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The Origin of Language: Biology, Information Theory, & Thermodynamics

by Michel Serres

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An organism is a system. The notion of system changes through history; it occupies different positions within the encyclopedia. This notion may be logico-mathematical: a coherent set of demonstrable propositions deduced from a small number of postulates. One speaks in this way of a system of axioms or a system of differential equations. For Descartes, Spinoza, or Leibniz, this is the classical ideal of knowledge. The notion of system may also be mechanical: a set which remains stable throughout variations of objects which are either in movement or relatively stationary. Laplace speaks in this sense of the solar system. Within a set of mobile material points distributed in space and governed by a law - Newton's law, for example-it is clear that time is fully reversible. If everything starts moving
in the opposite direction, nothing significant in form or state will change. The mathematical or logical system is independent of the time
variable; the ordinary mechanical system depends on a time but not on its direction. Hence the displacement, starting with the Industrial Revolution, toward physics and in particular toward the theory of heat, a displacement occurring after Fourier starting with Carnot. In another essay(1) I have called mechanical systems "statues" or stateurs: they are based on a fixity or an equilibrium. After Carnot they
become motors. They create movement, they go beyond the simple relation of forces, they create them by energy or power. They produce circulation by means of reservoirs and differences of temperature. As soon as one can build them and theorize about them-steam or combustion engines, chemical, electrical, and turbine engines, and so forth -the notion of time changes. The second law of thermodynamics accounts for the impossibility of perpetual motion of the second type; energy dissipates and entropy increases. From

this moment on, time is endowed with a direction. It is irreversible and drifts from order to disorder, or from difference to the dissolution or dissemination of a homogeneous mixture from which no energy, no force, and no motion can arise.

Curiously enough, philosophers and psychologists, who never hesitated to adopt as models systems like the first ones, tables of axioms
or statues, were often averse, during the nineteenth century, to this new development and to its practical and theoretical results. Almost all of them attempted to find some failing with it: they wished, I believe, that the motor would never stop. With very few exceptions,
almost all of them maintain, for example, the existence of an eternal return, despite findings to the contrary in physics. Freud, however, aligns himself with these findings: he manifestly adopts as an initial model a topology like that of Maxwell and Listing,(2) in which lines of
force are already called complexes, and an energy theory based on thermodynamics and linked to two fundamental principles: the conservation of energy and the tendency toward death. Freudian time is irreversible.

We are in the presence of three types of systems: the first, logico-mathematical, is independent of time; the second, mechanical, is linked
to reversible time; the third, thermodynamic, is linked to irreversible time. However, the three types all have closure in common. They constitute a partitioning of a given universe, either by the so-called closure axiom for the universe of discourse or by the independence of movements and stabilities in relation to all exterior influences (thus Laplace's solar world in relation to the stellar universe) or by thermal insulation. A physical system, in the third sense, is isolated-closed. One must understand by this that no flow of matter, no circulation of heat, light, or energy, crosses the walls that define it and demarcate it in space. Under this condition and this condition only,
the two laws of thermodynamics apply and are valid. With the slightest opening, the system is no longer governed by general equations.

Hence the general displacement of philosophical discourse from the nineteenth century to Bergson's posterity. Once couched in terms of differences, reservoirs and circulation, energies, power and relations of force, time and motors, deviations, oppositions and dissolution,
suddenly this discourse, as if reverting to the conditions of its own practice, begins speaking in terms of open and closed, of isolation and

closures. Today, in many respects, it has not progressed an inch in relation to the global problematic of Bergsonism. It has the same form
and function, let us say the same syntax, but it has changed domains. Instead of addressing the direct questions of matter and life, from which, precisely, this language had developed, it brought that language within the domain of the social sciences, language, and texts. Why?

For a very simple reason. Nineteenth-century thermodynamics, restricted or general, classical or statistical, had studied motors and, in
general, systems, producers of movement. The energies mobilized by its application and calculated by its theory remained on an entropic
scale, by which I mean within the realm of ordinary work and the displacement of objects. Hence one had a discourse which often concluded either with the cosmos in general or with organic life in particular. At the beginning of the twentieth century, communication theory introduced a series of concepts such as information, noise, and redundancy, for which a link to thermodynamics was rather quickly demonstrated. It was shown, for example, that information (emitted, transmitted, or received) was a form of negentropy. Now these energies, manipulated and calculated, were of a different order than energy of the first, or macroscopic, scale-they were very small in relation to this scale. But this change only minimally affected the whole of the theoretical armature already in place: information theory was considered the daughter of thermodynamics; theorizing immediately began about activities as ordinary as reading, writing, the
transmission and storing of signals, the optimal technique for avoiding obstacles along their path, and so forth. Of course, the theoreticians of information theory accomplished this with means inherited directly from the physics of energies belonging to the macroscopic scale. Success confirmed their enterprise. Hence, in a parallel manner, the great stability of traditional philosophical categories but their massive application in a different area: discourse, writing, language, societal and psychic phenomena, all acts which one can describe as communication acts. It immediately became obvious, or was taken as such, that a store of information transcribed on any given memory, a painting or a page, should drift by itself from difference to disorder, or that an isolated-closed system about which we
know nothing, an unknown of some sort, could be and, in certain cases, had to be a language pocket. By an act of simultaneous translation one can derive with relative ease the philosophical terms in use today. The system under consideration becomes a system of signs.

Right in the middle of the traditional classification of beings, a classification that no longer makes sense since matter, life, and sign are
nothing but properties of a system, we find exactly what I want to talk about: the living organism. Most often conceived of according to the models we have already considered, the organism has been seen as a machine (by figures and movements, or by invariance through variations) from the classical age up to the recent notion of homeostasis. Equilibrium and mobility. It is evidently a thermodynamic
system, sometimes operating at very high temperatures, and tending toward death according to an unpredictable and irreversible time (that of ontogenesis), but going up the entropic stream by means of phylogenetic invariances and the mutations of selection. It is a hypercomplex system, reducible only with difficulty to known models that we have now mastered. What can we presently say about
this system? First, that it is an information and thermodynamic system. Indeed, it receives, stores, exchanges, and gives off both energy
and information-in all forms, from the light of the sun to the flow of matter which passes through it (food, oxygen, heat, signals). This system is not in equilibrium, since thermodynamic stability spells death for it, purely and simply. It is in a temporary state of imbalance, and
it tends as much as possible to maintain this imbalance. It is hence subject to the irreversible time of the second law, since it is dying. But
it struggles against this time. We can improve upon the classical formulation of this problem. Indeed, due to the energy and information
torrent which passes through the system without interruption, it is henceforth impossible to conceive of it as an isolated-closed system, except, perhaps, in its genotypical form. It is an open system. It should thus be regulated by a thermodynamics of open systems which
has been developing over the past ten years and which provides a complex theory for this state of imbalance. In and by this imbalance, it
is relatively stable. But here invariance is unique: neither static nor homeostatic, it is homeorrhetic. It is a river that flows and yet remains
stable in the continual collapse of its banks and the irreversible erosion of the mountains around it. One always swims in the same river,
one never sits down on the same bank. The fluvial basin is stable in its flux and the passage of its chreodes; as a system open to

evaporation, rain, and clouds, it always-but stochastically-brings back the same water. What is slowly destroyed is the solid basin. The fluid
is stable; the solid which wears away is unstable - Heraclitus and Parmenides were both right. Hence the notion of homeorrhesis.(3) The
living system is homeorrhetic.

