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A Presentation of the Paradigm of Information in the 21st Century

Ever since the birth of philosophy, scholars have been working out fundamental problems and attempting to provide insight into things, man and their relationships. Science has not changed. Although some aspects of science (mainly specialized) drive us away from philosophy, a substantial part of it draws us closer to it. The accumulation of contemporary scientific results requires us to think about the scheme of things in our existence, all the more so as the emerging vision of nature is quite clearly facing a turning point. Information is becoming more and more central in relation to all kinds of knowledge. This is what this first chapter, which will lead us from technology and philosophy to biology and sociology on the basis of the notion of information as well as communication, aims to make clear.

1.1. After technology, the philosophy of information

1.1.1. *Information, issues and paradigms of the 21st Century*

Every age adopts a certain worldview, to use Heidegger's language, or a set of paradigms. In this case, we are in line with an epistemological perspective delineated by Kuhn. Some paradigms cover several fields. This was the case for the mechanistic paradigm, which brought together physical and biological sciences in the modern

age. The 1970s saw an even broader paradigm, covering physics, biology, sociology and politics take shape. These were the years of the systems theory. The thinkers of "globality" became quite well known. Prigogine and his new alliance, Edgar Morin and his method, or Varela and autopoiesis are only some examples. These scientists gathered for a famous symposium held in Cerisy in 1981, namely a kind of scientific council supposed to provide a universal doctrine based on self-organization, which, however, failed [DUP 83].

Since 1980, scientific subjects have made progress, with some notable developments in the 1990s, but overall the key issues have remained unsolved and scientific debates are still stuck on the same concepts that have determined the traditional controversies of the last decades. However, a new paradigm has been taking shape over the last few years. It bases reflections on Information and this time with universal Information in mind, as Information is not only the social issue of the 21st Century but also the central scientific and philosophical question that brings together quantum physics, statistical physics, cosmology, chemistry, biology and all the humanities. This paradigm revolves around some notions: information, communication, arrangement, Time, disorder, order and, without any doubt, the issue of Being.

The paradigm of self-organization was, on the one hand, in line with mechanistic philosophy and, on the other hand, relied on the theory of dissipative systems developed by Prigogine, as well as on the system theories elaborated since the 1950s. The paradigm of Information concerns all the branches of physics and plays a prominent role in quantum dynamics as well as cosmology, interpreting Gravity as the uncovering of an informational order in the universe. The great journey toward the universe of Information has begun, but it is facing a major turning point at the start of the 21st Century. All of science will be disrupted, without taking into consideration philosophy and theology.

Nothing can illustrate this paradigm shift more effectively than a reference to the cultural facts related to technological progress. The 18th Century was defined by the figure of the great watchmaker situated outside of the human sphere, whereas, here on earth, people

were fascinated by automata, simulacra supposed to represent life entering matter. Automata seem alive, as they are animated, just like animals. The hallmark of the 21st Century is the great computer, which organizes information in the universe. However, here on earth, people are fascinated by robots, which, as we should point out, incorporate an information-processing system unlike the purely mechanical automata of the Enlightenment. Moreover, computers have become simulacra supposed to embody awareness, just as automata represented life. As we can clearly see, a computer will never be aware, but this belief aptly illustrates how we have moved from a technological and mechanical era on to the age of information and the processing devoted to this information, which is artificial in machines that carry out calculations by using digital information and natural in the systems of nature that use what our understanding still cannot grasp, namely natural information.

Google, another symbol, has become the largest market capitalization ahead of Apple, without forgetting giants like Microsoft or Facebook. All these companies are linked to the dissemination of information, the way it is processed, the objects connected, and so on. We are now in 2017. Half a century ago, commodities and mechanical industries were the most important factors. It was the peak of the era of machines, energy and military–industrial complexes.

1.1.2. *Philosophizing means being concerned*

What is philosophy and why do we need it? Etymologically, philosophy is defined as the love of wisdom, which attributes a purpose to it. However, is it wisdom that man looks for on earth? We are not that sure. Philosophy has become a type of knowledge. Why should not we then conceive philosophy as the production of a set of types of knowledge and learning, focusing on general, not to say generic, kinds of reality rather than on singular things? Moreover, these realities are not separate from man. Because these realities, which philosophy deals with, concern us. They "surround" us, envelop us and influence us, while we are involved in this existential theatre, where we represent the actors and the audience. In other words, we are

interested in these things. Interest may mean two things: (1) a trivial and material thing and (2) a more spiritual thing, in keeping with its etymology – *inter esse* – an essence-to-essence relationship. We concern ourselves with and are interested in that which philosophy regards as knowable and deserving of sustained research.

Let us take a look at some previous eras. In Vedic India, sage philosophers were concerned with the cosmos. This is also the case for pre-Socratic Greece, before philosophy became particularly interested in Man after Pericles' "Golden Age". Outlining the themes that have concerned philosophers as well as society is nearly cliché. The topics that philosophy deals with are quite often very important, not too say critical, in a society, as philosophy enables the development of shared knowledge as well as the organization of human groups. We may think that philosophy predates the form of society, but if we believe the allegory of the owl of Minerva formulated by Hegel, philosophical knowledge arrives at nightfall, once historic events have taken place. Philosophers have concerned themselves with the cosmos, nature or "physis", Man and then God in the Middle Ages, putting Man once again on stage in Europe after the Renaissance. Modern philosophers have had a keen interest in Man, leaving nature to scientists, without preventing the development of philosophies of nature in the Romantic age at the beginning of the 19th Century.

1.1.3. *Technology affects us*

It has taken centuries of mechanical development for philosophers to develop an interest in Technology, which is the issue of the 20th Century, according to Ellul. However, technology had been known since ancient times as *techné*, meaning the craftsman's work. At the end of the Middle Ages, Europe had been invaded by water- and windmills, as these machines coupled with nature could generate enormous mechanical power for the time. The end of the Middle Ages saw the emergence of a new era that gave more importance to active rather than contemplative life. Men turned toward the temporal world. After Descartes, will became a key topic for modern philosophy.

