Less Predictable Realities

by Stanisław Lem

translation and introduction by Joanna Zylinska

The Polish writer Stanisław Lem is best known to English-speaking readers as the author of the 1961 science fiction novel *Solaris*, adapted into a meditative film by Andrei Tarkovsky in 1972, and remade in 2002 by Steven Soderbergh. Throughout his writings, comprising dozens of science fiction novels and short stories, Lem offered deeply philosophical and bitingly satirical reflections on the limitations of both science and humanity.

In *Summa Technologiae*—his major work of non-fiction, first published in 1964 and now available in English for the first time—Lem produced an engaging and caustically logical philosophical treatise about human and non-human life in its past, present, and future forms. After five decades *Summa Technologiae* has lost none of its intellectual or critical significance. Indeed, many of Lem's conjectures about future technologies have now come true: from artificial intelligence, bionics, and nanotechnology to the dangers of information overload, the concept underlying internet search engines, and the idea of virtual reality. More important for its continued relevance, however, is Lem's rigorous investigation into the parallel development of biological and technical evolution, and his conclusion that technology will outlive humanity itself.

Preceding Richard Dawkins's idea of evolution as a blind watchmaker by more than two decades, Lem posits evolution as opportunistic, short-sighted, extravagant, and illogical. Strikingly original and persistently contemporary, *Summa Technologiae* resonates with a wide range of contemporary debates about information and new media, the life sciences, and the evolving relationship between technology and humanity.

Intelligence: An Accident or a Necessity?

"Nonintelligent" animals and plants are capable of adapting to changes caused by environmental factors—for example, by seasons of the year. The evolutionary catalog of homeostatic solutions to this problem is enormous. Temporary loss of leaves, spore dispersal, hibernation, insect metamorphosis—these are just selected examples. However, the regulatory mechanisms, determined by genetic information, can only cope with the kinds of changes by which they themselves had been selected during thousands of previous generations. The precision of instinctive behaviour becomes ineffective when the need to find new solutions arises, solutions that are not yet known to a given species and are thus not fixed genetically. A plant, a bacterium, or an insect, as "homeostats of the first kind," all have built-in ways of reacting to changes. Using the language of cybernetics, we can say that such systems (or beings) are civilizations in the universe "programmed in advance" when it comes to the range of the possible changes they should overcome through regulation if they are to continue their existence—as well as that of their species. Such changes are mostly of a rhythmic nature (change from day to night, seasons of the year, high and low tides), or at least of a temporary nature (being approached by a predator, which mobilizes the innate defense mechanisms: fleeing or freezing suddenly "as if one was dead," etc.). When it comes to changes that would knock an organism out of its environmental equilibrium by "programming" some unforeseeable instincts into it, the answer of the "first-order regulator" turns out to be unsatisfactory—which results in a crisis. On one hand, the mortality of non-adapted organisms suddenly increases, while at the same time, selection pressure privileges some new forms (mutants). This can eventually result in reactions that are necessary for survival being inscribed into "genetic programming." On the other hand, an exceptional opportunity arises for organisms endowed with the "second-order regulator," that is, the brain, which—depending on the situation—is capable of changing the "action plan" ("self-programming via learning"). There probably exists a particular type, speed, and sequence of changes (we could call this sequence "labyrinthine," after the mazes in which scientists study the intelligence of animals, such as rats) that cannot be matched by the evolutionary plasticity of genetically determined regulators or instincts. This privileges the processes of the expansion of the central nervous system as a "second-order" homeostatic device, that is, as a system whose task consists in *producing test models* of various situations. The organism then either adapts to the altered environment (the rat learns how to find the exit from the maze) or adapts the environment to itself (man builds civilization) —and it does this "by itself," without relying on any pre-prepared action plans. Naturally, there also exists a third possibility—that of losing, when, after having created an incorrect model of a situation, the organism does not achieve adaptation and becomes extinct.