This river, almost stable although irreversible, this basin, poised on its own imbalance in a precarious state of quasi-equilibrium in its flow toward death, ferries energy and information, knowledge of entropy and negentropy, of order and disorder. Both a syrrhesis (rather than a system) and a diarrhesis,(4) the organism is hence defined from a global perspective. Not actually defined (the word means in effect the opposite of open), but assessed, described, evaluated, and understood. Or, within the context of an even more general circulation which goes from the sun to the black depths of space, the organism is a barrier of braided links that leaks like a wicker basket
but can still function as a dam. Better yet, it is the quasistable turbulence that a flow produces, the eddy closed upon itself for an instant,
which finds its balance in the middle of the current and appears to move upstream, but is in fact undone by the flow and re-formed elsewhere. And experience shows that there is no flux without eddy, no laminar flow which does not become turbulent.(5) Now, and
here is the crux of the matter, all times converge in this temporary knot: the drift of entropy or the irreversible thermal flow, wear and aging, the exhaustion of initial redundancy, time which turns back on feedback rings or the quasi-stability of eddies, the conservative invariance of genetic nuclei, the permanence of a form, the erratic blinking of aleatory mutations, the implacable filtering out of all non-viable elements, the local flow upsteam toward negentropic islands-refuse, recycling, memory, increase in complexities. The living organism, ontogenesis and phylogenesis combined, is of all times. This does not at all mean that it is eternal, but rather that it is an original
complex, woven out of all the different times that our intellect subjects to analysis or that our habits distinguish or that our spatial environment tolerates. Homeorrhetic means at least that: the rhesis flows, but similarity pushes upstream and resists. All the temporal vectors possessing a directional arrow are here, in this place, arranged in the shape of a star. What is an organism? A sheaf of times. What
is a living system? A bouquet of times.

It is indeed surprising that this solution has not been reached more quickly. Perhaps it seemed difficult to intuit a multitemporality. We

willingly accept, however, the fact that the things around us do not all share the same temporality: negentropic islands on or in the entropic sea, or distinct universes as Boltzmann described them, pockets of local orders in rising entropy, crystal depositories sunk in ashes-none of these things disturbs us. Living syrrhesis combines sea and islands. In a completely new sense, the organism is synchronous for meanings and directions, for the continuous and discontinuous, for the local and the global; it combines memory, invariance, plan, message, loss, redundancy, and so forth. It is old, mortal, and the transmitter of a new cycle. The organism is fixed on top of a temporal
converter -no, it is a converter of time. This is perhaps why it is able to learn about systems differentiated by their individual time: the world, fire, and signs.

Let us shift from the global to the local level, from the whole of the organism to the diverse systems that used to be called respiratory, circulatory, neurovegetal, and so forth, and then to organs, tissues, cells, molecules.... The passage could be plotted from homeorrhesis to
homeorhesis. In short, from this point of view the complex functions like a set of chemical reactions. The latter occur, in the case of mammals-of which man is one -at high temperatures, indeed, very high, in a homoiothermal environment.(6) There exist approximately a thousand different reactions of this kind. But at a given moment, for the complex in operation (living), their number, although probably
finite, is incredibly large, in view of the enormous molecular population. For an idea of its dimensions it must be placed on an astronomical scale. From a thermal and information point of view, these movements and transformations necessarily generate background noise. And this noise is certainly tremendous, for the numbers under consideration are gigantic. What prevents us from hearing it? Why is the sound muffled, the factory insulated?

All of information theory and hence, correlatively, of the theory of noise only makes sense in relation to an observer who happens to be
linked to them. Who is the observer here? The simplest answer would be to say that for our own organic system we are the Observer
or observers in question. Thus we should perceive this noise, the noise of a complex to which a receptor is linked. I use "perceive" in the
broad sense that this word had in the classical era. We should hear this deafening clamor just as we hear the roar of the sea at the edge of the beach. It should deafen us, drown us. Leibniz said the following in his language: the cloud of minor perceptions, external and

internal, should induce a state of discomfort and dizziness; it should prove intolerable. But, save for exceptional instances, we perceive almost nothing of this intense chaos which nonetheless exists and functions, as experiments have demonstrated conclusively. We are submerged to our neck, to our eyes, to our hair, in a furiously raging ocean. We are the voice of this hurricane, this thermal howl, and we do not even know it. It exists but it goes unperceived. The attempt to understand this blindness, this deafness, or, as is often said, this
unconsciousness thus seems of value to me. We have eyes in order not to see ourselves, ears in order not to hear ourselves. The observer observes nothing, or almost nothing.

At this point it is necessary to consider the general conditions of organic functioning, the system's globalizing forms. All that we now know about it leads us to describe a series of successive apparatuses called levels of integration -Russian dolls or interlocking objects, according to the image Francois Jacob proposed.(7) The cybernetic model temporarily allows us to imagine certain links between these levels, from molecular activity to the organization of the cell, tissues, organs, and so forth. In relatively simple cases it would even be possible to write a mathematical model, a system of differential equations representing cellular activity. The conditions at the limits of
that activity would describe the state of the boundaries, the limits of the level under consideration, and hence the nature of the proximity of one level to the next, the manner in which one level is submerged in the next. This process of proximity, of implication, of integration merits description. Consider any level of an interlocking system. Locally, as we have seen, it operates like a series of chemical reactions at a certain temperature. Let us forget for the moment their precise equations and the unique elements at work here. Let us
consider only the energy conditions at this one level. It mobilizes information and produces background noise. The next level in the interlocking series receives, manipulates, and generally integrates the information-background noise couple that was given off at the preceding level. How does this take place? Several recent studies allow us to elucidate the answer to this question.(8) *Indeed, if one writes the equation expressing the quantity of information exchanged between two stations through a given channel and the equation which provides this quantity for the whole unit (including the two stations and the channel), a change of sign occurs for a certain function entering into the computation. In other words, this function, called ambiguity and resulting from noise, changes when the observer changes his point of observation. Its value depends on whether he is submerged in the first level or whether he examines the entire unit from the next level. In a certain sense, the next level functions as a rectifier, in particular, as a rectifier of noise.* What was once an

obstacle to all messages is reversed and added to the information. This discovery is all the more important since it is valid for all levels. It is
a law of the series which runs through the system of integration. I now come back to my initial question.

This question only made sense if, at the last level, the most comprehensive of the whole system, the present observer, to whom the
noise and information phenomena are linked, had at his disposal or was equipped with a special listening instrument. A point of observation is not sufficient; to observe, one also needs the means to do so. Now the apparatus exists: it is made up of what classical philosophy called internal sensations or what different psychologies have successively described as intropathy, proprioceptivity, or coenesthesia, and whose functionings have to be linked to signals given off or received by the vagosympathetic system. The instrument exists and functions. What does it perceive? Nothing, or almost nothing, it seems, of what we recognize at the purely physical level as
background noise and information; nothing which resembles, with perhaps certain exceptions, a signal -a figure against a ground - isolated
from a vague and fluctuating cloud, from a multiple halo humming and buzzing at random. It does, however, perceive the signals that we
subsume under the two broad categories of pleasure and pain. It receives them and emits them. It is not meaningless to say that it receives signals that we translate immediately into these two words. Thus everything would take place as if pleasure and pain constituted the final state of a general listening, filtered in turn by the set of successive integrations. The final couple, the only one to be perceived,
would, in other words, be the last translation, the last rectification of the original physical couple of information-background noise. Of course, no one can call information fortunate and noise painful, for things are arranged in any number of chiasms. Suffering, at least sometimes, is a set of signals which opens up a path of readaptation or strategies for the repair, for the rebalancing, of the homeorrhesis. Here again, a change in sign appears. There must be noise in pleasure and information in pain. But this is probably something we cannot
know or evaluate properly. It is significant that the successive levels of organic integration-we understand the chain of the first levels fairly
well thanks to the experimental sciences, and we also understand the final segment because of the direct pathetic tie we maintain constantly with our own body-must always function as languages. On the one hand, at the cellular or molecular level, a proto-language

