THE POET JOHANN WOLFGANG VON GOETHE (1749-1832) AS A SCIENTIST AND THE SO-CALLED "NEW PARADIGM OF THE SCIENCES"

Otto Doerr-Zegers* and Héctor Pelegrina Cetrán**

The great German poet, dramatist, novelist and politician Johann Wolfgang von Goethe (1749-1832) was also a very original scientist. The principles he defended were in a way opposite to the prevailing science, fundamentally empirical, analytical, and aiming to reduce the observed, if possible, to mathematical forms (*Naturwissenschaftliche Schriften*, ***NWS***, Volume I, pp. 527, 528). Goethe, a great observer of nature since he was a law student in Leipzig, was not submitted to the rigid methods of objectifying research but tried to integrate his scientific-natural knowledge in his personal and wider view of nature and of the world. Some of his verses and/or fragments constitute examples of this integrating view, like: "If the eye were not sunny, how could we perceive light?" (*NWS*, Volume I, p. 20; Theory of Colours, 1840/2000, p. Iiii), or "There exists a delicate empiricism, which can be so identical with the object that it becomes an authentic theory" (*NWS*, Volume II, p. 723).

But what he has done is not a kind of poetry of nature. It is rather essential to acknowledge that he featured all the characteristics of a scientist: he was perseverant, he had knowledge of specialized literature, he carried out experiments himself and interpreted them reasonably well, he incorporated adequate means of investigation and, finally, performed oral and written communication of the results obtained. This is particularly applicable to his studies about light and colour, to which we will refer later. As guarantors of this scientific side of Goethe we can mention the physicist Johann Wilhelm Ritter (1776-1810), with whom Goethe studied the fluorescence phenomenon produced by ultraviolet rays; Wolfgang Döbereiner

* Department of Psychiatry East, University of Chile, Santiago
Center of Studies on Phenomenology and Psychiatry, Diego Portales University, Santiago de Chile
** Autonomous University in Madrid

(1780-1849), with whom he carried out experiments with the dark camera; and the physicist Thomas Johann Seebeck (1770-1831), the discoverer of thermoelectricity – the transformation of heat to electric energy – with whom he collaborated at Jena University (Ch. Cremer, 2011, p. 74). The aforementioned shows that Goethe was not just an amateur, but a real scientist.

Goethe's interest in natural sciences arose from two different sources. On the one hand, his tremendous observation capacity which had characterized him since he was a boy and becomes visible in innumerable ways, from concrete observations of nature - like those he made during his journey to Italy, when travelled through the Brenner pass and found little shells on the mountains, from which he deduced that in the past the sea must have been there (*Journey to Italy*, pp. 17-25), to statements like: "I imagine the earth, with its atmosphere, like a great living being perpetually performing movements of inspiration and exhalation…" (J. P. Eckermann, *Conversations with Goethe,* p. 197). In his Aphorisms he also insists in the importance of empirical observation, just like in his famous poetry, *Vermächtnis* (A legacy), whose fourth strophe says:

> Then you must trust in the sense
> because they will not leave you to look the false,
> if your spirit maintains you awake.
>
> With new look observe you with joy,
> while you stroll, sure and agile, by the meadows
> of a world full of richness (In: *Werke*, Volume I, p. 232).

.

The other source of inspiration of his scientific interests was the permanent contact with high-level scientists, who he knew when Secretary of Education and Culture of the Kingdom of Saxe-Weimar, a post he occupied for many years. As such he travelled around the educational institutions of the kingdom to control their functioning. At Jena University, where his soul friend Friedrich Schiller (1759-1805) taught philosophy and history, he had the opportunity not only to be interested but also to participate in studies and experiments about different natural sciences, such as geology, mineralogy, botany, zoology, anatomy and finally, the most important field for him, optics, and the theory of light and colour.

