirely in line with my previous argumentation that it helped intensify positive inner feelings in the sense of the reversed polarity mentioned above. This explains the enthusiasm of the skiers I filmed in Sankt Christoph and is clearly valid for virtually every sport devised by man, particularly for the steady stream of fashionable new sports that our affluent society practices. One may argue that rational reasons such as better health through physical fitness or business considerations also underlie the sports craze, but the true explanation for this varied and



often expensive activity clearly lies in our compulsion to test ourselves under new conditions, to achieve new physical prowess.

On the beach in Nice, I was able to film (with hidden camera and time lapse techniques) how an elderly lady took off her shoes and wandered up to her ankles into the meter-high surf. The protocol in my published report read: "The time-lapsed sequence revealed that she kept inching toward the breakers, apparently out of pure bravado. Finally a set of particularly large waves almost brought her to fall, soaking her long dress up to the waist".

The philosopher and sociologist Arnold Gehlen, who was also versed in comparative ethology, termed humans as "a risk-prone creature, a being with an innate predilection to suffer accidents". How very true this is evident in the conflicts fought all over the world by warring groups, tribes, principalities and countries (whereby material interests are almost always at the forefront). It is equally evident in sports, where a heightened zest for life is the driving motivation to scale a vertical cliff, to explore unknown depths in the sea, or to brave the air currents and updrafts with a paraglider. In every case, the slightest error can have fatal consequences.

The animal kingdom is full of examples of how different instincts can influence one another, trigger conflicts, or lead to synergistic effects. In this vein, human curiosity is intricately linked with the full range of other mechanisms that motivate us. It influences our sexual drives when we search for a new partner, or our feeding instinct when we try Chinese, Japanese or Thai food. We bath in the gamut of sensations that fear and surprise trigger whenever we visit an amusement park and ride on a merry-go-round or enter a house-of-horrors or a hall of distorting mirrors. Oriental banquets, for example, are renowned for their virtuoso sequence of dishes combined with music, dance, games and other entertaining surprises.

Another film sequence I shot more than 30 years ago on the beach at Nice showed another constellation in which curiosity creates positive feelings sensations. This time I directed the automatic camera at a young man who sat in the midst of the bathers reading the newspaper. The highly accelerated film revealed new aspects that I described as follows: "he plowed through the newspaper, then grabbed a second paper and plowed through it as well; upon finishing the second one, he reached for a third paper, and upon finishing that one returned again to the first". When people read newspapers and books they are often unaware of the fact that they are dealing with matters that are of little consequence to them. The many conversations that I filmed all around the world left me with the same impression. In many cases, exchanging information is by no means the prime motivation; rather, the aim is merely to establish contact, the simple pleasure of chatting for the sake of chatting. People can obviously derive great pleasure from hearing the latest gossip. This goes a long way toward explaining why so many of us are attracted to theater, movies and the TV screen: our sense of curiosity whets our desire for diversion. At least in our fantasy, we seek to flee the constraints of everyday life. Our senses pine for new sensations. An urge, a craving for the novel molds our will – curiosity in the true sense.



Very specific interests no doubt motivated the swarms of tourists I filmed around the Acropolis. Nonetheless, even these interests are ultimately fueled by life-long human curiosity. From the evolutionary perspective, the positive sensations mediated by such drives would appear to be pure luxury, wastefulness of the greatest magnitude. This widespread behavior can even raise doubts about natural selection. A more in-depth analysis, however, reveals the opposite to be true. After all, why do humans work, why do they produce goods or provide services for others? The obvious explanation is to earn money. And why do we need money? Foremost to secure our own existence and, if we have a family, to provide it with food. This means caring for, maintaining, monitoring, and when possible improving and enlarging our capable entity and all its additional organs, i.e. including the hypercell organisms that we have formed and that provide us with energy. Once this goal has been attained, once life is secured and all immediate commitments fulfilled, it is only natural to use the surpluses to indulge in those things that enhance our comfort, our well-being, namely in those things that provide satisfaction, pleasure, happiness or whatever other term we choose to apply. This, however, means that the innate human drives that satisfy such urges become the strongest motor in the third phase of evolution. They promote the formation of hypercell organisms and business enterprises. The more successful these entities become and the more profits they make, the more those persons entitled to the surpluses can afford the attendant joys, pleasures and positive feelings.

From the onset, humans were clearly geared to manipulating their innate instincts to heighten pleasure and reduce pain. This was by no means a disadvantage for the development and evolution of life. After all, nothing motivates people to apply their intellect and many talents to form and operate hypercell organisms and businesses more than earning even more money and improving well-being. This helps explain why natural selection in the third phase of evolution is influenced less by short-term events than by long-term ramifications. Again, the result is crucial, not the path – or detour – taken to achieve that result.

### Instinct and Intellect

Two additional drives whose mechanisms humans exploit deserve brief mention here: the group instinct and display behavior. Humans share the former instinct with all animals that live in packs or larger associations. It leads to life in communities that act as a unit and in which, in a subsequent evolutionary step, a division of labor may occur. This innate instinct leads group members to act together in procuring food or warding off enemies. In the sense of striving toward positive feelings, it mediates what we term the joys of communal living – shared meals (which clearly separates us from the animals) and the delights of feasts and games with many participants. The second drive, display behavior, is expressed in our efforts to impress other members of the group. Strictly speaking, it is less a clearly defined drive (like the others) than an innate behavioral tendency affecting a wide range of drives. Much in the same way that supplementary capabilities accompany and support fundamental capabilities (for example in locomotion or sensory perception), motivating mechanisms are hierarchically structured. In this sense, display behavior occurs in courtship displays and when enemies are fended off by artificially increasing one's apparent size and by feigning power and might; it is also expressed in the group instinct when a leadership position must be acquired and defended against rivals. Humans also express this behavior in striving for higher social rank in order to gain the respect and admiration of our fellow man, in order to live in the most sumptuous villas possible, to wear the most expensive clothes available, and to drape our spouses in the most expensive jewelry that can be bought, just to name a few examples. For rulers, display behavior became a tool to intimidate underlings and to strengthen one's own position or that of the family or clan. The arts, which can help make big impression, were sponsored over the ages by patrons motivated by the very same display behavior. This gave the business world a very reliable market for luxury goods whose main purpose was to impress others; it also enabled these businesses to operate with particularly large profit margins. In the final chapter I hope to demonstrate just how important it is to be able to correctly recognize and assess the biological basis of this particular drive.



It is also interesting to note that pleasure and pain are also conveyed by *acquired drives*, not only by *innate drives*. We term the former habits: they bridge the gap between instinctive behavior and the conduct we learn through upbringing and our intellect. Habits are already evident in animals such as dogs. These pets become accustomed to a certain resting place or to the daily rhythm of their owners and show clear reluctance when the normal course of events is altered. If someone has grown accustomed to stopping at a particular bar after work for a glass of beer or a shot of whisky – preferably with friends – then being forced to miss this rendezvous triggers clear unease. Walking into that bar, on the other hand, imparts great satisfaction. In various types of addiction, such acquired control mechanisms become compulsive. Customs or traditions are the terms we give to communal habits, and we all know how much these dictate our calendars. Fashion, for example, became a commercial tool to create new incentives for short-term habits at an ever quickening pace. And advertising became a most effective instrument to promote this tool.

The world's religions provided the most stringent and persistent dictates on how to live our lives. From an evolutionary perspective the metaphysical teachings themselves are less interesting than the fact that religion apparently arose shortly after humans first gained the capacity for logical thought. This early appearance, coupled with the global onset of the phenomenon, indicates that religions fill an important human need. In my opinion, they are a consequence of our ability to intellectually couple temporally and spatially distant causes and effects. Sooner or later this ability must have led some people to raise the tormenting question: what cause underlies my own existence? Any answer, no matter how improbable, was better than no answer at all. Once such an answer was born, it proved to be very persistent indeed, if not only because most were very hard to disprove. They had the great advantage of reducing the fear that accompanies ignorance. There was virtually no limit to the embellishments rhymed by human fantasy. A clerical caste who taught "the answer" along with the underlying rituals soon gained powerful stature. This cemented the morals of the community even more effectively than customs and law: an invisible, all-knowing judge is more threatening than one who cannot be everywhere at once. This development was supported by death, a phenomenon which humans were the first creatures to confront with full self-awareness; it was accompanied by the secret hope of playing a role in the Hereafter, a metaphysical world inhabited by gods and demons. Religion therefore played an extremely valuable role in bonding communities; they were an incentive for common ideals and a powerful compass for good and evil. On the other hand, such deeply ingrained beliefs inevitably led to conflicts with others, particularly to fanaticism and rigid intolerance. Although scientific progress has relegated the power of religion to the back seat, the question "why am I?" remains a burning issue to this very day and continues to preoccupy the subconscious of the human "germ cell" at the core of hypercell organisms. Since we have abruptly hit the limits of potential growth and, for better or for worse, will be forced to fundamentally reappraise our situation, religious answers are once again making headway. This will be the topic of the next, concluding chapter of this book.