It is after the turning point of 1820 that a new theme chosen by philosophy started taking shape. Technology became an important issue. It was examined by three philosophers who had significant influence on society: Hegel, Comte and Marx. However, for Hegel, it was more the anthropological aspect that was conceived in relation to work and the man concerned with the hammer. For Comte, man concerns himself with science and machines, whereas for Marx with machines and economics. This new philosophical situation is the result of an invention whose significance has not been assessed, despite the fact that it dates back to the end of the 18th Century. The steam engine represented a considerable breaking point in terms of generation of mechanical energy on two levels. First, in relation to its principle, with the use of heat converted into mechanical force, which differs from wind or waterways, whose energy is already mechanical. Heat can be converted into work. Second, the engine allows us to generate mechanical energy anywhere, independently of the presence of wind or a waterway. The steam engine generates a nomad form of energy, which will end up becoming a mode of transport with railways, steam-powered ships, cars and airplanes. With the invention of electricity, mechanical energy and even light energy is decentralized even more, reaching every household equipped with a network of electrical wires.

This mechanization of our existence led to a second stage in the philosophy of technology with great figures, who, from the 1930s onward, have analyzed this theme with unparalleled depth. Mumford, Spengler, Heidegger, Jünger and Ellul, followed by Habermas, left behind dazzling writings, which are, however, sometimes misunderstood and unfortunately forgotten, while the technological phenomenon plays a key role in our existences. The age defined by the philosophy of technology results from a rapid historical development that produces an unprecedented situation in history. Men have used machines, but if we think that they have taken hold of them, the opposite is equally true: machines have taken hold of men with their quasi-magical and captivating power. The same goes for war. We say that men take up arms, but also that men are conquered by arms. This allows us to bring together these two fields, war and technology, by means of a phrase by Gabor, the inventor of the laser: everything

that can be done (from a technological point of view) will be done. Technology's hold on men was Ellul's central theory, according to which technology is no longer controlled by men and evolves autonomously as if it produced its own purposes independently of the goals established by human thinking. Heidegger's famous phrase about science is quite apt in this context. I will gladly paraphrase it while also completing it: technology doesn't think, it advances!

Therefore, we are surrounded by this Technology, which has become not only a tool but also the specific feature of our anthropological environment, like a second nature superimposed on the cosmos and conceived as a technocosmos. This is why philosophy felt affected by this Technology, which evolves according to its own purposes. It is insofar as Technology brings about changes while also being the product of its change that we need to concern ourselves with this universal phenomenon that determines to a large extent our future. Technology seems diabolical in certain respects. It leads us to adapt ourselves, and it no longer necessarily produces progress in the sense established by the Enlightenment thinkers and those who have followed.

1.1.4. *Information affects us*

Technology has become second nature for us, but it still has not been completely understood in its philosophical sense, especially its metaphysical dimension. It took a long time for thinkers to concern themselves with Technology, occasionally making it the central theme of a work. The contemporary philosophy of technology began when Technology took hold of men, who do not know whether it will come to an end and, if this is the case, when we will be done with it. Philosophy is now concerned with another equally important issue, which, however, has not been at the center of deep thinking. The issue of the 20th Century is information, in every sense of the notion. Information goes hand in hand with communication!

Why does Information affect us now as much as Technology did a century ago? We could state this in a phrase. There was a time when men sent information and picked it up to make "good" use of it. Currently, the opposite has happened. We are picked up by Information. Information is an ingredient that drives our cognitive life, which is not related to the contemplative life of the past. In our age, communicating requires cerebral activity, even when this activity is passive, which is an oxymoron. Therefore, let us mention how man is mobilized by and for Information by recalling this TV manager's famous phrase about how TV programs use our brain time. Besides being controlled by Technology, we are picked up by Information.

Man has manipulated information and talked and communicated with signs and languages for tens of thousands of years. Animals also communicate with natural communication instruments. The new Information situation relies on the way information is transmitted. For a long time, men have communicated by using material media, with paper and books used to disseminate texts and images, without forgetting the architectural works and artworks situated in public places. Consulting books or seeing artworks allows us to develop a thought or to access a sort of intuitive, not to say contemplative, knowledge. In our age, Information tends to become a consumer product just like any other. Receiving information has become an activity that is no longer chosen or specifically targeted but semi-automatic, like the inopportune use of Technology. As soon as a machine is available, we use it; as soon as a piece of information can be accessed by the brain, it is received; conversely, several pieces of information that reach the brain are disseminated publicly through flat-screen TVs, blogs, smartphones and social networks. Regardless of the content, it is the information sent that represents the message. The shift from analog to digital has enormously increased the possibility of communicating.

The expression "talk for talk's sake" makes perfect sense in our age. Communicating and informing without sharing anything. Little by little, we are becoming a product of Technology as well as Information. Man seems like a machine of a communication system that has been left behind. Thus, the technological field has widened to

include those technologies that transform information through digitization, as well as dissemination and calculation technologies. A digitized piece of information can be manipulated by a computer. Classic material media (books, vinyl records) now include digital tools, USB drives, digital CDs, hard drives, or RAM. The cables used to supply electricity to power machines and light bulbs in the 1900s are also used to transmit digital communication, which reaches households and is converted into analog information when we listen to a CD, read a text on our screen, stream a movie, and watch it on DTV or with a DVD player.