Theory of colours

According to Octavi Piulats (2010), scholar on his scientific work, Goethe was the only thinker who presented to the western culture a scientific method different to the Cartesian and Newtonian paradigm which the European bourgeoisie had adopted as the only valid. In the field of optics his starting point was the simple observation, made in Italy, that the colours from yellow to red transmit warmth and joy and those close to blue, a feeling of coldness and distance (NWS, Volume I, pp. 227-230.; Theory of Colours, pp. 339-342), perspective entirely different from that of the famous founder of modern physics, Isaac Newton (1643-1727). The latter, with his notable experiment of making light pass through a crystal prism, succeeded in reflecting the colour scale on a screen. From there he concluded that colours are contained in the solar ray, that white is the sum of all colours, and black the absence of light (*NWS*, Volume I, pp. 534 and 535). Although he was not preoccupied by the distribution of colours in the rainbow, with his extraordinary mathematical mind Newton came to state the hypothesis that each colour has a mathematical equation that should be able to be quantified in the future (Piulats, 2010, p. 6 of the manuscript).

Goethe, after studying Newton's *Optics* (*NWS*, Volume I, pp. 525-553), was disappointed, because did not consider it useful for understanding "what is" colour. "He was not interested in dominating nature, but in understanding it from itself" (Piulats, 2010, p. 6 of the manuscript). In 1790 he published the first results of his long experiments with light and in 1809, his famous *Farbenlehre* (*NWS*, Volume I, pp. 19-254; Theory of Colours, 1840/2000, pp 1-355) came out, which he considered his greatest contribution to western science, because it represented "a new paradigm for understanding phenomena" (Piulats, 2010, p. 6 of the manuscript). Goethe carried out countless and complex experiments with solar light. One of them is the following: in a dark room he made light pass through a crack till a water prism, where refrangibleness takes place, and colours are reflected on a screen placed behind the prism. Then a coloured image appeared on the upper and lower edges, and white in the middle. If the prism is placed in such a way that its transversal cut is narrowed from the upper side down, then the upper edge will be coloured in blue and the lower in yellow. Blue is transformed in violet and yellow becomes red, as they come near darkness. With this experiment Goethe realized that the border between light and darkness has a meaning in the appearance of colour. And thus, he noticed that on the upper part of the screen the mass of light brightens the darkness, and blue is produced, while on the lower part darkness penetrates the luminous mass and yellow is produced. When moving away the screen from the prism, the coloured edges, upper and lower, became wider until they were mixed, and green appeared (*NWS*, Volume I, pp. 74-76; Theory of Colours, pp. 81-84).

The above would be the subjective moment of the experiment. In order to objectify it, he spread white dust over the beam of light and observed how on the upper edge lightness entered in little threads into darkness, while on the lower edge, there where there are yellow and red, the threads show that the dark penetrated lightness (*NWS*, Volume I, pp. 99-114; Theory of Colours, pp. 106-126). His conclusion was that colour is not produced, as Newton thought, by being contained in white, neither is darkness the absence of colour, but that colour is generated by the bipolarity between the light and the dark. Colours are generated over and over again when they hit light and darkness. In Goethe's words: "Here, therefore, the movement of dark against light, of light against dark, may be clearly observed" (*NWS,* Volume I, p. 106; Theory of Colours, p. 136).

The aforementioned would also explain the "psychology" of colours: Colours placed on the upper edge, grey, violet, and blue, are colours which temper darkness and transmit passiveness, which in violet and in grey leads to depression and to lack of life. On the lower edge, however, yellow is near the luminous beam and, consequently, it is the colour of strength and energy. And red, its extreme expression, is the colour of blood, carrier of life. Bluish colours are passive and red active. That is why they impact the psyche in a different way. In the centre is green, the exact balance between light and darkness, between action and passiveness (*NWS*, Volume I, pp. 227-230; p. 774).

In conclusion, colour would be an idea or archetype which is hidden in nature and is revealed to the animal and human world in the moment when, on the edges of objects, light and darkness collide. Goethe asks us textually, when discussing Newton's optics: "Do the limits of the light and the dark contribute something to the appearance of colour?" And he answers himself: "The entire chapter of our project about colours, which eventually arise by refraction, is about showing how the limits only are responsible for the emergence of colour" (*NWS*, Volume I, p. 531). In summary, colours are a synthesis of a dialectic polarity (Piulats, p.8 of the manuscript). Beyond the quantitative vibration, colour is an ideal quality and black or dark is something constitutive and essential in the genesis of colour and not something merely accessory, as Newton indicated.