# 8 The evolution of capability and its repercussions

My line of argumentation in the preceding chapters clearly shows that, as far as our behavioral control mechanisms are concerned, humans can hardly be viewed as harmonious, internally balanced systems. In our concept of time, the transition from uni- to multicellular organisms took place very slowly, but on the evolutionary timescale it was an extremely rapid process. As multicellular organisms, humans are – and into the foreseeable future will remain – subject to innate drives that powerfully influence our behavioral repertoire. As the core of the hypercell organisms that serve us, we are slowly feeling our way forward into a new freedom for which we are poorly prepared. The additional organs that make us so successful exert feedback and are developing faster than we can integrate them into our subconscious. Ever since the birth of insightful thought and self-consciousness, humans have had to deal with two different control mechanisms. The first is the one we learn through upbringing and experience and which is constantly being improved and transmitted to an ever-increasing number of descendants and other fellow humans through the written and spoken word and other media. Controlled by natural selection, it has led to enormous technical, economic and organizational advances. We owe the second control mechanism, which many refuse to acknowledge and whose effects often escape our self-conscious thought patterns, to our long chain of ancestors. These are the innate instincts that both enrich and burden our lives with a confusing array of pleasurable, painful, and inhibitory feelings. As I attempted to show, these mechanisms contributed significantly to the cultural evolution of various peoples; this ranges from our efforts to secure well-being and pleasure to the sublime feelings of happiness associated with the intellectual satisfaction that refined lifestyles and the arts can provide. On the other hand, we have been less successful in reducing the many conflicts that have raged between individual humans beings, within groups, as well as between states and peoples since the dawn of humanity. Positive examples include the abolition of slavery and serfdom and establishing equality before the law for all people. The basic conflicts, however, remain the same. Konrad Lorenz recognized this when he pointed this out that intelligent animals have improved their relationship to the *extra-specific* environment much more than their *behavior toward conspecifics*. He wrote: "The proof that this unfortunately also applies to humans is expressed in the crass discrepancy between our amazing success at controlling our physical environment and our shattering inability to solve intra-specific problems".



Lorenz attributed this in no small part to human aggression, an instinct that I will not go into here because the theory of hypercell organisms emphasizes two other motivations. As long as we view human beings as a *species* and as the current epitome of evolution, we must ask ourselves why this very creature treats members of its own species so brutally and ruthlessly. If, on the other hand, we do not view humans as the end of the evolutionary line, but rather as a link in the transition to even more powerful life-forms, then the scenario changes dramatically. Just as multicellular organisms, which consist of unicells, gave rise to new species, this development is repeated in the hypercell organisms formed by humans. Those hypercell organisms that successfully utilized new energy sources, new niches and new lifestyles also produced numerous individuals of precisely the same species (for example bakers, electrical engineers, pharmaceutical companies, insurance agencies) which entered into competition with one another. This at least partially explains the unfriendly attitude of humans toward their fellow man. Another important factor, however, helps fan animosity between individual human beings.

I have already discussed at some length the special role played by money. It not only serves as the cornerstone of trade and commerce and therefore the motor for species development in the realm of hypercell organisms, but it also functions as a "magic wand" that can in principle convert any one capability into any other capability. In the terminology I have introduced here, the *shift* or capability boost that money enables becomes the norm (whereas such shifts were rare events in uni- and multicellular organisms). The inevitable consequence is that money becomes a *supernormal stimulus*, a phenomenon already known to influence animal behavior (Fig. 6). Breeding birds, for example, have an innate instinct to roll displaced eggs back into their nests. If one experimentally places both a normal and an oversized, artificial egg into the nest of an oyster-catcher, then the bird prefers the latter, even though it cannot brood the artificial egg because of its large size. Researchers also refer to this as a *superoptimal stimulus*, which emphasizes that it is even more effective than the natural object that normally triggers the response. The cuckoo chick is another well-known example: its gaping beak induces the involuntary foster parents to feed the cuckoo more diligently than their own nestlings. In the toy business, Walt Disney introduced an entire range of animal figurines whose oversized eyes and heads attracted the children's sympathy more than life-like reproductions. In this functional sense, money is clearly an object that has gained a supernormal status in humans, simply because it provides access not only to food and other necessities of life, but also to any luxury items one desires, including every imaginable service. The only prerequisite: enough coins and notes to pay the bill. The fact that an inheritance can lead to lethal enmity even among close relatives, despite all familial bonds, is a well-known phenomenon. It is also no secret that whatever can be easily converted into money is an invitation to robbery and theft.



In my opinion, most human aggression can be traced back to the most primitive of all instincts developed in animals, namely the instinct to obtain food, i.e. vital energy. This is expressed in the drive to protect and enlarge our territory, our stock of customers, our market shares. Most wars are probably ultimately fueled by the drive for possessions, riches, money and power, even if this is not openly expressed.

