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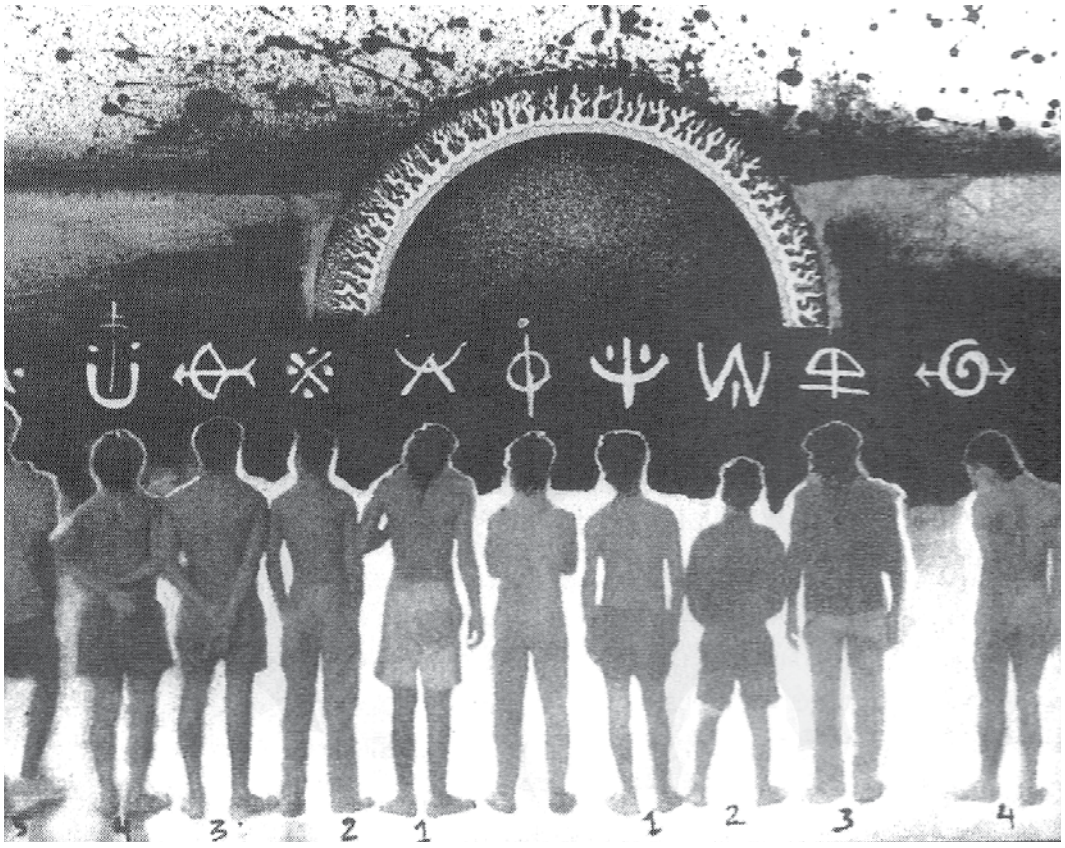
Increasing complexity breeds surprising behavior

Paths ot Discovery

William H. McNeill



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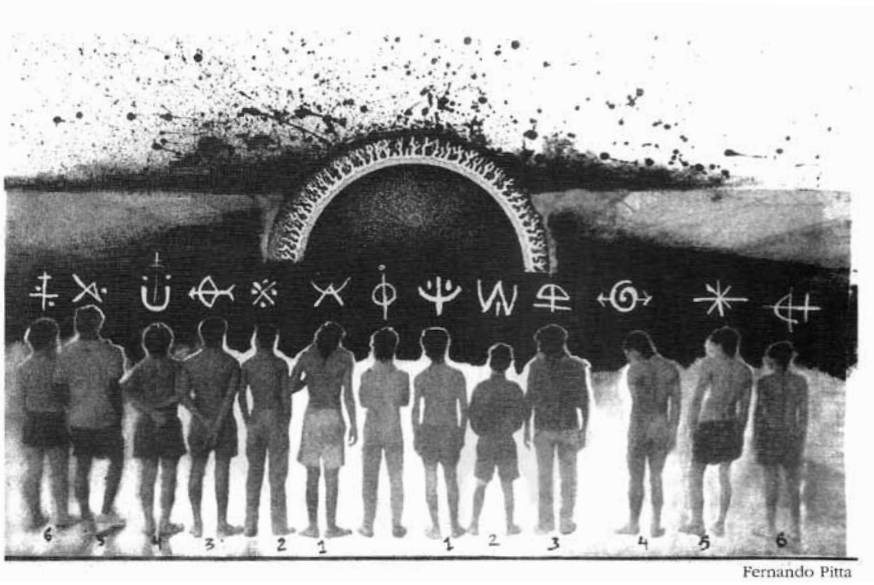
Fernando Pitta

World views are very important to us and reflect continuing historical change. As human beings, our social cohesion depends at least partly on shared world views. How different peoples arrange and rearrange competing world views is therefore likely to become one of the principal themes of public affairs in the 21st and succeeding centuries. My main concern here is to reflect upon recent changes in the scientific world view to which most university teachers and those they educate subscribe nowadays, with brief observations on other, widely prevalent outlooks upon this world that clearly are called for to put contemporary ideas in context.

Animism, the belief that moving objects are inhabited by spirits like ours, is the oldest, simplest and psychologically most accessible world view. It is alive and well today because it explains the persistent gap between personal intentions and frustrating experience so convincingly. And, as animists believe, invisible spirits inhabiting objects of the natural world resemble spirits inhabiting human bodies, the whole wide world turns into an enlargement of what we know best: the unstable to and fro of personal interaction. Animism thus becomes a very powerful world view by making all that happens both readily intelligible and understandably unpredictable.

Probably most human beings alive today explain part or all of the world around them in animistic terms, just as their ancestors have done ever since language first opened a door upon the world of spirits. In addition, most of humankind subscribes, at least part of the time and on suitable occasions, to one or another of the civilized religions that organize the spirit world around almighty God (or for Buddhists, an impersonal Nirvana) with a hierarchy of subordinate spirits, extending downward to include even the humblest of human souls.

What we know today as the scientific world view dates back to a few ancient Greek thinkers, and had antecedents among much more ancient Babylonian star gazers - the men who constructed tables recording the paths of the movable lights of the firmament on a spherical grid that astronomers still use today.

Mathematical modeling of the heavens took on new pouter and precision in the 17th century thanks to the work of Kepler, Galileo, Newton and an emerging community of other like-minded scientists, the resulting world view was indeed impressive. Newton's laws of motion applied both in heaven and on earth, miring the two realms as never before; and appropriate mathematical calculation made it possible to predict (and retrodict) such awful and conspicuous events as solar and lunar eclipses. When Edmund Halley calculated the orbit of the comet that now carries his name and correctly predicted its reappearance in 1758 (sixteen years after his death) the last visually obvious, ominous irregularity of the heavens submitted to the same web of math ematical prediction. And when by the beginning of the 19th century Laplace solved even such complicated problems as minute third bodv perturbations of the planetary orbits, he convinced himself and others that all the n motions of the heavens could be correctly calculated throughout time as accurate observational data about the mass and velocity of celestial bodies became available.