1.1.5. *Where can we situate a philosophy of information?*

As we have quickly explained, Information with a capital I represents an issue of a cultural and political order faced by the 21st Century, besides constituting a philosophical challenge. The idea of a philosophy of information is not very widespread, but it appeared on the radars of intellectual circles in the early 2000s. Luciano Floridi, a philosopher, was presented as a pioneer in this specialty. However, if we pay attention to this philosopher's intentions, we can legitimately think that the philosophy of information put forward lacks in scope, as it considers computers and information technologies, which, despite certainly affecting our existences, do not exhaust the richness of a broader reflection on information with two lines of inquiry. The first one is based on physics and information from a natural and metaphysical point of view. The second one follows on from Ellul's writings with this issue, which had already been put forward by technology: is information neutral? Or does it deeply change the nature of the man who uses Information but also becomes in part the product of this Information itself?

Browsing the Internet, we can find an extremely well-documented website used as a portal dedicated to actors who are more or less related to the philosophy of information, with two thorough lists that bring together philosophers and scientists, as well as several instructive notes about this subject, which a few decades ago was in its early stage and defined as ergodic philosophy by english-speakers until the 1980s. Nowadays, the notion of philosophy of information

has solid foundations in the field of knowledge. The fact remains that we still need to understand what it deals with and which are the key issues regarding Information.

The presentation of this website, called “information philosopher”, is clear. It starts from a well-defined principle involving the use of the tools and objects of Information to answer major unsolved philosophical issues. If we base our reflection on Information, how can we formulate and then shed light on the “classic” problems of ancient and modern philosophy? This “research program” suggests that Information is a tool used to solve major classic questions such as freewill, conscience or the interaction between body and mind. However, this program is not unambiguous. It mentions research of an ontological or metaphysical kind about information in the universe as well as in matter. This presentation of the key issue related to Information is developed in two ways, with an epistemological and ontological approach that will be bottom-up if we are trying to shed light on the philosophical and existential field with bottom-tier elements – quanta, information, atoms, and so on – or top-down if conscience and the living world are used to understand what happens in terms of matter and fields (of influences, information).

The philosophy of information covers several domains of knowledge: the relationship between man and the information manipulated, which also manipulates, or information in nature as it takes shape in quantum matter sciences, as well as the cosmos, and information as a central notion in the key metaphysical issue of the essence of the universe, Being and Time. The philosophy of Information completes the philosophy of Technology. Men have to determine two essential components, namely technological activity and the conscience emerging with inputs of information that organizes itself and is reflected. This anthropological configuration is in line with the century-old ontological configuration developed in many ways, elaborated and conceived by Descartes: matter and mind, will and representation, action and conscience. Now that modern sciences are nearing completion, a two-branched structure will take shape across the two types of physics, on the one hand pivoting on mechanics and on the other hand dealing with communication.

However, we should not forget the issue of the living world, which I have personally tackled by conceiving a technological substance and a cognitive substance. One acts in matter, while the other arranges the information received, with the issue of perceptions linked to the purposes.

If the philosophy of Technology lends itself to a universalization process, the science of machines cannot replace a philosophy of Technology, which studies the relationship between man and machine, as well as natural technology, which can be found in living systems, molecular assemblies and matter. The philosophy of Information will follow the same path. The science of information cannot replace an authentic philosophy of information, which, among other things, links conscience-related phenomena to quantum processes, matter transformations and the gravity-quantum order that governs information.

1.1.6. *The two philosophies, technology and information*

To conclude this general presentation of a "philosophical path" for the 21st Century, I will come back to the two-fold fundamental structure that links Technology and Information while also distinguishing between them. Scientific and technological progress has built a new world that, in order to be understood, requires a radical revision of the fundamental philosophy we have called ontology or metaphysics. The world shaped by men has given birth to a second artificial nature, the technocosmos extended by the mediacosmos, which includes all the forms of communication as well as the numerous connections between the so-called connected systems and now "objects". After the era of the philosophies of technology (1830–1970), we have now entered the age of the philosophies of information. These new types of thinking do not invalidate the previous ones, but they complete them, all the more so as information is disseminated thanks to technology, which always incorporates a minimum of formal cause.

The technocosmos and the infocosmos are complex questions to think about. However, if technology and information have become "second natures", it is because Nature contains technology and information (without forgetting the arrangement of things governed by Gravity). If men are affected by technological devices, we should not conceal the knowledge of Nature, which, well before the advent of the technocosmos and infocosmos, has developed through the evolution of the living world, including natural technologies as well as communication and cognition (see Dugué, *Le sacre du vivant* [DUG 14]). Life is technology and cognition. Finally, the physical world of matter and the cosmos can also be seen from this double perspective, with a classical kind of mechanical physics and a contemporary type of physics of information, especially quantum dynamics.

The two philosophies of Technology and Information concern not only men but also the natural world, raising in an unprecedented way the issue of the philosophy of Nature in the 21st Century with an interpretation, and even an extrapolation, of the results and descriptions found in biology and above all in the three kinds of contemporary physics: quantum, statistical and cosmological. The new philosophy of Nature will share some characteristics with the one that preceded modernity, but it will attribute a central role to Information, which, if it has "taken over" the theories of physics, should provide a new vision of nature that goes beyond its classic concept inherited from the 19th Century with forces, fields and energies. This vision is emerging from the perspective of a cosmos and matter arranged and ordered to communicate information and most importantly to create it and organize it. The arrow of time complements this creation of information, but before considering these elements, we should answer a question.

1.1.7. *What is information?*

Philosophical thinking still cannot grasp information, which, however, is constantly disseminated everywhere, in different shapes and several formats, whether natural, physical or technological. Technology also manipulates forms, but it acts on media with a given

extension – bodies and volumes – thus fashioning assemblies and arrangements. There is a fundamental difference between a technological operation and a transmission of information. A technological operation is carried out in relation to a material interface in space and within a temporal context. Information penetrates a system and is memorized, but this memory is managed so well that information may become effective, but not necessarily. When this is the case, a certain amount of extra time is often required. Information is intertwined in a cumulative process or it is combined and organized together with other pieces of information. "I point out once again that we are affected by information in the natural world". Information is sent and received, and it changes. A complex natural system organizes both its expression and perception with a dynamic link between the system and the forms, as well as a process involving handling information that changes during a rich existence in an environment that is open to experiences.