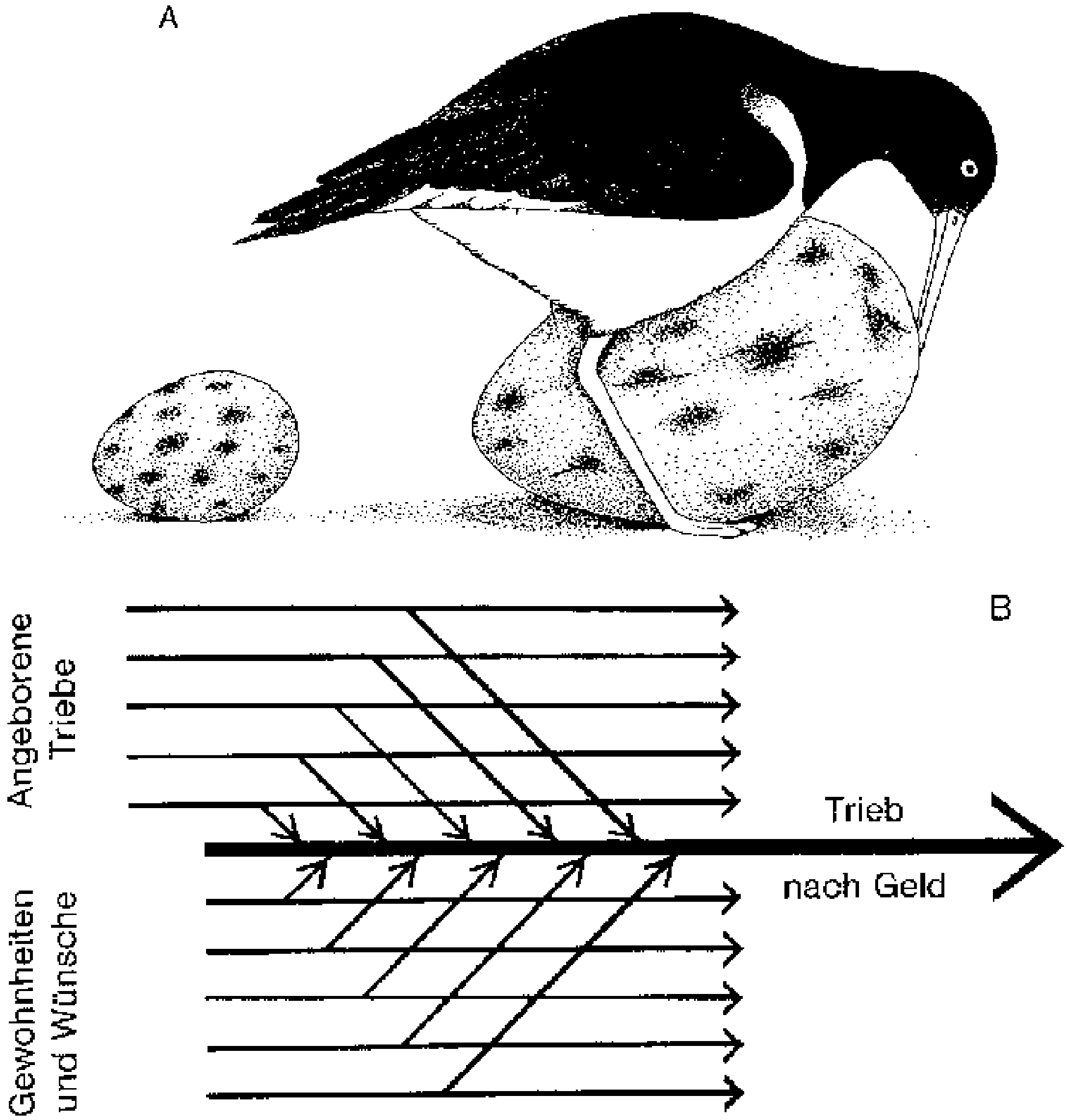





*Fig. 6: Example of a supernormal stimulus.*

*A: Some bird species innately roll a displaced egg back into the nest. If one experimentally places a normal egg and an oversized artificial egg of the same shape and coloration next to the nest of an oyster catcher (Haematopus ostralegus), then the bird disregards its own egg and attempts to roll in the giant egg even though it is too large to brood (after Tinbergen, 1951). This demonstrates the existence of key stimuli that can activate instinctive behavior even more strongly than the normal stimulus. In humans, this effect is successfully employed in advertising, the toy industry, cartoons and eroticism.*

*B: Innate human drives are complemented by habits and desires, which represent very powerful acquired motivations. Since human drives, habits and desires can all be satisfied with money, we have developed a particularly strong acquired central drive for money. As a result, money – the crucial universal mediator in the business world – developed into a supernormal stimulus that triggers a wide range of activities designed to help us to earn this money; after Hass, 1988.*

In an earlier book (1988), I outlined in detail how humans acquired the key drive for money via the process of conditioning (Fig. 6). Since money can help fulfil virtually every *innate* and *learned* drive (habit) or desire, some of the drive-related energy of each individual drive is diverted into a new central drive: acquiring money. I will return to this important topic again later in the chapter when we discuss environmental problems.

This book presents two new intellectual concepts. The first is the theory of hypercell organisms, which is a direct extension of Darwin's theory of evolution. The second is a call for a fundamental re-evaluation of how we look at organisms; rather than being based on our sensory impression of organisms, their parts, or their behavior, it stresses the capabilities that these organisms display in order to survive and advance life on our planet. This viewpoint is based on the fact that natural selection selects for the *capability exhibited* rather than for material structures or behavior patterns. After all, most vital capabilities can be provided by more than one strategy, and we can quantify most of the criteria that describe capability. My approach is therefore in full agreement with the principle of natural selection as formulated by Darwin, yet I scrutinize this process in greater detail.

Since it is difficult to deal with abstract capable entities, in this final chapter I would like to present specific examples of how life can be interpreted if we use capability rather than bodies, organs or behaviors as our basis of evaluation. In a next step I use this perspective to assess the current situation of humankind, the current threats we face, and the opportunities we have for averting these threats.



**The origin of life and the capability of unicellular organisms**

As outlined in the first chapter, I identify six fundamental capabilities as being vital for all organisms: first *energy gain*, second the *acquisition of substances and organ formation*, third *counteracting adverse environmental influences*, fourth the *utilization of favorable environmental factors*, fifth r*eproduction*, and sixth *structural improvement*. In asking how life first evolved, we must inevitably face the problem of how to imagine the onset of a process that sparked itself yet simultaneously had to fulfil so many and such different demands.

Science has quite a precise picture of what the primeval seas looked like four billion years ago when, according to modern theory, life arose. The energy of the sun's rays and powerful electrical discharges gave rise to a multitude of molecules in the primeval atmosphere; these were rich in free valences, i.e. in free energy, and were washed into the primeval sea by strong rains. Since most of the particles suspended in the water contained abundant free energy, nothing stood in the way of the first fundamental capability, that of *energy gain*. The second fundamental capability, the *acquisition of substances*, initially presented no problem due to the favorable environmental conditions: the basic building blocks of life had already been formed in abundance. As demonstrated in experiments conducted by Stanley Miller (1953), recreating those primeval conditions in the laboratory spontaneously gives rise to the building blocks (amino acids) necessary for protein formation as well as to the nitrogen bases (for example adenine) involved in information transfer by nucleic acids. The essential components for self-reproduction were therefore already available and, under favorable circumstances (chance), combined to yield autocatalytic, i.e. self-reproducing, structures. Those that proved best suited for the first life processes asserted themselves. In introducing the "hypercycle" concept, the molecular biologist and Nobel Laureate Manfred Eigen provided a plausible scenario in which these first autocatalytic processes took place in much the same way as certain chemical reactions involving free molecules in the cell protoplasm today: the course of events depends on the chance encounter of particular molecules. Brownian movement, which is effective on the microscopic level, probably also played a role. In a next step, these components fused into more consolidated structures. Interestingly, the theoretical approach that considers specific vital capabilities rather than material body itself leads to the same conclusions reached by molecular biology.

The earliest forms of life thus consisted of molecular structures that achieved greater capability by forming novel proteins with ever new features. The first organisms procreated using the reproductive mechanism of nucleic acids. Natural selection, which first came into play at that time, favored the best-suited variant.

One of the first and most important capability-enhancing developments was probably the formation of a membranous outer layer that protected the newly consolidated systems against *adverse environmental influences*. The crucial fundamental capability that marked the origin of life, however, was the *development of an organ that enabled species-specific reproduction*; it was capable of transferring instructions (information) on the assembly of specific structures to other, identical individuals. Whenever chance errors led to altered, more capable individuals, then these were automatically promoted by natural selection. To some extent, natural selection therefore helped promote the sixth fundamental capability, *structural improvement*.



The central control and reproductive organ (DNA) has changed only little over the ages. It consists of thread-like strands in which different sequences of the four different bases (adenine, guanine, cytosine and thymine) represent an alphabet that forms the individual words of the genetic language (the genetic code). As these first living entities became larger and more complex, the number of instructions that had to be passed on in order to produce offspring also grew. Information transfer thus became the first important supplementary capability.

As the supply of energy-rich molecules in the "primeval soup" of the world's oceans gradually became depleted, the selective pressure to obtain vital energy by other means increased. Two strategies gained the upper hand: the first involved life forms that were able to directly utilize the energy of the sun's rays, i.e. the first *plants*. They harnessed the energy in sunlight to build up their own tissue from inorganic building blocks. A second group of organisms, namely *animals*, became specialized in stealing the energy reserves from plants. They also predated each other, so that the stolen goods essentially "changed hands" several times. Natural selection played a role in promoting this process as well.

The fossil record shows that more than two billion years passed before these very primitive ancestors gave rise to highly specialized unicellular organisms with organ systems comparable to those of the unicells found today in virtually every drop of water. Their vital reproductive apparatus was now enclosed by a membrane and formed the nucleus. The remaining fundamental and supplementary capabilities were gradually taken over by increasingly powerful, highly differentiated organelles: the Golgi complex, vacuoles, tentacles, cilia, light sense organs, sensory setae, to name but a few. Several of these typically join forces to deliver a particular capability. In other cases, supplementary capabilities contribute to several different fundamental capabilities. At any rate, it is clearly evident how the entire organ complex is tailored to executing vital tasks.

Beyond the nucleus, the two most interesting organelles are the plastids, which are responsible for harnessing the sun’s energy (photosynthesis), and the mitochondria, which enable animals to release the bond energy contained in the ingested organic material. At the same time, every plant also contains such mitochondria; it uses them to break down its own molecules should these energy reserves be needed for other functions.

In the true Darwinian sense, this development, which I have only roughly outlined here, took place in small steps. Furthermore, the sexual process and its combination of different genetic information probably arose at a very early stage. This helped to accelerate evolution because it increased the probability of new, more capable new structures. Moreover, by that time, a good number of shifts had apparently already taken place. Two particularly important ones have left clear traces to this very day.



It has now been proven beyond a reasonable doubt that the plastids in plants and the no less vital mitochondria in all animals developed through an endosymbiosis. As their reproductive mode demonstrates, plastids are simply primitive blue-green algae that at some point in the distant past migrated into the body of unicellular organisms and became their organs. Similarly, mitochondria are simply bacteria that long ago entered the bodies of other unicellular organisms and became organs. This means that neither unicellular plants nor unicellular animals gave rise to the organelles that those organisms needed to gain energy. Much like some anemones gain well-developed legs without "financing" this development themselves by entering into a symbiosis with hermit crabs, the unicellular plants and animals gained access to vital energy-providing organs by joining up with other organisms.