A predictable cosmos, obeying universal mathematical laws, was genuinely awe-inspiring (note my animistic language!); and the multiple advances of physics and chemistry in the course of the following century allowed. growing company of physical scientists to bring more and more earthly phenomena under the jurisdiction of similarly universal, quantitative arid predictive laws. Even more surprising was the fact that new scientific theories sometimes had practical applications. Resulting improvements in manufacturing,

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communication and transport alidated a burgeoning theoretical complexity and enhanced the wealth and power Of countries where the physical sciences flourished. The scientific, mathematical, experimental and predictive world view thus acquired an enormous prestige that still endures, and deservedly so, since physicists and chemists continue to elaborate new theories and invent fresh practical applications that change human society profoundly decade after decade.

Yet everyday human experience does not fit easily into the stark world of the physical scientists. Incleed, all living organisms resist mathematical predictability. No two seasons are alike; crops fluctuate with the weather, and so do all other life forms. Aznong human beings the irregular impact of the business cycle and the tumult Of wars and revolutions are quite as troubling as epidemics and other biological instabilities. As a result, efforts to discover a science of society that could predict human behavior proved almost entirely vain, although by reducing the spectrum of human motivations to a narrow band of material appetites, economists did develop price theory around laws of supply and demand. But such laws neglected the strongest human motivations love, honor, hate and fear. They also assumed an institutional setting within which individuals lacked definite customary prescriptions for important aspects of everyday conduct and w era busy exchanging goods and services in a money economy. This approximated conditions prevailing in many European countries by the late 18th century, though not in all of them. Buying and selling remained entirely trivial for the subsistencecultivators of custombound Russian villages, for example, and the same was true among the world's isolated peoples, market behavior was seldom important Econoznists theories therefore never attained universality or accuracy to compaq with the achievements of the physical scientists, while other branches of the social science lagged even further behind.

Among geologists and biologists, however, non-mathematical and merely descriptive sort of science attained new importance in th second half of the 19th century with the publication of Charles Darwin's Origin of Species iI 1859. Across geological eons of time, natural selection among randomly varying individuals might indeed, as Darwin argued, explain the emergence of new plant and animal species. It also had the immense virtue of accounting for the varied array of fossils that geologists had begun to arrange and classify in the immediately preceding decades. But evolutionary biology was inferential and descriptive, entirely unable to predict or retrodict, and suffered from serious gaps in fossil evidence of how, when and where one species evolved into another.

More important at the time was the collision between Darwinian evolution and the Biblical story of creation. Just as Newton had merged the heavens and the earth into a single mathematical universe, Darwin explicitly merged humankind and other animal species into a single, evolving web of life by publishing The Descent of Man in 1871. Galileo's trial for heresy had shown how hard it was for ecclesiastical authorities to accept the new astronomy of the 17th century that demoted earth from the center of the universe. Darwin assaulted human pride even more directly by breaking down the barrier between us and other organisms. Resulting collision of religious and scientific world views has divided public opinion in the United States ever since, and the recent resurgence of religious identities in the public life of many other countries now makes this collision into a global phenomenon.

Long ago, when I was young, Biblical fundamentalism seemed to have suffered irremediable defeat among educated persons, partly at the hands of Darwin and the biologists, but far more directly from the critical examination of sacred scripture by philologists and historians, among whom Erasmus was the most eminent pioneer. His successors in the 19th century, treating the Bible like other documents from the past, discerned different manuscript traditions, different views of God, and innumerable small discrepancies in the sacred texts. It thus appeared that religious ideas and practices, like other dimensions of human thought and behavior, were not determined for all time by divine revelation, but had evolved through the centuries like almost everything else. Comparative study of other religions simultaneously reduced the doctrines of those faiths to the same evolutionary flux.

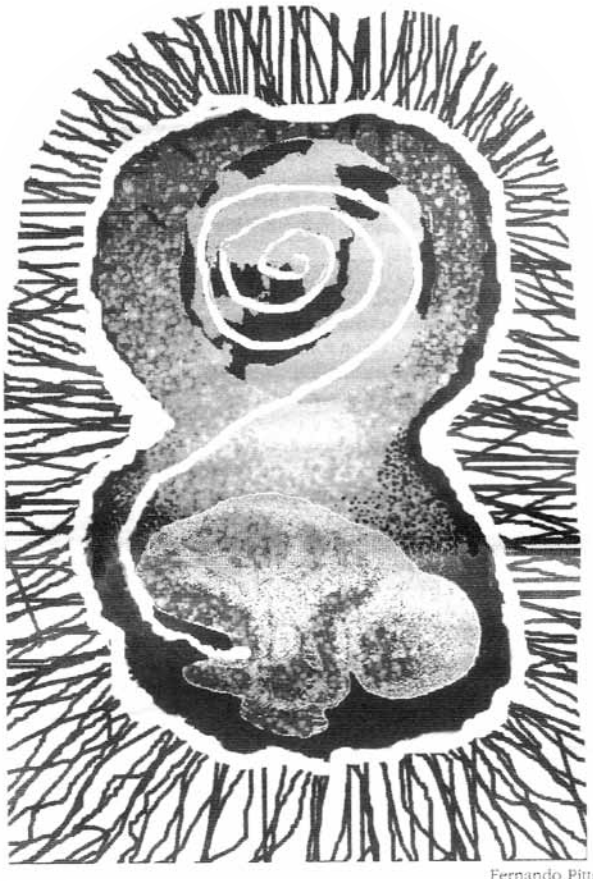
As this unsettling view of ever-evolving religious truth spread among educated persons of the western world, only the stars remained eternal. As a result, when I was growing up my teachers believed that logic, mathematics and the laws of physical science were the only things that never changed. They still inhabited a Newtonian universe, and preferred to believe that what physicists were doing with newfangled ideas about relativity and quantum mechanics merely expanded the old certainties by taking account of a few marginal discrepancies Physics and aslronolny remained exact, cumulative and predictive: the model towards which all the other sciences vainly aspirerd. Biology and groggy lagged behind, being less exact, cumulative mainly in trivial ways, e.g. by discovering new species or missing links in the fossil record, and quite incapable of prediction. Physiological chemistry was still a jungle of uncertainty since few of the complex molecules of living tissues had yet been deciphered, and details of their interactions were almost unknown. But the hope of reducing biology to chemistry already hovered on the horizon. That was where scientific progress beckoned, promising to raise knowledge of organic processes to the superior certainty and universality of the physical sciences.

The social sciences and history also aspired to universal, unchanging truth. They did so wistfully, for social scientists lacked anything like the biologists hope of rising to the level of the physical sciences by reducing human behavior to chemistry. To be sure, demography and studies of voting patterns offered intriguing possibilities for quantifying and predicting some aspects of human behavior: and economists juggled quantitative data on prices, interest rates, money supply and the like in hope of finding a way to cure the baffling depression of the 1930s.

But mathematical science about human societies,

considered as wholes did not emerge from such efforts. When sociologists and anthropologists tried to comprehend entire socieies they had to rely on private and personal intuitions. All too obviously, the question asked governed the result obtained - whether in tabulating responses to questionnaires, as American sociologists were accustotned to doing, or in recording anthropologists' observations of the behavior of small, simple societies.

Historians were even more disadvantaged since the evidences at their disposal were difficult to verify, impossible to replicate, and erratically preserved. Critical evaluation of sources - the boast of nineteenth century historiography - invited suppression of anything in the sources that violated the historians' notion of possible or probable human behavior. But since historians disagreed about what was possible and probable, revisionism everywhere prevailed. Real scientific truth was therefore reserved to the physical scientists. Others could only aspire to it.


Fernando Pitta

During my lifetime, efforts to repair defects in the social and biological sciences took divergent paths. Some sought to imitate the physical sciences, aiming at prediction through quantification. Others preferred verbal description, hoping to discern what mattered most in a given situation by considering professed human purposes and conscious intentions.

