



Bodies as communication systems. The relevance of Michel Serres's philosophy of science for health care

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Abstract

This article demonstrates the value of French philosophy of science for medical practice through an exposition of Michel Serres's philosophy of the body. It explores how Serres's examination of the similarity between scientific models and works of art can provide insight into different conceptions of the human body. What makes Serres's method of unique is that it does not see art and literature as subordinate to the natural sciences: they are both involved in mapping the communication lines of the body. Since early modernity, we can roughly speak of three successive communication models of the body: mechanical, thermodynamic and informational. This article finally discusses the relationship between those different conceptions and explains how they help to articulate different aspects of the body, health, and medical ethics.

Keywords Michel Serres · Philosophy of science · Philosophy of the body · Health care · Communication · Humanities

“Often philosophy and art – in this case, literature and painting – are blindly intuitive, anticipating inventions yet to come in the sciences.” (M. Serres, *Feux et Signaux de Brume*: Virginia Woolf's Lighthouse 2008).

Introduction

Philosophy of science for physicians often focuses on the demarcation between medical-scientific knowledge and pseudoscientific knowledge and the importance of falsification in clinical decision-making (Worrall 2010). Here, philosophy of science is supportive of common medical practice and assists the physician in clinical reasoning and in naming different models of health. The function of philosophy of science for medical practice is that of purification: it filters evidence-based medical knowledge from other domains of knowledge, intuitions and fallacies. However, such a conception overlooks an important tradition within the philosophy of science, namely that of ‘historical

epistemology’ which focuses on the genesis of medical knowledge by describing its tight links with other domains of knowledge and with its socio-historical context. Within this tradition, strongly rooted in France with philosophers such as Georges Canguilhem and Michel Foucault, the function of philosophy of science lies rather on articulation (Simons 2022). The articulation here consists in describing the processes that have played an important role, sometimes contradictory, in the establishment of what has become generally accepted medical knowledge and what has been left out. While Canguilhem focused on different normative conceptions of what is considered ‘disease’ by medicine and Foucault emphasizes the emergence of a ‘medical power’ in Western European societies since the Enlightenment, Michel Serres focused on the interplay between the arts and the different sciences in modeling the human body (Canguilhem 1991) (Foucault 1963).

Recently, Pols has argued that ethical principles in contemporary medical practices, such as dignity and autonomy, are the result of a historical process that introduced the “techniques of generalization and rationalization” (Pols 2023). With ethnographic studies of patients with addiction, cancer or ALS, Pols shows that everyday ethics is, however, closely related to processes of mutual attunement and aesthetic appreciation. Partially drawing on Foucault's 1984 lectures, she outlines a ‘historical ethnography’, which articulates the process on an increased focus on the

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universal and the manageable within medicine, leaving the diverse and concrete forms of life of patients and caregivers out of sight (Pols 2023, p. 191). Pols connects to the French philosophy of science in articulating the rather messy socio-historical background of the principles and values that guide contemporary medical practice. With reference to Michel Serres's idea of folded time, Pols describes this process of articulation as 'folding'. Pols:

Rather than placing events in an historical order, folding brings together texts from different times and places and makes them speak to one another. (Pols 2023, p. 19)

Interestingly, Michel Serres's early work in the philosophy of science, itself provides a folding of models that became prevalent in modern science. Applied to medicine, Serres's writings reveal the main frameworks of the human body in modern history and how they still play a role in today's medical gaze. Unlike Canguilhem's and Foucault's analyses of modern medicine that linked them to societal developments, Serres rather aims to fold developments in the natural sciences with art works, such as theatre, novels and painting. By doing so, Serres also shows what is excluded from the current framework of evidence-based medicine, in which therapy must be based on the best available evidence. In addition to Pols, Serres's philosophy of science reveals that in medicine not only medical-ethical, but also physiological and/or somatic principles are the condensations of a dynamic network that exchanges information between different domains of knowledge.

Michel Serres (1930–2019) was a philosopher and historian of science who, as a former marine, focused on navigating the *North-West-passage* between the natural sciences and the humanities (Serres 1980). His method consists of tracing the cross-links between seemingly disparate domains of knowledge and resists ever-increasing specialization in science. In a later work, Serres's method is called 'Pantopie' and described as follows:

[T]he utopia of tomorrow, which no longer consists in imagining other places, imaginary worlds, but in delivering all the possibilities that our world potentially or virtually contains. (Serres et al. 2016, p. 15)

The seemingly paradoxical fact that a historian of science is concerned with investigating the possible worlds of the future corresponds with Serres's conception of philosophy. Interviewed by Bruno Latour, Serres claims:

Now, philosophy is an anticipation of future thoughts and practices. [...] Not only must philosophy invent,

but it invests the common ground for future inventions. *Its function is to invent the conditions of invention.* This is true for Aristotle, Descartes, Leibniz...all the way up to Bergson. (Serres and Latour 1995, p. 86)

Hence, according to Serres, tracing the threads between different domains of knowledge in history opens up the possibilities for future inventions. A substantial part of Serres's philosophy concerns the human body. Serres wrote a proposal for a doctoral dissertation on the philosophy of the body early in his career, but to the advice of his supervisor Georges Canguilhem, he wrote his dissertation on Leibniz's mathematical models.¹ In the 1980s, he resumed his interest in the human body firstly in *The Parasite* (1980) and later when he began working on a project entitled *Philosophy of Mingled Bodies* which resulted in *The Five Senses* (1985) and *The Third-Instructed* (1991). Finally, towards the end of the last century, Serres made notes for a book *The New Body*, referring to the substantial changes the human body has undergone in the twentieth century, such as medicalization, biotechnological development, urbanization and virtualization.² In 1999, *Variations on the Body* appeared, in which Serres, by making use of examples from mountaineering, running, dancing and cycling, characterizes human bodies as thoroughly elastic and in a state of transformation. This was followed-up by *Hominescence* from 2001, in which Serres reflects on the major changes human bodies underwent during the 20th century, such as urbanization from the countryside to cities, dependency on communication technologies such as smartphones, and on medication such as vaccination, painkillers, and birth control. In *The Book of Medicine* (2001), a medical encyclopedia he directed together with Nayla Farouki, Serres advocates a renewed understanding of doctor and patient through developments in biotechnology, genetics and computer science.