Unicellular organisms proved to be extremely successful. Before the first multicellular organisms appeared, they were the undisputed rulers of the seas and other aquatic ecosystems. Even today, calculations show that they contribute at least 30% to the total plant and animal biomass on our planet. Under the constant pressure of natural selection, the cell developed into an astoundingly perfect construction. Nonetheless, physical and organizational factors placed limitations on its further evolution and improvement.

Multicellular organisms were the response to these limitations. They first arose when some of the daughter cells failed to separate after division and formed clumps whose size apparently imparted certain advantages. This led to ever larger aggregations (colonies) and a gradual division of labor. Fundamental and supplementary capabilities which up to this point had been assumed by organelles were then transferred to multicelled, much more capable organs.

### Capability in multicellular organisms

Viewing the evolution of organisms as an evolution of capability rather than of material structures opens up new perspectives on a number of issues: certain facts that previously received little attention become paramount. One such fact is that in the overall evolutionary process, only some of the fundamental capabilities were transformed to multicelled organs, while precisely the most important ones remained in the evolutionary domain of unicells. This occurred even though unicells were by no means prepared for the task and were inevitably at risk of being unable to live up to the new demands.

Let us begin by examining the interesting question of the organizational prerequisites for individual cells within the larger community to deliver differentiated capabilities, i.e. what prompts them to develop liver, eye, muscle and bone cells along with many other types of cells and to use these to form highly specialized organs. After all, in the normal course of events, each division and constriction of a cell yields daughter cells with precisely the same genetic makeup.

The solution to the problem, which no doubt also involved a long series of mutations and recombinations, is rather astounding: each somatic cell in a multicellular organism contains the entire information required to build the complete organism. In the daughter cells, however, certain messenger substances (repressors) suppress all those genetic commands that are not crucial for the respective differentiation. Therefore, only those relevant for the specific task kick into action. Let me use a practical comparison to illustrate how this mechanism works. Imagine the construction of a large factory complex by several thousand workers. The complete instructions for the building and all its furnishings are compiled in an enormous, multi-volume tome. Every worker is given the complete set of volumes, and all the pages that are not relevant for each individual's job are crossed out in red ink. The pertinent information for the individual worker is therefore restricted to those pages that are not crossed out. As a consequence, for some workers one or two volumes may well contain no relevant information at all, whereas that person will have to seek out a range of isolated passages in the remaining volumes. A modern businessperson can only shake his or her head in disbelief at such a solution. Not only would every worker have to carry such a bulky volume around at all times, but finding the correct instructions for a particular task would no doubt be difficult and time-consuming.



In the transition from uni- to multicellular organisms, however, no better solution was apparently possible. At that point in time it was already entirely impossible for the highly evolved cell to fundamentally change its reproductive mode through mutation and recombination. Each component cell of a newly evolved multicellular organism therefore inherited the total set of instructions for that organism. Additional nucleotides were constantly being added to the DNA strands within the nucleus, steadily increasing the length of the genetic code along these threads. The repressors, whose number no doubt also increased, were responsible for preventing the wrong instructions from being activated or the correct instructions from being issued at the wrong time. This mechanism is scientifically proven fact: considering the great number of viable multicellular organisms – both plants and animals – and particularly the very successful human race, it clearly functions excellently.

Before we go into the fundamental mechanism that determines every detail of our bodies, I would like to present three examples illustrating that key capabilities were also transferred to multicelled organs during the transition from uni- to multicellular organisms. The first example involves locomotory organs, which in the former are basically restricted to whip-like flagella and the synchronized, rowing motion of cilia. In multicellular organisms, much more powerful units took over this function, which is essential for most other fundamental capabilities. Hundreds of thousands of cells form the fins of fishes, the armored, multi-segmented legs of crustaceans, the limbs of amphibians and reptiles, the wings of birds, and our own legs, arms and hands. Each component cell of these powerful organs contains a full set of genetic instructions – in ever longer DNA strands – for the entire body and all its functions. An array of chemical messenger substances is responsible for ensuring that precisely the correct events take place in each cell.

The differentiations of sensory organs, which also consist of hundreds of thousands if specialized cells, are even more impressive. Our eyes and ears are perfect examples. Both are precision instruments whose capabilities by far transcend the primitive sensory organs of unicellular organisms. As many transitional stages demonstrate, our eyes and ears evolved through mutations and the recombinations inherent to the sexual process. Again, an army of signal substances, control units and accessory organs help ensure that full function is retained and that errors, should they crop up somewhere, be rectified. Obviously, this is simpler in more primitive organs of less highly evolved multicellular organisms than in the highly differentiated organs of more highly evolved representatives: certain bounds are placed on the perfect interplay between cells and their messenger substances.



The third example I would like to introduce is the organs serving in energy gain. In every animal, various sensory organs and the auxiliary, locomotory organs are used to recognize and pursue prey. Multicelled organs that serve in feeding include the mouth with all its teeth, the tongue, the salivary glands, as well as the esophagus, the stomach, and the intestine with its various auxiliary structures. Food, once partially broken down into its useful components, is conveyed into the bloodstream via the microvilli lining the intestinal wall. These substances are then conveyed to the individual cells and further broken down in the mitochondria. ADP-ATP batteries then bring the energy gained to the ribosomes, which assemble the required proteins. In the fundamental capability we are examining here, virtually every energy-gaining process has been taken over by multicellular organs: only the final fractionation step and energy production is carried out – as in unicells – by the mitochondria in the cytoplasm. The core function of the overall process therefore remains within the competence of an organelle. Note also that the tiny energy-transport batteries (ADP-ATP), which are already present in unicells, are produced by the individual cells themselves. The same holds true for the ribosomes that assemble the species-specific proteins: these organelles, which can be found in every cell, are also formed by that cell. Finally, it is worth mentioning that the multicellular body requires a separate system of channels in order to provide the cell, which once led a free and independent existence in the sea, with an adequate environment. This function has been assumed by the lymph system: it guarantees that each cell is surrounded by a thin layer of fluid whose chemical composition approximates that of the primeval sea. In order to maintain a specific osmotic pressure under changing environmental conditions, the membrane enclosing each cell is provided with numerous "ion pumps". This feature is for example crucial for those fishes that migrate from seawater into freshwater and vice versa.

These facts help underline my earlier contention that the cell is a highly adaptive but rather demanding building material. The fact that the human body is composed of $10^{13}$-$10^{14}$ cells, each of which maintains a separate, highly specialized "workshop" and therefore great versatility, should cause anyone active in the business world to shake their heads in disbelief. Nonetheless, when these units began to form multicellular organisms, the cell was already so perfectly organized that – beyond adding additional units – nothing fundamental needed to be changed.

Let us return once more to the processes taking place in the nucleus, first to the cell differentiation involved in forming multicellular organisms. In this process, the germ cell had to induce the daughter cells to differentiate according to plan: into muscle, nerve, connecting tissue, bone, and other cells. This is the responsibility of messenger substances which, in the respective cells, block all the commands that the differentiated cell does not need and only permits those that effect the desired differentiation. Furthermore, messenger substances that control subfunctions must also be present. In the case of the eye, for example, which consists of numerous, variously differentiated cell types, overall functionality is inconceivable without appropriate control mechanisms.



The full mystery only begins to unfold when we more closely examine the size of the cavity in the nucleus in which the DNA strands (chromosomes) float about as if in a tiny aquarium, and when we compare this with the length of the strands, which were originally dimensioned to enable reproduction in unicellular organisms. With the advent of multicellular organisms, many additional letters and words had to be added to the genetic code, increasing its length correspondingly. In the case of humans, geneticists have calculated that this chemical text, which issues the instructions for our entire bodies, consists of three billion letters. Compared with the number of printed lines in a book, this is equivalent to 30 times the pages in all 25 volumes of the Encyclopedia Britannica. Our concern here is the number and length of these strands (chromosomes). Each cell in the human body bears a complement of 46 chromosomes (diploid set). Each individual strand, in turn, is approximately 10,000 times longer than the diameter of the cell nucleus. If we compare the nucleus diameter to that of a wine glass, then the length of the DNA strands would measure nearly 700 meters!