Positivist science asks for the number of vibrations per unit of time which corresponds to a certain colour and sustains that the only difference between red and green is the different wavelength. Natural sciences start from the principle that in the world of objects only quantitative elements exist and that the qualitative which the human being perceives is only a consequence of the quantitative. Goethe says that if Newton had noticed the position of colours in the rainbow and how they appear, how they are developed and how they are inverted, he would have realized that colours are not contained in the solar spectrum (*NWS*, Volume I, pp. 534 and 535), but that they arise *a posteriori* each time solar light collides with dark edges on the objects (*NWS*, Volume I, p. 106).

Goethe, however, wondered about the relationship between red and violet and how they exist in the exterior world and in the interior world simultaneously. Thus, Goethe tells us that "the eye especially demands completeness and seeks to eke out the calorific circle in itself" (*NWS*, Volume I, p. 43; Theory of Colours, p. 28). In other words, red is not just an arbitrary name the human being gives to a quantity of vibrations of light that arrives to the retina, since it awakens strength and energy not only in us, but in the whole nature. “Exterior objects correspond with interior perceptions” (Piulats, 2010, p. 11 of the manuscript). It is a dialectic (polar) relationship between subject and object and not the disassociation of both. Newton’s theory, says Goethe, would only be useful for dominating colour, but not for understanding it. When a painter paints a picture with yellow light, this colour gives joy to the canvas and cheers up the painter. And this occurs because yellow is closely positioned to light and can, therefore, be used to improve the mood of depressive people (*NWS*, Volume I, pp. 207-209).

As a maximum expression of his way of regarding the intimate relationship between the perceiving subject and the world, of this correspondence we talked about, I would like to quote some of his words taken from the introduction to his work *Theory of Colours*: “The eye may be said to owe its existence to light. From indifferent auxiliary organs of the animal kingdom, light gives rise to an organ resembling it. And thus, it forms the eye in light and for light, so that the interior light meets the exterior light” (*NWS*, Volume I, p. 20; Theory of Colours, p. 3).

Theoretical consequences of the theory of colours

Goethe carried out more experiments with light than Newton, and present physicists calculate that all his work about light and colours would be equivalent to about 200 papers published in nowadays’ specialized journals (Cremer, 2011, p. 75).

Even though his ideas were opposed to the prevailing scientific paradigm (inspired, as we said, by Newton’s postulates), they directly influenced the work of important scientists of the 19th and 20th century, as for example, Hermann von Helmholtz (1821-1894), who was inspired in Goethe’s observations for the development of his physiology of vision, and Gustav Kirchhoff (1824-1887) and Robert Bunsen (1811-1899), who, inspired by Goethe’s ideas, made one of the most notable discoveries in the history of science: spectral analysis, which, when applied to the study of the sun and the stars, opened the doors to knowledge of the chemistry of the universe. Finally, three great physicists of the 20th century, Max Planck (1858-

1947), Werner Heisenberg (1901-1976) and Carl-Friedrich von Weizsäcker (1912-2007), the first two, Nobel Prize winners, expressly recognized the influence Goethe had had in their writings. Heisenberg confessed that in the period of developing his famous "Uncertainty or Indeterminacy Principle" (1927), he spent many hours studying Goethe's scientific work (Cremer, 2011, p. 83). And Carl-Friedrich von Weizsäcker wrote: "Goethe's light is not that of a lighthouse that only indicates the presence of a port, but that of a star that accompanies us in each one of our journeys…" (Quoted by Cremer, 2013, p. 76).