Organisms of the first type "know everything in advance;" those of the second type still need to learn what to do. An organism pays for the comfort of the first solution with its narrowness, of the second one with risk. The "channel" through which hereditary information is transmitted has a limited capacity, as a result of which the number of preplanned activities cannot be too high: this is what we mean by regulatory "narrowness." One knowledgeably assumes the existence of a preliminary period, during which an organism is particularly prone to errors. The cost of such errors for the civilizations in the universe can be quite high and can even include the loss of life. This is probably why both of these types of regulators have survived in the animal world. There are environments in which typical behavior, learned "from the cradle," is a more economical option than having to cope with the difficulties and cost of learning from one's mistakes. This, incidentally speaking, is where the "wondrous perfection" of instincts comes from. All this sounds fine, but what does it mean for the general laws of encephalogenesis? Does evolution always eventually need to produce powerful "second-order regulators" such as large brains in primates? Or, if no "critical changes" take place on the planet, does this mean that no brains emerge on it—since they are not needed?

It is not easy to answer a question posed in this way. The cursory understanding of evolution usually results in a naïve idea of progress: mammals had "bigger brains" than reptiles, which means "greater intelligence," and this is why the former ultimately drove out the latter. Yet mammals coexisted with reptiles as marginal, minor forms for hundreds of millions of years, while reptiles reigned supreme. It has recently been confirmed once again what amazing intelligence dolphins have in comparison with other oceanic creatures. Despite this, they did not take control over the water kingdom. We are inclined to overestimate the role of intelligence as a"value in itself." Ashby comes up with a number of interesting examples here. A "stupid" rat, which is unwilling to learn, carefully samples the food it encounters. A "clever" rat, having learned that food is to be found always in the same place and at the same time, seems to have a greater chance of survival. Yet if this food is poison, the "stupid" rat, which "is incapable of learning anything," will beat the "clever" one in the survival stakes thanks to its instinctive lack of trust, while the "clever" one will eat its fill and then die. Not every environment thus privileges "intelligence." Generally speaking, the extrapolation of experience (its "transfer") is extremely useful in the terrestrial environment. There are, however, some other environments where this trait becomes a disadvantage. We know that an experienced strategist can beat a less experienced one, but he can also lose to a complete cowboy because the latter's actions are "unintelligent," that is, completely unpredictable. It makes one wonder how evolution, which is so "economical" in every area of information transfer, produced the human brain—a device with such a high degree of "excess." This brain—which, even today, in the twentieth century, copes very well with the problems of a large civilization—is anatomically and biologically identical with the brain of our primitive, "barbarian" ancestor civilizations in the universe from a hundred thousand years ago. In what way did this massive "potential of intelligence," this excessiveness which, from the early days, seemed geared to build a civilization, emerge in the course of the probabilistic evolutionary game between two vectors: mutation pressure and selection pressure?

Evolutionism lacks a firm answer to this question. Experience demonstrates that the brain of virtually every animal is characterized by significant "excess," which manifests itself in the animal's ability to solve the tasks it does not encounter in everyday life when it is presented with them by a scientist conducting an experiment. The universal growth of brain mass is another fact: modern amphibians, reptiles, fish, and, by and large, all representatives of the animal kingdom have bigger brains than their ancestors from the Paleozoic or Mesozoic eras. In this sense, all animals have "become cleverer" in the course of evolution. This universal tendency seems to prove that, provided the process of evolution takes a long enough time, the brain mass must eventually exceed a "critical quantity," which will initiate the rapid progress of sociogenesis.

We should nevertheless refrain from turning this "gravitation toward intelligence" into a structural tendency of evolutionary processes. Certain factors connected with the use of "materials," or with the initial stage of the "construction process," can limit evolution's future capabilities in its early days and determine its developmental threshold to such an extent that "second-order regulators" will not appear at all. Insects, which are one of the oldest, most vital, and most fertile animal strains, serve as a good example here. There are over seven hundred thousand species of insects on Earth today, compared with eight thousand species of all vertebrates. Insects take up over three-quarters of the animal kingdom as a whole—yet they did not produce intelligence. They have been in existence for approximately the same period of time as vertebrates, so—from a statistical point of view (if it was to be decisive)—owing to the tenfold size of their population, they should have ten times as much chance of producing "second-order regulators." The fact that this has not happened clearly demonstrates that probability calculus is not a determining criterion in psychogenesis. And thus the latter is possible yet not inevitable; it is one of the better solutions but not in all cases, and it is not the most optimal one for all worlds. To construct Intelligence, evolution must have at its disposal diverse factors, such as not too strong gravitation, the relatively constant strength of cosmic radiation (which should not be too powerful), environmental variability that is not just cyclic, and many other, probably still unknown ones. Their convergence on the surface of the planets is most like-ly not an exception. Despite everything, we can thus expect to find Intelligence in the Universe, though some of the forms in which it will manifest itself may defy all our contemporary ideas.