As far as I can see, social science results were oddly contradictory. The principal phenomenon was that economists came suddenly to the fore as guides to public policy during the 1940s. Having armed themselves with appropriate macroeconomic concepts for interpreting new national statistics, as assembled by the principal combatant governments during World War II, economists found it possible to predict the effect of changes in fiscal policy with considerable accuracy. This lasted for about thirty years. The up shot was that in all the leading countries of the western world politicians were sometimes influenced by econoimists' advice, and eagerly took credit for a burst of economic expansion that was sustained into the 1970s. Simultaneously, in Communist lands quite different policies also led to rapid recovery from wartime destruction. This made command planning à la Russe a path to the future that seemed fully capable of competing with the politically modulated market economies prevailing in the rest of the world.

But from the 1970s unwelcome difficulties arose on both sides of the Iron Curtain. Communist productivity lagged, and in the rest of the world transnational flows of goods and services became so large that even for a country as big as the United States,the nation-as-a-firm was no longer even approximately autonomous. Consequently, fiscal adjustments on a merely national scale no longer had decisive effect. Global management alone could hope to regulate global exchanges, but public will and appropriate institutions were lacking. As a result, economists' predictions began to wobble and became more inaccurate; but having rather suddenly won acceptance as public soothsayers back in the 1940s, the profession clung to that role, struggling anew, as in the years of the Depression, to find out how economic statistics could again be made to guide policy accurately, whether at the firm or national levels.

A majority of economists therefore remain committed to ostensibly universal mathematical propositions, and treat cultural differences among human beings as trivial. An opposite development took place in anthropology and sociology, at least in the United States, where efforts to quantify and/or to discover universal patterns were largely abandoned. Anthropologists in particular discovered history, often because generous academic funding allowed them to return, years afterwards, to communities they had studied as doctoral candidates. Thus personal awareness of how things had changed since their student days entered into their understanding of what they saw before them, and made it impossible to suppose that timeless patterns of human cultures had ever existed. Acute observers turned themselves into micro-historians, often with persuasive results for understanding the meanings of specific ceremonies and events in particular small communities.

Sociologists, on the contrary, retreated into history rather reluctantly. But, disappointed by uninteresting results of their numerical surveys. and increasingly distrustful of efforts to articulate a systematic science of society apart from time and place, a number of American sociology departments decided to take the grand tradition of European sociology more seriously. They did so by importing a handful of European-trained professionals whose efforts to view human history as a whole owed something to Comte, something to Marx, something to Durkheim and Weber and something also to historical scholarship at large.

But agreement about how human society can best be understood has not emerged. Instead, confusion reigns. Sub-fields - demography, religious sociology, urban sociol-

ogy, criminal sociology and the like - combine historical and analytic description with quantification in different proportions. A plethora of problems produce no answers upon which everyone agrees. In this respect, at least, sociologists have indeed assimilated their intellectual tradition to that of the historians!

The main phenomenon among historians in my lifetime has been the energetic cultivation of new fields by diverse schools of eager, sometimes angry, revisionists. In particur, triumphalist national history, the staple of 19th century scholarship, was challenged by histories of the oppressed. In the United States, this initially meant the working class, but from the 1960s others have come to the fore, most notably women, Blacks, and Indians, or wit we now call "native Americans". Similarly, the view that the American people shared a precious and unique Western Civilization w parts of Europe has been challenged by those who argue that the historical heritages of every people of the earth are of equal value, even if, or especially because, they were mistreated by European imperialists in the recent past.

Global entanglements of the United States after 1941 had dramatic impact on what were initially called "Area Studies." Improved language training, and the import of experts from Europe and elsewhere, allowed American graduate schools to branch out into Russian, Asia, African and Latin American studies on a fully professional basis exactly when, in reaction to the collapse of colonial empires, study of these parts of the globe underwent a partial eclipse in Europe. Political scientists, economists and a few sociologists shared in area studies at first; but their efforts at social engineering, aiming to accelerate 'development' and 'modernization' in poor countries, met persistent disappointment. What mainly survives today is historical study of Asian, African, East European and Latim American societies. Necessary language training isolates one field from another; but a few world historians have tried to construct a vision of the whole human past by looking aercross resulting boundaries. My professional career was defined by that ambition. Other notable historians shared in the enterprise. Teaching world history is now mandatory in a good many school systems of the United States. What is taught under that rubric is another question, but widespread aspiration towards inclusiveness and a more global outlook is unmistakable.

The upshot is indeed confusing. Aggressive revisionism pervades much historical writing. Of late, argument about proper schooling has become intense in the United States because what really matters for citizens as well as for expert students of human society remains so utterly unclear. Yet the expansion of readily available information has been spectacular, and academic historians can no longer, as they did in my youth, remain cheerfully indifferent to what happened among the four-fifths of humankind that did not inhabit Western Europe and the United States. This strikes me as an obvious advance, even at the price of cacophonous confusion.

Divergent traditions of historical studies flourished in European countries and Japan, but it would be presumptuous for me to characterize them in a few words. As far as I am aware, the Anr^lales school in France constituted the main intellectual rival to English-language scholarship. Assuredly, contributors to that journal explored a grand array of new themes: the history of climate, of disease, of literacy and more generally of human adaptation tot and exploitation of, local landscapes. On the whole, the effect was similar to the challenge to the 19th-century sovereignty of national history that became so clamorous within the United States, with the difference that genuinely global history attracted less attention in France than among Anglo-American historians.

As for biology, the project of reducing physiological processes to chemistry turned out to be spectacularly successful. Innumerable complex molecules have been accurately analyzed, their exact architecture has been deciphered, and precise chemical reactions in plant and animal tissues have been plausibly surmised. The great landmark of the campaign to raise biology to the level of precision attained by the physical sciences was the decipherment of the structure of DNA by Crick and Watson in 19S3. Their triumph swiftly developed into a new, chemical-molecular understanding of the unity of all forms of life, each variant propagated from its own, distinctive modification of the DNA double helix. To be sure, the chemical path from DNA molecules to adult organism remains full of mysteries. But biochemists are busily deciphering some of its steps, and details are rapidly accumulating. What limits there may be to chemical analysis of life processes remains to be seen, for the enterprise is still in its initial stages.