Goethe's idea that light is "the most simple, indivisible and homogenous entity we know and is not composed of 'parts'", is closer to the postulates of modern physics than Newton's theory of the "particles", since for the Quantic Theory (Planck, Einstein) photons are also the most simple, indivisible, and homogeneous existing entities (Cremer, 2011, p. 82). His vision of the colours also approaches that of modern physics, if we think of the definition Niels Bohr gives of them:

"The colour results from the interaction of light (photons) with an 'obscure' state **A** (atom or molecule in poor energy state); this leads to a 'light state **B** (atom or molecule in rich energy state) and to the following transition from 'light' state **B** to 'dark' state **A**. In this process, a photon is emitted to the exterior with a certain colour" (Niels Bohr, 1913, quoted by Cremer, 2011, p. 82).

Modern physics renounces to explain what one should imagine by those 'states'. What counts is what can be observed and measured, like light or colour intensity. In any case, this quite corresponds to what was postulated by Goethe, when he said:

"He (the physicist) should form to himself a method in accordance with observation, but he should take heed not to reduce observation to mere notion, and to use and deal with these words as if they were things" (*NWS*, Volume I, p. 193; Theory of Colours, p. 283). And in one of his Aphorisms Goethe says: "Thought is more interesting than knowledge, but not more than intuition" (*NWS*, Volume II, p. 726).

Practical consequences of the theory of colours

1. From early on, Goethe was interested in the elaboration of optical instruments, particularly of microscopes. With the economic support of the Great Duchess of Saxe-Weimar he founded an Optical Glass Workshop in Weimar and hired as the director an important physicist: Friedrich Körner (1778-1847).
2. Körner then obtained the collaboration of a young and already outstanding optician, Carl Zeiss (1816-1888), who some years after Goethe's death became independent from Körner and founded a "Workshop of Optics and Mechanics of high precision" in Jena, origin of the famous firm known until today all over the world.
3. In the development of his enterprise and, above all, in the elaboration of high-resolution microscopes, Zeiss collaborated with outstanding Professors of Jena University, like the biologist Matthias Schleiden (1804-1881), creator of the Cellular Theory, and the physicist Ernst Abbe (1840-1905), who, in 1873, discovered "Abbe's limit" (*Abbes-Grenze*), which is the minimum dimension the human eye can distinguish with the help of high-resolution microscopes (200 nanometres). Abbe himself encouraged scientists and technicians to discover new technologies for overcoming that limit (to see Cremer, 2011, p. 86).
4. Abbe's limit could only be overcome with new technologies: the electronic microscope, laser beams, digital elaboration of images and nanoscopy. With these methods it has been possible to study the molecular structure of the cell, the structure of DNA and the genetic code as well as nanostructures of cells, bacteria and viruses, which has enabled to discover the cause of many diseases (Cremer, 2011, p. 87).
5. All this extraordinary development was initiated, in a way, in an optic workshop founded by Goethe in the '20s of the 19th century.
6. According to the present well-known German physicist Christoph Cremer (2011, p. 88), the technology used today in "supermicroscopy" consists lastly of "bringing different molecules to states of light and darkness (or, which is

identical, to states in which light is registered and in which light is not registered) and this is what allows to obtain images of very high resolution", which also coincides with what Goethe thought:

" …the eye sees no form, inasmuch as light, shade, and colour together constitute that which to our vision distinguishes object from object, and the parts of an object from each other. From these three, light, shade, and colour, we construct the visible world, and thus, at the same time, make painting possible, an art which has the power of producing on a flat surface a much more perfect visible world than the actual one can be." (*NWS*, Volume I, p. 20; Theory of Colours, p. 3).

Neurocognitive sciences and Goethe's theory of colours

The great Chilean neuroscientist, Francisco Varela (1946-2001), apparently without knowing Goethe's scientific work (since he does not mention him), was very interested in the subject of visual perception and, particularly, in colour perception. Thus, in his book *The Phenomenon of Life* (1991/1997) he dedicates an entire chapter to colour, and the research carried out by him on it. There we read, among other things, the following: "If we measure the light reflected by the world around us, we discover that one-to-one relationship does not exist between the luminous flux in diverse wavelengths and the colours we perceive in certain zones" (p. 188). He started from two facts of observation:

1. "The perceived colours remain relatively constant, despite great changes of illumination" ("**approximated colour constancy**") (p. 189).
2. "Two zones reflecting light of the same spectral composition reveal different colour according to the context where they are placed" ("**chromatic induction**") (p. 189).

