# INSATIABLE CURIOSITY

## Innovation in a Fragile Future

HELGA NOWOTNY

translated by
Mitch Cohen

# Insatiable Curiosity

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## Innovation in a Fragile Future

**Helga Nowotny**
Translated by Mitch Cohen

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For Isabel and Gideon

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# Insatiable Curiosity

# 1 The Emergence of the New

We cannot rely on nature to impose its own limits.
—Marilyn Strathern

## Curiosity and the Preference for the New

A young friend who works with the deaf described a telling difference in their languages. In the sign language of the Euro-American world, the sign that stands for the future points to the front, and probably everyone in Europe and America, deaf or not, would give this direction as the one in which we all think the future lies. Not so in Africa, where the gesture points backward. What lies in front of us, according to the African explanation, is the past because only it is already known. The future, by contrast, lies where we cannot see it—behind us or around us.

The future cannot be equated with the new, which can also be discovered in the past. The new differs from the old and yet must resemble it enough to make the difference recognizable. The difference thus created allows what is new to link with what already exists. New and old can exist beside each other, replace each other, or enter into connections in which what exists appears unfamiliarly new or what is new seems known. The new must be brought into the familiar world and enter into exchange with prior experiences. It must be given meaning and evaluated. The new must be different, but to be recognizable as the new, it requires observers to make a concentrated effort.

However we want to locate it spatially, the future lies temporally in front of us, embedded in the biological processes that follow the arrow of time from birth to death. All societies distinguish between segments of time categorized as past, present, and future. These temporal structurings are subject to historical changes and are components of cultural cosmologies. The temporal horizon separating the future from the present can appear as a hard-edged, abrupt line at the boundary between chaos and order or as a narrow gap through which it is possible to enter an eternity removed from change. The future can be conceived as a smooth transition or as an "extended present" with the open future horizon that entered history with the European modern period. With it arose for the first time the feeling of acceleration that is connected with the extent of the changes and the increased appearance of the new. The future itself, however, cannot be reached any faster. It cannot be overtaken and is in fact, just as the Africans regard it, around us, in front of us, and behind us all at the same time. The future *is*. Its content, its shape, and its fullness—the images we construct of it—always have significance only in the here and now.

But where does the fascination of the new come from? Everyone wants to know the future, especially her own, to be safe from unwanted surprises and to be able to at least partly master the unknown, which is always also a potential threat. But the desire to control the future seeks to protect what one already has and what one has achieved. The fascination with the new, by contrast, is activated by curiosity and the desire to explore the unknown. This curiosity induces us to take the next step that leads beyond familiar terrain. However tentative, cautious, or inexperienced this step may be, it goes wherever longing and the discovery of one's own latent wishes and desires may lead. The thin line separating the present from the future is irrevocably crossed. Curiosity aims to explore a space that must still be furnished for us. With questions and gestures more spontaneous than goal-oriented, curiosity explores what it does not yet know and what seems interesting and worth knowing, often for reasons it cannot name. It actively strives to hone itself on reality and to gain experience that gives reality a clearly perceptible form that can be interacted with. To gain this experience, curiosity uses all the senses and means available to human beings. It is insatiable in two ways: first, because the space of possibilities and reality that is to be explored still approaches infinity; and second, because more and more means and instruments, mostly but not entirely scientific and technical in nature, are at our disposal to expand the space of our experience.

The experiences triggered by curiosity, which are often based on trial and error, are an important reservoir and cultural resource for individually and collectively imagining the future. In connection with the economic development of the third world, the anthropologist Arjun Appadurai sees the conventional definition of culture as a decisive hindrance limiting the scope people urgently need to shape their lives. Culture is usually set in relation to the past and serves to preserve our legacy and tradition. But economic growth and development are associated with the future—with plans, hopes, and goals. In the anthropological understanding, the future usually has no place in models of culture. The science of the future is economics. It assumes that people have preferences and desires, and it models their expectations and their calculating behavior.[1]

But the ability to imagine the future—indeed, the desire for an imagined future—is a cultural ability inherent in all people, including those who, because of their miserable economic circumstances, supposedly have no future. The capacity to aspire, as Appadurai calls it, cannot be reduced to individual preferences and the field of markets but grows out of cultural norms and values. While the affluent have a greater range of experiences at their disposal, know their own wishes and aspirations better, and know the means that can be used to achieve the latter, they are usually also in a more advantageous position to try out new experiences and to implement them purposefully. The capacity to aspire puts them in a better position to navigate an unknown future. This ability to claim the future for oneself is a cultural resource and should be made available also to those who currently do not have it, like the poor in the developing countries.

But it is also a cultural resource potentially available to all who currently feel overwhelmed by the plethora of innovations and the speed with which they are created and introduced. Fear of the future arises from the feeling of losing control over how one leads one's life. It suppresses curiosity and narrows the scope of experience. It reduces one's possibilities for trying out the new. Neither the deep insecurity that accompanies this nor the experience of being steamrollered by events and developments is historically new. The nineteenth century was convulsed by the effects of the industrial revolution and lived through a previously unknown wave of revolutions that "dissolved everything solid into air," as Marx put it. Psychiatrists diagnosed new syndromes like neurasthenia, which they traced to the failure of the human organism and especially of the nervous system to keep up with these changes.

Subtle literary testimony and astute observations still give us today a taste of the intensity of the emotions at that time—for example, when electric lights, the telegraph, and the railroad enter the world of Marcel Proust's literary characters, when Marcel makes his first telephone call, and when he experiences the arrival of his first automobile. He sees these as the great "compressions" of social life, as various communities begin interlocking and become more compact and as the isolation of small villages like Combray is overcome. Everyone is subjected more intensely to social pressure than they were before, which leads to greater conformity and greater anxiety about the authenticity of the self. It is as if this accelerating physical and communicative contact with others does not so much foster as suspend communicative closeness and the intimacy of daily life—the feeling that others see one, the feeling of constant surveillance. Since there are indeed fewer places where one is not seen or can hide oneself, there are also fewer reasons to avoid contact. There are fewer occasions to be alone and to develop a self that is independent of society.[2]

The dependencies that today obscure the view of an imaginary future bear the stamp of globalization, that inscrutable network of world domination and markets, the outsourcing of jobs, and the increase in worldwide competitive pressure. Behind these are structural shifts and fractures that accompany the advance of neoliberalism, on the one hand, but also the shift from classical industrial production to the conceptual and knowledge industries, on the other. Scientific and technological knowledge and the products and infrastructures they bring forth thus have central importance. They are regarded as the driving force for continued economic growth and as indispensable in achieving decisive competitive advantages.

The map available for navigating this sea of opportunities and dangers is confusing because, depending on position and experience, it offers different starting positions for realistically exploring the future. For some, the space of the future is filled with new technological visions and highly promising mini-utopias that hold the potential to make life easier, better, and more beautiful. For others, the horizon of the future is darkened with dystopias. At stake is the maintenance of one's own identity, whether endangered by a cultural diversity that is seen as a threat or by a step-by-step loss, felt as a confiscation, of control over one's own life through growing dependence on technology and scientifically generated innovations. The circumstances under which something new can be tried out, driven by and in playful association with curiosity, then dwindle. The possibility of having new experiences and of encountering a changing and emerging reality with practices that permit trial and error and the exploration of one's own wishes and their implementation also dwindle. The capacity to aspire suffers under this.