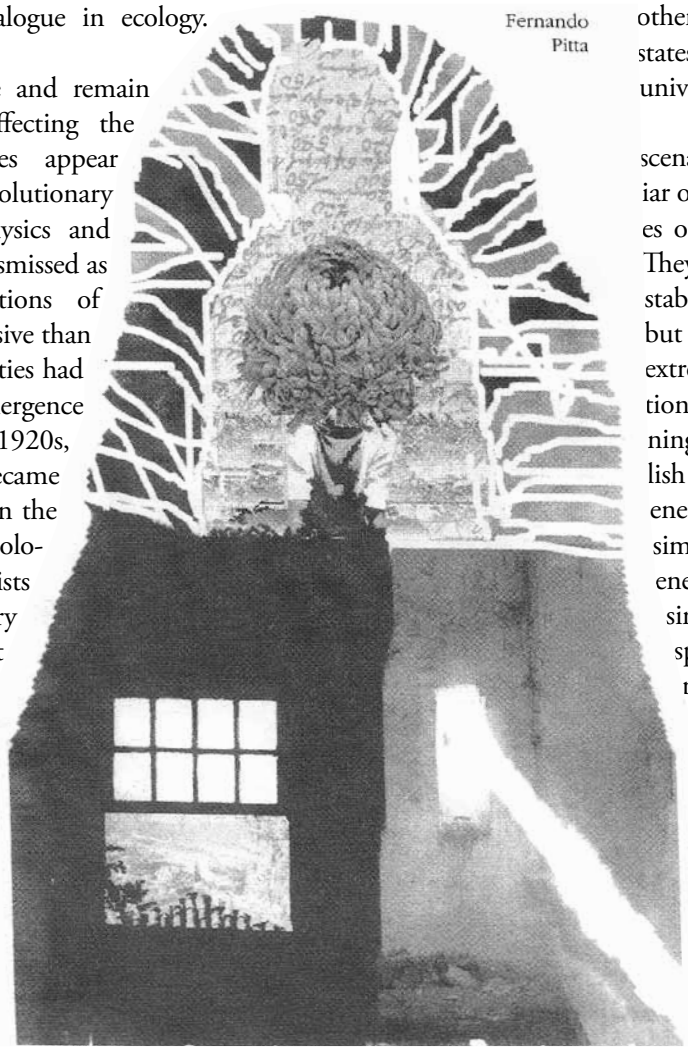
New forms of collective behavior arise from spontaneos appearances of incresaing levels of complexity

Still, not all biologists are chemists. Some preferred to study intact living organisms and their interactions, discovering patterns quite as complicated as those prevailing among organic molecules. In combination with those who persisted in studying fossils, this school of biologists seems to have agreed that Darwinian gradualism is not an accurate description of biological evolution. Instead, what they call 'punctuated equilibrium' prevails. This refers to relatively sudden changes in the array of plants and animals sharing the earth's surface, separated from one another by periods when nearstability prevailed for comparatively long periods of time.

What precipitated outbreaks of rapid change remains controversial. Celestial accidents, like the catastrophic collision with an asteroid that may have killed the dinosaurs, is one possibility. More gradual climate change, associated with fluctuations in solar radiation and/or changes in oceanic circulation (perhaps provoked by continental drift) may have served as a different sort of external trigger. Other theorists suppose that an inherent instability is built into complex eco-

systems whereby a delicately balanced, finely tuned, maximally efficient group of organisms becomes vulnerable to minute disturbances of the tightly-knit equilibrium simply because each life form has become so intimately interdependent with the fixed behavior of an exact array of others. If so, even small random events"like the proverbial butterfly wing, whose flutterings, meteorologists like to remark, may provoke a hurricane" would have its analogue in ecology. No one it sure.

The physical sciences were and remain different, for the rip-tides affecting the social and biological sciences appear trivial when compared to the revolutionary upheaval that transformed physics and cosmology What my teachers dismissed as new-fangled, marginal corrections of Newton proved far more subversive than they could imagine. Old certainties had begun to crumble with the emergence of quantum mechanics in the 1920s, but the universe as a whole became open-ended and unstable only in the 1950s when a coalition of cosmologists and small-particle physicists began to compose a new and very surprising story oi how it all got started and proceeded to evolve across the past ten to fifteen billion years.


Fernando Pitta

I confess that at the micro level, I completely fail to understand the mysteries of quantum mechanics whereby an electron is both a wave and a particle and can go through two separate slits of an interferometer at the same time and only appear at a specific place when its impact is somehow measured! But currently fashionable cosmology seems intelligible, even if the confidence with which experts debate its successive phases seems presumptuous and amazing to someone as mathematically naive as I. Still there is something intuitively attractive in starting with a Big Bang, and then in initia] micro-seconds, as temperature and density diminished, allowing space and time to framcthe dispersion of matter and energy into a few initial catch basins"hydrogen and helium nuclei for matter; and gravity, electro-magnetic force and the weak and strong nuclear forces for energy.

Subsequent changes that cosmologists have come to accept are scarcely less startling. The shining, erstwhile eternal, stars are now believed to be stormy nuclear reactors, radiating energy set loose by the formation of heavier atomic nuclei in their interiors. Born by virtue of gravitational concentration of cosmic dust particles, the larger stars are expected to implode when their hydrogen fuel is exhausted, and then to explode, scattering cosmic dust again and allowing a new generation of stars to form from matter that includes some of the new, heavier elements. Indeed, astronomers now assign our sun to the third generation jot of stars, thanks to its mix of heavier elements. Successive explosions and concentrations do not exhaust the celestial repertoire of drastic change. Instead, the very biggest stars become Black Holes; others turn into tiny neutron stars of unimaginable density, while quasars and still other manifestations of extreme states of matter and energy dot the universe.

What I conclude from this scenario is that laws of physics familiar on earth and in the nearby fringes of our galaxy are a special case. They may be stable, or apparently stable, for long periods of time, but do not endure forever. Instead, extreme conditions of concentration and/ or dispersal at the beginning and at the end of time establish regimes in which matter and energy, as physicists know them, simply do not exist and when energy, as physicists know them, simply do not exist and when space and time also lose their meaning. Moreover, amidst our expanding universe, the ultimate limits of our familiar matter, energy, space and time, are sporadically approached, or perhaps even crossed, in the neighborhood of Black Holes, quasars and the like.

Such a cosmos is strikingly at variance with the regular, fixed and eternal laws of physical science that prevailed in the classrooms of my youth. Changes of physical-chemical regimes that are sometimes radical, often sudden, and always unpredictable in detail, have displaced the eternal uniformity and mathematical predictability that astronomers and physicists imputed to the natural world between the 17th and 19th centuries.

Most striking of all is the way in which the cosmos that physicists and astronomers now believe to exist begins to resemble the chaotic and changeable world that biologists and social scientists have always struggled to understand. Let me explore a bit further this apparent congruence of the sciences, which I believe will turn out to be the primary intellectual achievement of the 20th century.

First of all, the role of the observer in creating what is observed always hampered historians and social scientists in their efforts to arrive at eternal, objective truths. This same dilemma now haunts the physicists as well. Einstein's relativity and the oddities of quantum mechanics both drew attention to the inescapable involvement of the act of measurement with

what is measured. Cosmologists now discuss the "anthropic principle", arguing whether the universe they surmise to exist may perhaps be compelled to conform to what human minds and humanly-created instruments are capable of observing. The resulting epistemological dilemma is acute even though practicing scientists usually prefer to disregard it. But the notion, propagated in the seventeenth century, that physical science, relying on the certainties of mathematics, could achieve accurate predictability and an unambiguous description of external reality is no longer very plausible. Physics and chemistry, in short, have joined the rest of the sciences, navigating a changeable world in the face of serious uncertainties about the role of the observer in affecting what is observed, even if Newtonian laws of physics still hold for nearly all practical human purposes.

Nonetheless, when I read about how ingeniously particle physicists contrive to discover what they are looking for by systematically blocking out "background noise" from their experiments what they do seems quite as arbitrary and intuitive as my own intellectual procedures when I focus attention on some bits of information from the past and disregard others simply because they are not relevant to the hypothesis I am exploring.

Disregarding irrelevancies and confining attention to part of the available sensory input is, I believe, characteristic of all animal and human behavior. We do it all the time, quite unconsciously. Receiving and comprehending the sounds of speech means excluding other sounds from the focus of attention. How human beings make sense of speech-sounds is hard enough to explain. But how our resort to verbal and mathematical symbols enables us to act upon, and react to, the world around us successfully is far more mysterious. Nonetheless, that is what human beings have done ever since they developed articulate language something like 40,000 years ago. Just think how magical it is for our arbitrarily invented symbols to have such power! Yet they are what define common hopes and programs of action for human groups of every size, from nuclear families to nation of hundreds of millions of persons, and they are what guide our intervention in natural processes to attain desired ends. The basic question is simple enough: How are human words, wishes and actions connected to things out there? How indeed ?