From which Varela concludes: "We cannot explain our experience of colour as an attribute of things in the world simply appealing to the intensity and the composition in wavelength of the light reflected on a zone". And then he quotes the great painter Kandinsky, whose observations support both his experiments and Goethe's ideas. "If two circles are drawn and they are painted yellow and blue respectively, a brief contemplation reveals in yellow an expansive movement starting from the centre and a remarkable approach to the viewer. Blue, on the other hand, curls up on itself, like a snail retreating into its shell, and moves away from the viewer. The eye is goaded by the first circle and absorbed by the second." (p. 190).

Later he makes several statements, whose content is clearly found in the line of sight that Goethe had of colours, like, for example:

1. "The colours we see are not placed on a pre-given world, but on a perceived world which emerges from our structural coupling" (p. 195).
2. "Objectivistic perspective takes for granted that surface reflectance is present in a pre-given world which is independent from our perceptive and cognitive aptitudes" (p. 196).
3. "This approach supposes a considerable and artificial simplification of our real perceptive situation. Pre-given objects are never presented to the visual system. On the contrary, the determination of the what and the where of an object, as well as the limits of the surface, the texture and the relative orientation … is a complex process which the visual system must continually *reach*." (p. 196).
4. "…colour categories are not in a pre-given world which is independent from our perceptive and cognitive aptitude. The categories red, green, blue, purple, orange … etc. belong to *experience*, they are *consensual and corporeal*: they depend on our biological and cultural history of structural coupling … the colour presents a paradigm of a *cognitive domain* which is not pre-given nor represented, but has *emerged,* and belongs to *experience*." (p. 201).

Goethe's principles of science

The expert in the scientific Goethe who has been mentioned several times, Professor of Barcelona University, Octavi Piulats (manuscript and ulterior publication as chapter of a book in 2010), has made an excellent synthesis of Goethe's scientific principles. Given its didactic character and how useful this synthesis seemed to us to show how Goethe anticipated many of the principles constituting the present paradigm of sciences, below we have summarized six of the seven principles outlined by that author, but basing them on textual quotes of Goethe himself or on references to the exact place where the subject is treated in his scientific work (*Naturwissenschaftliche Schriften* I and II, 1964), in particular in his *Outline of a Theory of Colours* (Volume I, pp. 17-244) and in his *Aphorisms and Fragments (*Volume II, pp. 685-781).

1. **There is no need to separate** – as it occurs in the Newtonian paradigm and in natural sciences in general – reason from feelings. According to Goethe, for understanding a phenomenon of nature, be it vegetable, animal or mineral, it is necessary to be capable of apprehending the bio-emotional aspect thereof, because emotion is a constitutive part of the phenomenon. Thus, Goethe says with respect to the yellow colour: "In its highest purity it always carries with it the nature of brightness, and has a serene, gay, softly exciting character" (*NWS*, Volume I, p. 208; *Theory of Colours*, p. 307).
2. **It is necessary to avoid** that which natural science does in terms of separating the object of its context. Thus, we see how:
   a) **Natural sciences unlink the part from the whole**, a starting point which necessarily leads to over-specialization and holistic vision is lost. In the writings where Goethe faces Newton's theory, he states at a given time: "The most beautiful has been and will continue being to contemplate the phenomenon of nature in its entirety, from all perspectives" (*NWS,* Volume I, p. 540). And in another part, he manifests: "The worst that can occur to physics… is to take the derivate for the originative… and try to explain the originative from the derivate. An infinite confusion results from there…" (*NWS*, Volume II, p. 692).

b) **Natural sciences unlink the object to investigate from its origin**, that is, from its history, but also from its purpose (Aristotle's final cause). Goethe's visionary evolutionary thinking, with wise observations about the evolution of the earth, of the plants and of the animals, is already showing us the value he gave to the dynamic process of the genesis of any entity or reality. His concept of metamorphosis, applied above all to the evolution of plants (*NWS*, Volume II, pp. 133-174), is another demonstration of the dynamic way of how Goethe always considered nature. The "*Stirb und werde Prinzip*" (the "Die and become principle") (poem "*Selige Sehnsucht*" – Blissful Yearning, *Werke*, Volume I, p. 248) is another demonstration thereof.