These opposing processes make it more difficult for people today to conceive the future and to develop clear ideas about their own scope of influence. This explains the fateful oscillation between regression to the hubris of blind faith in progress that so calamitously characterized the twentieth century and the temptations of a fundamentalism that clutches at fragile and false securities to avoid encountering the future. Conceiving the future—conceiving it differently—demands that we escape the polarities of utopias and dystopias and replace them with other images that are neither taken directly from science fiction nor fueled by media-staged apocalyptic or superhuman fantasies. Conceiving the future demands knowledge and imagination, a shifting back and forth between seriousness and play, science and irony. Knowledge must be spanned widely and, like the convergent technologies much praised today, must strive for an integration that draws from all available sources—the humanities as well as the natural and engineering sciences, the arts as well as technology and the experience of simple everyday life. Conceiving the future means examining the assumptions on which it supposedly rests. The inextricable and confusing bundle of forces and processes—of institutions and power relations in which the insatiability of curiosity encounters the diverse possibilities of its realization and implementation in the framework of a globalized capitalism and the political disorder of the world—must be seen as what we make of it culturally: a continuation of modernity.

Of course, modernity takes on new accents and fractures. In a situation characterized by loss and failure as well as by the striving to fill the emptiness of the future, to constrain it to a forming will, and to try out the freedoms that its possibilities promise, the historically socialized glance and the language of gestures are still forward-oriented. And yet new uncertainties are mixed in with the old, familiar language of gesture and its meanings. Uncertainties appear that result from the innovations with which science and technology open up a world that is different from everything previously thought, known, and seen. We are as able to see into the inside of our bodies using imaging techniques as we are to look through telescopes back millions of years to the primal history of the universe. Modern medicine extends the human life span, and yet worldwide epidemics still repeatedly break out and are still hard to stem. While some already dream of immortality, millions of people die for lack of basic medical care.

But the new that promises the future has a name. It suggests too much and too little at the same time and is as elusive and vague as it is demanding and determined. It is based on a fundamental societal consensus that is nevertheless brittle and must be constantly renegotiated. The name of the new is *innovation*. The word is often used in a deceptively simple form to mean a preference for the new. But what is worth striving for is not the new in general or innovations for their own sake or even the "mysterious banality" of fashion. As a typical phenomenon of modernity, innovation is contingent but not arbitrary. It replaces the unambiguous, traditional order with an unstable equilibrium in which the stability is the result of a demanding connection between various instabilities and is no longer their prerequisite. Fashion is an interplay between social contingency (everyone wants to be original and just like the rest) and temporal contingency (every present appears new and different due to the prerequisite of a past that permits it to be perceived in this way). Fashion plays with chance, which can be neither mastered nor foreseen, and is nonetheless able to operationalize it. It creates reference points and models that are to be deviated from to realize one's own original variants. The model is used to construct an identity of one's own by means of deidentification.[3]

Innovation creates instead the impression that it is the new, state-of-the-art navigation map that offers orientation on the uncertain journey into a fragile future. Driven by the capacity to aspire, it does not predetermine either content or goal. Instead, it promises to provide new experiences that must measure themselves against and hone themselves on an equally changing reality to lead to robust results. Innovation reminds us that the possibility of failure is always on board; it nonetheless encourages us to continue the journey. It plays with coincidence and the attempt to instrumentalize coincidence. It strives to increase the diversity of new forms because that is the only way the new can arise outside an already determined space of possibilities, the only way that, without wanting to predetermine the new, it can extend its effect beyond the process of arising by leading to further innovations. The new combination of already known or existing components, which Joseph Schumpeter said determines the process of innovation, points in the direction of a diversity with the potential to become ever greater. For the more innovations there are, the greater is the number of components from which new combinations can be produced in a rapidly growing process of combinatorics, without the contents being foreseeable and without categories for their description already existing. But the contexts of application must also multiply to offer the diversity of new forms the space of possibilities in which innovations not only arise but can also stabilize, solidify, and materialize. The "essential new" can be neither anticipated nor described, but it requires enough empty places where it can dock and a future that is empty enough to be open for the capacity to aspire but cannot be pinned down to its fulfillment. And yet—such is the law of the new—this future must be different than the present. There must be a clearly recognizable difference from what already exists.

## Difference and Diversity

From the standpoint of evolutionary theory, sexuality can be understood as a machinery that creates differences. This is a biologically tested and proven method of creating the new. The advantages are numerous. A population that reproduces sexually can develop more rapidly than is the case with asexual organisms. Its descendants have a greater diversity of phenotypes, and in the short term, this diversity promises greater chances of adapting to changed environmental conditions. In the long term, it is an insurance against the unforeseeable since it increases the number of options and thereby the chances of survival.

Human societies have invented cultural machineries for creating differences. The experience and assertion that something is new, says sociologist Niklas Luhmann from the perspective of systems theory, mark the decision to use previously redundant possibilities to create structures. They are nothing other than an aspect of the system's self-description. That's why this change in the self-description underscores discontinuity to deconstruct traditions and to be able to reorganize connectivity.[4] The change appears on the meta level in the "difference that makes a difference." The new thus always implies a relation to the existing system; it maintains a relationship to the old.

The cultural machinery that creates differences functions by consciously or unconsciously drawing boundaries between the old and the new. Depending on how these distinctions are set, the new can appear as something whose contours are already known or as a radical break with the given. The less foreseeable the new is, the more it overtaxes perceptual and descriptive competencies. The new appears in two variants. First, it presents itself as a recombination of already existing and thus known elements—as a more or less continuous further development of the existing that pushes forward on the temporal axis into the future. The second variant is discontinuity—the break that brusquely underscores the contrasts to the existing and the ways that the new is different in thinking, seeing, doing, and living.

In the myths of origin—those ideas of the world and the forces reigning in it that almost all early societies developed—these two initial strands appear in the emergence of the new. Either the world and humanity begin with an act of creation (whoever the creator may be and whatever quality this act may have), or the myth of origin takes recourse to iterative processes that generate and regenerate themselves without a clear beginning. Today we are in the process of generating a third myth of origin—that of the scientific-technological civilization that constantly produces innovations out of itself. These come from unexpected scientific-technological breakthroughs or emerge as answers to societal demands for new solutions to problems. This scientific-technological myth of origin posits that the new beginning is constantly repeated and yet is different each time. The origin is the process of innovation itself, a process that has prerequisites but that, thanks to scientific-technological curiosity, continues to create out of itself.

Despite the seemingly arbitrary setting of boundaries and distinction, the definition of the new is never random. The perception and the need to describe the new demand cutoffs and distinctions so that quantum jumps and marked transitions can be recognized. In this way, the new can be distinguished from what already exists and from what arises elsewhere. The different strands of conceiving the beginning are carried forward in the processes of continuity and discontinuity, which together constitute the interweaving of the texture of life. Although there is no compelling reason why evolution must increase complexity, this is what we observe in biology.[5] The increase in complexity depends on a small number of large transitions in how genetic information is passed on between generations. Some of these transitions are unique, like the transition from the prokaryotes to the eukaryotes (now also called archaea and bacteria) and the emergence of the genetic code. Others, like the origin of multicellularity and animal societies, arise several times and independently of each other. There is no doubt that the evolutionary transition from ape to man correlates with an increase in cognitive faculties, which were again increased with the acquisition of speech competence. We already find among the primates a connection between the size of the brain and the complexity of the social system. The origin of language is still one of the most fascinating topics of research.