(stereospecific information and thermal noise) is already functioning; on the other hand, at the most highly integrated level, a language is still functioning, but now as individuated signals equipped with something like meaning: calls for desired objects or warnings against dangerous ones. And again, because chiasms and ambiguity complicate matters, we can find a refusal of desire and a call for suffering.
Hence the multiple, integrated system, about whose implicative surroundings I often know nothing, may be considered as a series of transformations which effects a move from the noise-information couple to the meaning-obstacles couple and finally to meaning. Each integration functions as a filter, a rectifier. We thus have a hypercomplex apparatus that finally gives a meaning to the Shannon couple-which can only be dealt with as long as it has no meaning.(9)
Everything transpires as if the central problem of information theory were resolved, automatically, by living organisms. They can be described as apparatuses which produce language from noise and information, each according to its order of complexity: for each system, indeed, for each species, there exists an original set of signals.

For this reason it is simple to generalize several categories or ordinary functions. Repression in the Freudian sense, for example, remained
an enunciation based on a mechanical or hydrodynamic model. Henceforth the entire integrative system can take charge of it; its physical
model is much more complete and we can speak about it by using a discourse which ultimately can be expressed in mathematical terms. This is because we are dealing with a very general function operating in the proximity of two given levels. On one side, transformations, fixations, a set of energy displacements occur-no metaphor is needed here, for the processes under consideration are simply chemical or
thermodynamic. On the other side, the entire complex of these movements is grasped by the observer, that is, by the integrating level
as such, by the change in sign of the ambiguity function.

These matters are straightforward. Let us imagine a system with two or several elements. In an initial case, these elements are either completely different or identical with one another, repetitive. The information quantity is thus either a sum or a reduction to the information of a single element. This is the case of disorganization, of inorganization. If the system is organized, the elements are in relation to one another and are therefore different and similar at the same time. Here ambiguity arises. From a point of view within the system, the transmission of information along a given circuit from one element to another subtracts ambiguity because it is a noise, an

obstacle to the message. For an observer outside the system, ambiguity must be added, for it increases the system's complexity. It functions in this case as information at the level of the unit's organization. In one case, it covers up; in the other case, it expresses. The
entire symbolic function is embedded in this process, the entire strategy of free association, Freudian slips, jokes and puns. Now the point
is that the theory of changes in sign is valid at the most elementary levels: a cell containing a nucleus, cytoplasm, membranes, and organelles. Henceforth, despite the most radical differences between embedded systems, they will at least share this process of reversal at their boundaries. Repression is only a particular example of this general process, which lays down the law for the chain. It is probably for this reason that we perceive nothing of the deafening background noise given off by the system, except for interesting pieces of
information relating to the general functioning of these transformations or to their local breakdown. The senseless din is made
meaningful by the series of rectifiers.

At this point the unconscious gives way from below; there are as many unconsciouses in the system as there are integration levels. It is
merely a question, in general, of that for which we initially possess no information. It is not a unique black box, but a series of interlocking
boxes; and this series is the organism, the body. Each level of information functions as an unconscious for the global level bordering it, as a
closed or relatively isolated system in relationship to which the noise-information couple, when it crosses the edge, is reversed and which
the subsequent system decodes or deciphers. In each link of the series the question of language is formulated and reformulated by the
transformation of the message, the channel, and the noise: by translation. In fact, residual background noise is progressively eliminated:
what was supposed to interfere begins constructing; obstacles combine to organize; noise becomes dialect. I imagine this occurs from
the depths of the molecular chaos, in which information appears in its spatial simplicity and material forms, throughout the signifying and articulated message through the sequence of rectifiers. What remains unknown and unconscious is, at the chain's furthermost limit, the

din of energy transformations: this must be so, for the din is by definition stripped of all meaning, like a set of pure signals or aleatory
movements. These packages of chance are filtered, level after level, by the subtle transformer constituted by the organism, and they come crashing at our feet, like the surf at the edge of the beach, in the forms of eros and death. In this sense the traditional view of the unconscious would seem to be the final black box, the clearest box for us since it has its own language in the full sense. Beyond it we plunge into the cloud of meaningless signals. Perhaps this box protects us from the deafening gasps of the stochastic; perhaps the box
serves to turn them. back into symbols. The unconscious is the last black observer of chance. It is an instance of order. It, too, turns destructive randomness into autonomy.

In this way, more generally, categories or common functions of psychoanalysis could be rewritten in terms of the new organon which
maintains the advantage of being at the same time a physics of energy and a theory of signals. Formerly, when a given system was analyzed it was a standard -and justifiable-practice to write two distinct accounts of it: the energy account and the information account.
For a computer this would be the bits on IBM cards or the like plus the necessary energy for heating the filaments. The two accounts had no proportion in common; they were not even on the same scale. An enormous coefficient separated them (10-16). The same thing is not true for the organism: its extreme complication, the great miniaturization of its elements, and their number bring these two
accounts closer and make them comparable. Hence the difference between a machine and a living organism is that, for the former, the information account is negligible in relationship to the energy account, whereas, for the latter, both accounts are on the same scale.
Henceforth, the theoretical reconciliation between information theory and thermodynamics favors and advocates the practical reconciliation between those funds of knowledge which exploited signs and those which exploited energy displacements: this was Freud's first dream.(10)

The change in sign for the ambiguity function now resolves an earlier difficulty. It had not been inelegant to conclude that the organism combines three varieties of time, and that its system constitutes a temporal sheaf. No simple matter for intuition, this conclusion remained unexplained. Now it is clear. Let us again consider the rectification of what is transmitted from one level to another.

Background noise, the major obstacle to messages, assumes an organizational function. But this noise is the equivalent of thermal disorder. Its time is that of increasing entropy, of that irreversible element which pushes the system toward death at maximum speed. Aging, for example, is a process that we are beginning to understand as a loss of redundancies and the drifting of information into background noise. If the integration levels function correctly as partial rectifiers and transform the noise of disorder into potential organization, then they have reversed the arrow of time. They are rectifiers of time. Entropic irreversibility also changes direction and sign; negentropy goes back upstream. We have discovered the place, the operation, and the theorem where and with which the knots
of the bouquet are tied. It is here and in this manner that time flows back and can change direction. Due to the numerous reversals of the temporal vector, the fluctuating homeorrhesis acquires a fleeting stability. For a moment the temporal sheaf makes a full circle. It forms a turbulence where opposing times converge. Organization per se, as system and homeorrhesis, functions precisely as a converter
of time. We now know how to describe this converter, as well as its levels and meanderings, from whence come anamnesis, memory, and everything imaginable.