It is difficult to provide a definition of information. On the most general level, a piece of information is a mathematical element associated with a dynamic element. It is also that which can modify the inner state of a system or even a simple material element. Let us try to develop in outline the notion of information according to different ontological fields, including, for each of the five sections presented, a philosophical and scientific research program:

1) Physics: the dynamic nature of information is universal. This characteristic has been discovered on the basis of quantum physics, with the photoelectric effect as an elementary informative process. However, photons are not the only mediators of information in Nature, as molecules can communicate when they come into contact with a receptor. A liquid medium with ionized water constitutes a good environment communicating thanks to the circulation of the proton H^+. Then, we can climb up one level in the hierarchy of beings and consider communication on a cellular level with the linking mechanisms that describe the interaction between molecules communicating their membrane receptors situated at the periphery of living cells. We find here the image of the key and lock, except for the fact that the process is dynamic. Molecules vibrate, as quantum dynamics teaches us.

2) Biology: Information takes on a specific meaning when it allows animals to perceive their surrounding and to communicate, without forgetting plants and mushrooms, which also communicate by using chemical substances. It is then in relation to man that information becomes quite peculiar, with formal signals, whose interpretation and expression are reserved for this species only. The philosophy of Information can also be developed from an evolutionist perspective. The information system evolves with species, but species also evolve thanks to information. This second possibility opens new perspectives for research in the 21st Century. Life plays not only with the types of communication used by species in the environment, but also with molecular kinds of communication that are invisible to animals and men, who, however, have been able to uncover some of these unperceivable communication mechanisms, especially viruses.

3) Social sciences: Information also has certain significance in the field of social sciences in relation to language, which, according to Spengler, was perfected 5,000 years ago in the service of great human enterprises, and civilizations. Then, the agora era arrived. We are still in line with the issue of public space structured by the semantic information vehiculated by language, which was pertinently analyzed by Habermas. Science and technology use language with the aim of building a "Faustian society". Philosophy's long-term goal is a society of judicious people founded on an interpersonal usage of language. Another issue is represented by the question of the performative, which represents the effectiveness of communication and can be found in not only speech acts but also image acts.

4) Ontology: Plato's Ideas fit into the philosophy of Information, memory and reminiscence. Plato leads us toward a true ontology at the cost of a wrong teleology. In truth, Ideas emerge with time as time approaches eternity. Being is time that has rejoined eternity. Idea as a synthesis of information, Concept as power of development of arrangements. Other "ontological" developments are in sight. Here are some suggestions. Dialectic between Idea and Concept, or between finality and effectiveness. Idea, Platonian world, Concept, world of the soul. Idea, global, Concept, local, thinking activity, conceiving the world, arrangement. Ideas, Concept, Percept.

5) Theology: Information affects theology. What is the Revelation if not a set of pieces of information provided to men by one or more "authors" who do not all agree with one another? However, no one can deny that the Scriptures have a recognized meaning and were written by men who are the authors or "messengers" if we admit the "divine" origin of the Revelation. Maybe we can also regard the Trinity as a way of grasping Information in terms of a Mystery.

1.1.8. *Universal thinking*

We have only caught a glimpse of this immense line of thinking that, developing between technologies and information, leads us toward this new paradigm pivoting on a new alliance between men, the cosmos and nature. There is a possibility that we will discover in Nature, and even in matter, a feature of information that shares some aspects with the "performative" discovered in human communication. However, it is tricky to grasp this quasi-performative feature, as Nature in some sense lies hidden, whereas science must be equipped with adequate methods to uncover these phenomena.

The performative character of information will lead us toward what Heidegger had glimpsed in his analysis of technology and its essence, which has nothing technological about it. What is this essence and can we establish a connection or a secret complicity with information? This inquiry will play a significant role in the universal philosophy of information. However, we will have to start questioning the physical sciences to discover where Information is situated, which are its features, where it goes and for which goals it is used. We now know that information is by no means fixed or static. The universal philosophy of nature conceives any piece of information on a dynamic level and every type of communication takes place with resonance as its inherent trait. Resonance fueled the controversial theory of Luca Turin, a specialist in olfaction and a supporter of the hypothesis of the dynamic interaction between odoriferous molecule and its cellular receptor. On the other hand, the conventional hypothesis is based on form or, in other words, the key-and-lock paradigm.

An overview shows that not only physics but also philosophy is falling in line with a way of thinking where Information is a central notion that develops differently in relation to the goal established as well as the way of studying it. Information, with its central role, tends to be given as much importance as energy and forces in classical mechanics. This remark also holds true for philosophy, once again in relation to the issue of information, which is gradually becoming more central in the humanities. Information is considered from its several perspectives: communication, performation, transformations of conscience and organization of a collective semantic and semiotic space. A general overview allows us to locate a "modern philosophy" centered on the themes of will, action, political power, historical forces and Marxism, which will be succeeded by a "postmodern philosophy" that will distance itself from societal forces while also focusing on the importance of communication, forms and information sent, as well as on the abilities of aware subjects with the potential to think, project and find their place, while also considering the world and the environment to semantize and interpret these data. The issue regarding the order and hierarchization of information is central, all the more so as hierarchized and semantized information acts as an efficient core that causes phenomena with a shape and organization.

1.2. CRISPR-Cas9: from mechanism to information in biology

Biology also makes us question information. The presentation of a recent and publicized discovery leads us to think about the informational turning point faced by science at the beginning of the 21st Century.