Models and Reality

Modeling is an imitation of Nature that takes into account few of its characteristics. Why only few? Is it because we cannot do better than that? No, it is mainly because we have to defend ourselves against the excess of information. Such an excess can actually signify inaccessibility. A painter paints pictures, yet, even though he has a mouth and we can talk to him, we are not going to find out how he does it. He does not know himself what is going on in his brain when he is painting. The information is contained in his head, but it is inaccessible. In modeling, one has to simplify: a machine that is capable of painting a very poor picture will tell us more about the material, that is, cerebral, foundations of painting than the "perfect model" of the artist—his twin brother—would. Modeling practice involves selecting certain variables and ignoring others. There would be an ideal correspondence between the model and the original if the processes of both were identical. This is not the case. The results of model development are different from those of any actual development. This difference can be caused by three factors: the simplification of the model in relation to the original, the model's own characteristics that are lacking in the original, and last but not least, the indeterminacy of the original itself. When we imitate a living brain with an electric one, we must consider a phenomenon such as memory as well as consider an electric network that represents the neural network. A living brain does not have a separate memory container. Actual prolegomena to omnipotence neurons are universal—memory is "disseminated" all over the brain. Our electric network does not manifest any such characteristics. We thus have to connect special memory banks (e.g., of ferromagnetic kind) to the electric brain. Besides, an actual brain shows certain "randomness," an incalculability of actions, while an electric one does not. What does a cyberneticist do? He builds a "generator of accidentality" into the model—which, on being switched on, sends randomly selected signals into the net. Such randomness has been prepared in advance: this additional device uses random number tables, and so on.

We have thus arrived at what looks like an analogy of "incalculability" or "free will." After taking these steps, the similarity of output parameters in both systems, the neural and the electric, has increased. Yet this similarity has only increased with regard to the corresponding "inputs" and "outputs." The similarity does not increase—and does, in fact, decrease—if, alongside the dynamic "input–output" relation, we take into account the entire structure of both systems (i.e., if we take into account a higher number of variables). Even though the electric brain now has "volition" and "memory," the actual brain does not have either an accidentality generator or a separate memory bank. The closer this model moves toward the original one within a range of certain imitated variables, the further away it moves from that original model within a range of others. If we also wanted to take into account the changeable excitability of neurons, which is conditioned by the existence of its limit point, while every organism achieves this state through the very biochemistry of its transformations, we would have to equip each of the switch elements ("neuristors") with a separate electrical system, and so on. However, we consider variables that do not manifest themselves in a modeled phenomenon as insignificant. This is a special case of the general mode of information gathering, one that assumes that an initial selection always takes place. For example, for an ordinary person speaking on the telephone, the crackling sound counts as "noise," whereas for a communications engineer who is examining the line, certain information can be conveyed precisely by such noise (this example is provided by Ashby).

If we thus wanted to model any phenomenon by taking into account *all* of its variables (assuming for a moment that this would be possible), we would have to construct a system that would be *more extensive* than the original one, as it would be equipped with additional variables that are characteristic of the modeling system itself but that the original one lacks. This is why, as long as the number of variables is small, digital prolegomena to omnipotence modeling works well. On increasing their number, this method quickly reaches the limit of its applicability. The modeling approach therefore has to be replaced by a different one.

In theory, it is most efficient to model one phenomenon with another identical phenomenon. Yet is this possible? It seems that to model man, it is necessary to construct him; to model bioevolution, it is necessary to repeat it on a planet that is exactly like Earth. The most perfect model of an apple is offered by another apple, of the Universe by another Universe. This may sound like a *reductio ad absurdum* of imitological practice, yet let us not be too quick in passing such a verdict.

The key question is as follows: is there something that, in not being a faithful (model) repetition of a phenomenon, contains more information than this phenomenon? Absolutely: a scientific theory. It covers a whole class of phenomena; it discusses every single one but, at the same time, all of them. Of course, a theory does not take into account many variables of a given phenomenon, yet, owing to the goal that has been set, these variables are not significant.