Similarly, the cultural machinery of innovation produced a number of marked transitions. They led to an increase in complexity, combined with an increase in social abilities to cope with the consequences—that is, to process them and turn them to productive use. Again and again, the flash of creativity manifesting itself individually or in small groups in art or science formed the basis for starting and crystallization points for innovations. In retrospect, the societal or economic conditions that led to heightened creativity can be reconstructed, but only very general statements about the emergence of creativity can be made.

With the beginning of the modern age, the production of the new was delegated primarily to one institution. Modern science appeared beside technology, which had long been independent of it. Since its institutionalization in the seventeenth century, science has specialized in the production of new knowledge and in discoveries. Combining different pieces of existing knowledge produces new knowledge the same way that putting together existing technological components leads to new technological inventions and ultimately to technological systems. Phenomena have long since been produced that do not appear in nature (most recently, synthetic genes). What nature organically shows us can be done is imitated with increasing success and inexorably helps open up invisible areas on the molecular level. What can be converted into information becomes information and can be accordingly processed. The convergent technologies based on successful connections among the biological, informational, nano-, and cognitive sciences open up a broad field in which brain and matter, body and environment can interact in a controlled fashion. These and other transformations that spring from science and technology touch on humanity's self-understanding as much as they change our social life together. The ensuing public debates oscillate between technical utopias and social dystopias. The first celebrate new possibilities of application and of applied knowledge and promise an arsenal of technological fixes for problems currently insoluble. The second point to the destabilizing potential that threatens human life together and that lament the loss of freedom and the delegation of responsibility to an electronically controlled world.

In the short period of the last three or four hundred years, a given, divinely created world transformed into a possible and enabling world whose discovery, invention, and recombination are owed to new ways of looking at things, technologies, and natural-scientific and technical mechanisms of explanation, access, and control. The myths still conveyed a certain idea of the world and its powers that promised security. They provided an image of the only possible world in which every sign and every unforeseen event could be interpreted to correspond with the overarching order and confirmed the corresponding view of the world. With the scientific interpretation of the world, the space of possibilities began expanding, and the possible world began multiplying. Here is where we find the development of the ambivalence so characteristic of modernity, which is expressed not only toward science and technology.

A concept of security and of a rationality promising security that is limited to a Cartesian viewpoint cannot keep pace with the multiplication and expansion of possibilities. Stephen Toulmin distinguishes between two forms of rationality. One is the Cartesian, which claims for itself a monopoly on knowledge and asserts that it knows the sole access through reason. The counterposition is represented by the enlightened skeptic Montaigne, who couples his belief in reason with skepticism, which is to be applied to both the questions and the answers. These two sides of rationality are two forms of reflexivity that stand in a field of tension in all modern societies. The point is thus not the confrontation between the Enlightenment and fundamentalism—between the religious and the secular understanding of the world—but a contradiction inherent in the Enlightenment itself. An exclusive monopoly on interpretation is claimed in the name of the natural sciences, against which stand other interpretative claims in the names of other complementary but also contradictory forms of knowledge.[6] If the first, cool variant of reason still bets on a mostly deterministic reality solely reacting to "facts," then the skeptical variant opens a space for the imagination and for a subjectively experienced reality that emotions and aesthetics help shape.

The "scientific method" that marks the natural-scientific monopoly on interpretation is, in reality, a bundle of extremely disparate methods, experimental and nonexperimental approaches that change and develop further over history. It provides precise, usually mathematically formalized possibilities of depiction and of controllable intervention and makes it possible to liberate the newly discovered or newly generated from the suspicion of being false or deviant. To speak with Luhmann, this is how the "true/false" code entered science. In a long-lasting process of emergence and refining, the struggle was over the "facts," which alone stood for reality, as described and explained by the natural sciences. The aim was to "cleanse" the facts to be able to put them on a solid foundation of proof that is stripped of their original context and thus generally valid. Only then could they be separated from "values"—from the wishes, feelings, and capacity to aspire that repeatedly threatened to contaminate the facts again.

Since the new is, on principle, open and includes everything that stimulates curiosity (which was increasingly conditioned and socialized and whose methods were refined), the scientific procedure seeks to continue posing questions. It does not primarily serve to solve problems but to develop them further. Grasping a problem—posing a question in a manner that makes it possible to tap new dimensions that take the problem further—is often considered the fruitful beginning of a new research program. The horizon of knowledge is as open as the horizon of the future. In this phase, the capacity to scientifically aspire takes its full effect. This is science in the making, the still open, preliminary process of research.

This principled attention and openness toward a realm of the possible, destined to be reduced to become actualized, aims to change the prior possible into the later factual. This also explains why scientific knowledge has the status of being provisional knowledge. Rational procedures that serve to test the various possibilities and that themselves are considered scientifically secured create certainties, but they remain reliable knowledge only for an indefinite period. The cultural dynamics of modern science are based on this movement forward. Opening a wide variety of possibilities begins their—temporary—selection for probable or actual givens. Even these operations are never brought to a final conclusion. The dissolution of the visible world into its invisible components, which are made visible by the use of instruments and image-giving technologies, opens up another growing space of knowledge. Or as Luhmann says, "Dissolution and recombination are conducted as a unity, and this unity, as much as the comparison, is a condition for the appearance of *new* knowledge, i.e., for acquiring knowledge. It is thereby necessary to want what is at the same time unwanted: the increasing probability of uncontrollable recombinations."[7]

## The Taming of Curiosity

Wanting what is not already wanted, controlling what is still unforeseeable: these are the problems that move research and the public today, though in different ways. If not everything that is scientifically possible can or should be realized, what criteria of selection should be applied, and what societal orientation is there for the production of what does not yet exist? The social order strives for at least a minimum of societal continuity and foreseeability. The striving for consensus increases the pressure on the selection in another way—not having to accept everything that appears to be technically and scientifically feasible or not accepting all technological visions. At the top of the list of the fears that are publicly articulated today is the threat of loss of control over oneself and over how one leads one's life.

Today, the advance of liberal democracies and neoliberal economic systems has led to the celebration of what is regarded as its foundation, the autonomy of the individual, which is the result of centuries of struggle for liberation from political domination and religious censorship, at the same time as the neurosciences have cast doubt on whether the assumption of free will can be justified. And while consumers are subject to the suggestion that their decisions in purchasing products is freer, more informed, and more independent than ever before, in one area of research called *neuroeconomics*, imaging techniques like PET and fMRI are coupled with sophisticated experiments in behavioral economy to find out how purchasing decisions are actually made and how they can be influenced.

Today, the cultural-historically unique preference for the acquisition of new scientific knowledge is coming to a socially explosive head. On the one hand, the aim is to keep the machinery that creates differences and brings forth the new running efficiently—indeed, to enhance it. On the other hand, it is turning out that the innovation machinery has a number of societal blind spots. Aside from existing interests, the expanded space of possibility itself must first be explored. Most of the effects on society are not known since technological-scientific innovations also presuppose social innovations and depend on them for their success. For this reason, a balance is needed that guarantees the necessary degree of societal orientation, on the one hand, and that can produce a sufficiently dynamic preliminarity, on the other. But how can the accompanying instability in relation to the "play of possibilities" be accepted by society? How can a basic societal consensus be found that affirms and accepts the unforeseeability that is inseparable from research?