1.2.1. *Brief review of a significant scientific discovery*

The meaning of the world can often be spelled out with clichés and other set phrases, some of which have become classic. However, clichés are not enough. We must therefore concisely describe the significant developments and breakpoints in the determining sectors of

existence, such as art, politics, philosophy and science. If the reader follows the media, he or she will have probably noted that a recent scientific discovery has spread in newspapers and on TV shows, followed by the appearances of Emmanuelle Charpentier, one of the most prominent scientists since the development of a tool for genetic engineering with a mysterious code as its name: CRISPR-Cas9. This tool is there for a reason. It is the result of studies carried out on the information mechanisms of the rudimentary cells named bacteria. This research is in line with the information paradigm that the author is trying to outline by covering different knowledge domains, from physics to society by way of biology.

The CRISPR-Cas9 designates a molecular system found in bacteria, whose function is broadly known, which has, however, been tweaked so as to make it an effective tool in the field of genetic engineering. The CRISPR system was discovered around 25 years ago in a Spanish laboratory by Francisco Mojita during his PhD studies. Strange and nearly palindromic sequences separated by sequences called spacers have been detected in a type of bacteria. A palindrome is a series of letters that reads the same backward as forward. This property allows the transcribed RNA to form 3D ribonucleic structures with the base pairs. These structures, such as hairpins, are sometimes involved in mechanisms of DNA nicking. The discovery of CRISPR sequences was published in 1993. It took two decades of research and several contributors to meet two goals, only one of which was expected.

The first goal involved trying to find out the role of these sequences, which turned out to be the elements of a complex immune defense system used by bacteria against intruders, essentially viral phages and plasmids. Briefly, a bacterium incorporates the viral sequences into its genome. It acquires a sort of genetic memory that will be used to fight against the next exogenous infection. The mechanism is fairly complex. It uses several proteins that can destroy the viral DNA by using a complementary RNA matrix that targets the sequence to eliminate.

The second objective had not been predicted at first. Emmanuelle Charpentier was involved in this research on the mechanisms of the CRISPR defense system, which can be of three kinds and mobilizes "Cas proteins". She wondered whether this mechanism could be used to carry out specific cuts in any kind of DNA, from plants to mammals, including insects and other species. By using the type II related to the Cas9 protein, she met her goal by collaborating with another expert in molecular genetics, Jennifer Doudna. These two scientists have been rewarded many times since 2013, while laboratories all over the world have entered the race and are publishing quite convincing results. Virtually all living genomes are cut by this high-precision molecular tool, which does not innovate in relation to its principle but turns out to be much more accessible and practical than former restriction enzymes, for example, zinc finger nucleases. The CRISPR-Cas9 system works by using an RNA that corresponds to the gene we wish to cut. In order to understand this achievement, we should imagine the former system as a CD that requires a player to be read. However, every time a new CD is used, the player needs to be changed. Thanks to the CRISPR-Cas9 system, we only need to adjust the CD, namely use the RNA that allows us to target the DNA sequence we want to nick.

1.2.2. *From Monod's biology to information biology*

Does the discovery of the CRISPR-Cas9 system mark a new stage in biology or is it merely a conventional but impressively effective molecular tool? In the latter case, we would be facing a situation like the development of computers from the bulky IBM computers programmed with punch cards all the way to present-day PCs. In the former case, however, this discovery could fall in line with a new paradigm and provide a symbol or an emblem of it. If we look back 50 years, we can find some evidence of the changes in the scientific and modern notion of the living world (post-vitalist).

The 1960s mark the booming of so-called molecular biology. Monod and his colleagues discovered "molecular mechanisms" present in cells. These discoveries confirmed the mechanistic notion of life with the key concept of feedback. The lactose operon is one of

the first gene regulation mechanisms highlighted, and it represents the most famous example of gene regulation in bacteria. Lactose is a nutrient that a bacterium can metabolize, provided this element is present in the culture medium. If this is the case, the bacterium must synthesize the enzyme required for the metabolic process. If lactose is not present, a repressor prevents the gene from being transcribed to provide the RNA coding the enzyme that allows digestion of lactose. However, when lactose is present, a subtly adjusted mechanism makes it possible to suppress the repressor. Thus, the gene is activated and transcribed. Lactose will be metabolized.

The mechanism related to the operon works according to the principle of the thermostat invented at the end of the 19th Century. A thermostat uses a bimetal system that changes shape in relation to the temperature. Once a temperature threshold has been crossed, the position of the bimetallic strip changes and it is no longer possible to make contact so that the switch cuts the power that supplies the heating system. Once the temperature goes down, the bimetallic strip returns to its shape and allows the switch to activate the heating once again. The thermostat principle gives us a simple idea of how cybernetic systems, for example, those that can be found in a self-guiding missile picking up space information and correcting its course in real time to reach its target, work. Cybernetic mechanisms are quite widespread, whether in manmade machines or in natural processes, regardless of their scale. Moreover, natural mechanisms adopt another principle, which involves shape adjustment and changes in configuration. These mechanisms represent the foundations of allostery, another discovery attributed to Monod and his colleagues. When an oxygen molecule binds to hemoglobin, the configuration of hemoglobin changes so that the second molecule can bind more easily and so on. Shape adjustment mechanisms also enable molecular communication with the key-and-lock principle, which explains how a molecular mediator binds to its related receptor. This is the case for adrenaline, which, by binding to the adrenergic receptors of cardiac muscle cells, increases the heart rate.

Adjustment also works in immune processes, which, in vertebrates, use a group of molecules called immunoglobulins, commonly known as antibodies, which bind to antigenic determinants present on pathogens like bacteria or viruses. Antibodies are a sort of collection of figures that allow us to determine the identity of an organism and to detect what is foreign to its identity, which represent a potential threat in case of invasion and diffusion. This library is coded by a set of genes that form a complex (HLA in men) and can produce several antibodies thanks to posttranscriptional mechanisms such as RNA splicing.