The body is an extraordinarily complex system that creates language from information and noise, with as many mediations as there are integrating levels, with as many changes in sign for the function which just occupied our attention. I know who the final observer is, the
receiver at the chain's end: precisely he who utters language. But I do not know who the initial dispatcher is at the other end. I am confronted indefinitely with a black box, a box of boxes, and so forth. In this way, I may proceed as far as I wish, all the way to cells and
molecules, as long, of course, as I change the object under observation. All I know, but of this I am certain, is that they are all structured
around the information-background-noise couple, the chance-program couple or the entropy-negentropy couple. And this holds true
whether I describe the system in terms of chemistry, physics, thermodynamics, or information theory, and whether I situate myself as
the final receptor of an integrated apparatus. By reversing the ambiguity function, things naturally converge. Either I am submerged in
signal exchanges or I observe the global set of exchanges. But from now on I understand and can explain what happens when the

observer changes his point of view, when the subject becomes object, and the obstacle becomes a piece of information, or when introspection veers off into experience, and psychology flows into physics. Inversely, when the object becomes subject it temporarily increases its autonomy. Everything occurs as if Freud, who started from energy models of thermodynamics, had intuited, by a dynamics of language, the subsequent development of thermodynamics into information theory. The reunions are not exactly unexpected. The realms of the subjective and of the objective are no longer at odds. The observer as object, the subject as the observed, are affected by a
division more stable and potent than their antique separation: they are both order and disorder. From this moment on, I do not need to know who or what the first dispatcher is: whatever it is, it is an island in an ocean of noise, just like me, no matter where I am. It is the
genetic information, the molecules or crystals of the world, the interior, as one used to say, or the exterior -none of this is important
any longer. A macro-molecule, or any given crystallized solid, or the system of the world, or ultimately what I call "me"-we are all in the same boat. All dispatchers and all receivers are structured similarly. It is no longer incomprehensible that the world is comprehensible. The
real produces the conditions and the means for its self-knowledge. The "rational" is a tiny island of reality, a rare summit, exceptional, as miraculous as the complex system that produces it, by a slow conquest of the surf's randomness along the coast. All knowledge is bordered by that about which we have no information.

It is no longer necessary to maintain the distinction between introspective knowledge, or "deep" knowledge, and objective knowledge.
There is only one type of knowledge and it is always linked to an observer, an observer submerged in a system or in its proximity. And
this observer is structured exactly like what he observes. His position changes only the relationship between noise and information, but
he himself never effaces these two stable presences. There is no more separation between the subject, on the one hand, and the object, on the other (an instance of clarity and an instance of shadow). This separation makes everything inexplicable and unreal. Instead,
each term of the traditional subject-object dichotomy is itself split by something like a geographical divide (in the same way as am I, who speak and write today): noise, disorder, and chaos on one side; complexity, arrangement, and distribution on the other. Nothing

distinguishes me ontologically from a crystal, a plant, an animal, or the order of the world; we are drifting together toward the noise and
the black depths of the universe, and our diverse systemic complexions are flowing up the entropic stream, toward the solar origin, itself
adrift. Knowledge is at most the reversal of drifting, that strange conversion of times, always paid for by additional drift; but this is complexity itself, which was once called being. Virtually stable turbulence within the flow. To be or to know from now on will be translated by: see the islands, rare or fortunate, the work of chance or of necessity.

Notes:

(1) "Don Juan au palais des merveilles: Sur les statues au XVIIe," Les Etudes philosophiques 3 (1966):385-90.

(2) See chapter 4, note 14. -Ed.

(3) The word "homeorrhesis" is formed from the Greek words homos, meaning "same," and rhysis, meaning "flow." Serres retraces the
normal term describing the equilibrium of a self-regulating system, "homeostasis," by "homeorrhesis" in order to emphasize the idea of continual movement and exchange as opposed to the less dynamic idea of stasis. -Ed.

(4) The Greek verbs syrrhein and diarrhein mean "to flow together" and "to flow through." Again the attempt is to capture the dynamic nature of the organism by means of a terminology that avoids suggestions of the static. The word "system" is-abandoned because of its
origin in the Greek verb histanai, "to cause to stand." -Ed.

(5) See La Naissance de la physique dans le texte de Lucrece: Fleuves et turbulences (Paris: Minuit, 1977), and "Lucretius: Science and
Religion," chapter 9 of the present volume. - Ed.

(6) Homoiothermy is a similar example of homeorrhesis. In a certain sense, the poikilothermal, or cold-blooded, organism is better adapted to the environment. The homoiothernial organism, of more recent date in the history of evolution, is more fragile. It is probably condemned to a niche adjusted for relatively stable temperature intervals. In fact, it produces them as often as possible. Bees

had already discovered this process for their hives. Hence the homoiothermal organism is much more dependent than other species on
the environment, on its own species, and on the Other or Others. This is especially true when its offspring -and this is the case for a human infant- has not received at birth a perfect set of homoiothermal equipment. The homoiothermal organism generates the need
for communication. It is, in energy or thermal needs, analogous to what will be common speech, in terms of signals and information. I imagine that one of the first forms of behavior, like one of the first signals, may be reduced to this: "keep me warm." The homoiothermal
organism initiates touch and contact, erotic communication, and language. It is a homeology.

(7) See Francois Jacob, The Logic of Life: A History of Heredity, trans. Betty E. Spillman (New York: Vintage Books, 1976), p. 302. -Ed.

(8) See Henri Atlan, L'Organisation biologique et la theorie de l'information (Paris: Hermann, 1972); "On a Formal Definition of Organization,"Journal of Theoretical Biology 45 (1974):295-304. (See also Henri Atlan, Entre le cristal et la fumee: Essai sur l'organisation du vivant [Paris: Seuil, 1979], pp. 5-130. -Ed.)

(9) See Claude Shannon, The Mathematical Theory of Communication (Urbana: University of Illinois Press, 1964). -Ed.

(10) See Sigmund Freud, Project for a Scientific Psychology, in The Standard Edition of the Complete Psychological Works of Sigmund Freud, ed. James Strachey (London: Hogarth Press, 1966), 1: 283-343. -Ed.

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The Origin of Geometry

by Michel Serres

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Renan had the best reasons in the world for calling the advent of mathematics in Greece a miracle. The construction of geometric
idealities or the establishment of the first proofs were, after all, very improbable events. If we could form some idea of what took place

around Thales and Pythagoras, we would advance a bit in philosophy. The beginnings of modern science in the Renaissance are much less
difficult to understand; this was, all things considered, only a reprise. Bearing witness to this Greek miracle, we have at our disposal two
groups of texts. First, the mathematical corpus itself, as it exists in the Elements of Euclid, or elsewhere, treatises made up of fragments.
On the other hand, doxography, the scattered histories in the manner of Diogenes Laertius, Plutarch, or Athenaeus, several remarks of
Aristotle, or the notes of commentators such as Proclus or Simplicius. It is an understatement to say that we are dealing here with two
groups of texts; we are in fact dealing with two languages. Now, to ask the question of the Greek beginning of geometry is precisely to
ask how one passed from one language to another, from one type of writing to another, from the language reputed to be natural and
its alphabetic notation to the rigorous and systematic language of numbers, measures, axioms, and formal arguments. What we have left
of all this history presents nothing but two languages as such, narratives or legends and proofs or figures, words and formulas. Thus it is as
if we were confronted by two parallel lines which, as is well known, never meet. The origin constantly recedes, inaccessible, irretrievable.
The problem is open.