For as François Jacob aptly put it, "What we can suspect today will not become reality. There will be changes in any case, but the future will be different from what we think. That is especially true for science. Research is an endless process about which one can never say how it will develop. Unforeseeability is part of the essence of the venture of science. If one encounters something really new, then by definition this is something that one could not have known in advance. It is impossible to say where a particular area of research will lead." And he adds, "One must also accept the unexpected and the disquieting."[8]

Between society's preference for the new (as expressed in the institutionalization of modern technosciences and their societal status, which saw several centuries of a process of cultural forerunners, diverse revaluations, and many-layered revolutions in the structure of society) and a publicly articulating civil society that now presses for additional selection criteria in the process of acquiring knowledge, a zone of uncertainty is emerging and growing. It is essentially based on the fact that all knowledge that produces the new expands without itself being able to provide the criteria in accordance with which it can be limited again. The greater the desire for the unexpected that is brought forth by research in the lab, the more the pressure of expectation grows to bring it under control and steer it in specific directions while excluding other directions. The aim is to tame scientific curiosity and yet to give it free rein. The pressure for this comes from two seemingly opposite directions.

The taming of scientific curiosity takes place in the public space and is initiated by changes that are visible in a broader framework. One form of this taming takes the direction of a privatization of knowledge, or more precisely of the increasing tendency to register and exercise rights of ownership and disposition over scientific knowledge, data, methods, and new forms of life or organisms created in the laboratory. Perhaps researchers themselves unconsciously contribute to this when, seeking to protect their legitimate interests, they register ownership rights to their findings and see themselves and behave more like knowledge owners than like knowledge workers.[9]

Behind this development is the shift in the increasing level of investment in research from the state to the private sector. With this, a regime moves into research that has already successfully dominated the industrial and service sectors and that is now also supposed to efficiently cover the rising need for investment in science and guarantee greater efficiency in producing knowledge. Intellectual property rights, patents, licenses, and similar arrangements aim to ensure that competitive thinking and a greater proximity to the market lead to a more rapid transfer from the laboratory to marketable products or new technological systems. The trend to the privatization of knowledge is thus part of a broader pattern of societal changes. If the growing need for funding is to be covered by the private sector while the public research budget stagnates, then intellectual property rights will expand, and this will inevitably change the way researchers work, including their relationships to each other. Equally, basic research, in which future applications are still mostly uncertain, will move closer to possible contexts of application.

The second tendency is for civil society to have a greater voice in decision-making processes that center on complex scientific-technological matters and that are expected to have far-reaching effects on people's lives. If, in the first tendency, the shift in financing was the starting point for increasing privatization and "propertization" of scientific curiosity, then the second tendency has to do with the process of democratization, which does not stop short of the institution, science. A civil society whose level of education is higher than ever before demands a voice in the decisions on scientific-technological developments that touch on the self-understanding and value structure of modern societies. Even if by far not everything that scientific curiosity pursues is controversial, we cannot overlook the fact that the most promising and future-oriented areas of research, like the bio- and nanotechnologies and developments in biomedicine and the neurosciences, become the focus of public protests and rejection. At the center are questions of identity and protection of the private sphere, changes in kinship relations due to progress in reproductive medicine, involuntary exposure to risks, and the approach to the resources and services of nature. Many publicly expressed worries are based on the fear of losing control over how one leads one's life and on the threatening loss of the self in a confusingly complex world shaped by science and technology and in the midst of an inexorable process of globalization.

In one case, science is accused of no longer paying enough attention to the public interest and of becoming too dependent on markets and their economic constraints. In the second case, the accusation is that science is not public enough because it does not adequately take account of the legitimate claims of civil society and becomes too dependent on the state and industry. In one case, scientific curiosity is to be tamed by subjecting it to the regime of private economic use and its efficiency, while in the other case the domestication is to be achieved through a democratization of scientific expertise, including a public voice in the setting of scientific priorities. But these two directions are only seemingly opposites and above all should not be seen in isolation. The increase in prosperity in the Western industrial societies and the spread of the new information and communication technologies have led to a striking departure from the idea of a paternalistic and centralized welfare state that knows and can satisfy its citizens' needs. Instead, science increasingly counts on private and privatized means. The rhetoric of the empowerment of the individual, who best knows her own interests and knows how to and wants to decide on her own, merely underscores the attractiveness that private property and the power of disposition have won in the thicket of growing interdependencies and diverse dependencies—the promise of greater individual autonomy.

The democratization of scientific expertise, which is skeptical about the credibility of scientific impartiality and its disinterest, also demands that science provide greater public accounting and that research orient itself more toward what moves people positively and negatively today. The shift from the state to the market and the continuing privatization of areas that used to be within the purview of the state have created the figure of the freely choosing, freely deciding consumer and voter. It therefore also lies within the latter's competency to buy or reject the products coming to market that are owed to science and technology and also to judge other results of research and research's orientation in the future. Privatization thus not only is a powerful theme in neoliberal ideology and political rhetoric but also has captured the public imagination by promising greater individual autonomy. The freely choosing consumer is the twin sister of the authentic, free individual.

In this way, the two directions converge in the attempts to tame scientific curiosity. Privatization and "propertization" of the production and products of scientific knowledge are nothing else than the expansion of a regime that helped the industrial societies achieve their high degree of economic growth. Since science and technology are today regarded as the crucial driving forces for further growth and improvement of the standard of living, they too should be brought into the regime that has been successful thus far. The efficiency of markets, competition, and intellectual property rights should also prove its effect on the growth of productivity and the increase of scientific-technological output. A knowledge-based society also increases its production of epistemic things, various kinds of abstract objects, and technical artifacts that are subject to the same rules.

The democratization of scientific expertise is also merely the expansion of the principles of governance that have served the Western liberal democracies well. Today, science and technology are no longer viewed with awe but are part of everyday life. Mediated by the educational system and the qualifications and certificates people acquire, they determine people's chances for upward social mobility, their working world, and the course of their biographies. It is thus logical to extend the concept of citizenship to science and technology. "Scientific citizenship" comprises rights and duties and asks about both the functions that an expanded concept of citizenship could fulfill in social integration and also the duties that arise from it for citizens as well as for political institutions and administration.

The decisive question, of course, will be how far the attempts to domesticate scientific curiosity can go without endangering autonomy, which science will continue to require in the future. The autonomy of science developed out of currents and struggles similar to those that led to the concept of the autonomous individual. The freedom of action that science enjoyed was always also de facto limited and historically changeable. If the public character of science and its service to the public interest are under discussion today, this is also a result of the withdrawal of the state, which permits science as an institution to step out from its shadow and protection. It is more intensely exposed to the forces of the market but also to the demands raised and protests staged in the name of democracy. How far the vision of a privatized production of knowledge can go will also be measured by the degree to which it is politically acceptable. More efforts will be required to create public spaces for negotiating what scientific curiosity can and may do.[10]

## Curiosity Receives Support: The Role of the Symbolic Technologies

Curiosity is a cognitive ability that the brain uses to explore the environment. To unfold curiosity's potential, the use of cognitive tools—particularly thinking, the capacity for abstraction, and the technical skills needed to produce material tools that change the environment—has to be embedded in cultural practices and anchored in a social structure. The human brain and its capacities are unique, not so much because of their biological development (which is not unique) but because of the human capacity to create and assimilate culture and pass it on to the next generation. The human brain and its capacities are the hybrid product of biology and culture. By itself, the brain can achieve little. The sources of experience may be initially individual, but for experience to be usable, it must be processed by culture and the synergies that result from interactions among many other human brains.