Like his philosophy of science, Serres's philosophy of the body is a voyage of discovery into various domains of knowledge. *The Five Senses* presents the body as thoroughly sensuous and offers a road map into its chambers, black boxes, spiral rotations, and labyrinths. Serres's depiction of the body by making use of literature, paintings as well topology, information theory is that of a communication system. Rather than being composed of compound organs, Serres emphasizes the importance of the skin that is continuously being folded and woven through streams of information and noise. In a section on the medieval tapestries *The Lady and The Unicorn*, he writes for example:

¹ Source: Fonds Michel Serres, Bibliothèque Nationale de France: Site Richelieu, Paris (FR). I am very thankful to Guillaume Delaunay for sorting out Serres's manuscripts for me.

² Fonds Michel Serres, Bibliothèque Nationale de France.

The skin comprehends, explicates, exhibits, implicates the senses, island by island, on its background. They inhabit the tapestry, enter the weaving, form the canvas as much as they are formed by it. The senses haunt the skin, pass beneath it and are visible on its surface, the flowers, animals and branches of its tattooing, eyes that stud the peacock's tail; they cross the epidermis and penetrate its most subtle secrets. (M. Serres 2016 [1985], 60)

The reader will find many more of such sentences, written in a poetic style, with Serres picking from various vocabularies (weave-making, tattoo art, flora and fauna, anatomy and epistemology) offering surprising combinations.

The main aim of this article is to show how philosophy of science can contribute to medicine by articulating different conceptions of the body and care. Here I use Michel Serres's idea of folding together knowledge from the natural sciences and from the arts. A secondary aim of this article is to answer the question how Serres's interdisciplinary model of science, developed primarily in the 1960s and 1970s, helps us to better understand the philosophy of the body of his later work. I will demonstrate through a reading of the scientific models presented in the *Hermès*-series, how philosophy of science can contribute to the articulation of the body in medicine and how this articulation creates the conditions for anticipating the future of medicine that Serres discusses in *Hominescence*.

Methodologically, I connect to French philosophy of science by articulating the different conceptions that play a role in contemporary thinking about the human body through applying Serres's idea of translation between communication systems. I choose the articles and chapters from Serres's work that explicitly deal with the similarities between natural sciences and the humanities. In doing so, I will focus on the differences between models of the body as a 'mechanical statue' that is moved by natural forces during the 17th and 18th century, as a 'thermodynamic engine' that runs on heat in the 19th century, and as an 'information-processing network' that receives, stocks and emits small-scale energies mid-20th century. Having outlined these differences, I turn to the question of how these models relate to each other and how they affect contemporary conceptions of the body. Because of Serres's emphasis on translation, I am interested not so much in the ruptures between these images, but rather in how these models can be thought of as combinations, as different ways of folding an image of the human body. Finally, I show how Serres's early philosophy of science can be used to add depth and explanation to his later reflections on the human body, such as those in *The Five Senses* (1985) and in *Hominescence* (2001).

Communication systems in *Hermès*

Published in the 1960s and 1970s, all five volumes of the *Hermès*-series are concerned with communication, interference, transport and translation between different systems. Fables, paintings, novels as well as mathematical formulas and scientific theories all present a model of a system. They show how different things in the world are constructed and how they are related, in Serres's terms: how systems *communicate* with another by exchanging forces, energy, or data. Within the natural sciences, astronomy describes systems of different planets and stars that communicate via the transmission of heat and movement. But also, within the humanities, we can think of different characters in a novel who communicate with each other via their gestures, utterances and emotions. And within life sciences, the human body can be described as a network of communication that processes flows of energy, oxygen and signals (Serres 1982, p. 74).

According to Serres, all systems reveal to us a *network* of how different elements are in a relationship of communication and translation with another (Serres 1968, 1969). He hereby distinguishes 'structure' from 'model': the general *structure* of a network underlies a particular *model*, for example hierarchical, dialectical or decentral models which further specify the lines of communication between the elements of a system (M. Serres 2023 [1968], 25). Serres inherits from information theory that communication between the elements of a system is possible, because in principle all objects can be modelled as receivers, processors, and emitters of information (Brillouin 1962). A sundial, for example, receives light from the sun, processes light into a shadow, and transmits information of the position of the sun to a human receiver that gets informed with the time of the day. According to Serres, mapping things in terms of information exchange frees the traditional substances from their local cell or region. In his doctoral thesis on Leibniz, Serres writes that "it is impossible to think a sole notion in an isolated or fragmented manner, in its pure regional signification" (Serres 1968, p. 10). It follows that the natural sciences as well as human sciences and the arts are involved in mapping global networks.