I have tried to resolve this question three times. First, by immersing it in the technology of communications. When two speakers have a
dialogue or a dispute, the channel that connects them must be drawn by a diagram with four poles, a complete square equipped with its
two diagonals. However loud or irreconcilable their quarrel, however calm or tranquil their agreement, they are linked, in fact, twice:
they need, first of all, a certain intersection of their repertoires, without which they would remain strangers; they then band together
against the noise which blocks the communication channel. These two conditions are necessary to the dialogue, though not sufficient.
Consequently, the two speakers have a common interest in excluding a third man and including a fourth, both of whom are
prosopopoeias of the,powers of noise or of the instance of intersection.(1)Now this schema functions in exactly this manner in Plato's
Dialogues, as can easily be shown, through the play of people and their naming, their resemblances and differences, their mimetic
preoccupations and the dynamics of their violence. Now then, and above all, the mathematical sites, from the Meno through the
Timaeus, by way of the Statesman and others, are all reducible geometrically to this diagram. Whence the origin appears, we pass from
one language to another, the language said to be natural presupposes a dialectical schema, and this schema, drawn or written in the sand,
as such, is the first of the geometric idealities. Mathematics presents itself as a successful dialogue or a communication which rigorously
dominates its repertoire and is maximally purged of noise. Of course, it is not that simple. The irrational and the unspeakable lie in the

details; listening always requires collating; there is always a leftover or a residue, indefinitely. But then, the schema remains open, and
history possible. The philosophy of Plato, in its presentation and its models, is therefore inaugural, or better yet, it seizes the inaugural
moment.

To be retained from this first attempt at an explanation are the expulsions and the purge. Why the parricide of old father Parmenides,
who had to formulate, for the first time, the principle of contradiction. To be noted here again is how two speakers, irreconcilable
adversaries, find themselves forced to turn together against the same third man for the dialogue to remain possible, for the elementary
link of human relationships to be possible, for geometry to become possible. Be quiet, don't make any noise, put your head back in the
sand, go away or die. Strange diagonal which was thought to be so pure, and which is agonal and which remains an agony.

The second attempt contemplates Thales at the foot of the Pyramids, in the light of the sun. It involves several geneses, one of which is
ritual.(2) But I had not taken into account the fact that the Pyramids are also tombs, that beneath the theorem of Thales, a corpse was
buried, hidden. The space in which the geometer intervenes is the space of similarities: he is there, evident, next to three tombs of the
same form and of another dimension -the tombs are imitating one another. And it is the pure space of geometry, that of the group of
similarities which appeared with Thales. The result is that the theorem and its immersion in Egyptian legend says, without saying it, that
there lies beneath the mimetic operator, constructed concretely and represented theoretically, a hidden royal corpse. I had seen the
sacred above, in the sun of Ra and in the Platonic epiphany, where the sun that had come in the ideality of stereometric volume finally
assured its diaphaneity; I had not seen it below, hidden beneath the tombstone, in the incestuous cadaver. But let us stay in Egypt for a
while.

The third attempt consists in noting the double writing of geometry.(3) Using figures, schemas, and diagrams. Using letters, words, and
sentences of the system, organized by their own semantics and syntax. Leibniz had already observed this double system of writing,
consecrated by Descartes and by the Pythagoreans, a double system which represents itself and expresses itself one by the other. He
sometimes liked, as did many others, to privilege the intuition, clairvoyant or blind, required by the first [diagrams] over the deductions
produced by the second [words]. There are, as is well known, or as usual, two schools of thought on the subject. It happens that they
trade their power throughout the course of history. It also happens that the schema contains more information than several lines of

writing, that these lines of writing lay out indefinitely what we draw from the schema, as from a well or a cornucopia. Ancient algebra
writes, drawing out line by line what the figure of ancient geometry dictates to it, what that figure contains in one stroke. The process
never stopped; we are still talking about the square or about the diagonal. We cannot even be certain that history is not precisely that.

Now, many histories report that the Greeks crossed the sea to educate themselves in Egypt. Democritus says it; it is said of Thales; Plato
writes it in the Timaeus. There were even, as usual, two schools at odds over the question. One held the Greeks to be the teachers of
geometry; the other, the Egyptian priests. This dispute caused them to lose sight of the essential: that the Egyptians wrote in ideograms
and the Greeks used an alphabet. Communication between the two cultures can be thought of in terms of the relation between these
two scriptive systems (signaletiques). Now, this relation is precisely the same as the one in geometry which separates and unites figures
and diagrams on the one hand, algebraic writing on the other. Are the square, the triangle, the circle, and the other figures all that
remains of hieroglyphics in Greece? As far as I know, they are ideograms. Whence the solution: the historical relation of Greece to Egypt
is thinkable in terms of the relation of an alphabet to a set of ideograms, and since geometry could not exist without writing,
mathematics being written rather than spoken, this relation is brought back into geometry as an operation using a double system of
writing. There we have an easy passage between the natural language and the new language, a passage which can be carried out on the
multiple condition that we take into consideration two different languages, two different writing systems and their common ties. And
this resolves in tum the historical question: the brutal stoppage of geometry in Egypt, its freezing, its crystallization into fixed ideograms,
and the irrepressible development, in Greece as well as in our culture, of the new language, that inexhaustible discourse of mathematics
and rigor which is the very history of that culture. The inaugural relation of the geometric ideogram to the alphabet, words, and
sentences opens onto a limitless path.

This third solution blots out a portion of the texts. The old Egyptian priest, in the Timaeus, compares the knowledge of the Greeks
when they were children to the time-wom science of his own culture.(4) He evokes, in order to compare them, floods, fires, celestial
fire, catastrophes. Absent from the solution are the priest, history, either mythical or real, in space and time, the violence of the elements
which hides the origin and which, as the Timaeus clearly says, always hides that origin. Except, precisely, from the priest, who knows the
secret of this violence. The sun of Ra is replaced by Phaethon, and mystical contemplation by the catastrophe of deviation.

We must start over -go back to those parallel lines that never meet. On the one hand, histories, legends, and doxographies, composed
in natural language. On the other, a whole corpus, written in mathematical signs and symbols by geometers, by arithmeticians. We are
therefore not concerned with merely linking two sets of texts; we must try to glue, two languages back together again. The question
always arose in the space of the relation between experience and the abstract, the senses and purity. Try to figure out the status of the
pure, which is impure when history changes. No. Can you imagine (that there exists) a Rosetta Stone with some legends written on
one side, with a theorem written on the other side? Here no language is unknown or undecipherable, no side of the stone causes
problems; what is in question is the edge common to the two sides, their common border; what is in question is the stone itself.

Legends. Somebody or other who conceived some new solution sacrificed an ox, a bull. The famous problem of the duplication of the
cube arises regarding the stone of an altar at Delos. Thales, at the Pyramids, is on the threshold of the sacred. We are not yet, perhaps, at
the origins. But, surely, what separates the Greeks from their possible predecessors, Egyptians or Babylonians, is the establishment of a
proof. Now, the first proof we know of is the apagogic proof on the irrationality of . (5)

And so, legends, once again. Euclid's Elements, Book X, first scholium. It was a Pythagorean who proved, for the first time, the so-called
irrationality [of numbers]. Perhaps his name was Hippasus of Metapontum. Perhaps the sect had sworn an oath to divulge nothing. Well,
Hippasus of Metapontum spoke. Perhaps he was expelled. In any case, it seems certain that he died in a shipwreck. The anonymous
scholiast continues: "The authors of this legend wanted to speak through allegory. Everything that is irrational and deprived of form must
remain hidden, that is what they were trying to say. That if any soul wishes to penetrate this secret region and leave it open, then it will
be engulfed in the sea of becoming, it will drown in its restless currents."