Half a century after Monod, the use of bacteria constitutes the basis for a significant discovery as well as a Nobel Prize seemingly acknowledged by the observers of scientific life. These details are quite clearly anectodical in view of the scientific issues at stake, which, in order to be understood, require us to refer back to the remarks made in the last two decades about the distinctive nature of the CRISPR-Cas9 system, considered as the basis of an immune mechanism inherent to bacteria, whose characteristic is that it keeps a form of immune memory by incorporating the viral sequences of the phages or plasmids found by a bacterium during an infection. It is these sequences that are inserted as “spacers” between the palindromic patterns.

Let us now try to situate these immune processes in the framework of a paradigm by playing with the appropriate metaphor for this situation. In other words, if the lactose operon makes us think of a thermostat, which technological object could be associated with the CRISPR-Cas9? My suggestion is to use the image of a CD that contains the viral sequence and that we suppose to code music sequences like a digital CD playing, for example, a symphony by Mozart. A bacterium contains a genetic heritage that we can imagine as a set of scores written by Mozart. Now let us imagine a phage whose CD plays Johnny Hallyday. The bacterium hears Johnny and recognizes him as an invading element. Therefore, it integrates this CD into its databank as a “spacer”. It is not even necessary to copy the whole disk, Johnny’s voice is enough, as the “spacer” is just a partial recording of the viral sequence of the bacteriophage made by the

bacterial genome. When this bacterium encounters Johnny's CD a second time by "hearing" his voice, it decides to deactivate the information contained in it and, in order to do so, it elaborates a copy based on the "spacer", which, by binding to the Cas9 protein and another factor, will be able to deactivate Johnny's CD before it can reproduce in the bacterium and sing so loud as to destroy the bacterium.

This metaphor, where the CD player and the music bank recorder represent the DNA, inevitably falls in line with a paradigm, namely the paradigm of information. However, this paradigm will only very slightly resemble a biological interpretation in terms of information such as it was elaborated by Henri Atlan by using Shannon's theory. A bacterium is known as a metabolic regulator. It is in this sense that it colonizes our digestive system while allowing it to work correctly. The CRISPR-Cas9 system attributes another function to the bacterium: the regulation of genetic information involving viruses. We still need to determine the complete features of this function, its role and why Nature has developed such a system.

Recent works have highlighted a CRISPR system in mimiviruses, which are some of the giant viruses studied by virologists. The authors of this study conceive the CRISPR-Cas system as an immune system developed by this very complex virus in order to prevent an exogenous element, the Zamilon virophage, from parasitizing it. More precisely, a system similar to CRISPR has been found on the A line of mimiviruses, which is exactly the line withstanding the attack of the Zamilon virus, unlike lines B and C. We can legitimately think that the virophage is likely to alter how mimiviruses work by disrupting their system of information management, and that a virus line has been able to counter this invasion. This suggests that viruses have a purpose that concretizes itself by managing to mobilize this immune defense against a disruptor that is semantic rather than physiological (a bacterium in an animal). The giant virus tends then to keep its information and defend itself against information elements that these mechanisms detected as undesirable. This strange world seems to conserve the internal structure of its semantic organization in the same way as we humans pay attention to language and to the

different words and signs that make it up. However, just like our language can incorporate new words, viruses, bacteria and even all organisms can integrate genetic elements that allow them to increase their information heritage.

Here we are on the verge of a universal hypothesis: is information in biology a means or an end? This is a major philosophical issue and a broad line of inquiry. What is the purpose of the living world, provided there is one, and what is the role of information, on condition that we can rigorously conceive what this information is on a phenomenological level, as an element that is sent, and on an ontological level, as that which governs the organization of information, since it is made of the same "ontological block" as the information that is sent? Ontology and phenomenology are two philosophical concepts that have a bright future with the advent of information in biology as well as in physics.

As usual, science offers two paths. One involves technological designations, tools and instruments that make it possible to reach objectives, make things become a reality and carry out several operations to obtain results as part of a project. It is this path that has been followed by all technological inventors and, in our case, by the technologies that allow us to nick DNA in relation to the sequences chosen. The other path is in the service of knowledge. If it complements the first one, it also frees itself from technological needs to go down the road of philosophical reflection about the how of things and above all the "why" and the what for or, in other words, the origin and purpose of things. The CRISPR system makes us face up to the enigma of life and encourages us to think about the existence of this so-called genetic information, which plays a central role in the universe of bacteria and viruses. Don't these mechanisms of immune defense, at play in viral nucleic sequences, suggest a sort of competition in relation to information, involving molecular assemblies that are not even alive in terms of autonomy, as viruses need living organisms to replicate?

Monod wrote “Chance and Necessity”, a book where he presents his ideas about nature and the place of Man in the universe. A new book will have to be written. It will be based on the results obtained in physics and biology with discoveries pivoting on information. A “passage” between two scientists like Monod and Charpentier. We move from a biology of mechanisms on to a biology of communication. Which will be the new worldview, when we know that the mechanistic (and atomistic) paradigm is losing ground in favor of a notion of Nature centered on information? “Informed chance” or “the communication and necessity of the path and the destination”? We will find this communication as an element that allows us to analyze some features of human societies and, in the last chapters, we will remark on how physics, like biology, is jumping from the era of mechanisms to the age of communication in matter and the cosmos.