Departing from the idea that various disciplines are involved in mapping a specific model of communication, Serres aims to develop a 'delocalized' transversal science that traces the interconnection between those models. Serres:

If the object (in general) of objective knowledge (in general) is discovered at the intersection of a growing multiplicity of approaches, its specificity is increasingly well recognized. (Serres 1972, p. 34)

Hence, what Serres's method of 'Pantopie' aims to do is to trace how various disciplines intersect in developing their model, so that it becomes clear how we can understand the contribution of a discipline in gathering knowledge about a general object and translation becomes possible. First, a 1784 painting by George Garrard of a landscape consisting of "pulleys and tackle, wheels, gears, and chains" reveals the same network of motions as the mathematician and physicist Joseph-Louis Lagrange wrote down in his 1788 *Analytical Mechanics* (Serres 1982, 54–5). Secondly, Émile Zola's novel series of the Rougon-Macquart family published between 1870 and 1903, can be read as a translation of 19th century life sciences, such as Darwin's evolutionary theory and Claude Bernard's biochemistry. According to Serres, the dynamics between Zola's characters folds together "a scheme, a network of circulations, a map where burning energies move, explode, extinguish, on the paths of genealogy" (Serres 1975). And lastly, the caring gaze of Mrs. Ramsay in Virginia Woolf's novel *To the Lighthouse* (1927) anticipated the logarithmic relation between perception and negentropy as has been formulated by Léon Brillouin in 1956 (Serres 2008).

Mechanical statues

In the chapter *Turner translates Carnot* from *Hermès III*, Serres argues that the difference between two paintings informs the viewer of a historical switch between a mechanical and a thermodynamic system of communication (Serres 1974, 233–42). In a painting of George Garrard from 1784 of the Whitbread beer brewery, we see men, horses, tools and vessels as the producers of movement. Before the Industrial Revolution, movement and work was produced by some natural force, such as water, wind, horsepower and human muscles. The running machines were windmills, horse trams, water wheels, sailboats, and human bodies. Typically, forces were naturally given and movement took place within the same region, within the same depicted scene (Serres 1977a, 44–5). The scenery of Garrard's painting expresses the laws of Isaac Newton (1643–1727), where movement implies a universal and given force, the acceleration of a mass, and the equation of action with reaction. The painting represents a geometrical model in which bodies consists of lines, points, and circles (Serres 1974, p. 234). Movement here is explained according to a particularly *immobile* scheme: bodies are solid, cannot transform, and everything rests as long as the forces of action and reaction are in equilibrium (Serres 1977a, p. 44). Therefore, Garrard's painting depicts the same communication system as was described by Western philosophers and scientists in the 17th and 18th century.

Such a system presents us a particular model of the body, namely as a *mechanical statue*. In a chapter on Molière's play *Don Juan* (1665), Serres writes:

A statue is an art object or a ritual icon. In the Classical age, it additionally becomes an automaton, an anatomical figure, a laboratory apparatus, and a mechanical model of the living being. (M. Serres 2023 [1968], 235)

Simultaneously being an object of art, a laboratory apparatus, and a mechanical model, the statue expresses common structure between different fields on knowledge. The statue with an ingenious cog is the model of the body in Vesalius's *De humani corporis fabrica* (1543), illustrated by a Renaissance painter, in the also lavishly illustrated Descartes *Traité de l'homme* (1629–1633), and eventually in Lamettrie's *L'homme machine* (1748). We come across the same statue as a model of the human body in the humanities of the early modern period. For example, in Molière's play *Don Juan*, Don Juan's servant Sganarelle exclaims:

Can you see all the elements which make up the machine called man, without marvelling how they all fit in with one another? These nerves, these bones, these veins, these arteries, these... these lungs, this heart, this liver, and all the other ingredients there are [...]. (Molière 1989, 62)

Serres argues that one features of such a mechanical statue is that it remains stable throughout their variations and are based on a fixed point or equilibrium, just like the clock or water pump (Serres 1973, 1974, 1977a). Another feature of the statue is that its time is *reversible*, meaning that no substantial change will take place in the system when elements start moving in the opposite direction. The last characterization is that the system is closed: all force and movement come from within the sketched network and cannot disappear. Within the mechanical model, the natural forces of the wind, the water, the animal and the muscle were given and *transported* to the mill, the boat, the tram or the heavy tons. Movement can be thought of as the transmission of forces between two points: high and low, for the fall and the weight, albeit without counterforce. Movement therefore implies a non-equilibrium, a difference between action and reaction. The mechanical statue presents the human body as cold and static, it moves by replacement and is represented by forces (Serres 1977a, p. 45).

Hence, Garrard's painting from 1784 charts the same mapping of communication between its elements as the physicists, physicians and philosophers of his time, for whom bodies consist of lines, circles, and triangles. Serres:

Line and geometry dominate color and matter. Garrard says something important here: he says, in and means of the art of drawing, exactly what Lagrange says by expressly denying himself any possible drawing. *Analytical Mechanics* appeared in 1788, contemporary to Garrard's painting. It contains a Statics, the theory of rest, and a Dynamics, the theory of motion. (Serres 1982, p. 55)

Interestingly, in his painting of the same Whitbread-brewery eight years later, in 1792, Garrard shows the viewer the very same scene, although with slight transformations. The background scenery of fresh air and the static buildings has been replaced by the fire and the dark smoke coming from factories, phenomena that are difficult to map within a mechanical framework. The Industrial Revolution is already taking place, the scenery changes, although still in the background. The painting of the Whitbread-brewery therefore depicts the end of an era (Serres 1974, p. 235).

Thermodynamical engines

The Industrial Revolution begun around 1756 in England with the invention of "Spinning Jenny", a spinning wheel with eight spools still driven by the hand. In 1764, due to innovations by James Watt, the steam machine became available for general use. The steam machine was able to transform heat into movement, an insight that eventually led to the formulation of *thermodynamical* laws that describe the movement of heat within a particular system. One of its formulators, the physicist Sadi Carnot wrote in his *Reflections on the Motive Power of Fire* (1824):

Wherever there is a temperature difference, motive power can be generated. (Carnot cited by Serres 1977a, p. 47).

Hence, for Carnot, force ('motive power') is not naturally given, but is *produced* by a difference in temperature. The mechanical statues from Garrard's painting have become *engines*, namely systems that produce circulation by means of differences in temperature (Serres 1977a, p. 259).