This is one of the oldest questions of philosophy and I am not about to solve it. Indeed, I do not think anyone ever will. I am content to recognize the mystery, wonder at the success humans have achieved by acting on the basis of agreedupon meanings, and reflect on how this phenomenon of human society compares with and departs from other surprising novelties arising at other levels of complex behavior with which the biological and physical sciences are concerned. New forms of collective behavior arise from what appear to be spontaneous appearances of increasing levels of complexity whether at the physical, chemical, biological or symbolic levels. This strikes me as the principal unifying theme that runs through all we know, or think we know, about the world around us.

I have already paraphrased recent cosmological speculation about how the complexity of the observable universe may have emerged from the concentrated uniformity of the Big Bang. According to this view, physical laws of nature differ with different regimes of space, time, matter and energy, sometimes shifting very quickly, sometimes stabilizing towards enduring equilibria, at least locally and on occasion, but continuing to be liable to drastic and sudden changes, depending on how the contrary forces of concentration and dispersion prevail. Physics and cosmology have thus become examples of evolutionary uncertainty on both macro- and micro scales, however precise Newtonian predictions may be for intermediate scales and under our locally prevailing conditions.

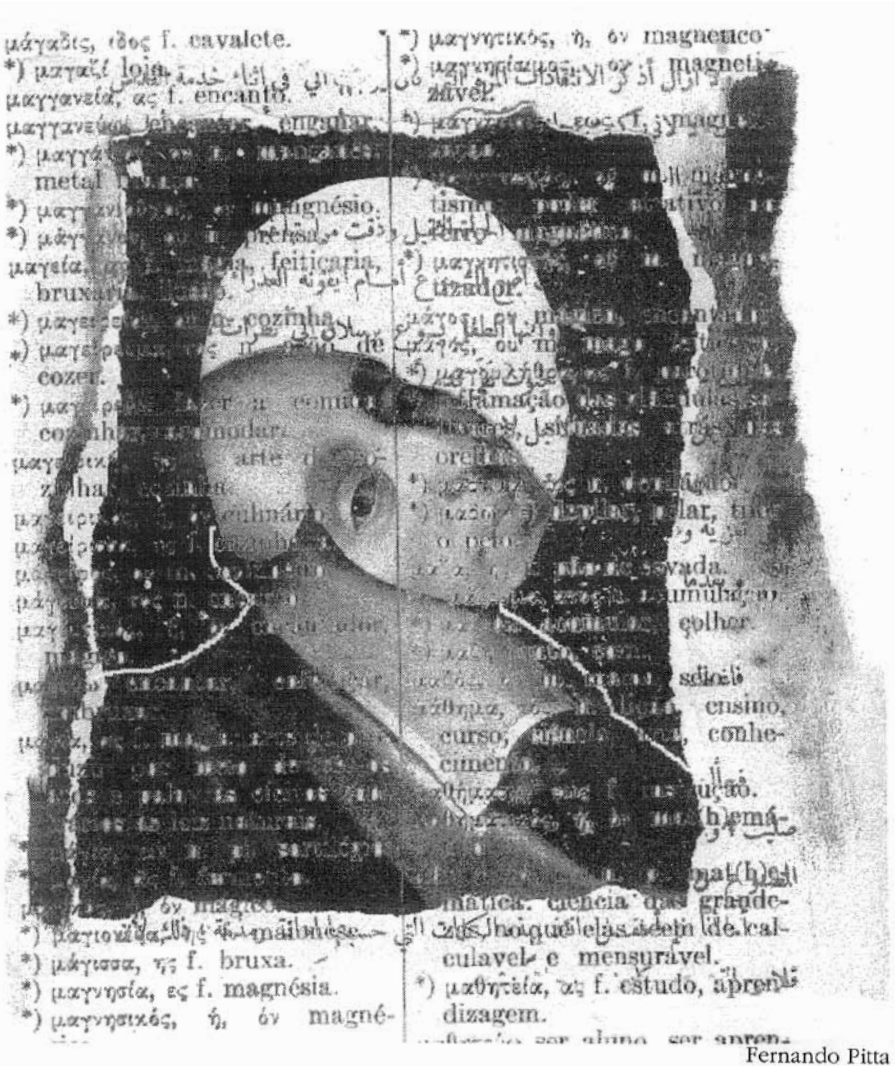
Such a science obviously resembles biology as never before. Speculative biochemists like to believe that terrestrial life emerged from an aqueous solution of large molecules when some of them began to replicate themselves as proteins and other molecules that compose plant and animal tissues now do every day.

Whatever its start, the regime that prevails among the complex molecules now constituting earth's bio-mass soon imposed new balances on the earth's physico-chemical system. Forests, for example, altered rainfall patterns on land, while decaying organic matter laid down strata of limestone under the sea. On a global scale, plants eventually transformed the earth's atmosphere by releasing oxygen, making the earth hospitable to animals, who ate the plants and one another, establishing a series of ecological equilibria across geological time, each of which gave way to its successor in bursts of change whose precise provocation remains unclear.

It is tempting to compare the emergence of organic life on earth with familiar physicochemical changes of regime, like what happens to water molecules in a pot on a hot stove. Reaching a critical temperature, water molecules begin to boil by establishing a geometric pattern of rising and falling convection currents. This accelerates the diffusion of heat through the mysteriously concerted motion of innumerable separate molecules. Similarly, living organisms also accelerate the diffusion of solar energy by capturing it from the environment, (directly as plants do or indirectly as animals do either by eating plants or by eating animals that eat plants) and then using such captured energy to build and sustain their various body chemistries. Of course the concerted action that knits living organisms into a single ecosystem is far more complicated than the geometrical concert of columnar movement that prevails among boiling water molecules. But the end result is similar, for both regimes accelerate the dispersal of energy, and they persist only by vitue of that fact.

Yet the almost unimaginale complexity of organic interactions within the biosphere and whith the inorganic environment makes the ecosystem far more unstable over time than anyting columns of boiling water molecules are capable of. That is because enourmous, convoluted living molecules do not always reproduce themselves accurately, and resulting variations in molecular architecture and behavior, in turn, introduce the possibility of organic evolution, with all the changing impacts on earth's physicochemical environment I just referred to.

Liability to error allows us to envolve



Fernando Pitta

If we turn attention to humanity's earthly career, congruities between history and organic evolution seem evident. In a word: punctuated equilibrium describes them both. For example, experts now seem to agree that the development of language provoked the onset of rapid invention of new tool types and changes in other aspects of human life some 40,000 years ago. A second drastic transformation set in when hunting and gathering began to give way to food production about 12,000 years ago. Subsequent spurts of change also occurred when human beings began to harness wind, flowing water, coal, oil and nuclear reactions between about 6000 and a mere sixty years ago. On a quite different plane, the rise of states and of organized religions also altered human behavior profoundly; and by concerting the hopes, fears and conscious intentions of large numbers of people, allowed our ancestors sporadically to enlarge the repertoire of human skills, knowledge and power over one another and over nature as well.

The secret of the human career on earth surely lies in the fact that we react to the world and to one another largely on the basis of symbols. And plainly, human languages and the symbolic systems of mathematics constitute yet another sort of equilibrium, evolving over time much as living organisms evolved and mayhap also alternating between approaches to stability and bursts of rapid change like the punctuated equilibrium of the biosphere and of the physico-chemical universe.