It boggles the imagination how 46 approximately 700m long threads can find space in a fluid-filled wine glass without becoming hopelessly entangled and still retain the capacity to undergo complicated maneuvers and functions. During each division they must become extremely compact, rendering the chromosome visible under the microscope. In the course of this process they apparently become packed in special "packets". The chromosomes align themselves in the center of the nucleus and one set is pulled into each of the developing daughter cells by the central bodies (centrioles) and the spindle apparatus, a process that is also visible under the microscope. Before the next division the DNA strands lose their compressed form and duplicate themselves in full by adding on the respective complementary bases. In the sexual process, which I only briefly touch upon here, the same number of equally long strands of the sexual partner penetrate the nucleus of the egg. If this entire scenario seems implausible enough, then we can further complicate matters by asking: "what moves these endless strands, which lack any locomotory organs of their own? What prevents them from becoming entangled? How do they become condensed into packets? And how, during duplication, do delimited sections of the strands unravel (from their double helix configuration)? Moreover, there are grounds to believe that the repressors lay a type of protective sheath over those genes that are to be blocked during cell differentiation; this raises the question of how such sheaths avoid impeding subsequent cell division processes. The manner in which all this proceeds automatically, without auxiliary tools, remains largely unknown even today.

The nucleus along with its internal structures was designed for the needs of unicellular organisms, which underwent continual improvement over a period of two billion years but whose dimensions remained largely unchanged. All this leads to one conclusion: an organelle responsible for two fundamental capabilities (reproduction and structural improvement), which then had to expand these functions to cover the needs of the much larger and considerably more differentiated multicellular organisms, was clearly heavily overtaxed. This is all the more evident when we consider the organelle's third impressive achievement: by regulating differentiation, it gave rise to the full range of multicellular organisms, including man. The fact that this all proceeds virtually error-free is a truly astounding feat.



From an evolutionary perspective in which *capability* is paramount, the fact remains that two of the most important fundamental capabilities, reproduction and structural improvement, were *not* transferred to multicelled organs in the transition from uni- to multicellular organisms. Furthermore, a third fundamental capability, namely energy gain, largely remained within the competence of an organelle. This drives home the magnitude of the constraints that were shed when, during the transition from multicellular to hypercell organisms, both reproduction and structural improvement were shifted to multicelled entities (in the central nervous system), and how both were then very rapidly transferred to additionally formed organs (for example written language and research institutions). The same holds true for energy gain, which leap-frogged the multicellular phase: the use of external energy to power additional organs was directly shifted from an organelle (mitochondrion) to additional organs such as hydropower plants.

## Capability in hypercell organisms

Since we are unaccustomed to viewing capability as the paramount factor, we must reset our sights in examining how capabilities *shifted to better-suited organs* in the course of evolution. Our standard approach has been to focus on the development of the animal or plant *body* and to concentrate on the continual improvement of its components in investigating its overall evolutionary progress. As the preceding section has demonstrated, viewing organisms as capable entities and therefore focusing on the ongoing development of capabilities opens up an entirely new array of questions and assessments. Thus, some key capabilities in multicellular organisms remained bound to organelles; while this allowed some measure of improvement, it never yielded the advantages of multicelled organs. Let us apply this novel perspective to evaluating the path of evolution and the accompanying problems. Let us also begin our examination of how capabilities were transferred to additional organs by using the same set of clear and simple shifts that I listed earlier. The first example involved locomotion as a crucial capability in most animals. It shifted from the flagella and cilia of unicellular organisms to the much more efficient fins, legs and wings of multicellular organisms. The subsequent shift to additional organs is no less spectacular. In humans, for example, locomotion shifted from the legs to the bicycle, to the automobile, and to the railway system as a communal organ.

I illustrated the shift in the sensory organs from uni- to multicellular organisms with the organs involved in visual and acoustic perception. These organs underwent an extraordinary development not only in the vertebrates, but in the molluscs and insects as well, and they are hardly comparable with the analogous organs of unicellular organisms. In the human-controlled hypercell organisms, the eye's capabilities were further enhanced by eyeglasses, telescopes, microscopes and television, while those of the ear were enhanced by the telephone, telegraphy and radio. The sense of smell, which in multicellular organisms has improved to the point where certain insects can even detect individual odor molecules, hypercell organisms boosted their capabilities through analytical instruments that detect chemical compounds. Hypercell organisms have even added additional sensory organs that enable previously unknown capabilities, for example Geiger counters that detect and measure radioactivity.



Energy gain – as my third example – was considerably improved in multicellular organisms by auxiliary units such as the mouth, stomach, intestine, circulatory system (in plants: leaves, branches, trunks, roots, sap channels). The basic competence, however, remained in the domain of organelles: the mitochondria and the plastids. This illustrates how capabilities can be enhanced by new organs while the central function remains entrenched at a lower evolutionary level of organ development. The situation is no different in the human eyes, ears and nose: their capacity is decisively improved through additional organs, whereby the core function perseveres in multicelled organs. Energy gain is a more complicated case. In hypercell organisms a division occurs in that the controlling core (a human) continues to rely on the energy gained from food (like all multicellular animals), while the power for additional organs, which determine the competitiveness of most hypercell organisms today, has shifted to external energy.

The interested reader can no doubt come up with a whole array of other vital capabilities and determine how these are delivered in unicellular, multicellular and hypercell organisms, how they shift from certain organs to others, how they are often merely enhanced by new additional organs, or, as in the above-described example, how they may split into parallel, disparate yet ultimately mutually interdependent channels. At this point I would like to briefly return to the two particularly important fundamental capabilities of reproduction and structural improvement.

As indicated earlier, reproduction in hypercell organisms has also split up into two channels. The human beings at their core continue to reproduce in the same manner as all multicellular organisms, whereby additional capable entities such as medical doctors, medications and hospitals can provide anciliary services. On the other hand, our crucial additional organs, which are separate from the cell body, are reproduced in an entirely different manner: initially through written or oral instructions, later through specialized hypercell organisms from which they can be purchased. In this case, the individual need no longer deal with organ reproduction him/herself. Favorable environmental conditions lead to a situation in which such organs are produced by others as long as demand remains, whereby their purchase price is several times lower than that of an equivalent "home-made" article.

As far as structural improvement is concerned, it helps to recall the cumbersome and uneconomic process that led to gradual improvement during the long evolution of uni- and multicellular organisms. Statistically seen, the odds of taking a step with positive selective value via mutation are pegged at a mere $1:10^8$. Virtually all mutations lead to faulty progeny that succumb in the competitive struggle. On the other hand, the odds that a step with positive selective value takes place through the sexual process (by recombining various mutations) is several orders of magnitude greater. Nonetheless, considering the difficulties associated with this process, it must be labeled highly ineffective despite the wealth of animal and plant life on our planet. These difficulties include: the need for two partners from the same species to find each other; the need to at least temprarily abandon innate inter-individual distances, an event that requires special behavior control mechanisms; the formation of obligatory secondary sex characters; and the complications that arise during genetic recombination and fertilization. Such results could only be achieved over the course of very long time periods – and in my opinion only with considerable support by numerous *shifts*. This situation changes dramatically with the advent of the additional organs purposefully built by human beings. The information melting pot (the goal of the sexual process) can be achieved much more effectively and at less cost through conversations, discussions, technical literature, seminars, university lectures and the like. At this level of function, all the additional organs and behavior patterns behind progress in hypercell organisms and business enterprises were formed at an ever-accelerating pace.



This example once again clearly demonstrates how capability-oriented thought can lead to radically different evaluations of the very same facts. In light of the major role that the sexual drive and all its ramifications plays in modern society – not least in connection with the population explosion as one of the great problems of our time – nothing would seem more far-fetched than mentioning it in the same breath as discussions, lectures, research and seminars. Nonetheless, from an evolutionary standpoint, both processes serve to promote the same capability.

### Capability in business enterprises

As argued earlier, business enterprises cannot be clearly delimited from the hypercell organisms that spawn them or from governments, with which they are allied or even identical to on many levels. As the life process becomes an increasingly powerful force, the structures that perpetuate it also consolidate.