According to Serres, the difference between the mechanical statue and the thermodynamic engine in art is evident in the blazes and clouds of smoke in William Turner's later paintings. *Rain, Steam, and Speed - The Great Western Railway* (1844) shows the steam train thundering through a classic landscape with a river and roman bridges. The train takes with it a large cloud of smoke and ash that overshadows the classic geometric shapes. Inside the train we can clearly see a steam furnace converting coal into speed. To make this

this thermodynamic process visible, Turner turned the furnace around, toward the viewer's nose. Serres:

Turner no longer looks from the outside; [...] he enters into the boiler, the furnace, the firebox. He sees matter transformed by fire. This is the new matter of the world at work, where geometry is overturned. Matter and color triumph over line, geometry, and form. (Serres 1982, 56–7)

With the advent of the thermodynamic engine, the system of communication transformed. Lines and shapes give way to colors and clouds; forces are not natural but are produced by heat and energy; the spectator must cough, feels the heat and squeezes his ears for the noise - the engine is everywhere. So, Turner shows a world composed of matter instead of lines and forms: heat waves, turbulent currents, and stochastic particles.

There a new time is being fired in the oven. On these totally new edges, which geometry and the art of drawing have abandoned, a new world will soon discover dissolution, atomic and molecular dissemination. The boiler's fire atomizes matter and gives it over to chance, which has always been its master. (Serres 1982, p. 58)

On the one hand, Turner (1775–1851) historically followed Carnot's law with his paintings; on the other hand, Turner was able to translate thermodynamics into an image that anticipated the statistical physics of Maxwell (1831–1879) and Boltzmann (1844–1906). Their theories taught that thermodynamics is best viewed as applying to large groups rather than individual objects. With this, the precision of the mechanics of early modernity was abandoned. The mechanics in which a determined number of celestial objects could return to their initial state gave way to an irreversible process of unnumerable particles adrift (Schneider and Sagan 2005, p. 54).

Whereas the mechanical statue was moved by the difference between action and reaction, the thermodynamical engine runs on the difference between the couple hot and cold. Even Carnot's descriptions of high temperatures that 'fall' and low temperatures that 'rise' are still reminiscent of the mechanistic view. What is different however, is that the mechanical tons and mills by weight and fall merely *move*, whereas the thermodynamical difference in temperature produces a *transformation* of the body. A heated metal bar changes its length, for example, just as heated or cooled liquid changes its volume through expansion. Serres:

In reality, heat *transforms* bodies, it *transforms their state*. From solid to liquid and from liquid to gas. [...] It is no longer just spatial transport (and its representation) that is at stake, it is the transformation of matter, the transubstantiation. (Serres 1977a, p. 48)

Hence, the thermodynamical model gives us the insight that solid bodies are in fact merely a phase state in temperature and that bodies are involved in a continuous process of transformation. This is why Carnot speaks of heat as “a vibrational motion of molecules” and Serres calls the Industrial Revolution “a revolution on *matter*” (Brillouin 1964, p. 4) (Serres 1974, p. 235). Thermodynamical bodies are not solid objects anymore, but rather fluid collections: atmosphere, clouds, liquids, rain showers, oceans and eventually the earth itself all transform through the continuous dissipation of heat.

Whereas the mechanical laws were based on a fixed point and implied a constancy of bodies, the only thermodynamical constancy was the difference in between the cold and the hot source. Therefore, thermodynamical motors were mapped into the network as driven by *circumstance*, according to Serres: “This is a completely new phenomenon that will turn philosophies on their head.” (Serres 1977a, p. 48) Serres observes that philosophies, but also artworks and the great novels after the steam machine subsequently presented the body as driven by circumstances, transformation, and adaptation. Serres:

The organism is not a simple or compound machine, Descartes is dead, nor is health a passive, static equality; the body is an engine that burns a fuel, transforming thermal energy into force and movement, second Cartesianism. (Serres 1975, p. 62)

Here, Serres already indicates that vitalist philosophies of the body as a transformational motor – at places, Serres mentions Bergson, Darwin, Freud, Nietzsche, Canguilhem, and Foucault – show at the same important parallels with the old mechanical philosophies of the body (Serres 1975). Perhaps most importantly, the thermodynamic model implies that its laws only apply for a closed system. The emphasis on the circumstances namely conceals that, although the ‘open’ body receives heat from the outside reservoir, the transmission of energy remains limited within the walls of the environment, the ‘milieu’, the Umwelt, or the landscape. The thermodynamical body is therefore only half open. Another characteristic is that nineteenth century thermodynamics was based on the study of engines and machines *as a whole*. Serres:

[...] By this I mean in the realm of ordinary work and the movement of objects. Hence a discourse that often ended up either in the cosmos in general, or in organic living organisms in particular. (Serres 1977a, p. 261)

This implies that newly formed philosophies where human bodies were seen as producers of movement were still lacking a proper understanding of microbodies, such as cells, tissues, and parasites. The focus on the energies at work remained limited to those on the level of the whole person or the subject. Lastly, Serres claims that philosophy in the 19th century – Kantianism, positivism, Hegelian dialectics as well as Nietzschean vitalism – was still centered around the idea of the Eternal Return, and therefore assumed a return to the worldview of Aristotle (Serres 1977a) (Large 1997). The engine of the thermodynamical era therefore makes use of a reservoir that is infinite, whereas the difference between hot and cold is finite.