3. Goethe **harshly criticizes the separation between subject and object** postulated by natural sciences:

   a) These interpose between the subject (of the researcher) and the object (to investigate) devices and machines which only search for establishing measurements. These are useful, but they enclose the danger of impeding direct contact with the phenomenon. Goethe says: "The phenomenon cannot be separated from the observer, because it is absorbed by and involved *in* the individuality of this" (*NWS*, Volume II, p. 752). And in another moment he states: "Nature and idea cannot be separated without destroying art and also life" (*NWS*, Volume II, p. 703).

   b) It is necessary to prevent human language and its richness from being substituted by mathematical language, which is only useful for grasping quantitative relationships of the external world. In this context Goethe manifests: "It is necessary to observe phenomena in themselves and to see how relationships which will allow us to get to their laws arise in and from them" (*NWS*, Volume II, p. 723).

4. Goethe criticizes the fact that **sciences are oriented toward axioms and theorems**, something which is not incorrect, but which juxtaposes different axioms without order or accord. He defends the need to find originative fundaments to give cohesion to the plurality of theorems and laws of physics. (*NWS*, Volume I, pp. 579-580).

5. **Goethe questions the causality principle of mechanistic character** and protests for its indiscriminate application to the organic world. He postulates the principle of "reciprocal causality", in which the effect, simultaneously has retroactive character and influences over the cause. The principle of metamorphosis can explain the transformations of nature without falling into mechanicism (*NWS*, Volume II, p. 699).
6. **That such an absolute power should not be given to mathematics** (*NWS*, Volume I, pp. 194-196 and Volume II, pp. 676-772). In his "Aphorisms and Fragments" Goethe states: "You hear people say that only mathematics are certain, but they are no more nor less than other forms of knowing and acting. It is certain when it is reasonably applied to things over which it is indeed possible to have certainty…" (*NWS*, Volume II, p. 768). He thinks that it is necessary to discover the form of grasping the qualitative elements of nature as well. For that there would be three ways:
   a) Observation enables us to verify that in nature all is given in polarities, some of them complementary, other contradictory or repulsive, other which can be interspersed, and phenomena must be understood as the synthesis of these polarities (*NWS*, Volume I, pp. 201, 205, 863 and 864).
   b) It is necessary to always pay attention to the interesting phenomenon of augmentation (*Steigerung*) (*NWS*, Volume I, pp. 151-153) (to see also R. M. Holm-Hadulla, 2019, p. 172).
   c) It is necessary to try and come up from the polarities to the primary phenomenon (*Urphänomen*). In "Aphorisms and Fragments" Goethe tells us: "We call them primordial phenomena because nothing exists over them, but they are susceptible of being reached by a gradual process of ascent to them and then of descent to the concrete case of daily experience". And a little later he expresses: "In this sense we consider the mistake natural sciences make when placing derivate

phenomena in the upper position and the primordial phenomenon in the inferior very big" (*NWS*, Volume I, p. 691). Two pages later he states: "Let us not forget that there is a great difference between phenomena: the primordial, pure phenomenon is never contradicted in its eternal simplicity; the derivate phenomenon, instead, suffers stagnations and frictions and transmits only confusion (op. cit. p. 695).

The new paradigm of sciences and its coincidences with Goethe

In the exposition of the so-called "new paradigm of sciences" we will fundamentally bear in mind what was developed by one of the authors of this study (Héctor Pelegrina-Cetrán), in his work *Anthropological Fundations of Psychopathology* (2006), and then we will compare some of the most important concepts of this paradigm to Goethe's ideas about nature and science.