From an evolutionary standpoint, we can draw certain parallels between the current state of development and the earliest beginnings, i.e. the origin of life. Favorable environmental conditions played an important role in sparking life because they fulfilled fundamental capabilities. At the level of hypercell organisms and businesses we see how two such fundamental capabilities, namely reproduction and structural improvement, have become partially or entirely superfluous. In reproduction this is the case when successful humans make the transition into another species by themselves assuming the build-up costs for new individuals of that particular species. The situation is much the same in structural improvement, where research has increasingly become the domain of state institutions, i.e. of the community, or when efforts in a particular direction are dropped when further progress poses a threat. It is entirely possible that environmental issues will turn out to be the main motor behind further development: after all, environmental degradation is the first common enemy that life as a whole must face. A common enemy, a threat that affects everyone, can work wonders by virtually eliminating individual interests and disputes and spawning a uniform entity with a common goal.

The only truly novel aspect linked with the development of larger states and business enterprises is our attempt to harness intractable nuclear energy. Characteristically, it first found use as a weapon of mass destruction and is now to be elevated as an external energy source for additional organs. Every reactor represents a potential nuclear bomb despite the most stringent security standards and even when the by-product and waste disposal problems have been solved: it merely needs to be taken under fire or sabotaged to lose its protective shield and to subsequently devastate the environment. Moreover, the history of man has with utmost clarity demonstrated the alarming regularity of new conflicts and no lack of unpredictable psychopaths. If we dare hope that the life process will finally consolidate itself, then we must abruptly terminate this experiment. The gates, which have been briefly opened, must be hermetically sealed despite any losses that the community may incur.



Money, which has fueled progress in hypercell organisms and businesses, represents another unfettered source of power with similar wide-ranging repercussions. In free market economies this universal mediator is increasingly mutating into an all-powerful seducer and idol. It is certainly no easy matter to separate the inherent advantages and risks of money and to seize the advantages and ward off the risks. In my opinion, parental guidance and the proper education of children play a decisive role in this critical stage in the evolutive process.

### The threat of self-destruction

Since the size of our planet is limited and offers only finite space and vital resources, the unbridled reproduction of hypercell organisms and business enterprises has reached a critical level. In their book "The limits of growth" (1972), Dennis L. Meadows and his collaborators were among the first to emphatically stress this dilemma, and ever since then a wide range of efforts have been made to counter the widespread environmental damage. Organizations such as Greenpeace and Global 2000 have made a remarkable effort around the globe – including activist tactics and calls for altered consumer behavior – to draw attention to the many problems that are rapidly becoming acute. From the evolutionary perspective, however, every effort along these lines will have only limited success unless we tackle the root causes of this evil: the ever-increasing growth of the human population coupled with exponential economic growth (Fig. 7).

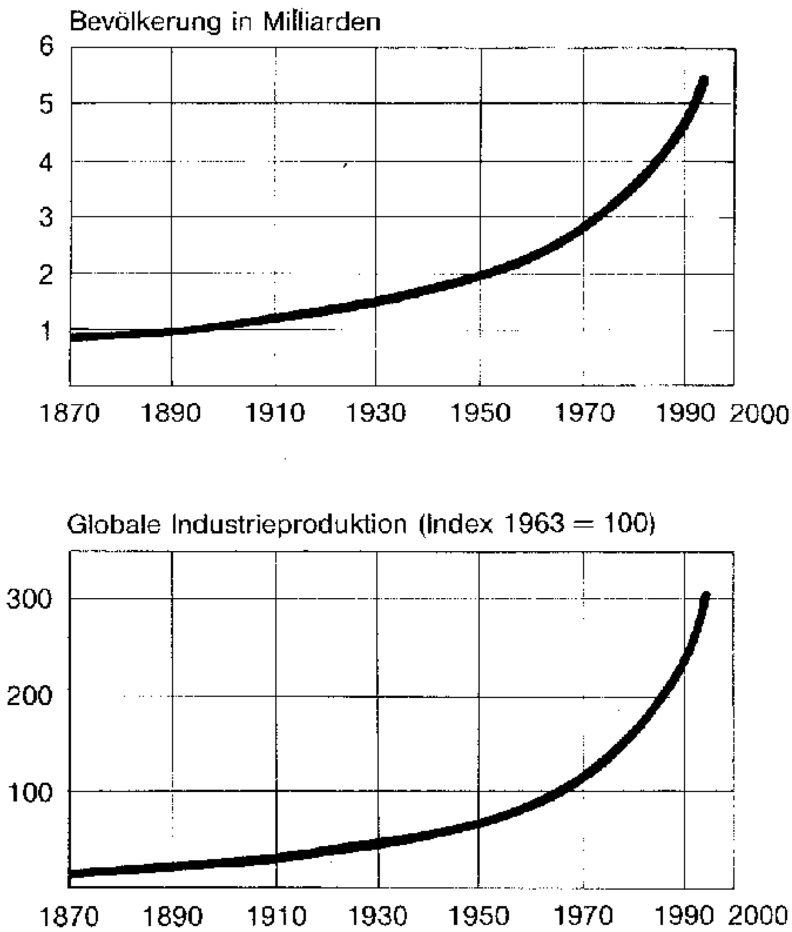



*Fig. 7: The explosive growth of the human population and of industrial economies. Both curves, which are based on the most recent surveys, show a growth trend that is incompatible with a planet of finite size. Every schoolchild can recognize this. The inability of the leading minds in the field of economics and politics to do so can be explained by the clear consequences that we would all rather negate. Perhaps we would react similarly if we knew that a comet was approaching the Earth and would destroy our planet at a precisely predicted time. Nevertheless, this rapidly approaching, self-inflicted catastrophe can be averted. The prerequisite, however, is a fundamental re-assessment within the next one or two generations. We must supplement the admonition "know thyself" on the frieze over the temple of Delphi with the maxim "know thy limits".*

*Population (in billions) / Global industrial production (index 1963 = 100)*

The objective of the present book is to present evidence that humans, rather than being the epitome of evolution, are merely one of its component parts and that the formation of our additional organ complexes also adheres to its laws. I would therefore do my theory and my line of argumentation injustice by applying them to hotly contested issues of the day. Moreover, my theory runs counter to many currently held dogmas in various scientific disciplines, so that there will be no dearth of opponents. Under these circumstances, I believe it better to only briefly address the issue of whether the ideas presented in this book allow us to draw conclusions that can help resolve the fateful and sudden crises that have materialized.

First, we can take note of the fact that three factors have played an undisputed role ever since the dawn of evolution: growth, innovation and reproduction. Every type of organism that possessed these capabilities was automatically favored by natural selection. And now, in the cosmic microsecond of a mere 50 years, have all these fundamental principles somehow changed? No. It would be as implausible as it would be absurd to claim that the most crucial and stalwart values all of a sudden need to be re-thought and re-assessed. I further contend that this would be an impossibility, even with the best of wills. We, along with all other organisms, are programmed according to these values right down to the last fibers of our bodies. Based on our insightful thought, we may well be in a position to comprehend the sudden changes that have occurred and their consequences; nonetheless, drawing serious consequences from this is an entirely different matter, especially since our short life span makes it difficult to imagine that a single individual's actions could in any way influence the overall course of events.



This is compounded by the information overload that almost all of us must cope with today. The media flood us with an uninterrupted stream of news from all over the globe, leaving us with precious little time to form our own opinions. This is superimposed by a behavior that is also innate to all humans and which ethologists term the "crowd effect"; in humans it expresses itself in the ability of the mass to exert a strong influence on the behavior of the individual – even if this is against that individual's own will and good sense.