The thermodynamic machines of fire, steam, combustion and explosion all run on two sources. According to Carnot, where there is a difference in temperature, there will be production of movement. We can also observe this way of thinking in Volta’s pillar in 1800, the forerunner of the battery, which consists of two poles: *positive* and *negative* (Serres 1977a, p. 51). However, the two sources are in fact not real antipodes: the hot vat is only warmer than the cold, the positive and negative poles are both part of an electromagnetic circulation system, and the fall of water only comes from a somewhat higher place in the landscape. Reducing these streams and fluxes into two oppositional poles, is according to Serres, “a remnant of the Classical age, a naturalization of the fixed point” (Serres 1977a, p. 51). In this sense, the thermodynamic engine still presumes an Archimedean point from which all movement can be deduced.

According to Serres, the thermodynamic way of thinking about the body is apparent in Émile Zola’s novel *Docteur Pascal*. Pascal Rougon’s laboratory shows elementary similarities with Turner’s coal furnace: its locked door matches the closure of the oven; Pascal’s information storage in an accounting system matches the coals that store energy; the reader’s position matches the viewer of Turner (Bell 2010, 193). In his laboratory, Doctor Pascal developed a theory of the heredity of diseases according to irreversible time, based on the history of the Rougon-Macquart family. From this, Serres comments that the Rougon-Macquart series themselves illustrate an efficient thermodynamic scheme:

The genetic grid, imposed by a decision of the author himself, clarifies the reading much more than tradition says. Suitably generalized, it leads to a thermodynamic grid, which is more powerful and more efficient, especially when a few theories on chemical

or general transformation processes are added. (Serres 1977a, pp. 197–8)

Zola, who studied under Claude Bernard and read Darwin, describes one of Pascal's convictions as follows:

Heredity, instead of being resemblance, was an effort toward resemblance thwarted by circumstances and environment. [...] There was then a perpetual becoming, a constant transformation in this communicated effort, this transmitted power, this shock which breathes into matter the breath of life, and which is life itself. (Zola 2004)

Note the presence of the thermodynamic way of thinking of Pascal about genetics in terms of circumstance, perpetuality, transformation and vital energies. In microbiology beginning in the mid-twentieth century, we see this thermodynamic way of thinking about genetics giving way to a completely different vocabulary (Serres 1972).

Negentropic networks

It is in the recognition of the above sketched classic and mechanistic assumptions within the model of the thermodynamic engine, that Serres sees the value of information theory, the microbiology of Jacob and Monod, and the mathematical mapping of space in topology of Riemann, Poincaré and Bourbaki for understanding the human body (Brillouin 1962) (Jacob 1970) (Bourbaki 1961) (Serres and Latour 1995, 12–3). In the twentieth century, information theory introduced the linguistic notions of *information*, *communication*, *translation*, *signal* and *noise* within a framework of physics. One result was that macro-level thermodynamical laws could be translated to the microscopic level of chemical 'signals' between cells. Erwin Schrödinger showed that information was a reversal of thermodynamic entropy, that organic life "avoids the rapid decay into the inert state of 'equilibrium'", and therefore "feeds on negative entropy" (Schrödinger 1967 (1944), 70). The intersection of language acts, such as reading, writing, storing and transmitting signals with the domain of physics, also implied that the information transmitted by a letter, a painting or a tragedy, "should drift from difference to disorder" (Serres 1982, p. 73).

The human body is an energetic, 'hard' thermodynamic engine for which time is irreversible, slowly moving towards decay. But from now on, it is also a 'soft' and 'negentropic' information system that produces language from information and noise. Serres:

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). (Id.)

This presents a model of the body as a *processor* of various streams ("food, oxygen, heat, signals") that flow through it. With the help of information theory, we are in a position now to regard the body as an 'open system' of signs which maintains its own imbalance within the entropic stream towards death. Serres:

[The organism] is a river that flows and yet remains stable by the continual collapse of its banks and the irreversible erosion of the mountains around it. (Serres 1982, p. 74)

In 1977, Serres published his book on flows and turbulences in Lucretius's poem *De Rerum Natura*. Here, Serres rereads Lucretius's ancient atomism in the light of 20th century physics such as wave mechanics, quantum and chaos theory: its aim is to abandon the classical mechanistic "framework of solid objects", and to replace it by a hydraulic model which considers "the world, the objects, the bodies and my soul" as fluxes, streams and eddies "adrift" (Serres 1977b, p. 14 & 46). The things that make up the world such as our bodies, are rather fluid and river-like, because they incessantly receive, store and emit signals from every direction. "We are plunged into the space of communication", writes Serres, describing the generalization of information theory, "the space of signals is physical space of signals is physical space itself." (Serres 1977b, p. 63). All irreversible streams, laminar flows and fluxes of signals could not exist without deviation, without there also being eddies and turbulent flows of information. The living body not only drifts towards chaos and death, but also remembers information, reprograms its immune system, recycles energy, and increases in complexity (Serres 1982, p. 75). Hence, Serres's hydraulical model involves the incorporation of different – even: oppositional – patterns of informational flux. The flows of the body are aging as well as repairing, and are making possible learning and habits, nutrition as well as excretion, sickness as well as healing, and disintegration as well as retention. All directional arrows of information are "arranged in the shape of a star", according to Serres, "[w]hat is an organism? A sheaf of times. What is a living system? A bouquet of times" (Serres 1982, p. 75).