1.3. Toward a theory of the information act

1.3.1. *Image act, the power of images*

Information is essentially a mediation, something shared, a formal content sent as part of a type of communication. Information employs a technological environment, but its effect is not immediately technological since, by technology, we mean a process that involves matter, mechanical – and even electrical – forces, with spatial and temporal boundaries. The technological effect is immediate, but we can see how the effect of a piece of information may be postponed or delayed, as this information is memorized and remains latent and apparently inoperative, while actually growing, becoming intertwined, mixing and becoming involved in the genesis of a formal and cognitive system that produces semantic and organizing processes. A click on a screen allows us to send an instruction to the Internet server, which in turn sends signals to the computer, and the page requested is displayed. This is an instantaneous electric effect. The brushstroke of a painter concretizes itself as a colored trace on the canvas. The effect is instantaneous and mechanical. The same goes for a sculptor who, in order to create his work, hits on the chisel to take off a piece of marble. The shape of mushrooms in a forest is memorized and the

effect of this information will be effective for a few months or years later, in this same forest or in another one. A piece of information written on a hard drive will be reactivated, but thanks to an artificial program, whereas finding a mushroom has nothing artificial about it. These remarks have spelled out some properties of information, which sometimes follows meandering not to say enigmatic or secret paths. The environment of communication surrounds us and affects us in relation to our cognitive or gnoseological constitution, which will determine a psychological reaction and, if appropriate, a mechanical one when receiving information. For example, perceiving a danger will make us flee instantly, whereas looking at a Rembrandt will kindle a spiritual emotion and keep our eyes fixed on the canvas.

1.3.2. *Thoughts about Horst Bredekamp's study, the theory of the image act*

Information plays a specific role according to the nature of who conveys it and who receives it. An atom receives a piece of information from the radiation field and alters the shape of its electron cloud. An image used (and sometimes subtly fashioned) by men has a certain influence that was for a long time ignored by philosophy. This is exactly the topic of Horst Bredekamp's book, in which, by analyzing 200 images covering several thousands of years, he conceived the theory of the image act by following the theory of the speech act elaborated by Searle and Austin, which may be summed up in this famous phrase: to do things with words! In other words, language can in some situations claim a performative effect. The fact of speaking leads us to do what we have said. What has been discovered to be performative in language also exists in relation to images, whose power is acknowledged, as is shown by the recurrent controversies about iconoclasm in the Byzantine or Protestant period. The force of images is conceived thanks to Bredekamp's learned inquiries [BRE 15].

Performing and informing are two complementary notions. Informing means, in relation to one of its several etymologies, providing an "internal form" that enables a supplementary ability to act. In this sense, performing means providing a form that sets off one

or more actions. The prefix "in" represents an internal dimension. The performative effect also assumes a linguistic penetration in the subject, where it exerts a type of effectiveness remarked through the acts of this subject. The theory of the image act also describes a penetration of the image into the subject. The image is both a form and a type of dynamics, defined in the introduction of the book as *enargeia*, a name borrowed from Aristotle's poetics, meaning a being in action. Thus, language produces an effect. It perfectly simulates an embodied presence. It is this presence itself that will be at the center of a thorough inquiry that aims to uncover this "embodiment" emanating from the image. Language enounces and images do too, but with a specific semantization unlike that of language or music. *Enargeia* also means persuasion. The speech act must be persuasive. A performative image must convince the viewer of its power to influence, the presence that inhabits it and the interior life it embodies. This vision is perfectly in line with the common thread pointed out previously in relation to the concept of information from a perspective that is both formal and dynamic.

Therefore, images have an influence. They exert power or rather a force. A sentence by Leonardo da Vinci spells out with unparalleled depth the ambiguous and undoubtedly secret, nearly magical, interplay that develops between the inhabited imagine and the viewer. An individual keeps his freedom if he covers an image, or he must draw a line under any form of personal free tendency by exposing himself to the influence of this image (p. 13). People have expressed reservation on the force of images, which involves a magical line of thinking that, as we know, does not agree with the reason of the Enlightenment and modern science.

Is an image, in the manner of technology, like Janus, exerting a double influence? According to Plato, images represent the foundations for thinking and action but, on the other hand, they conceal the truth. Plato was not hostile to images in the service of civilization, but he feared those that had the potential to disrupt the calm of the social order (p. 34). Behind images, we can find the obsession of an influence that philosophers cannot bring under control. Bredekamp has undoubtedly read book X of the Republic, in

which Plato suggests that we sideline poets, as they spread a poison for the soul and disrupt the good use of reason. In the contemporary period, Heidegger dealt with images by peculiarly thinking about the ambiguousness of an artwork in relation to the triggering of effects, while also acknowledging the unshakeable and secret nature of some works, which we cannot bring under control. Lacan will be even more distrustful and engage in an excessive protectionism. Lacan takes away from artworks their power to provoke, thus favoring works that are markedly soothing. We need to guard against the objects' look (p. 39). Lacan had uncovered this game of mirrors, where the "viewer" of the work is also looked upon by the object. In the end, an image is ambivalent. It represents a mediation between the subject and himself or it is used as a means of structuring a collective space. Through images, the people of a community participate in a form of communion that unites them by means of an immaterial link.

After these general considerations, Bredekamp invites us to understand three categories that allow us to classify image acts according to a structural, participative and dynamic mode that determines the link between the work and the subject that is influenced by it because, if an image has a certain force, it will produce different effects according to the "power relation" it faces. Rather, we may refer to an influence or force relation. We always need to keep in mind that an image act involves two apparatuses, that of the viewing subjects (or onlookers) and that of the images. The movement of the force will then be centripetal or centrifugal, outward- or inward-looking. The theory of the image act plans to investigate the origin of the power of an image, formerly regarded as the effectiveness of a Godly power and then hidden during the Enlightenment (p. 91). This question will not be solved in Bredekamp's book, but the solution can be seen in the three categories to which image acts belong:

1) In the schematic act, the life of the image is uncovered with a process where a subject seems to transfer some force to the image, which becomes animated and endowed with the essential attribute of life, which is self-movement or, in other words, animation.

2) In the substitutive act, an exchange between body and image takes place. This exchange does not lie in the assimilation between a body and an image, but it relies on the traditional ambiguity involved in considering the body and one's image, despite being separate, as the same thing.