Our symbols are certainly liable to error; and error invites correction when discrepancies between expectation and experience multiply. The result is far more rapid changeability in human behavior than the genetic changeability that lies behind organic evolution. Yet if one accepts the notion that the genetic code constitutes chemical information about how to build a living organism out of a fertilized cell, it is apparent that human symbols are similar inasmuch as they also convey information from generation to generation about how to get what people want and need. Both sorts of information trigger the unfolding of coherent processes, and their liability to error is what allows them to evolve. Changes that conduce to survival tend to spread; with the result that living species and the ecosystem as a whole, like human beings in particular, have sustained themselves by sporadically capturing more and more energy from the physico-chemical processes taking place on and near the earth's surface.

And because our symbols, and behavior shaped by symbols, changed so much faster than genetic codes across the past forty millennia, humans radically outstripped other species, increasing our share of the earth's energy enormously and often at their expense. Resulting imbalances may be approaching a critical point. Ecological alarmists tell us so every day and they may be right. But human behavior remains flexible and if real disaster looms, we might be able to fend it off by changing our behavior in time. The more we know about ourselves and about the biological and physico-chemical systems within which we live, the more capable we become of making appropriate adjustments. Or so a rational optimist can hope. But since knowledge also enhances destructive powers, humanity's career on earth in time to come will remain uncertain, along with the further path of organic evolution and the long range future of the solar system, the galaxy and the universe itself.

Such uncertainty about the future does not diminish the 'scientific' vision of a grand continuity extending across al levels of reality from physicochemical systems to the biosphere and to human societies and our symbols. Similar patterns seem to

prevail at each level. At the least, the gap of my youth between social studies and the exact sciences has narrowed dramatically. Human beings, it appears, do indeed belong in the universe and share its unstable, evolving character. Our behavioral variability may indeed constitute an extreme - rivaled, if at all, only by the plasticity of domesticated plants and animals and, in the wild, by the pace of organic evolution among disease germs when exposed to new-fangled antibiotics. But what happens among human beings and what happens among the stars looks to be part of a grand, evolving story featuring spontaneous emergence of complexity that generates new sorts of behavior at every level of organization from the minutest quarks and leptons to the galaxies, from long carbon chains to living organisms and the biosphere, and from the biosphere to the symbolic universes of meaning within which human beings live and labor, singly and in concert, trying always to get more of what we want and need from the world around us.

World history has an obvious and honorable part to play in the emerging convergence of the sciences around this grand evolutionary world view. Advances upon what I was able to do when I started to write a history of the world in 1954 are easy to point out. A first step would be to meld ecological history more fully into the cultural history of humankind. More generally, history written with awareness of the physicochemical energy flows that sustained human societies - surveying how our predecessors tapped organic and inorganic sources of energy - would seat the human career on earth more squarely within the biological and physical sciences than I ever thought of doing.

I also feel sure that an adequate world history must take respectful account of the older, competing world views. To be sure, animism and the principal higher religions of the world fit into the emerging scientific world view without much difficulty, since both of them clearly conduced to survival by concerting common action and by making everyday experience meaningful and more nearly tolerable for believers. How these older world views can best make room for the scientific world view is not so clear, but since religion remains a necessity for human beings, especially in times of trouble, a workable modus vivendi is very much needed. Like the problems of epistemology, this is a very old question Lo which I have no answer. All the same I suspect that sustaining an always awkward symbiosis of secular science with sacred religion will remain quite as important for the future as it was in the past.

Evolution and Deceit

Eduardo Giannetti da Fonseca

In his essay, "Paths of Discovery", William McNeill stresses the role of error in human adaptation and evolution. I will try to show here how deceit also operates in the great chain of being.

All living creatures obey two commandments of nature: to survive and reproduce. To obey these commands an organism will do anything. However, if these ends are common to all organisms, they develop different ways of achieving them.

Among these techniques is the art of deceit. Certain morphological traces and behavioral patterns evolve to deceive attackers and avoid the defenses of other organisms. The art of deceit can operate between members of different species, as well as between members of the same species, and even, especially among humans, with the same individual practicing self-deception. All of us on our special niches on the great chain of life practice deceit, from microorganisms, such as protozoa, to *homo-sapiens,* whose techniques of knowledge and communication are more powerful than those of any other species.

While microorganisms and vegetables can only resort to morphological resources, linked to the organism's form and external properties, animals can use behavioral strategies to deceive their fellow creatures. The mask that disguises is joined by the gesture that cheats.

For animals there are two basic stratagems to fool fellow creatures: deceit by concealing and the deceit by active misinformation. The first stratagem is by tricks of camouflage, mimicry and dissimulation. The chameleon, changing colors to evade a predator, is a good example of this kind of survival sport. The second is active misinformation - like the fox pretending to be dead in order to avoid a predator - employing well-known practices such as bluff, cheating and diverting attention.

While we cannot know what happens in the mind of animals that deceive others, one thing is clear: The closer we get in the scale of evolution to man, more numerous are the possibilities for the art of deceit. Behavioral flexibility helps. The lack of language limits the repertoire of deceit.

We may ask how much living creatures practicing "deceit" are really "deceiving" each other. Since their actions are i nvoluntary, can they be characterized as deceit? Are we indulging in anthropomorphism if we see deceit in the strategies which living creatures use to face the challenge of survival and reproduction?

To some extent, the notion of deceit, as well as the idea of gravity, may reflect an objective reality. Deceit thus would be only a particular type of relationship between two living creatures in which the morphology and/or behavior of one of

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them creates a discrepancy between reality and appearance that distorts perceptions and modifies the action of the other.

But we still may ask: Does the idea of deceit, which makes sense for humans, have any meaning for other beings that seem to us to act in a misleading way? To speak of deceit in the kingdom of nature seems, in some way, to infer the existence of an external observer capable of perceiving and interpreting a special type of interaction between other organisms. Thus, deceit is not independent of the perspective that humanity applies to living things. It is a human judgment, made in view of human experience.

Ironically, mankind rediscovers itself while thinking about nature. In other words, man's reflection about nature reflects the own way man lives with himself and other men. Hence nature, which can only be known by man, is seen in the mirror of human life.

We even may consider, according to Genesis, that man began to distinguish himself from the world around him, nature due to deceit. God told Adam and Eve not to eat the fruit of immortality. The serpent, however, told Eve that God's command was deceptive: She and Adam would not die if they ate the fruit. On the contrary, they would become more like God, becoming capable of judging between good and evil. This really happened. The serpent, thus, did not lie. The survival of Adam and Eve gave proof of this. But God did not lie either. The death to which God referred was not the organism's sudden and literal death, but a conscious anticipation of death. It is clear from this story that this deceit was neither an initiative of God nor of the serpent, but was a mistake of understanding.

The invention of language took the art of deceit into a new paralise

From then on, Adam felt a need to be master of all things. He began to give names to things and other creatures. This truly was a Big Bang in expanding the universe of deceit. One thing is the physical universe, where biological organisms do not let themselves be cheated by man's linguistic skill and slyness. Another thing is the universe of Man, where we can manipulate nature to our benefit through the exchange of information and coordination that language makes possible. If there is no natural guile that convinces a fish not to run from its pursuers or the polio virus to seek a new host, language enables the fisherman to learn his job and use bait to catch the fish and medicine can, through vaccination, prepare the organism to fight the virus before an attack.