The conception of the body as a bundle of different (neg) entropic flows and times finds its counterpart in contemporary quantum physics (Rovelli 2019), but we also find it in literature, as exemplified in Serres's article on Virginia Woolf's novel *To The Lighthouse* (1927). Whereas Woolf's

book is often understood as ‘stream of consciousness’ within the domain of the human mind, Serres explains it as enveloping a physical theory of information streams. *To The Lighthouse*’s three chapters indicate three different *tempi*, or: rhythms of time. The flashing lamp of the lighthouse in the first chapter suggests that time is regular and reversible, *mechanical*, whereas the erosion, demolition and decay of the house after it has been left suggests that time is *entropic*, irreversible, thermodynamic, and moving towards chaos. The eight beautifully growing children in the book suggest that irreversible time also leads to the “new and positive”, and therefore indicate *negentropic* time (Serres 2008, p. 111). According to Serres, the novel provides an answer to how these times are related, since it explicitly answers Berkeley’s question “What becomes of the things of the world when no one perceives them?” in terms of time. In the first part of the book, everything that exists falls under the eyes of Mrs. Ramsay: her presence and sense of beauty opposes the entropy of things. When no one occupies the house, and no one cares for it in the next chapter, darkness and grief invade: cracks and holes appear. Serres argues from this that *To the lighthouse* contains an answer to Berkeley’s question because it describes the decay of the house when Mrs. Ramsay’s is absent. With the disappearance of her attentive gaze, the house begins to crack and creak. Through her daily presence, Mrs. Ramsay herself protects and glows like a lighthouse that can transmit signals to ships by flickering light to prevent shipwreck. Serres:

The Lighthouse shines in the tempest; the sound and sense of the horn pierce the fog; they save. Similarly, perception protects us with its light. And not only us. Yes, certainly, it guides the life of our bodies: were we blind, deaf, bereft of taste and smell, we would burn ourselves to death, poison ourselves, fall into gullies. But perception also protects the things of the world. Without it, what would become of the world? (Serres 2008, p. 123)

According to Serres, Woolf’s novel foreshadows Brillouin’s main thesis from 1956 that information can be seen as negentropy, as a temporary eddy within an ocean of noise (Brillouin 1962).

Applied to medicine, Serres is concerned with health and the influence of (bio-)medical discourse for conceptualizing the healthy body in a chapter on Nietzsche’s *The Antichrist* (Serres 1977a, 171–93). Nietzsche regards Christianity as a sickness for European culture, hence his frequent usage of medical terms like corruption, failure, depravity, rottenness, contamination, decomposition, infection, and poison. Interestingly, in his criticism on Christianity, Nietzsche utilizes a dichotomy between being healthy and being corrupted.

Health for Nietzsche, according to Serres, consists of being purified from bacilli, microbes, viruses or parasites. A healthy state can therefore be found in white sheets, clean hands, and the pure, cold air from the mountains. Promoting health consists in the aseptical method of expulsion and purification.

Remarkably, Nietzsche’s way of writing shows some important similarities with the work of his contemporary Louis Pasteur (1822–1895), one of the founders of biochemistry. Both authors discover secret pathogens; microbes and viruses that are responsible for the disintegration of the organism (Pasteur) or the Roman Empire (Nietzsche). For Nietzsche, Christian priests and theologians are the main carriers and vectors of the epidemic (Zwart 2012, 139–140). According to Serres, Nietzsche “chases the bad, the weak, and the sick, he washes the ground with lustral water, climbs the mountain and expulses the carriers of the virus” (Serres 1977a, pp. 174–5). In this sense, Nietzsche’s aseptic philosophy of health is based on an outdated medicine of contagion, which itself has its roots in religious practices such as washing hands and exorcism.

The model of the body as a negentropic network provides us with a less dichotomous conception of health and sickness. This is most clear in *The Parasite*, in which noise is presented as the interruption as well as the condition for information (M. Serres 2007 [1980]). In this, Serres is inspired by La Fontaine’s fables, short stories with animals depicting a certain morality. One of them is the tale about a grasshopper making music all summer while an ant continues to stockpile food. When winter comes, the grasshopper knocks on the ant’s door for food. The ant refuses, making the grasshopper out to be a parasite and commanding him to keep dancing if he likes music so much. Serres thus shows that a rational and transparent system like that of the ant also has its drawbacks. The grasshopper may be expelled, but the stock also spoils due to bacteria and worms. One parasite has merely given way to another.

Interestingly, Serres links this tale to Canguilhem’s discussion of health of the neurologist René Leriche (Canguilhem 1991, 91–101). In reaction to the notion of health as a biomedical fact, observed by the doctor, Leriche wrote in 1934 that health “is life lived in the silence of the organs”, indicating that a healthy body can be regarded as the absence of an interruption of one’s activities (Canguilhem 1991, 91). This corresponds to the ant trying to clear its home of intruders while the grasshopper makes noise by making music and knocking on the door. Canguilhem concludes that Leriche’s notion that diseases are a necessary condition to produce scientific knowledge of a healthy body:

Disease reveals normal functions to us at the precise moment when it deprives us of their existence. [...]

If health is life in the silence of organs, then, strictly speaking, there is no science of health.(Canguilhem 1991, 101).

According to Serres, the interrupting noises and sounds of the grasshopper not only enable a medical science, which is Canguilhem's position, but also give insight into how the body can be thought of as a network of different systems exchanging information and noise. The body's noises of pain and suffering provide knowledge and information about its normal functions, the ant needs to integrate the grasshopper, the expelled parasite, into his system.

Could health be the silence of organs? And sickness makes noise. It is always talking, always making noise at the door while we are doing something; it never stops scratching in the attic during our sleep. We get up, look; there is nothing there. We go back to bed and it starts again. (M. Serres 2007 [1980], 78)

This is an important warning against tendencies to idealize the healthy body, the absence of pain or the continuation of a happy mood. Serres argues that noise, interference or entropy is implied in every act of communication, such as the synchronization between assemblies of neurons, the transportation of blood to the organs, or the touching of the membranes of neighboring cells.