Paleontologists like André Leroi-Gourhan have long been interested in the close connections between hand and tool, face and language, and the influence of the motor functions of the hand and face on the connection between thinking and the instruments of material activity and sound symbols. When graphic symbols emerged, the formation of sounds and signs (graphism) was originally closely connected and only later replaced by a separation between the idea of the picture (art) and script, but today they are experiencing a renewed mutual rapprochement. The tool, says Leroi-Gourhan, "leaves the human hand early and becomes the machine: in the end, thanks to technological development, the spoken language and visual perception are subjected to the same process. The language that humans had objectified in the works of their hands, in art and script, now reaches the highest degree of its separation from them and they entrust their innermost phonetic and visual qualities to wax, film, and the magnetic tape."[11]

The rise and spread of the new information and communication technologies turned the development that was just beginning in Leroi-Gourhan's time into one of the key technologies of the closing twentieth century. Attention usually focuses thereby either on the economic effects, such as the increase in productivity, or on the scientific-technological achievements that lead to further advances, which were made possible by enormously increased computer capacities. Much less often are questions asked about the effects that these technologies, like other cognitive tools, have on the development of the human brain and the meaning of innovations in this context.

Along with language and the development of cultures of oral transmission, one of the most significant innovations in human history was the invention of script. The evolutionary psychologist Merlin Donald posits that the abilities to use script and symbols changed the functional organization of the brain. His hypothesis is that the use of script effects a cognitive reorganization of the brain individually as well as collectively, especially when the majority of the members of a society uses it.[12] Long years of schooling, for instance, enable people to achieve an adequate level of literacy (and thus of the use of symbols) in various fields—technical, mathematical, scientific, but also musical—and by mobilizing uncounted neural resources alters the way people think and carry out their work. Recent investigations of dyslexic Chinese and European children, incidentally, shows that, in all of them, a certain part of the brain functioned less well than in a control group of children without weakness in reading and spelling. But it also turns out that the regions of the brain activated when reading Chinese are different from those activated when reading Latin script.

Literacy is not the result of a Darwinian evolution. The biological evolution of humans unfolded long before they invented symbols. Literacy is neither natural and given nor universally distributed. Humanity existed for thousands of years without script, and most languages developed at a time when there was no form of writing yet. Nevertheless, all children can learn to read and write if they have the opportunity. The neuronal basis of literacy is cultural.

The ability to read and write is a consequence of the invention of external symbols—that is, their materialization and material depiction. But their effect does not end with the suspected reorganization of the human brain. Donald assumes that they lead to much greater changes, expressed in the whole of perception and recognition and thus also in how a human society thinks and how it remembers. New forms of mental representation arise. So these are extremely powerful technologies that work with symbols. Once invented, they unleash their inherent creative force and continue their effects on their own. From musical and mathematical notation systems to the broadest spectrum of artistic forms of expression, from diagrams through maps to multimedia imaging techniques, they comprise the entire spectrum of the material culture of our days. Without symbolic technologies, our society's scientific, technological, and cultural institutions and its highly technologized work achievements would be unimaginable. Symbolic technologies made it possible to build up an externalized cultural storage system that is available as a constant group memory and that, analogously to the individual memory, constantly changes and is active. The external symbols are themselves highly developed technologies. They are *cognitive machines* that change how we see, think, grasp, and deal with the world. Their central importance is that they free human consciousness from the limitations laid on us by biological memory. From an evolutionary standpoint, this is a radical innovation.

Whereas the preliterate cultures essentially had two technologies of memory storage at their disposal, storytelling and mimesis, today people have an enormously expanded set of symbol-technological instruments of preservation. Nonetheless, it is astounding how slow the development was from Ice Age cave art through the first calendar notations and earliest navigational aids to the invention of script and how long it took before the latter was reflectively used. For example, it is known that, in ancient Greece, the written notations of historical events made it possible for the first time to compare the accuracy of oral tradition with them. New concepts arose—like evidence and standards of validity and procedures for verifying them. When modern science began institutionalizing itself in the seventeenth century, it presented the demonstration of its experiments to the public, which functioned as a witness for what was seen and shown. But to this day, it has entrusted the real validation and certification of its results to writing, after appropriate quality control through peers. Publication in a specialized scientific journal aims not only to make the results public but also to put them into script.

Even if symbols are often invented by individuals, they build on the common stock of knowledge, and their use, their spread, and their further development is a collective enterprise to an even greater degree. To make full and efficient use of the power of symbolic technologies, a society must have corresponding tools, infrastructures, work habits, and communication mechanisms at its disposal. The presence of symbolic technologies alone does not suffice to trigger a cognitive revolution, and under certain circumstances it can even prevent one.* What was emerging at the beginning of modern science—namely, that cultural and social mixing and the reduction of class boundaries and hierarchies promote the creative flow of ideas and are the indispensable precondition for the circulation of knowledge—is also true for the use and societal spread of symbolic technologies.

For Merlin Donald, human creativity unfolds at the interface between the cognitive activities of the brain and the materiality of symbolic technologies—in art as well as in mathematics, the sciences, and the development of institutions. The power and efficiency of symbolic technologies is based on the existence of an externalized field of memory and operation. This permits mental operations at the disposal of consciousness to extend their radius of effect. Thoughts can be "externalized" by shifting them into an external field of memory and operation. This produces the necessary capacity for distancing, which is the precondition for every form of reflexivity. Games between the internal and the external can be invented, and experiments can be conducted between proximity and distance in which

* In history, for example, the tendency to secrecy has repeatedly prevented the spread of existing knowledge.

various viewpoints and arguments are tried out and one can practice putting oneself in the place of the other. Moreover, these fields of memory can be reformatted and changed in accordance with the intended use. Human consciousness acquires a mirror world that makes it possible to swing back and forth between internal and external representation. The capacity for a *multifocal attention* arises that has practice in mediating between the tensions resulting from the dynamic diversity of standpoints and perspectives.

Today, symbolic technologies form a cognitive and materialized network that is cast over society and that organizes itself and strengthens the production of knowledge and the emergence of the new. Their initially slow spread was followed by a phase of acceleration that is still far from reaching its limits. The rise and development of symbolic technologies underscores the entanglement between the biological equipment of the human brain and the cultural inventions that it has brought forth, whereby the social structures take the active and necessary role of coupling the two. This hybrid nature contributes to the emergence of the new and corresponds to the dependency of the unfolding of biological potential on culturally and socially produced conditions. It also underscores the double shape of every innovation. On the one side stand individual creativity and the uniqueness of the individual. The creative abilities and their effect can be retrospectively described and analyzed, but the decisive creative moment eludes observation. On the other side are the diverse interdependencies, the plethora of social and cultural dependencies on others and on a community that can foster or inhibit individual creativity. This interplay, which constitutes the dynamic of the new, has not been adequately studied since it was long overshadowed by the fascination of a concept of the genius that arose in the Renaissance and that lives today in the cult of the star.