1. **Substantialist vs dialectic thinking**: during more than two millennia, from the pre-Socratic Greeks of the 6th century B.C. until the end of the 19th century, the identity of each "thing" was assigned to a homogenous and not modifiable "sub-stance", coming from outside of the thing. The substance was understood as a static essence granting identity to the entity, in a permanent way and beneath its changes. Present paradigm maintains that the being of things is not fixed, but a dynamic process actively configuring the stable structures which appear differentiated, but not separated, from the other structures to the contextual environment. As the famous logician and mathematician Alfred North Whitehead pointed out: "the dynamic processes of *actualization* constitute the stable forms (the entities) *entering in the concrete*". In reality itself, there would not be things, but only processes. In the new world view ***to be is to become***, as the Nobel Prize winner Illia Prigogine said: "Contemporaneous cosmology places us in front of a history of the universe and a subsequent deployment of structures, each time more complex" (1983, p. 50). And in page 56 of the same book, he states that: "Activity is an internal property (of the matter) and not an element imposed

from outside". In the same sense the philosopher Xavier Zubiri affirms in this book "Man and God": "All the real... is intrinsically and formally respective". Many other authors have developed this dynamic, dialectic and anti-substantialist vision of reality in their works, as it is the case of A. von Auersperg & Th. zu Oettingen-Spielberg, 1965; G. Bachelard, 1970/2004, 1971/1973; C. Levy-Strauss, 1968; N. Luhmann, 1982/1998; I. Prigogine, 1996; R. Thom, 1988/1990; J. Wagensberg, 1985; and X. Zubiri in other works, 1980, 1982, 1983.

For Goethe, nature is given in dialectic polarities (*NWS*, Volume I, pp. 863 and 864) and its own essence is **metamorphosis**. We already mentioned his famous principle *Stirb und werde* ("die and become"), which so categorically appears in his poem "*Selige Sehnsucht"* (Soul Longing) and which deals with the love of a butterfly for the flame which will mean its death. Below, the fifth strophe with this famous expression:

And so long as thou hast not
This: 'Die and then become again!'
Thou art but a dark guest
Upon this sullen Earth.

2. ***Elements vs. structures and systems***: for the previous paradigm, the real was composed by singular elements, which, by coupling, constituted the complex entities. The new paradigm conceives the real as structures and systems. The well-known philosopher of science, Mario Bunge, states in his book *Emergence and convergence* (2004): "The systemic perspective is part of the ontology inherent to modern scientific world view" (**p. 63**). And later he adds: "Besides being changing, every concrete system (...) interacts with its environment". And again, in Illia Prigogine's words, in his book *The new alliance: the metamorphosis of science,* written in collaboration with I. Stengers (1979/1983): "No element of Nature is a permanent support for changing relationships; each one receives its identity from its relationships

with others...” (p. 104). A member or an organ separated from its organism loses its “organicity”. This view has been imposed in all sciences, from biology, which considers life as an “autopoietic system”, constituted by the communicative structure between the organism and its ecologic niche, up to humanities, where gradually structuralisms and post-structuralisms have begun to reign. In the words of H. Jonas, in his capital work *The Phenomenon of Life* (1966/2001): “The basic freedom of organism was found to consist in a certain independence of form with respect to its own matter… its emergence with emerging life indeed marks an ontological revolution in the history of ‘matter’” (p. 81). In general terms, Murphy and O’Neill point it out in their book *The biology of the future*: “Contemporaneous evolutionary theory gradually drifts apart from restrictive reductionism” (1999, p. 53). And explicitly and in rescue of the unity of the organism, lost to a great extent in the 19th century by the mechanistic reductionism of biology, Goodwin indicates in his outstanding essay “*The leopard spots: The evolution of the complexity*” (1988): “Organisms are as real, as fundamental and as irreducible as the molecules from which they are made. They constitute a characteristic level of emergent biological order.” The scientists who have developed the systemic thinking more in their respective sciences are: L. v. Bertalanffy, 1949/1963, 1968/1981; B. D’Espagnat, 1981/1983; C. Levy-Straus, 1958/1968; K. Lewin, 1941/1963; N. Luhmann, 1982/1998; H. Maturana, 1980; P. Teilhard de Chardin, 1955/1965 and F. Varela, 1991, 1997.