Rigorously speaking, there is never silence. The background noise is always there. If health is defined by silence, health does not exist. Health remains the couple message-noise. Systems work because they do not work. Nonfunctioning remains essential for functioning. (M. Serres 2007 [1980], 78–9)

Exactly because there is noise there can be communication between organs. Destabilization, death and sickness are continuously involved in the functioning of our bodies, which undermines the dichotomy between sickness and health and calls for a multivalent or fuzzy logic of care. What Serres sketches here are the outlines of a notion of health that includes a body that is in constant transformation. The noise of the grasshopper is essential here, because noise lets the body fall into disorder, which makes a metamorphosis into a new order possible.

A philosophy of mingled bodies

With Serres's method of pantopie, then, we find three different mappings of the human body in Western modernity. Early modern mechanics presents a world in which things

(mills, horses, boats) interact at the level of compounds, as we have seen reflected in Garrard's landscape painting and Molière's comedies. While thermodynamics provides an understanding of how the world functions as an engine or furnace, endowed with *entropy*, information theory opens the door to an understanding of how all micro-levels of the body are involved in receiving, storing, and emitting *information* with temporary flows of *negentropy*. This results in the following table:

Mechanical 'Statue' (1600–1800)	Thermodynamic 'Engine' (1800–1950)	Negentropic 'Network' (1950–)
Garrard, Molière	Turner, Zola	Woolf
Natural forces (wind, water, muscles)	Energy (fire, gas, electricity)	Information (signal, noise, code)
Closed system	Half-open (reservoir)	Open
Reversible time	Irreversible time	Multiplicity of times
Analysis on the level of compounds, organs	Level of the whole body, organism	Cellular, subatomic level
Descartes, Newton, Lagrange, Lamettrie	Carnot, Bernard, Darwin, Nietzsche, Freud	Brillouin, Bourbaki, Monod, Rovelli, Wiener

Although a similar tripartite division of physical systems was also made by Norbert Wiener, the peculiarity of Serres's philosophy of science is that the three communication systems can be generalized to other disciplines, as we have seen in literature and art (Wiener 1965 (1948)). The question that arises with the above table is how the different models relate to each other. Because Serres frames the various models as communication systems, it is obvious that he assumes that communication *between the models* must also be possible. To Latour, he says:

Do you know that this is a very old custom, our truly Western way of thinking, which cleaves time at revolutions? [...] At a particular moment everything stops, and we start counting over again from zero and assign negative numbers to the preceding area. The Chinese don't compute this way, nor do the Hindus. We think and live history by the kind of ruptures you're talking about. (Serres and Latour 1995, pp. 137–8)

Hence, rather than thinking in terms of ruptures or revolutions, Serres tends to look for various folds or metamorphoses in relation to an invariant structure, as in topology. The history of science thus shows the variations in contemporary views of the body and reveals openings for future practices.

In a text on the difference between the mechanical and thermodynamic system of communication, Serres argues that the difference should not be thought of as successive paradigms, as Thomas Kuhn had argued about the revolution

from geocentrism to heliocentrism (Serres 1973) (Kuhn 2003 [1962], 164–190). Serres:

[T]here's another kind of dynamic that precedes the general statics of systems. From now on, the laws of heat will be considered as preceding the laws of movement [...]. (Serres 1973, p. 442)

Exactly where thermodynamics shows the world in terms of heat, cooling, gas and clouds, processes that are irreversible, it simultaneously shows a history that *precedes* the mechanistic system consisting of reversible solid objects, forces and motions. Thus, what Turner shows in his paintings is not only a departure from mechanics, but also the laws that make the mechanical system possible in the first place. The mill, the horse and the scales are only tiny pockets of relative stability in a furnace that transforms everything. The difference between the mechanical model of communication and the thermodynamic model is not that the latter replaces the former, but that the latter provides a *translation* of the former, mapping a more general physics.

Serres applies a similar analysis to the difference between the thermodynamic system, which runs on energy, and the information system, which processes information in terms of bits. Serres refers several times in *Hermès* to Brillouin, who provides the connection between these two different models:

Information is usually measured in bits (binary digits), and entropy in thermodynamical units. The ratio between those units is approximately 10^{-16} , and this means that a very large number of bits (say 10^6) still represents a negligible contribution (10^{-10}) to entropy. (Brillouin 1962, p. 293)

The connection between energy and information (“sixteen zeroes”) implies that the two models are not opposed to each other, but that the *hard*, material world of the thermodynamic engine and the *soft* codes and signs of the information network can be seen as mapping different loops of communication (Serres 1974, 73–104) (Kroth 2024). Virginia Woolf's Mrs. Ramsay watches over her housemates (softly), temporarily counteracting the entropy of the hard world.

The difference between the hard (forces, energy) and the soft (information, code) as different loops of communication is extensively reflected in Serres's philosophy of the body in *The Five Senses* (1985). In the first chapter, Serres presents the body as consisting of all skin (“veils”) and compares the constellation of the human body with a woven tapestry with its clear contours made up of complex knots, warps and weft. Here, the skin is not a shell like a glove, but the basic

tissue of the organs and the beginning of consciousness. “The skin, a single tissue with localized concentrations, displays sensitivity. It shivers, expresses, breathes, listens, loves and lets itself be loved, receives, refuses, retreats [...]”, Serres writes, clearly echoing the triplet receiving, stocking, and emitting from information theory (M. Serres 2016 [1985], 52). This body image of overlapping veils is consistent with information theory in the sense that the skin favors the soft, small scales of information. From Serres's reading of Virginia Woolf, we know that small perceptions carry with them a negentropic time and are thus constitutive of the complexity of the body.

Since Serres's philosophy of science regarded the successive models of the body as different loops of communication, this does not mean that the mechanistic model and the thermodynamic model have suddenly disappeared. For example, he writes about how the human body, consisting of bones, muscles, nerves and skin, mixes these different loops:

Our body, warm, powerful, resistant and therefore hard, an object on the entropic scale, mingles its hardness with the softness of small-scale energies: information first, meaning and language last. It is as though life were a stage in this process. Our body mingles soft and hard and thereby produces and receives the same mixture. (M. Serres 2016 [1985], 114).