With all their ingenuity and complexity, these examples form part of the relationships between man and nature, which are less complicated than relations between humans themselves. In all social relationships, the overwhelming subjectivity of human experience in the world and life steals the scene.

Even if deceit existed before language, the invention of language took the art of deceit into a new paradise. An extraordinary tool for creating discrepancies between reality and appearance was added to the basic repertoire of the natural world, until then restricted to using morphological and behavioral devices to practice deceit by concealment and misinformation.

Among the forms of deceit peculiar to man perhaps the most intriguing is selfdeceit. The repertoire of this type of deceit varies: hallucination, dreams, refusal to accept the shocks and frustrations of reality and day-dreaming. Consumption and enjoyment of works of art in general, and of pieces of narrative fiction in particular, can be seen as a kind of sacred space and prime time of day dreaming. Fictional travel with art is like taking vacations from our own concrete and personal subt jectivity. It is as if we were resting from I, our own selves to daydream other lives, beliefs and emotions, as in the theater. According to the philosopher Denis Diderot, "the citizen who enters the Comedie leaves behind all his vices, to recover them on the way out. Inside the theater he is just, impartial, a good father, a good friend, a friend of virtue; many times I saw next to me wicked men profoundly angered with actions they would not hesitate to commit if they were in the same situation in which the playwright placed the character that disgusted him. "

The behavior of Diderot's character has a simple explanation: no one stands to live with a repulsive ethical image of himself for a long time. What offends and shocks others, seen from outside, becomes, seen and lived from inside, odorless and reasonable. But in addition to this moral psychological cause, an evolutionary psychological cause can explain some types of self-deceit as not just hypocrisy. From a Darwinian naturalist point of view, to lie and deceive a fellow creature is a universal and innate tendency of the human animal. It is a mechanism of survival and reproduction as natural as, say, sweating and courting. Consequently, the natural kingdom's repertoire of deceit is seen only as a preamble to the farcical epic to come.

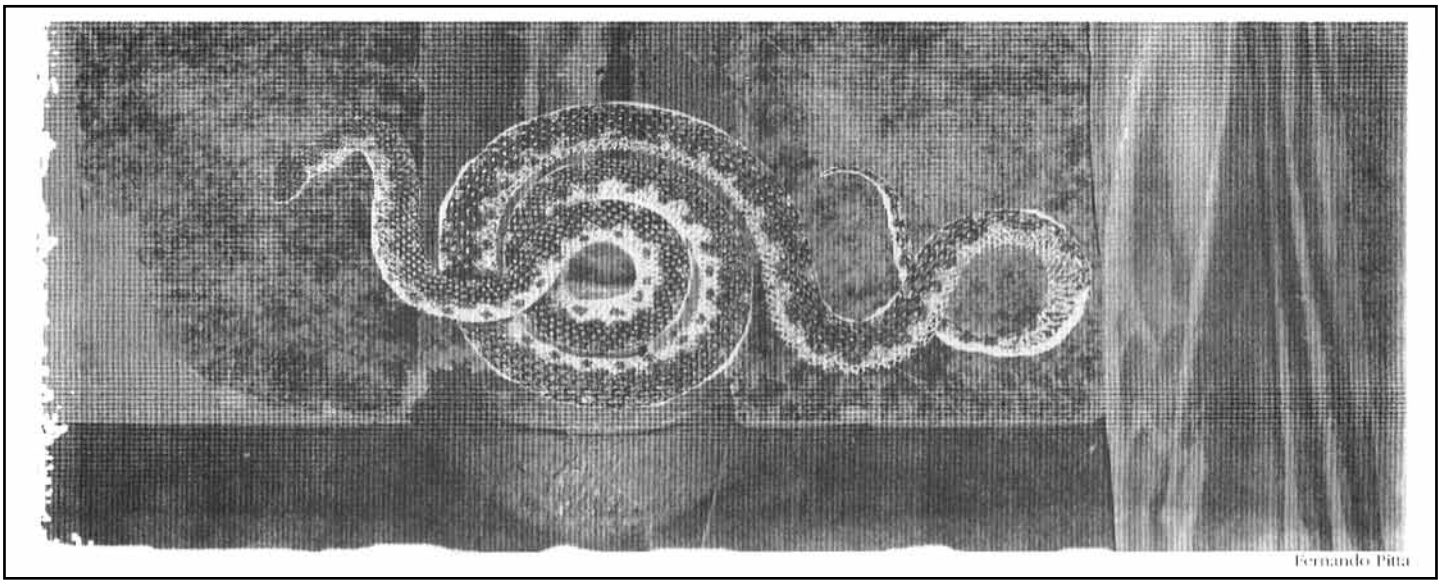
The great problem for the deceiver is that he is not alone. He cannot allow his varnish of credibility and honesty to show suspect flaws or cracks. As Plato cites Protagoras reporting the pressure exercised by the community over the citizen of the polis: "He who says he is not just can only be mad." To lie, thus, is an art.

All human animals are, at some time, active deceivers or victims of deceit. All intermittently face both situations. True evolutionary competition is, consequently, one between two strategies facing each other on the stage of practical life: active versus preventive deceit. The result of evolutionary competition shows that the self-deceiving deceiver, sincerely convinced of the falsehood he creates, is more skillful in the art of deception than the cold and calculating deceiver of others.

It is difficult to resist feelings of astonishment and verbal impotence when confronted with the damage and suffering that man's natural propensity to deceive others and himself can cause. These consequences assume especially frightening proportions when, as with the Spanish Inquisition, Nazism and

Soviet Communism, they are produced by collective selfdeceit. But collective self-deceit is the aggregate result, often with new properties, of the interaction between many individual episodes and forms of self-deceit. The main victim of self-deceit is frequently the self-deceived. With self-deceit one can radically lose familiarity and pleasure with one's identity, giving the impression of living a lie.

Still, the positive value of self-deceit may be more important than its negative value. Much of the strength of a creative artist who can continue his work, despite all frustrations, may come from an idea of the final realization that was initially a belief with very low chances of becoming true. Thus, the false ex ante can become true ex post, or, as William Blake observed in his *Proverbs of Hell:* "if the fool wuold persist in his folly he would become wise."


Fernando Pitta

Much of human prudence comes from the double character of rationality: calculation of both the means and the ends. Goals that at first sight seem attractive thus become undesirable in the light of what we would have to abandon to achieve them or when compared with alternative goals that we could pursue. Rationality is thus an invaluable instrument when we must avoid unnecessary errors in evaluating means and ends. It may not be paradise, but at least it protects us from many hells.

The problem is that judicious calculation and prudence, endowing rational thought with analytical sobriety and pusychological acuity, make us skeptical and devious in the face of ambitions of creation and grandeur. "All great endeavors", recalls Plato, "are risky, being true the saying according to which what is of value is never easy to achieve" (Republic 497). Thus cowardice comes from rational calculation, human miracles from self-deceit.

We must ask, then, what justifies the audacity and possible sacrifices bred by self-deceit. The answer to the question is not, however, in the results. In the case of Paul Gauguin, for example, before he went to Tahiti no one could imagine realistically that some day he would become a great and famous painter. Thus, even in cases without the success of Gauguin, it is possible to consider that the value of genuine search, although it may be revealed as pathetic and self-deceitful in the end, does not depend on the value of what is achieved. The bet has a value of its own, independent of the outcome. What is even justified because the illusory belief that one will be able to achieve much (the impossible) is often the necessary condition for one to achieve at least something (the possible).