A glance back at the often neglected premodern technological history of Europe reveals the degree to which precisely technological innovations depend on social and cultural factors, which can be joined by local and temporal shifts and simultaneities or nonsimultaneities. The technological historian Steven R. Epstein posits that the industrialization of Europe in the eighteenth and nineteenth centuries was the result of a long-term process of small but cumulative innovations that can be traced back as far as the Middle Ages. Although technological progress was slow in premodern Europe between the thirteenth and eighteenth centuries, it was lasting and proceeded without interruption. Flourishing periods were not interrupted by such long-lasting stagnation as they were in the great Asian cultures of China and India. In addition, the geographical centers that led in technological innovations increasingly shifted from the south to the northwest. In each new region that they penetrated, the innovations mixed with the local given situation and found a way to combine with it to produce further steps of progress. Such a mixing process of technological diffusion and recombination under different social, economic, and institutional conditions was completely lacking in premodern Asia. Third, says Epstein, all premodern technological knowledge—knowledge of how one makes things so that they function—was conveyed by persons. Technological knowledge is embodied in its practices. Geographical shifts or the rise of new leading centers is possible only if those with practical knowledge take it with them. This kind of mobility was more possible in Europe than in Asia because family bonds were less rigid and locally anchored and because, in Europe's fragmented political and economic systems, a competition in tendering bids could promote mobility.[13]

At the beginning of the twenty-first century, premodern technology can still be encountered locally, but "knowledge of how one makes things so that the function" has reached a highly technologized and science-based level. The contrast between nature and culture—between, on the one hand, the natural and the phenomena, organisms, and components occurring in nature and, on the other hand, artificial products created by people—appears to be dissolving and merging in a "vireality," a fusion of virtuality and reality. But we have not yet arrived in cyberland, despite the fascinating and frightening glimpses that, warning or enthusing, reach us from there. Reports so far see humanity's future home as an inhospitable place.[14] Before such a future draws us into its thrall and brings about this imagined fusion of brain activity and emotions, of bodies and technology, that the new biotechnologies and other convergent technologies have brought at least into the realm of possibility, we should ask again how far curiosity can extend into the future and what answers, if any, it can find there.

### The Curiosity to Know the Future: Nature Knows No Future Tense

When the introduction of the new is controversial, when resistance appears and opposition forms, invoking a body of higher, morally bound values, the issue is often unsettled questions of placing a boundary between nature and society. This dichotomy may be false and constructed, empirically and historically disprovable, but it persists with a stubbornness that is again and again mustered to defend ingrained interests. In the conventional argumentation, nature stands for the given and for something willed by a higher power. Nature is regarded as the norm that defines normality. Human intervention, by contrast, stands for a transgression of set limits that subversively undermines and endangers normality.* But the attractiveness of invoking a nature that stands for the immutability of normative claims and for stretches of time that exceed human scale does not take us far since the next step requires us to decide where the domain of nature ends and who is authorized to determine this. The arduous debates and struggle over a societal consensus will increase in the future.

The belief in the immutability of nature screens out knowledge of the societal processes that lead to knowledge and the capacity to intervene in, manipulate, and control nature. Resistance against the new is often rallied in the name of an authority that seems to stand outside of societal norm-setting and that is therefore granted a right to set pre- or suprasocietal norms. At the beginning of the modern era, when there arose for the first time in Europe the modern concept that politics is neither guided nor secured by God's pleasure, the focus was on the problem of the practice of human freedom and the limitations

* Biologists also make this distinction, speaking of changes caused by humans as supernormality.

to be placed on arbitrary political power. Two institutions came into question because of this focus. One was the legal system, which was to be primarily responsible for working out the norms, regulations, procedural directives, and guarantees that gradually determined the construction of the constitutional state under the rule of law and for ensuring their implementation. The other institution was science, which was equally young and hardly institutionalized yet. According to Yaron Ezrahi, an Israeli political scientist, science was historically conceived as an apolitical authority with the capacity to discipline political activity, criticize decisions, and place limits on the secular state. This—political—function of science was sometimes used to depoliticize and veil the exercise of power through the invocation of scientific and technological rationality. But the certification of a science-based reality contributed crucially to replacing the will of God with the laws of nature and led to a restraining of the arbitrariness of political action.[15]

Even in its beginnings, modern natural science showed that mechanisms could be found with which the scientific community could reach consensus on disputed issues. In a time wracked by religious and civil wars, this doubtless contributed to solidifying the moral prestige of this young institution, which nevertheless was wise enough to accept the limitation placed on it by the state and religious powers—namely, not to interfere in their affairs.

The authority of science as an apolitical authority is based on a legitimacy derived from the authority of nature. The natural laws it investigates are higher laws that are nonnegotiable and cannot be subjected to a state power or a judge's ruling. Science certifies that the reality of nature is removed from the jurisdiction of human laws and their arbitrariness but that there are nonetheless procedures "to reveal its secrets," to manipulate it and make it serviceable. This makes the institution, science, the apparently infallible mediator between nature and society. Science claims the authority to speak in the name of nature. To successfully advance its program of exploration, it must be free of state and religious interventions for it "speaks truth to power." The other way around, through its procedures of quality control, especially peer review, the scientific community guarantees that the knowledge produced is reliable. These two strands—science's claim to speak in the name of a higher, apolitical authority and its claim to guarantee to the public the reliability of the knowledge it creates and certifies—are the basis for its autonomy to this day, even as the public character of science is coming under pressure.

In this way, science became the referee in all questions that it can answer on the appeal to nature and its own apolitical authority. But the more successful and consequential human interventions in nature became, the more clearly visible were the limitations of this institutional arrangement that was otherwise so successful for science. The faster the pace of scientific-technological innovation, the greater the proportion of "social knowledge," which, in analogy to Epstein's definition of technological knowledge, I would like to define as knowledge that knows social contexts and ensures that they function. Scientific-technological innovations have to be emplaced in already existing organizational forms, social structures, and biographies. To be successful, they must be accepted and altered in such a way that they identify and meet latently present needs. They must contain answers to only diffusely articulated expectations, and their promises must be redeemable not only as “technological fixes” but also within the disorder of social reality. The rapid path via technological solutions, as practically effective as it can sometimes be, runs the danger of overlooking social contexts that cause the problem and that can reappear all the more insistently in another place.

In the public discussions of controversial questions related to values and ethical principles, it is also becoming ever clearer that nature—and therefore also natural science—proffers no standards for human activity, so science cannot answer these questions clearly. Thus, Hubert Markl, then the president of the Max Planck Society, wrote that the German debate on stem cells, which is probably conducted more heatedly in Germany than anywhere else, entails far more than the ostensible topic. It refers not only to stem-cell research and preimplantation diagnostics but also to the questions of what it means to be a person and what the freedom and tasks of science are. To be a person, Markl argues, is a culturally defined attribute rather than a biologically determined fact. Even if persons are biological beings, being a person goes beyond that. This is why a person cannot be defined solely in terms of molecular genetic facts, like the 43.2 million nucleotides that are arranged in a specific way inside a zygote. Personhood is thus also defined by the culture, which gives us many different answers.[16]

Science never completely managed to prevail in enforcing its monopoly on interpreting an “objectively” graspable reality or in reducing the content of public controversies to "hard facts." On the one hand, publicly discussed values stubbornly resist being cleanly separated from the supposed facts since on closer examination the facts often turn out to be the results of determinable or preset political and social framework conditions or questions. On the other hand, the concept of scientific objectivity is itself subject to processes of historical change, as the history of science shows. To maintain its claim, the processes for obtaining objectivity would have to adjust to the changed technological givens as well as to the changed social dynamics of the scientific community.[17] In addition, alternative claims to interpret reality that have withdrawn from science (for example, alternative medicine) were able to survive in premodern niches, where they fulfill other social functions.