We are faced with a new difficulty here. We should ask whether a theory contains only as much information as we ourselves have introduced into it (having created it on the basis of observed facts as well as some other theories, e.g., measurement theory) or whether it can contain more information. The latter is impossible, you say? Yet it was on the basis of the theory of a physical vacuum that quantum field theory predicted a number of phenomena. Alongside the beta decay theory emerged the results of the theory of superfluidity (liquid helium) and also of the solid state theory. If a theory is largely supposed to predict phenomenon x, and then it turns out that some other phenomena that have been deduced from it—whose existence we did not know about before —also take place, where did this “additional” information actually come from?

It came from the fact that, generally speaking, there exists a continuity of transformations in the world. It came from their feedback. We have “guessed” one thing, and this one thing has subsequently “led” to the others.

This sounds convincing, but how does this information balance actually work? We have inserted x bits of information into the theory, and then we get $x + n$? Does this mean that if a system is complex enough (the way the brain is), it is capable of creating additional information, more extensive than the information it possessed in the preceding prolegomena to omnipotence moment, without receiving any additional information from outside? This would be a true informational *perpetuum mobile!*

Unfortunately, this issue cannot be resolved on the basis of current information theory. The amount of information is greater the lower the probability of the arrival of a given signal. This means that if a message arrives that stars are made of Emmentaler cheese, the amount of information received will be truly enormous because the arrival of such a signal is extremely unlikely. Yet an expert will accuse us here, and justly so, of confusing two different types of information: selective information—that is, information that can be drawn from a set of possible signals (stars made of hydrogen, of entelechy, of borogoves, of cheese, etc.), which has nothing to do with the correctness, or appropriateness, of information about a certain phenomenon—and structural information, that is, information that is a representation of the situation. And thus the sensational news about the cheesing of stars contains a great amount of selective information and zero structural information because it is not true that stars are made of cheese. Perfect. Let us thus take a look at the theory of physical vacuum. It shows that beta decay happens in such and such a way (which is true) as well as that an electron’s charge is infinitely great (which is not true). The first result, however, is so valuable to a physicist that he is prepared to make up for it with interest paid on the incorrectness of the second one. Yet information theory is not interested in the physicist’s choice because this theory does not take into account the value of information, even in its structural state. Besides, no theory exists “on its own”; no theory is “sovereign”: it is partly derived from other theories and partly combined with them. And thus the amount of information contained in it is very difficult to measure, since, for example, information contained in the famous $E = mc^2$ formula “gets into” this formula from a whole lot of other formulas and theories.

Yet maybe it is only today that we need theories and models of phenomena? Maybe, on being asked such a question, a wise man from another planet would silently hand out a piece of an old shoe sole picked up from the ground to us, communicating in this way that the whole truth of the Universe can be read from this piece of matter?

Let us stay for a moment with this old sole.

This anecdote can have some amusing consequences. Please take a look at the following equation: $4 + x = 7$. An obtuse student does not know how to access the x value, although this result is already “entailed” in the equation, but it remains hidden from his misty eyes and will only “reveal itself” after a prolegomena to omnipotence basic transformation has been performed. Let us thus ask, as righteous heresiarchs, whether it is not the same case with Nature. Does Matter by any chance not have all of its potential transformations “inscribed” in it (i.e., the possibility of constructing stars, quantoplanes, sewing machines, roses, silkworms, and comets)? Then, taking the basic building block of Nature, the hydrogen atom, we could “deduce” all those possibilities from it (modestly starting from the possibility of synthesizing a hundred elements all the way through to the possibility of constructing systems that are a trillion times more spiritual than man). We could also deduce all that is *unrealizable* from it (sweet kitchen salt NaCl, stars whose diameter equals a quadrillion miles, etc.). From this perspective, matter already entails as its foundational assumptions all those possibilities as well as impossibilities (or prohibitions); we are just unable to crack its “code.” Matter would thus be a kind of mathematical problem— with us, like that obtuse student mentioned earlier, being unable to get all the information out of it, even though it is already contained within it. What we have just said is nothing else than tautological ontology...×

Endnote

[1] Both of the texts below are excerpted from *Summa Technologiae* with the permission of University of Minnesota Press.

Bios

Stanisław Lem (1921–2006) was the best-known science fiction author writing outside of the English language. His books have been translated into more than forty languages and sold over 27 million copies worldwide.

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