What we see here is that Serres's philosophy of the body seeks to integrate the three scientific models. The body is a processor of forces, heat, and sensations simultaneously, operating on different scales of energy.

Finally, the idea of different folds of the body is also strongly present in *Hominescence* (M. Serres 2018 [2001]). Here, Serres argues that the human body has undergone a significant anthropological change in the 20th century. Because of medicine (antibiotics, painkillers, contraception, vaccinations), hygiene measures and working conditions, our bodies are getting older and taller. Less determined by chance, pain, and suffering, they demand health, security and control. Rather than seeing our bodies as rigid, solid, real and actual, we increasingly see our bodies as plastic, metamorphic, and virtual. The new body is no longer pre-programmed by nature or God, but is programming itself via sport, exercise, diets, and drugs. This calls for a new medical ethics that confronts the downsides of this new body, such as the unequal distribution of health (between neighborhoods and globally), the increased weight of individual responsibility, and the dependence on medical supplies that stimulates overdiagnosis, medicalization and addiction. In addition to Pols's diverse and local everyday medical ethics, we see in the later Serres a renewed attention towards the

global and the abstract in formulating an ethics of care (M. Serres 2018 [2001]).

Due to the above sketched developments, Serres argues that our bodies are in a phase of adolescence: a period of rapid development, intense emotions and the gradual acquisition of more responsibility for the world: “a common house” as Serres calls it here. *Hominescence's* last chapter sketches a “contemporary humanity” dependent on digital and microbiological technologies:

Before becoming human, communication characterizes the living thing as an open system; cells communicate with each other in bodies as much as bodies with each other amid their ecological niche. At the small scale (chemical reactions) and at large scales (thunderstorms and galaxies), energy and information are again exchanged with inert matter. (M. Serres 2018 [2001], 175)

In this sense, in his later philosophy of the body, Serres still dwells heavily on the idea of different loops of communication, such as forces, energy, and information. The different networks of communication require sensitivity to the flows of communication that make up different times and intervals. What we see here is how Serres's method of translating body images and worldviews as communication systems relates to modern forms of communication, such as through smartphones and quantum chips. Contemporary communication technologies see the human body as a conduit of information: soft and flexible. However, communication streams collide, turn around, and take a side path (M. Serres 2016 [1985], 114). By integrating a bouquet of times into the body, it becomes clear that the human body can also be hard, rigid and powerful. From this perspective, modern communication technology overlooks the fact that the body also consists of many other communication streams that introduce a “Big History” of elementary particles, our solar system, and the Cambrian explosion into our body (Spier 2015). By integrating multiple times into a bundle, Serres proclaims the idea of a global humanism that depends on “bio-techno-structures”, different loops of communication.

Conclusion

This article began by asking how philosophy of science can help articulate different conceptions of the body and care. Departing from Pols's method of folding in articulating in the creation of medical principles, it explained how Serres's pantopie articulates different conceptions of the body in modernity reflected in the exact sciences and in the arts. From Serres's early work, we learn that different

conceptions of the body could be understood as mapping the communication flows between their elements. The analytical mechanics of the body reflect different flows of communication between bodies than negentropic touch and gaze. Bodies are both hard and soft, transparent and dark, solid and fluid, and spread both information and noise. In this sense, a generalized physics of the body consists in mapping the possibilities that it potentially or virtually contains.

From different theories and different eras, the body can be viewed as a communicative system. The skeleton, organs, cells and tissue exchange information among themselves in terms of forces, energy or data. The works of art and novels are not reflections on a pre-existing reality, but, like models in science, are concerned with mapping various streams of information. Indeed, a painting by Turner or a novel by Woolf can even be seen as anticipating scientific inventions (respectively, statistical thermodynamics and negentropy) and looking ahead to “future thoughts and practices”, just as Serres argued about the task of philosophy. Serres's method also teaches that complicated scientific theories are not only accessible to specialists, but find their counterparts in comedy, novels and paintings.

By using authors like Woolf, Nietzsche and La Fontaine and importing them into natural science and medicine, Serres demonstrates how the humanities themselves carry with them a physics of the body that is concerned with the individual, the deviant, and the sensitive. In this way, Serres joins Pols who shows that abstract medical principles are the stiff residues of concrete, diverse and noisy everyday practices. Adding to Pols, Serres's analysis of communication systems shows how medical discourse itself is an attempt to filter information from noise. From a Serresian perspective, Pols's description of the historical transition from pre-modern to ‘modernist ethics’ in medicine, deduced from abstract principles to counterpart malpractices, is a refolding of a communication system that installs a rationalistic ethics as a channel through which to communicate, rather than via the king or religion from the ‘ancien régime’ (Pols 2023, 59–62). General, solid principles such as autonomy, dignity or health function as a signal, whereas disagreement, deviation or resistance are regarded as noise. Rather than a ‘transformation of subjectivity’ (Pols 2023, p. 114) this entails a general refolding of the channel (from sovereignty to rationalistic ethics), the filter (from obedience to alignment with principles), the receiver (from local care practices to the individual patient) and the messenger (from the reverend to the caregiver). Such a system of communication through rationalistic ethics explains why the emphasis for the health care provider becomes ‘new public management’ and ‘accountability’ and the patient is regarded as an isolated, calculating and self-interested individual, hereby closing the channels of sensibility, mutual attunement and sub-optimal

circumstances. ‘Reinventing the good life’, as Pols formulates it, then involves installing a multiplicity of channels to communicate about suffering, illness and the body that gradually allow for the noises of improvisation, play and the specifics of the situation (Pols 2023, 128–135).

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