Legends and allegories and, now, history. For we read a significant event on three levels. We read it in the scholia, commentaries,
narratives. We read it in philosophical texts. We read it in the theorems of geometry. The event is the crisis, the famous crisis of
irrational numbers. Owing to this crisis, mathematics, at a point exceedingly close to its origin, came very close to dying. In the aftermath
of this crisis, Platonism had to be recast. The crisis touched the logos. If logos means proportion, measured relation, the irrational or
alogon is the impossibility of measuring. If logos means discourse, the alogon prohibits speaking. Thus exactitude crumbles, reason is
mute.

Hippasus of Metapontum, or another, dies of this crisis, that is the legend and its allegorical cover in the scholium of the Elements.

Parmenides, the father, dies of this crisis-this is the philosophical sacrifice perpetrated by Plato. But, once again, history: Plato portrays
Theaetetus dying upon returning from the the battle of Corinth (369), Theaetetus, the founder, precisely, of the theory of irrational
numbers as it is recapitulated in Book X of Euclid. The crisis read three times renders the reading of a triple death: the legendary death of
Hippasus, the philosophical parricide of Parmenides, the historical death of Theaetetus. One crisis, three texts, one victim, three
narratives. Now, on the other side of the stone, on the other face and in another language, we have the crisis and the possible death of
mathematics in itself.

Given then a proof to explicate as one would a text. And, first of all, the proof, doubtless the oldest in history, the one which Aristotle
will call reduction to the absurd. Given a square whose side AB = b, whose diagonal AC = a:

We wish to measure AC in terms of AB. If this is possible, it is because the two lengths are mutually commensurable. We can then
write AC/AB = a/b. It is assumed that a/b is reduced to its simplest form, so that the integers a and b are mutually prime. Now, by the
Pythagorean theorem: a2 = 2b2. Therefore a2 is even, therefore a is even. And if a and b are mutually prime, b is an odd number. If a is
even, we may posit: a = 2c. Consequently, a2 = 4c2. Consequently 2b2 = 4c2, that is, b2 = 2c2. Thus, b is an even number.

The situation is intolerable, the number b is at the same time even and odd, which, of course, is impossible. Therefore it is impossible to
measure the diagonal in terms of the side. They are mutually incommensurable. I repeat, if logos is the proportional, here a/b or 1/,
the alogon is the incommensurable. If logos is discourse or speech, you can no longer say anything about the diagonal and is irrational.
It is impossible to decide whether b is even or odd. Let us draw up the list of the notions used here. 1) What does it mean for two
lengths to be mutually commensurable? It means that they have common aliquot parts. There exists, or one could make, a ruler, divided
into units, in relation to which these two lengths may, in turn, be divided into parts. In other words, they are other when they are alone
together, face to face, but they are same, or just about, in relation to a third term, the unit of measurement taken as reference. The
situation is interesting, and it is well known: two irreducibly different entities are reduced to similarity through an exterior point of view. It is
fortunate (or necessary) here that the term measure has, traditionally, at least two meanings, the geometric or metrological one and the
meaning of non-disproportion, of serenity, of nonviolence, of peace. These two meanings derive from a similar situation, an identical

operation. Socrates objects to the violent crisis of Callicles with the famous remark: you are ignorant of geometry. The Royal Weaver of
the Statesman is the bearer of a supreme science: superior metrology, of which we will have occasion to speak again. 2) What does it
mean for two numbers to be mutually prime? It means that they are radically different, that they have no common factor besides one.
We thereby ascertain the first situation, their total otherness, unless we take the unit of measurement into account. 3) What is the
Pythagorean theorem? It is the fundamental theorem of measurement in the space of similarities. For it is invariant by variation of the
coefficients of the squares, by variation of the forms constructed on the hypotenuse and the two sides of the triangle. And the space of
similarities is that space where things can be of the same form and of another size. It is the space of models and of imitations. The
theorem of Pythagoras founds measurement on the representative space of imitation. Pythagoras sacrifices an ox there, repeats once
again the legendary text. 4) What, now, is evenness? And what is oddness? The English terms reduce to a word the long Greek
discourses: even means equal, united, flat, same; odd means bizarre, unmatched, extra, left over, unequal, in short, other. To characterize
a number by the absurdity that it is at the same time even and odd is to say that it is at the same time same and other.

Conceptually, the apagogic theorem or proof does nothing but play variations on the notion of same and other, using measurement
and commensurability, using the fact of two numbers being- mutually prime, using the Pythagorean theorem, using evenness and
oddness. It is a rigorous proof, and the first in history, based on mimesis. It says something very simple: supposing mimesis, it is reducible
to the absurd. Thus the crisis of irrational numbers overturns Pythagorean arithmetic and early Platonism.

Hippasus revealed this, he dies of it -end of the first act.

It must be said today that this was said more than two millennia ago. Why go on playing a game that has been decided? For it is as plain
as a thousand suns that if the diagonal or are incommensurable or irrational, they can still be constructed on the square, that the
mode of their geometric existence is not different from that of the side. Even the young slave of the Meno, who is ignorant, will know
how, will be able, to construct it. In the same way, children know how to spin tops which the Republic analyzes as being stable and
mobile at the same time. How is it then that reason can take facts that the most ignorant children know how to establish and construct,
and can demonstate them to be irrational? There must be a reason for this irrationality itself.

In other words, we are demonstrating the absurdity of the irrational. We reduce it to the contradictory or to the undecidable. Yet, it

exists; we cannot do anything about it. The top spins, even if we demonstrate that, for impregnable reasons, it is, undecidably, both
mobile and fixed. That's the way it is. Therefore, all of the theory which precedes and founds the proof must be reviewed, transformed.
It is not reason that governs, it is the obstacle. What becomes absurd is not what we have proven to be absurd, it is the theory on
which the proof depends. Here we have the very ordinary movement of science: once it reaches a dead-end of this kind, it immediately
transforms its presuppositions.

Translation: mimesis is reducible to contradiction or to the undecidable. Yet it exists; we cannot do anything about it. It spins. It works, as
they say. That's the way it is. It can always be shown that we can neither speak nor walk, or that Achilles will never catch up with the
tortoise. Yet, we do speak, we do walk, the fleet-footed Achilles does pass the tortoise. That's the way it is. Therefore, all of the theory
which precedes must be transformed. What becomes absurd is not what we have proven to be absurd, it is the theory as a whole on
which the proof depends.

Whence the (hi)story which follows. Theodorus continues along the legendary path of Hippasus. He multiplies the proofs of irrationality.
He goes up to . There are a lot of these absurdities, there are as many of them as you want. We even know that there are many
more of them than there are of rational relations. Whereupon Theaetetus takes up the archaic Pythagoreanism again and gives a general
theory which grounds, in a new reason, the facts of irrationality. Book X of the Elements can now be written. The crisis ends,
mathematics recovers an order, Theaetetus dies, here ends this story, a technical one in the language of the system, a historical one in
the everyday language that relates the battle of Corinth. Plato recasts his philosophy, father Parmenides is sacrificed during the parricide
on the altar of the principle of contradiction; for surely the Same must be Other, after a fashion. Thus, Royalty is founded. The Royal
Weaver combines in an ordered web rational proportions and the irrationals; gone is the crisis of the reversal, gone is the technology of
the dichotomy, founded on the square, on the iteration of the diagonal. Society, finally, is in order. This dialogue is fatally entitled, not
Geometry, but the Statesman.