The Canadian philosopher and sociologist Marshall McLuhan wrote that every technical advance leads to "a type of narcotization of humans which renders us dazed, deaf, dumb and blind". For our central nervous system, "every extension of our somatic body is a shock against which the body rebels with this reaction". The automobile, the telephone, television, and the growing flood of new additional organs and additional opportunities clearly overtaxes broad sectors of our brain to which our consciousness has no immediate access

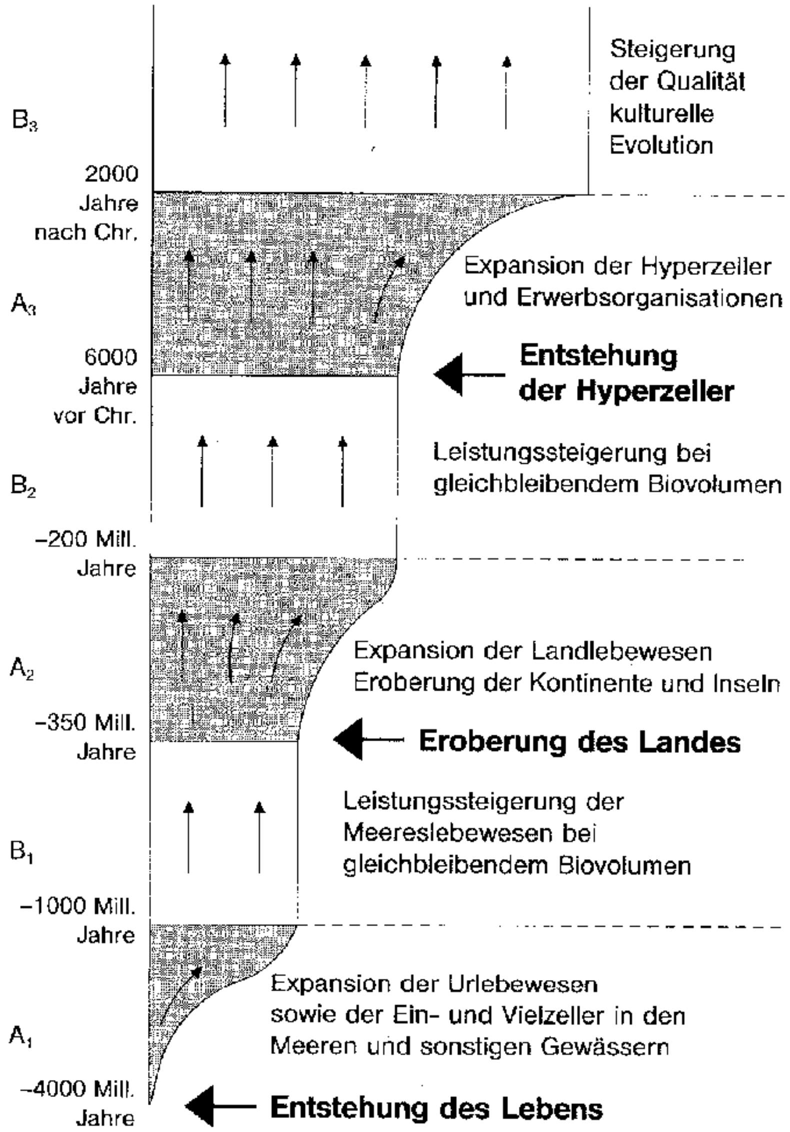





*Fig. 8: Periods of quantitative and qualitative growth (highly schematic). The expanding development of life over the last 4 billion years ($A_1$, $A_2$, $A_3$) has already been interrupted twice by compulsory periods of zero growth ($B_1$, $B_2$). We are currently entering a third such phase ($B_3$). Economists currently have difficulty envisioning zero growth; instead, we are striving to promote economic growth. At the same time, the finite size of our planet is incompatible with an ongoing procreation of humans and the hypercell organisms and business enterprises they form. Zero growth is the only hope of averting a global catastrophe. The fact that evolutionary history was already characterized by two long periods of zero growth puts us in a position to evaluate the consequences. Once quantitative expansion is checked, qualitative growth becomes the dominant factor. The task is then to achieve the best qualitative result at the lowest cost. Applying this to our situation means regulating reproduction, curbing our pursuit of luxury, and introducing constraints on industry and economy that are dictated by environmental considerations (after Hass, 1982).*

*improved quality*
*cultural evolution*
*expansion of hypercell organisms and business enterprises*
*origin of hypercell organisms*
*improved capability at steady biovolumes*

*expansion of terrestrial organisms*
*invasion of continents and islands*
*invasion of land*
*improved capability in marine organisms at steady biovolumes*
*expansion of primitive organisms along with uni- and multicellular organisms in the sea and other aquatic habitats*
*origin of life*

and which, like a computer, must somehow evaluate and order the new input. In a certain sense, the human race is less and less in a position to deal with far-reaching problems that have no apparent immediate implications for the individual.

This is also the appropriate point to mention the incredible power of industrialized economies to sell products and services that help promote further growth. The adage "grow or die" is fully applicable: I have only rarely come across an economist who can envision "zero growth". Most are quite ready to combat and restore recognized damage or to commit ever larger sums of money to rectify past errors. The one thing that apparently no one can imagine is that – once the damage has been repaired – we cannot simply take up where we left off. We will have to gear up to resetting our sights (Fig. 8).

After all, upon recognizing a threat, the human race has more than once not only changed its ways but managed to rise to new heights. The bottom line is that we are all sitting in the same, large boat that has sprung numerous leaks. The situation can be mastered, but only when every citizen of Planet Earth becomes fully aware of our predicament.

## Summary and Outlook

This book presents a long line of argumentation and the reader may find it helpful to see the most important facts and conclusions briefly recapitulated here. In his book on the origin of species, Charles Darwin argued that the different species do not represent individual acts of creation, but all stem from common ancestors. He presented an enormous wealth of evidence for this theory and demonstrated that man is also an integral part of the evolutionary process. Since the descendents of the individual species are not exact carbon copies of each other, but show variable traits, natural selection inherently ensures that the best adapted organisms survive and reproduce. Over long periods of time this led to a higher development in which natural selection became the controlling mechanism.

The present book contends that mankind, in contrast to widely held opinion, is not the momentary epitome of this development. Rather, from a functional perspective, each human being is on a level comparable with that of those unicellular organisms that gave rise to multicellular organisms. Just as every multicellular organism continues to stem from a single cell (the germ cell), the even larger and more capable entities I have termed hypercell organisms always stem from a human being: our own subjective viewpoint has hampered us from recognizing the evolutionary significance and status of these hypercell organisms. Every working person along with his/her tools, workshops and businesses is a component of these larger organisms: in the progression involving uni- and multicellular organisms, they represent a third era in the evolution of life. In the subsequent development, the many new species spawned by hypercell organisms gave rise to even larger and more powerful organizations, above all business enterprises. Depending on the form of endeavor, these in turn gave rise to numerous additional species whose success and further development continue to be subject to natural selection. Although a range of new criteria were developed to evaluate these entities, the efficiency of the new species remains subject to the same fundamental, quantifiable criteria that are decisive for uni-, multi- and hypercell organisms. Similarly, their evolution is inherently controlled by natural selection.



Traditional biological thought holds that the physical structure of organisms and their organs as well as their behavioral repertoire are the key criteria for their selective value. Nonetheless, I have presented numerous examples, especially in Chapter 1, of how the very same capabilities can often be delivered by very different body structures, organs and behaviors. More than one road usually "leads to Rome". From this I conclude that the decisive factors determining selective value are not material structures or behaviors, but capability. And, as I have stressed, this can be attained by any number of different means. Advances via mutation and recombination at one level can be surpassed by advances at an entirely different level that was not even originally developed for the particular function. I contend that six fundamental capabilities are decisive for all organisms – and I place hypercell organisms and their business enterprises in this category – and I treat these in more detail. Briefly recapitulated, these are: energy gain, acquisition of substances, defense against adverse and utilization of favorable environmental factors, reproduction and structural improvement. All fundamental capabilities are accompanied by numerous supplementary capabilities that enable specialization and which form the hierarchic makeup of the former. Wilhelm Oswald pointed out that every organ and all tools fashioned by man can be viewed as energy transformers whose respective configurations allow them to convert consumed raw energy into useful energy. I share this opinion and consider this insight to be a cornerstone of my theory.

To date, quantifying the selective value of various species was considered possible only in exceptional cases because the activities of species are so intricately interrelated. If, on the other hand, organisms are viewed as capable entities rather than material bodies – a standpoint that confronts conventional thought with considerable problems – then it becomes apparent that their efficiency can be evaluated based on the same universally applicable, quantifiable criteria. I term these criteria cost, precision and time required for the task. Obtaining even more precise data requires distinguishing between the build-up and functional period of the capability-providing organs. In the latter period, a further distinction can then be made between operational times, quiescence, and phases in which functions changed. I present a number of examples for this as well.

In uni- and multicellular organisms, organs arise through various differentiation processes. In Chapters 2 and 4, I argue that organs need not necessarily be firmly attached to the cellular body and that the material from which and the manner in which they are formed is of no consequence. The key criterion is their capability. A wide range of examples shows that many plant and animal species use innate behavior to form additional organs that are separate from the body (the spider's web) or that consist of inorganic material (the clay nests of certain birds) or have not been produced by the organism itself (the empty snail shells that hermit crabs convert into their protective organs). Even other organisms can be transformed into organs of another capable entity (the foster parents that the cuckoo induces into brooding its eggs). The same also holds true for hypercell organisms that are paid to provide services for others. In uni- and multicellular organisms, limits were placed on the degree to which capability could be enhanced by such additional organs because their formation is governed by innate control mechanisms in the central nervous system; they arise by mutation and recombination and are therefore bound to the genetic code.