3) The intrinsic act relies on the force of the form on subjects. A good example is the press conference held in February 2003 at the UN headquarters a few weeks before military action was carried out in Iraq. The American delegation had the reproduction of Picasso's *Guernica* covered with a blue veil. This is proof of the belief in the power of images and how some people attempt to protect themselves, even if this means that their behavior appears grotesque, which is what happened during this iconic farce taking place at the UN.

It is the second category, which involves the exchange between body and image that explains most clearly the image act while also representing an issue for our age. Images and bodies have been trading places for centuries, participating in the societal game of veneration and admiration or, on the contrary, of punishment and aggression. In the body-image substitution, the image destruction is lived as an attack to bodies and, therefore, as a physical aggression. The Huguenots' iconoclastic destructions had a warlike aspect, representing a retaliation against the physical violence of the Catholic groups. Another method aims to show men as images as they have been killed. This process has been recently reversed in the last century. Men are killed in order to be used as images. We will then think about the executions filmed by the activists of the "Islamic State" group in Iraq and Syria. In History, images have been used to win the support of contemporaries. Nowadays, other images are used to create a state of fear. The image act produces a reaction to the "things" shown and seen. "The destruction of works and lives makes it possible to create active images supposed to legitimize a long-term strategic action" (p. 210). Images spur action as substitutes of individuals and, conversely, they strengthen figures in relation to their functions performed through images. What should we think then of the republican tradition of displaying the image of the president in city halls, which is so dear to France? An image is a form of energy that conveys a form, or a form that acquires energy. A substitutive image

act is an information act that produces changes in the state of the acting subjects. The cartoons of Mohammed in a Danish newspaper have caused violent demonstrations in the Muslim world.

In the living dimension of an image, energy is transferred from the subject to the object. In the substitutive act, a double movement takes place: the body moves into the image and the other way around. In the third case, it is the form of the image that affects the spiritual energy of the subjects, to the extent that it becomes a force that inhabits them and entails a defense reaction, if it is necessary to protect oneself. Could we claim, by paraphrasing the phrase related to speech acts, that it is possible to do things with images? With the living dimension of the image, "showing" becomes intention. We look at the sword shown on its effigy and we grab it to make use of it. With the force of the image, we are simultaneously "created" and overcome by the image. Hence, the mirror phrase: "looking means being created". We are captured by the image and, by extension, by the information spreading in the mediacosmos.

Thus, the theory of the image act shows how an entity of the world of information transforms itself in the subjects to become involved in a mechanism (the action of the bodies and of the subjects) or a "physical action" with its pathos when looking inhibits or creates fear or peace. This aspect is explored in the chapter devoted to the intrinsic image act. Formal structures penetrate the psyche of the subjects, who are then under the eye of the image. Bredekamp invites us to refer to several analyses on this fascination power of images, from Nicholas of Cusa to Warburg, which emanate from beings that transmit their unstable inner life to external and peripheral worlds. The process is the opposite of the one of the living image, where a living dimension is assigned to the object. In the intrinsic act, it is the life of the image that, through the dynamic game of subject and mirror, invades the psyche, overwhelming the spirit with this overabundance of pathos. Form is dominant, sometimes a talisman in several knowledge domains, in relation to scientific models, and sometimes the force of form involves a lasting impregnation of memory.

The conclusion of the image act provides the starting point of a research program, as the knowledge domains elucidated look like paths to explore. Images and their acts cannot be reduced to the ambiguous links and secret interplays linking works and men. The animal kingdom can also make use of images, and this direction represents a promising path in relation to the role of forms in the living world and its evolution. As the author has made clear, the image act interferes with natural selection through sexual selection. Males do not necessarily use force to drive rivals away. They know how to take advantage of the force of images to seduce females and obtain offspring involved in the evolutionary game of species.

1.3.3. *Language and image resonances*

The theory of speech acts dates back to the 1960s. It belongs to the broader context of the philosophies of Information insofar as an utterance conveys information or, more precisely, a performative utterance presents itself as a singular piece of information in order to possess a force that can deeply affect those who receive it. This is the case for a marriage proposal, a word of thanks, a threat or an apology. We also use the notion of word act, which is more suitable if we refer to the performative process. A word is not just any linguistic formulation. Giving one's word is a process involving two parties. The effectiveness of a word act relies on a cognitive process by which the subject resonates with the semantic content of the utterance received.

Resonance also plays a central role in the outlined analysis on the power of images provided in the conclusion of Bredekamp's work. The viewer himself will also be either receptive or insensitive to the force of the image. This link between subject and image is dynamic. It is based on the form of the image seen and the activity of the viewing subject. It is a mirror game between the external form of the image and, to use Kant's terminology, the inner form that resonates with the image. This dynamic game gives us the impression of entering the image, of transfixing it, or of being somehow seen and inhabited by the image.

At this point in my reflection, I think that this mirror game is in line with the quantum phenomena described in the following pages in a monadological context: two waves resonate and seem to be one the mirror image of the other. Another more striking correspondence takes shape with the theory of the chemical orbitals. As we will see, an anti-bonding orbital (which "electronically" links two atoms) can be interpreted as a high-energy and therefore unstable link, caused by the phase opposition between the two atomic orbitals, whereas a bonding orbital is more stable, since there is a phase effect or, in other words, in terms of monadology, the atoms linked by bonding orbitals "look" at each other and communicate while atoms linked by anti-bonding orbitals turn their back to each other. From this point of view, the resonance that produces the image act can be interpreted as a communication relationship between the subject and the image, with the feeling of being looked at, or even inhabited, by the image. Co-penetration and bonding relations characterize the image act, whereas an anti-bonding relation sets apart the subject from the image, both facing each other but not communicating and even ending up driving each other away with aversion.