The Rosetta Stone is constructed. Suppose it is to be read on all of its sides. In the language of legend, in that of history, that of
mathematics, that of philosophy. The message that it delivers passes from language to language. The crisis is at stake. This crisis is sacrificial.
A series of deaths accompanies its translations into the languages considered. Following these sacrifices, order reappears: in mathematics,
in philosophy, in history, in political society. The schema of Rene Girard allows us not only to show the isomorphism of these languages,

but also, and especially, their link, how they fit together.(6) For it is not enough to narrate, the operators of this movement must be
made to appear. Now these operators, all constructed on the pair Same-Other, are seen, deployed in their rigor, throughout the very
first geometric proof. just as the square equipped with its diagonal appeared, in my first solution, as the thematized object of the
complete intersubjective relation, formation of the ideality as such, so the rigorous proof appears as such, manipulating all the operators
of mimesis, namely, the internal dynamics of the schema proposed by Girard. The origin of geometry is immersed in sacrifical history and
the two parallel lines are henceforth in connection. Legend, myth, history, philosophy, and pure science have common borders over
which a unitary schema builds bridges.

Metapontum and geometer, he was the Pontifex, the Royal Weaver. His violent death in the storm, the death of Theaetetus in the
violence of combat, the death of father Parmenides, all these deaths are murders. The irrational is mimetic. The stone which we have
read was the stone of the altar at Delos. And geometry begins in violence and in the sacred.(7)

Notes:

(1) The line from Speaker 1 to Speaker 2 represents the channel of communication thatjoins the two speakers together. The line from
Noise to the Code or Repertoire represents the indissoluble link between noise and the code. Noise always threatens to overwhelm
the code and to disrupt communication. Successful communication, then, requires the exclusion of a third term (noise) and the inclusion
of a fourth (code). See "Platonic Dialogue," chapter 6 of' the present volume. See also Michel Serres. Le Parasite (Paris: Grasset, 1980).
-Ed.

(2) See "Mathematics and Philosophy: What Thales Saw..... chapter 8 of the present volume. -Ed.

(3)This third explaiiatioii appears as "Origine de la geometrie, 4" in Michel Serres, Hermes V.- Le Passage du Nord-Ouest (Paris: Minuit,
1980), pp. 175-84. -Ed.

(4) Plato, Timaeus, 22b ff.

(5) An apagogic proof is one that proceeds by disproving the proposition which contradicts the one to be established, in other words,
that proceeds by reductio ad absurduni. - Ed.

(6) The reference is to Rene Girard's theory of the emissary victim. See chapter 9, note 9 in the present volume. - Ed.

(7) It is just as remarkable that the physics of Epicurus, as Lucretius develops it in De Rerum Natura, is framed by the sacrifice of Iphigenia
and the plague of Athens. These two events, legendary or historical, can be read using the grid of phvsics. But, inversely, all this physics can
be read using the same schema, since the term inane means "purge" and "expulsion." I have shown this in detail in La Naissance de la
physique dans le texte de Luctice: Fleuves el turbulences (Paris: Minuit, 1977). (See also "Lucretius: Science and Religion," chapter 9 of the
present volume. -Ed.)

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Michel Serres

Michel Serres is a 'voyager' between the arts and the sciences, and a thinker for whom voyaging is invention. Invention is also called 'translation', 'communication', and 'metaphor'. By way of introduction to Serres's simultaneously philosophical, scientific and poetic
work, we refer to a nodal event in the history of science: thermodynamics, and the consequent transcending of the closed system of
Newtonian mechanics. To transcend the closed system is, for Serres, to fuel invention.

In 1824, a French army engineer, Sadi Carnot drew attention to the fact that in the steam-engine heat flowed from a high-temperature region (the boiler) to a low-temperature region (the condenser). Although Carnot incorrectly concluded that no energy was lost from the system, he did appreciate that the more efficient the system, the less the energy required for its operation, and that it was the difference in the temperature between the boiler and the condenser which produced energy. Carnot's work ended prematurely when he died at the age of 36. A number of people like Hermann Helmholtz and Rudolph Clausius in Germany, and William Thompson (Lord
Kelvin), in Glasgow, further developed Carnot's work, with the result that in 1865, Clausius coined the term 'entropy' for the heat lost

from any mechanical system. The era of thermodynamics had arrived. Its first and second laws are, respectively, that 'The energy of the world remains constant', and that 'The entropy of the world tends to a maximum.' Entropy is also the tendency towards disorder in a system.

Of interest here with respect to Serres is the difference between a simple mechanical notion of energy, and that of thermodynamics. In Newton's mechanical model, no energy in principle is lost from the system: the mechanics of the system are reversible. There are in principle no chance effects. 'According to the second law of thermodynamics. . . the unidirectional motion of [a] projectile would be continuously transformed by the frictional resistance of the air into heat, that is, into random, disorderly motions of the molecules of the air and the projectile'.

This randomness or disorder - as in the unstable borders of a cloud, or in the effects of steam, or in the movement of the tides is only now being taken in charge by chaos theory. Prior to this, stochastics - the theory of randomness - like the theory of probability developed principles aimed at explaining disorderly phenomena.

From this brief outline we note that a Newtonian mechanical system is a system of reversibility: time in it is reversible. With the thermodynamic system, contingency and chance predominate, making it a system of irreversible time. To give a sociological twist to this, we can note that Bourdieu has called the logic of practice the logic of irreversible time.

Serres is ostensibly a philosopher of science. But unlike even his mentor, Gaston Bachelard, he has never accepted that any particular science - let alone natural science conforms to the positivist determination of a hermetic and homogeneous field of enquiry. In a recent work, Serres has indicated that the shape and nature of knowledge more closely approximates the figure of the harlequin: a composite figure that always has another costume underneath the one removed. The harlequin is a hybrid, hermaphrodite, mongrel figure, a mixture of diverse elements, a challenge to homogeneity, just as chance in thermodynamics opens up the energy system and prevents it from imploding.

Michel Serres was born in 1930 at Agen in France. In 1949, he went to naval college and subsequently, in 1952, to the Ecole Normale

Supérieure (rue d'Ulm). In 1955, he obtained an agrégation in philosophy, and from 1956 to 1958 he served on a variety of ships as a marine officer for the French national maritime service. His vocation of voyaging is therefore of more than academic import. In 1968, Serres gained a doctorate for a thesis on Leibniz's philosophy. During the 1960s he taught with Michel Foucault at the Universities of Clermont-Ferrand and Vincennes and was later appointed to a chair in the history of science at the Sorbonne, where he still teaches. Serres has also been a full professor at Stanford University since 1984, and he was elected to the French Academy in 1990.

With the recognition of the interrelation between different sciences and different forms of knowledge, as well as between science and different artistic practices, has come Serres's effort to plot the way that different knowledge domains interpenetrate. Even more: Serres has set himself the task of being a means of communication (a medium) between the sciences and the arts - the Hermes of modern scholarships. With the advent of information science, a new figure for representing science becomes possible: this is the 'model' of communication. Accordingly, we have three elements: a message, a channel for transmitting it, and the noise, or interference, that accompanies the transmission. Noise calls for decipherment; it makes a reading of the message more difficult. And yet without it, there would be no message. There is, in short, no message without resistance. What Serres initially finds intriguing about noise (rather than the message) is that it opens up such a fertile avenue of reflection. Instead of remaining pure noise, the latter becomes a means of transport.
Thus in the first volume of the Hermes series noise is analysed as the third, empirical element of the message. Ideally, communication must be separated from noise. Noise is what is not communicated; it is just there as a kind of chaos, as the empirical third element of the message, the accidental part, the part of difference that is excluded. Every formalism (mathematics, for example) is founded on the exclusion of the third element of noise. Every formalism is a way of moving from one region of knowledge to another. To communicate is to move within a class of objects that have the same form. Form has to be extracted from the cacophony of noise; form (communication) is the exclusion of noise, an escape from the domain of the empirical.