How strong the alliance between science and the state actually was went unnoticed until it began to break down. What welded them together in the twentieth century was the systematic use of science in the two world wars, followed by nuclear arming and other forms of military research in the time of the cold war. This influence of the state on science and the state's claim to the right to use its monopoly on knowledge paradoxically became especially noticeable in basic research. Basic research produces decisive breakthroughs and new scientific knowledge but often at the same time also new technological applications. The freedom of action needed for theoretical and technological-practical basic research was granted, but then the new knowledge and technological artifacts were selected for military-operational utility. With the end of the cold war, this regime of close alliance was replaced in part by a decentralized form of funding research that is oriented toward worldwide economic competition.

With the advance of the market and transatlantic economic interdependence, the nation state lost further ground and importance. On the one hand, the assumption that scientific and technological standards of rationality guide state policy was also undermined, and Enlightenment thinking was replaced by so-called postmodern configurations. The media take a significantly larger role in democracy mediating the public realm and thereby in redefining the boundary between public and private. The institutional constraints that separate, including normatively, the realm of politics from the economy and the private sphere are mixing in an often unclear way. At universities in the United States (but not only there), new guidelines are repeatedly promulgated whose function is to harmonize academic freedom with industry's interests in fostering research. Specialized journals, especially but not exclusively in the life sciences, demand that submitters reveal possible conflicts of interest, and ethics commissions are supposed to ensure that commercial interests do not hinder research's interest in publishing negative as well as positive scientific results.

If today mistrust, tension, and loss of credibility in the relationship between science and the civil society are lamented in many places, the reasons are in part to be sought in the dwindling normative consensual basis in liberal democracies that oriented themselves toward scientific rationality and the technocratic structures of the state and that were supported by science's apolitical, neutral stance. While the state relinquishes some of the competencies it used to exercise to marketlike institutions in the name of greater economic efficiency, the institution, science, has to make greater efforts to credibly maintain its apolitical neutrality in the public sphere. Scientific and technological expertise is in greater demand than ever before, but the reason for this is the increasing density of regulation and the growing complexity of decisions with a scientific-technological content. The greater demand is accompanied by the equally greater vulnerability to objections and protests made in the name of a pluralistic political diversity.

The current self-understanding of the pluralistically organized liberal democracies prevents any one authority from having the right and the credibility to legitimize decisions or in general to speak in the name of nature, which stands above society. Society's share in the coevolution of science, technology, and society has grown too strong to permit such a solution of conflicts. The twentieth century, which was one of devastating, frightening political projects as well as of monumental scientific-technological projects, assumed in its megalomaniacal optimism about progress that the guardrails and coarse patterns of orientation that modernity had normatively set up for societal development and progress could be followed straight to the future. Today's thinking is turning away from this belief. The advances toward a scientific-technological future are surrounded by imponderabilities and uncertainties. Politically, this is expressed by politics' fragmentation as the reverse side of the coin of pluralism and by its short-term thinking. Science and technology have lost some of their privileges and part of the protected space that the state and politics granted them. Above all, they can no longer invoke higher criteria of rationality to offer those securities on which the human capacity for judgment, decisions, and action could be anchored and legitimated. The rationality of action has been splintered into a diversity of rationalities that invoke an explosive and unstable mixture of economic and private interests, scientific and technological orientation, remaining state competencies, and the demands of a civil society—all this in a public theater that the media illuminate and stage.

A normative basic consensus can be found, at best, by accepting an openness toward the future and by viewing society as a laboratory serving the public good—under limitations that must be concretely worked out. Instead of being able to trust in secured prognoses for the future and in a science that acts mostly apolitically and independently of external interests, what is needed are pluralistic negotiation processes. Nature provides no answers for most of the questions that arise from the growing knowledge of its functioning and from the need for decisions and action that results from the successful interventions in and manipulations of it. This means that we must accept effort and conflicts and work to create public spaces in which we can negotiate what cannot be otherwise decided.

But this does not mean that nature has disappeared as a normative authority in societal discourse. In this regard, it is useful to distinguish between images of science existing in society from images of nature in societal discourse. The images of science are fed from a broad spectrum of sources of imagination, including those that science projects onto society. As the historian of science Simon Schaffer has shown, they oscillate between two poles. At one end, scientific activity is presented to the public in a way that suggests its direct connection to everyday experience and everyday understanding. Scientific activity then becomes a continuation of general thinking, and all people can understand it. The (even today still usually male) scientist acting in this image resembles a hobby tinkerer. He has craftsmanlike skills like those encountered in everyday life and is inventive and practical.

The opposite pole is represented by an image characterized by an unbridgeable separation from everyday experience and everyday understanding. Here, science appears as an extraordinary activity open to only a few especially gifted minds and leading into realms that unmistakably go far beyond everyday understanding. The accompanying image of the scientist (again usually male) is of someone passionately and totally living his ideas, someone who is guided exclusively by his curiosity. This image of science finds its counterpart in the idealization of basic research, which stands sharply apart from expectations of utility. Schaffer says the two images are evoked alternately as circumstances demand. The heroic figure with the characteristics of genius who is above all the economic and other constraints, preconditions, and consequences of her action lives unproblematically alongside the practical figure who is found everywhere in everyday life.[18]

The images of nature that are present in societal discourses also oscillate between two opposites. On the one hand, nature is imagined as the epitome of threat. Its powers can be tamed to a certain degree by means of human cleverness, knowledge, and technological imagination, but this state is never lastingly guaranteed. Since nature will always be more powerful than people, it is unpredictable. Anthropomorphically speaking, it can "strike back" at any time and even "avenge" itself for what has been done to it. On the other hand, an image of a nature requiring protection is also imagined—endangered species, diminishing biodiversity, continued degradation of the environment and its resources, which all must be brought to a stop. In one case, nature becomes a deterring example that, deeply amoral, comprises every imaginable brutality and cruelty. In the other case, it becomes a moral role model that can teach us how to preserve diversity and how to nurture it. In both cases, nature is normatively charged and normatively interpreted. It becomes a mirror of cultural achievements and equally of their failure, a mirror of ourselves that reveals deep-seated ambivalence. But the gaze is unable to see itself.

The success and the failure of freedom are both inherent in the project of modernity. A glance back into the past provides adequate evidence for both options and permits at least a careful weighing. Clinging to utopian and dystopian ideas, wishes, and fears darkens the glance into the future. In the face of the new, the play of imagination can begin, but communicating the new is already difficult because the language for this is lacking and the images are deceptive. Different patterns of argumentation can promote or hinder the new. The language that the new is clothed in is either not yet available at all or not yet made for it. It triggers varying associations and holds much scope for interpretation. It easily falters where the point is to dampen the shock of the new, which nonetheless has to struggle on its radical path to a changed way of viewing things. A historical example can illustrate this.

For almost no other radical theoretical edifice of ideas is this as true as for Charles Darwin's *The Origin of Species*, published in 1859. Darwin was very aware of the problem. When Wallace's surprising letter from the South Seas reporting on his notes and theoretical considerations, which mostly corresponded to Darwin's own, reached Darwin one day, Hooker, Lyell, and other friends of Darwin urged him to begin compiling the observations he had painstakingly noted more than twenty years earlier along with the associated theory (which he originally termed a mere "abstract"). Darwin clearly understood that one of his biggest problems thereby would be to clothe the knowledge he was introducing in a new language that would enable its acceptance and stabilization. Whereas other natural philosophers of his time consciously relied on predictions, experiments, demonstrations, or mathematical proofs because they thought they saw in them the means for public accreditation of scientific truths, Darwin's approach was doubly unusual.[19]

His content demanded a lot from his readers. He spread before their imaginations a world ruled by irregular and unforeseeable contingencies. He revealed a nature that was cruel and full of errors and in which there were no moral laws or purposes. Animals and plants were not the result of a creator's special design or plan. As he wrote at the beginning of his primary work, Darwin was firmly convinced that the species were not immutable. He asked his readers to accept his answers for the sole and simple reason that they were the facts. To this purpose, he invited them to participate in the information, observations, and sorted evidence he had gathered over a period of more than twenty years and to accompany him in carefully weighing the conclusions he had drawn. In the text, many different strands of narrative and argumentation are interwoven and enriched with rich, inventive metaphors. But ultimately what counts is the structure of the arguments Darwin mustered to persuade his readership.