The intellectual capacity of early humans, however, had advanced to the point that they were able to form additional organs for specific purposes and of using language to convey to their descendants and other fellow humans the instructions on how to produce and utilize these organs. This marks the first time that an organism gained the ability to form and apply a wide range of such units (for example tools, weapons, clothes). We became specialists in manifold specialization. A division of labor soon developed in the groups that early man formed, with some members specializing in producing goods, others in providing services required by the community. Money became the universal mediator that enabled a person – through his or her own work – to enjoy services provided by others. The result was that such newly arising hypercell organisms split into a large number of species, whereby natural selection continued to determine which ones were successful and multiplied; this also set the compass for the evolution of a steady stream of new species. Reproduction between different species – a key evolutionary advance – also became possible in the era of hypercell organisms. All hypercell organisms are composed of human beings which, as the controlling core, enjoy the fruits that the former produce. A blacksmith is under no pressure whatsoever to invest his profits in further blacksmiths. Each individual is therefore in a position to form quite different hypercell organisms. This allows individuals to both change their professions and therefore their species – yet another advantage. Since information can be transferred over ever greater distances (by letter, telephone, radio, television, email), advances are being made at an ever greater pace.

Energy gain through exchange processes adds a third variant beyond that found in plants (photosynthesis) and animals (gain of foreign organ structures, release of the chemical bond energy contained therein): the prerequisite for this is money as a mediator. Money is earned by producing goods and services; these in turn can be used in a second exchange process to purchase food and other necessities. I have therefore termed this type of energy gain in hypercell organisms "gain through two-fold exchange". Parallel to this, many species of hypercell organisms (hunters, fishermen, farmers) made use of the predatory habits inherited from their animal predecessors or specialized in forcibly procuring money and objects that can be turned into cash (thieves, robbers, blackmailers). In most armed conflicts, the theft of foreign territories and valuables was an elementary motivation if not the sole incentive. Additional forms of energy gain were continuously being added. Tools and weapons were originally powered by the body's own energy, an uneconomical condition. In the course of the successive energy transformations – which begin with the search for prey and continue when that prey is consumed and digested, whereby energy reaches the cells via the bloodstream and is then set free and converted into special tasks – the total losses amount to 80-99% of the free energy. This is converted into heat that is lost to the environment. A much more rational strategy is to utilize the free energy available in the environment, such as that contained in wind and rivers, and later also to harness that contained in wood, coal and crude oil to directly power additional organs (sailboats, water mills). The losses here are considerably lower. In this case, electricity proved to be a universal mediator comparable to money. It enabled one form of energy (e.g. hydropower) to be conveyed over great distances and to then be converted into kinetic energy (machines), light energy (light bulbs), and heat (heating ovens). This gain of external energy, as opposed to nutritional energy, is considerably more economical in powering additional organs (especially all manner of machines) and greatly promoted the evolution of hypercell organisms and mankind. It also determines the course economic development, whereby efficiency remains the key criterion. Human intellect is not the true controlling factor here. Although our intellect created much, only those creations that proved successful were able to persevere. Natural selection, which weighs ever new factors that determine success, therefore also controls the entire sector in which additional energy sources are developed.



Major business enterprises are particularly affected by this situation. Mass production was introduced: bit by bit, human capabilities were transferred to additionally formed organs, even functions of the brain as amply demonstrated by the advances in electronics, particularly in the computer industry. The ever-expanding and more powerful industries remain anchored in the business mode involving two-fold exchange. Here, the innate predatory instinct in humans tends to disturb good business practice by promoting predatory strategies. Customer-oriented, target group-oriented and co-worker oriented strategies are the product of rational considerations and are only gradually coming to replace the innate instinct program titled "still predators at heart" and "quick money". This new approach is the only avenue to build up a stock of customers (the key to success) and to bind good staff members, which are no less important, to the company. Also, businesses are more powerful because they globalize their activities and undertake long-range planning. On the other hand, the attendant supervision and control hierarchies make them more cumbersome; this ultimately leads such companies to split into smaller, more flexible businesses, a process in which natural selection continues to play a role. From the evolutionary perspective, the potential for social friction is clearly much higher in such mega-industries than in the considerably smaller and less complex hypercell organisms. The tight affiliation with government institutions is also affected.

My theory may well proffer a surprising explanation for the formation of states, a process that has been scrutinized by philosophers and state theorists for millennia. As I have laid out in this book, the additional organs formed by humans are the backbone for all organisms participating in the third and fourth phase of evolution. They allowed evolution to cast off the yoke inherent in the link to the DNA strands in the tiny nucleus of every cell in a multicellular organism's body. I treated this largely neglected topic in more detail in Chapter 8, the final chapter. While additional organs have enormous advantages, they also have a particularly serious drawback. Since they are equally useful to others, and they lose virtually no value when transferred from one person to another, they must be protected from theft and robbery. The only conceivable and effective solution was a huge communal organ, the state: its task was to protect the property of its citizens, of hypercell organisms and of business enterprises. Armies, cannons and airplanes helped ward off attack by other states, while the legislature, police, courts and jails fended off predatory tendencies from within. Such an enormous organ can rather quickly be subjugated by a hypercell organism or a business enterprise through subversion and dictatorship.



The course of human history is paved by a large number of such dramatic events. On the other hand, democratic processes can also play a role in converting states into business enterprises. Examples include trade subsidies, tourist attractions, credits designed to stimulate the economy, etc. John Kenneth Galbraith pointed out symbioses between industrial giants and large nations (the USA in particular). We live in an age in which virtually every interest is interwoven with a range of other interests.

In Chapter 7, I demonstrated the curious role that humans play in the era of hypercell organisms and business enterprises. In contrast to the germ cell that gives rise to and is ultimately "lost" in the overall structure of each multicellular organism, human beings, who are not firmly attached to their additional organs such as workshops, factories, businesses and industries, have an entirely different status. We are fully mobile. Humans are, of course, to some extent bound to the hypercell organisms they control and to the businesses in which they are employed because the latter provide us with essential income. On the other hand, what we do with this money is largely up to the individual. Considering our palette of innate instincts, it is little wonder that we structure our lives to optimize our comfort, our sense of pleasure, and our pursuit of happiness. If sufficient funds are available, we tend to surround ourselves with an ever-increasing inventory of gratifying goods. We are almost left with the impression that humans are parasitic creatures that carefully explore and exploit every source of positive emotions slumbering within us. Nonetheless, this analogy does not hold. The hypercell organisms and businesses whose coffers are milked for their profits are in no way damaged by our inclinations. On the contrary, in the third and fourth era of evolution, this very underlying predisposition has become the strongest motor behind our effort to earn money. The market economy has every reason to fan these embers. A steady stream of new improvements, amusements and luxury items of every type are being produced and marketed, all made palatable by clever advertising; the consumer is constantly being lured into ever-new channels of consumption.

In the meantime this development has reached critical proportions. All signs unmistakably point to the fact that this endless line of products and activities has overwhelmed our planet and its finite resources. Their negative impact on the other inhabitants of Earth, on our atmosphere, on terrestrial and aquatic habitats and, ultimately, on our own species is becoming more noticeable by the day.

In the final chapter I briefly outlined these dangers and the rather low odds that we will be able to resolve the situation, which has caught us highly unprepared. Obviously these considerations are tangential to the thrust of the present book, in which I have added some further thoughts to Darwin's great masterpiece. Whether this insight into our phylogenetic development and our current situation can help us to better resolve it remains to be seen.

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I am fully aware that this book will continue to have ambiguities and mistakes despite every effort to eradicate them. I would be grateful for any critical remarks. My theory takes on traditional schools of thought and fundamental tenets still held today (such as the traditional organ concept, the species concept, the notion that material structures of organisms are the criterion of selection). I have therefore made every effort to avoid misunderstandings by making my presentation simple and clear. The idea was to provide an overview of the most important topics and to achieve a balance between brevity and necessary detail. I am fully aware that this book would have to be expanded considerably to fully address the many contradictions that arise vis-à-vis traditional interpretations. Nevertheless, I considered it more important to present a readable book for the interested layman. After all, the theory of the hypercell organism seeks to address not only the experts in the respective branches of science, but also all those who have given thought to their own existence and its significance.