In his book, The Parasite, Serres recalls that 'parasite' also means noise (in French). A parasite is a noise in a channel. And so when

describing the rats' meals in a story from the fables of La Fontaine - the meals of two parasites - Serres also refers to noise: 'The two companions scurry off when they hear a noise at the door. It was only a noise, but it was also a message, a bit of information producing
panic: an interruption, a corruption, a rupture of information. Was this noise really a message? Wasn't it, rather, static, a parasite?

Serres addresses the theme of noise and communication to show that 'noise is part of communication'; it cannot be eliminated from the system. Noise in language as in other systems of communication has its equivalent in the very notion of system itself. For, 'we know no system that functions perfectly, that is to say, without losses, flights, wear and tear, errors, accidents, opacity - a system whose return
is one for one'.

Serres's interest in 'noise' as the empirical third excluded element in human existence has led him to translate (traduire) between apparently heterogeneous domains in an effort to forge 'passages' (e.g., northwest passage) between them - passages not just of communication, but also of non-communication, and static. At one point in his intellectual trajectory, the notion of structure seemed to serve the purposes of translation - and therefore, transport very well. Indeed, Serres characterises the structuralist method as a method
in the ‚etymological sense: that is to say, a mode of transfer'. Beginning as part of Serres's mathematical training in algebra and topology,
structure is brought to the human sciences where a structural analysis,

examines one or two particular models reduced to a form (or to several): a pre-established, transitive order. Then, analogically, it finds this form or structure in other domains, et similia tam facilia. Whence its power of comprehension, of classification and of explication:
geometry, arithmetic, mechanics, method, philosophy.

Influenced less by Saussure, than by the Bourbaki group of mathematicians, Serres finds in structural analysis a means of travelling
between different domains, and even between different realities. Structural analysis inevitably leads to comparison, and this is why Serres
has great respect for Georges Dumézil's work; for Dumézil was able to show, through a comparison of sets of relations, that

Indo-European mythology has the same structure, despite the variety of contents. In a very precise formulation Serres says: 'with a given
cultural content, whether this be God, a table or a washbasin, an analysis is structural (and is only structural) when it makes this content
appear as a model' - a structural model being defined as 'the formal analogon of all the concrete models that it organises'. Rather than 'structural analysis', Serres proposes the term, 'loganalyse'.

Through its non-referential and comparativist approach to place (no single place constitutes the object of structural analysis), the structuralist place is both 'here and there' at the same time. It is a highly mobile site that is constituted through an enunciation. There is no fixed point, here and now, but a multiplicity of spaces and of times. This implies, too, that there is no punctual empirical, subject, but
rather a subject as a discontinuous virtuality.

Serres's more recent work has emphasised the importance to him of poetry and the effect of new technologies (such as information technology) on everyday life. Poetry, in a sense, is the noise of science. Without poetry there would be no science. Without science - or
at least philosophy - there can be no poeticising and fictionalising. Serres's reading of Jules Verne, Emile Zola, and the paintings of Turner
serve to confirm this point. In Verne, for example, the meaning of coming to grips with non-knowledge is demonstrated.
Non-knowledge is the mystery - the noise, we could now say necessary to the constitution of knowledge as such. Non-knowledge in
Verne is the unknown that one must venture into in order to constitute knowledge. The unknown is composed of worlds for which
there would be as yet no concept or language. With Zola and Turner, the principle of stochastics is illustrated by their artistic endeavour
in presenting steam, smoke, water and a variety of indeterminate phenomena.

For Serres, 'the perception of stochastics replac[ing] the specification of form' is a breakthrough in linking the sciences. For science is a system, just as poetry is a system. Rain, sun, ice, steam, fire, turbulence - they all engender chance effects. Modern physics begins here
with the realization that turbulence prevents the implosion of systems. The ‘outside' of the system is what prevents implosion.

'What exists', says Serres, 'is the most probable' (i.e. disorder, chance, and the exception). The real is not rational. 'There is only science
of the exception, of the rare, and of the miracle' (i.e. of law, order, rule). System in the Classical Age is an equilibrium; in the nineteenth century it is thermodynamics and meteorology becomes a metaphor for knowledge.

In The Parasite, Serres asks whether system is a prior set of constraints, or whether, on the other hand, system is the regularity manifest
in the various attempts to constitute a system. 'Do these attempts themselves constitute the system?' Serres asks. Noise, we have seen is the system. 'In the system, noise and message exchange roles according to the position of the observer and the action of the actor.'
Noise is a joker necessary to the system. It can take on any value, and is thus unpredictable so that the system is never stable. Instead, it is
non-knowledge. Systems work because they do not work. Dysfunctioning remains essential for functioning. The model, then, is free of
parasites, free of static (as in mathematics), while the system is always infected with parasites which give it its irreversible character. The
system is a Turner painting. With his representation of the chance effects of clouds, rain, sea, and fog, Turner interprets the second law of thermodynamics - the law made possible by Carnot. Turner translates Carnot. Such is Serres's poetic insight.

Two figures, then, inform Serres's oeuvre: Hermes and the Harlequin. Hermes the traveller and the medium allows for the movement
in and between diverse regions of social life. The Harlequin is a multicolored clown standing in the place of the chaos of life. Two regions
of particular interest to the voyager in knowledge are those of the natural sciences and the humanities. Should science really be opened up to poetry and art, or is this simply an idiosyncrasy on Serres's part? Is this his gimmick? The answer is that Serres firmly believes that
the very viability and vitality of science depends on the degree to which it is open to its poetical other. Science only moves on if it receives an infusion of something out of the blue, something unpredictable and miraculous. The poetic impulse is the life-blood of natural science, not its nemesis. Poetry is the way of the voyager open to the unexpected and always prepared to make unexpected links between places and things. The form that these links take is of course influenced by technological developments; information

technology transforms the senses, for example.

Serres's writing is a challenge for good reason. In his view, not to stimulate the reader to find the coherence in his work - as he has done
with others - is to render it sterile and subject to the collapse that inevitably awaits all closed systems. In the history of physics Serres has
argued that Lucretius anticipates the framework of modern physics. De rerum natura (On the Nature of Things) has conventionally been treated as a piece of poetic writing that has little relevance to modern science. But, Serres argues, clearly, turbulence of all kinds is fundamental to Lucretius's system. With the idea of the clinamen - of infinite variation in the course of an object's trajectory - Lucretius anticipates the theory of disorder - entropy - of modern physics. More than this, though, Serres endeavours to show that a mathematics
can be produced in light of Lucretius's writings of the last century before Christ.

By extension, the history of science itself is subject to turbulence: it is subject to chance connections of all kinds being made between various domains. Against the rigid orderliness of convention, Serres proposes the relative disorder of poetry, that is, of the miracle, chance and the exception. In its own way, Serres's writing is a glimpse of this miracle of poetry in an island of order.