Although Darwin presents the sequence of chapters as if they corresponded to the chronology of his daily research work (thereby implying that his ideas developed from the observations and facts), the actual course of the development of his theory was much more complicated and many-layered and was certainly not linear. The concept of "natural selection" was not simply present in nature, nor could it be presented under the injunction to "look and understand." As Janet Browne underscores, Darwin had no mathematical equations or formulas in hand to prove his theory. His book contains only words borne by strong convictions, visual presentations, the weighing of probabilities, interactions between large numbers of organisms, and the subtle consequences of tiny coincidences and changes. He often employed analogies between what was known and what was unknown. He relied on statistical frequencies to support his arguments. He consciously employed a strategy of progressively weakening his reader's resistance by adducing factual examples. And of course he was aware that the whole of his factual material was inseparable from his theory. In a sentence that has become famous, he expresses this in his characteristically simple and disarming manner: “How odd it is that anyone should not see that all observations must be made for or against some view if it is to be of any service!”[20]

Literary historians and historians of science have often commented on Darwin’s skillful use of language and his cultivated, accommodating manner, which won readers’ sympathies. It can be shown that some of Darwin’s arguments that appeal to nature have the purpose of giving him the necessary cover for the novelty of his ideas. Gillian Beer investigated the question of why Darwin uses the term “natural selection” rather than simply speaking of “selection.”[21] “Natural selection” presupposes a counterterm, “artificial” selection. The term “natural selection” is based on the analogy with “artificial selection” and thus on an analogy between the processes of selection, which must unfold either under natural or artificial conditions. Artificial selection includes all human activities aimed at effecting rapid genetic change—in agriculture or in breeding pigeons, dogs, or orchids. It is based on a technology, accessible also to amateurs, that includes human aims as well as intentional results. It includes the market.

Gillian Beer suspects that Darwin made this distinction not least because of his experiences on his journeys on the *Beagle*. On these journeys, he had seen the devastating effects of colonial conquest and the genocide committed against aboriginal peoples. In *The Origin of Species*, Darwin avoids mentioning humans, knowing full well that he would trigger controversies if he did (he speaks of his own “abominable volume”). Gillian Beer concludes that the term “natural selection” allows Darwin to pursue the questions that the term “artificial selection" excludes—questions of nature's long temporal scale in contrast to the short-term scale of breeders and of nature's complete indifference in contrast to human intentions and their drive for mastery, planning, and management.

Darwin's theory distinguishes itself clearly from the views of his contemporaries (with the big exception of Alfred Russell Wallace)* and from the preevolutionary thinkers. A key to this is that for Darwin diversity and deviation are central principles of survival. The truly creative forms, the decisive difference, are owed to the nonconformity that arises from being different. For Darwin's theory and its reception, that only increases the urgency of the problem that the "natural" is frequently equated with what is considered normative. For Darwin, deviation, rather than conformity, is decisive for survival. Differences from parents, rather than similarities to them, are what count because this is the only way that existing ecological niches can be expanded and the exploration of new niches can be nudged

* In 1858 on the South Sea island of Halmahera, Wallace wrote his famous letter in the form of an essay, titled "On the Tendency of Varieties to Depart Indefinitely from the Original Type," to Darwin, triggering confusion and despair in the latter. Darwin's friends Lyell and Hooker thereafter arranged a meeting of the Linnean Society at which were read aloud a previously unpublished essay that Darwin wrote in 1844 and the abstract of a letter that he had written to Asa Grey the year before. Both contain the Darwinian theory of natural selection and the origin of species through modification. Thus, Wallace's essay came later, and Darwin's priority was ensured. Darwin's book *The Origin of Species*, whose composition was triggered by Wallace's essay, was published soon after. Darwin became famous, while Wallace was forgotten for a long time.

forward. Nature always moves on the verge of the monstrous—and according to the laws of evolution, it must. For what may initially seem like a monster can later prove to be a new type that has merely waited for the proper conditions before developing. At the right moment, what was initially monstrous can become the norm and define normality.

Whereas the concept of natural selection expands, the concept of artificial selection narrows. If the first stands for exuberance and plenty, the latter indicates parsimony and the ruthless exclusion of everything that is not adapted to current conditions. In a small population, selection does not mean fertility but extinction. The intrusion of an alien species can lead not to the native species' improvement but to its disappearance, as Darwin was able to observe in the result of the encounter between the Spanish and the *Indigenes* in South America. He had seen how the invasion of the Spaniards made the aboriginal population regress from settled to nomadic, quite in contrast to the stepladder of the "natural" rise of every civilization.

Darwin was thus able to denude one of the nineteenth century's most prevalent terms of its "naturalness." It is usually worthwhile to question the self-evidence of terms and concepts that are employed. But it is seldom so important to make oneself aware of their function as when nature and what is regarded as nature's binding authority are brought into play as arguments. Nature stands precisely *not* for immutability but for diversity and deviation from what has existed heretofore. If everything is constantly changing, then "natural" can be understood only as an appeal to the knowledge of the past. Then it is an expression of the attempt to ward off the future and to ensure that deviance is forgotten. In the following, Gillian Beer summarizes the role that "nature" has to play in argumentation:

> Nature is how things *have always already been*, i.e., lasting and universal.
>
> Nature is how things were *in the past*, i.e., ideal and nostalgic.
>
> Nature is how things *normally* are, i.e., as a matter of course and the norm.
>
> Nature is how things *should be* or *should have been*, i.e., as described by imperatives and ideals.
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> But if we want to know how things *will be* (instead of how they should be), this is not part of the concept of "nature."[22]

Nature knows no future tense—and yet it constantly provides for the emergence of the new. What begins with insatiable curiosity, the exploration of the unknown, and the inexorable appropriation of a future that nevertheless eludes all claims to possession—the emergence of the new—follows differing paths. Nature has long time scales and the laws of evolution. Human societies, which themselves have emerged through evolution, also have cultural and social forms at their disposal. They are able to imagine their future and various designs for it. The capacity to aspire helps these imaginings to come to realization, although under manifold limitations. As fragile as the future may appear and as fragile as it is, conceiving it anew and conceiving it as different grows out of what has already been achieved. The unprecedented potential of scientific knowledge and of technological abilities opens up a tremendous realm of possibilities. The collective wager on the future that we have made goes by the name of *innovation*. But it, too, is unable to say how things will be or how they should be. To this end, societal debates are needed, along with strategic sites for finding a consensus. Language is needed to describe the new, and selective appropriation is also required. Needed are the cultural resource of reflection and the attitude that has accompanied us since the beginning of modernity, ambivalence. It contains a yes and a no—and nonetheless permits us to act in the face of a fragile future.