Even in economics, the privileged space for the application of instrumental rationality, self-deceit is necessary. The decision to invest, to tie up capital to create a new business, buy equipment, train a worrk force or open a research lab, should be based on what? If all potential entrepreneurs acted only on prudent calculation, making new investments only when they knew all that they must know to be rationally sure that they would not lose their bets, the economy would become seriously depressed. The hiatus between rational calculation and entrepreneurial action is, therefore, filled by what Lord Keynes called "animal spirits": the subjective certainty that moves the great entrepreneur, moving him to go beyond rational calculus as he forgets what he knows or cannot remember.

So self-deceit, in the most different areas of endeavor, can act as primeval and unexplainable hope: the illuminating and saving blindness that protects us from living completely within the absurdity of our errors and the certainty of our end. Virtue, however, may lie in the balance between rational calculations and the drunkenness of self-deceit. This is summarized in two inscriptions at the temple of Apollo in Delphos. One recommended continuous search for selfknowledge: "know thyself". The other inscription established a norm to be observed in life and sociability: the moderation principle synthesized in the maxim: 'nothing in excess."

The proximity between the two Delphic precepts makes one think. The search for self-knowledge and the principle of moderation are complementary. The man who knows himself recognizes his limitations and, thus, does not reach beyond his capacity or condition. On the other hand, he who can identify and soberly examine his own feelings and desires is partly able to see them from outside and distance himself from them, reducing the risk of being tyrannized by them.

On the other hand, self-ignorance favors excess. Overes-

timation of one's own capacities, the inflammation of self-confidence, shows that the individual has, in some way, lost contact with his internal reality. Thus the impregnable and overwhelming certainties that drive him distort his perception of limits and his sense of proportion.

But too much self knowledge is also frightening. What would the inner life be like of someone who entirely banished self-deceit? Would he be incapable of being mistaken about himself? Blessed with perfect objectivity about his subjective experience, the human animal "cured" of self-deceit never allows himself to embark on the fictional and illusory constructions of his sleeping or awakened mind. This kind of monster would spend all his time on rational projects, in which the probability of success is mathematically sure. The poet Fernando Pessoa, who was far from being immune to self-deceit wrote that the human animal, in the absence of self-deceit, is a "healthy beast, postponed corpse which procreates" *["besta sadia, cadáver adiado que procria. "]*

"Consider Your Seed"

Rubens Ricupero

In Dante's Inferno, before sailing into the unknown darkness, Ulysses tells his fearful shipmates: "Consider your seed: You were not made for brutish life but to find virtue and understanding." (Canto XXVI)

Considerate la vostra semenza:
Fatti non fosti a viver come bruti
Ma per seguir virtute e conoscenza.

We may better consider our seed because of the humanistic explorations of men like Desiderius Erasmus (1466-1536) and William McNeill, one of this century's leading historians, awarded the Erasmus Prize in Amsterdam last December. "The peoplebuild cities, princes pull them down," Erasmus wrote in his *Adagia.* "The industry of the citizens creates wealth for rapacious lords to plunder; plebean magistrates pass good laws for kings to violate; the people love peace, and their rulers stir up war." Though five centuries separate their lifetimes, Erasmus and McNeill, each in his own way, advanced the humanist tradition with their devotion to reasoned behavior, to the long view and to steadfast intellectual independence.

We embrace William McNeill as a friend and a member of the Fernand Braudel Institute of World Economics, a *Braudel Papers* author ["The Rising ride of Urban Violence" No. 6/1994] who participated in two of our international conferences in Brazil. We are grateful fur this opportunity to pubish "Paths of Discovery," adapted from hit; Erasmus Prize lecture, a courageous and innovative summaion of scientific and historical thought, weaving ogether apparent opposites, ideas whose initial contradiction gradually converge. The first con^Tergence is between an animist or religious world view and the scientific view, one giving birth to he other, belief and negation meeting on the ,round of common action to enhance the survival if man and to give meaning to his experience. The econd pair of converging opposites joins world views of the physical sciences and the sciences of ociety, history among them.

McNeill's convergence shows deep affinity with the work of Teilhard de Chardin, the great French Jesuit anthropologist who helped to find the "Peking Man." Teilhard also tried to reconcile scientific and religious world views and join, in an inclusive and unifying way, scientific knowledge of the cosmos, life and spirit.

Amid contrasts and convergence between different views of reality, McNeill finds in the link between escalating complexity and adaptive behavior "the principal unifying theme that runs through all we know about the world around us,') adding that "surprising new forms of collective behavior arise from what appears to be spontaneous appearances of increasing levels of complexity whether at the physical, chemical, biological or symbolic levels."

The explanation of the adaptive success of the human species is simple: we react to the world and to each other largely on the basis of symbols, whether in language or mathematics. These symbols enable us to correct errors when discrepancies between prediction and experience occur. Thus the adaptability of human behavior is much superior to the capacity for genetic change in organic evolution.

Reading this and other texts by McNeill produces clear and fascinating linkages that join the respective domains of nature and culture, bringing together ideas of astrophysics and biochemistry with those of history. At this juncture perhaps, particularly Tailhardian in the continuity of matter, life and spirit, McNeill moves away from the great precursor of all those obsessed with the search for a global meaning for history, the Neapolitan Gianbattista Vico. In his *New Science,* Vico asserts the rational character of the historic process. Not that rationality is intrinsic to history or that history complies with rationality, but because reason gives man the power of endowing history with an intelligible meaning and direction. But Vico goes much further. For him, man can only understand what belongs to the domain of culture and history, for human beings can only

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comprehend what they themselves do and create.

McNeill's intellectual heritage descends from Erasmus and the Renaissance, through the Enlightenment. In his criticism of *The Clash of Civilizations* of Samuel P. Huntington, he shows no attraction to theories of civilizational rise and fall, or to the idea of the decline of the West, as set forth by Spengler, Toynbee and Huntington himself. He argues that Toynbee neglected two factors. The first is that contemporary civilizations always interacted with one another, even across long distances. The second is that human ideas and skills, propagated through these encounters have a cumulative character. Cultures change through those encounters with external influences; ideas such as representative democracy, human rights, the market economy, though originated in 18th Century rationalism, have universal appeal. The central phenomenon of history has always been the borrowing and adaptation of skills and ideas to increase power and wealth, enlarging our niche in the ecosystem. For that reason, cultural continuity must be combined with a willingness to receive and incorporate outside contributions. The trend towards global cosmopolitism thus offers the best hope for the future.

A sort of epistemological optimism pervades the inspired passage in which, after stating that the gap of his youth between social studies and the exact sciences had narrowed dramatically, McNeill takes off for the heights: "What happens among human beings and what happens among the stars looks to be part of a grand, evolving story featuring spontaneous emergence of complexity that generates new sorts of behavior at every level of organization from the minutest quarks and lepton to the galaxies, from long carbon chains to living organisms and the biosphere, and from the biosphere to the symbolic universes of meamng within which human beings live and labor trying always to get more of what we want and need from the world around us".

At the end, the road rejoins the departure point. The higher religions fit into the emerging scientific world view without much difficulty for "sustaining an always awkward symbiosis of secular science with sacred religion will remain quite as important for the future as it was in the past". Teilhard said the same thing with different words: "All that raises itself, converges". We arrive at the final synthesis, the view of the forest of global history and not only of the single trees of fragmented histories. The history of the types of knowledge has led us to the knowledge of history. Finally, the human adventure mingles with the quest for knowledge of us and the world. As Ulysses told his crew, man was created to strive for selfimprovement and understanding.