As we have seen, Goethe postulates that there is no need to ever separate the object from its context, that is, from its system, because then totality is supplanted by the part. This (the **part**) is only understandable in relation to the **whole**. Science must, certainly, investigate parts (elements), but in such a way that reference to the holistic is never lost. The holistic vision must always predominate over specialization. Thus, Goethe says in one of his Aphorisms: “To avoid misunderstandings, I want to clarify that my way of looking and treating the objects of nature always advances from the general to the particular, from the global impression to the observation of the parts…" (*NWS*, Volume II, p. 719). Therefore, contemporaneous science postulates the need of the study of reality not only in an "interdisciplinary", but "multi-disciplinary" vision.

3. ***Mechanic vs. emergent causality***: in the previous paradigm, causality operates as an external action of an isolated element over another. The effects are "sub-products" of the causes. In the new paradigm the facts are generated by systemic interaction. It is an emerging causality with retroactions (feedback) and proto-actions (final cause). Emerging causality allows to understand how from lower levels of structuring of the matter, more complex new forms arise (life, for example) (A. von Auersperg & Th. zu Oettingen-Spielberg, 1965; M. Bunge, 1972, 2004; D. Deutsch, 1997/1999; H. Jonas, 2001; P. Teilhard de Chardin, 1955/1965; F. Varela, 1997/2010; C. Waddington, 1968/1976; V. von Weizsäcker, 1956/2005; A. N. Whitehead, 1929/1956). This is explicit in the framework of contemporaneous biology of systemic vision. Thus, the researcher Piere Luigy Luisi writes in his work *The emerging life. From chemical origins to synthetic biology*: "Living organisms create their own environment (niche) and the environment creates the life of the organisms (...in a mutual co-emergence)" (2010, p. 239). And once again B. Goodwin, in his already mentioned work maintains that: "The sciences of complexity lead to the construction of a dynamic theory of the organisms as the primary source of the emergent properties of life" (1994, p. 14). Xavier Zubiri also expresses it in the strongest terms in his book *Respectiveness of the real:* "Relationships would not be consecutive to real things, but constitutive of them" (2006, p. 179). Likewise, when he says: "What we call things would be nothing but knots of relationships" (p. 181).

In point 5 of Goethe's scientific principles, we explained his criticism to the mechanistic form of understanding the causality of natural sciences of positivist cut. Let us remember that he proposed a principle of "reciprocal causality", in which the effect has a retroactive character and, in turn, influences the cause: “Retroaction of the effect over the cause is a historic process…” (*NWS*, Volume II, p. 746). He also speaks of the intimate relationship between cause and effect: “The thinking man makes a mistake when he asks for the cause and the effect, since both together constitute one (only) not separable phenomenon” (*NWS*, Volume II, pp. 745-746). And shortly before, he had said: “Nature is infinitely diverse in its effects and is able to produce the similar by very different ways” (*NWS*, Volume II, p. 745). That is to say, something analogous to what present physics, chemistry, and biology state when they speak of “emerging causality”. In a way, this has also meant to again acknowledge the value of the concept of Aristotle’s “final cause” (Metaphysics, Book II, Paragraph 994, pp. 512 y 513).

4. ***Determinism vs. indeterminism***: the ontology of the previous paradigm is determinist, since everything which occurs is pre-determined by the conditions which caused it and, following backward the chain of causalities, it would be possible to come to the idea of God, of the Pure Spirit or of the Universal Reason. In the ontology of the new paradigm the opinion has been decanted that there exists a true **ontic indeterminism**, observable both in the field of quantic dynamics and in that of complex structures (catastrophe theory and chaos theory) as well as in evolution. Well, in the ambit of biologic indeterminism a specific type of “human indeterminism”, which is **liberty** would emerge (A. v. Auersperg & T. zu Oettingen-Spielberg, 1965; P. Teillard de Chardin, 1955/1965; W. Heisenberg, 1990; R. Lewin (1992/1995); N. Luhmannn, 1982/1998; K. Popper, 1988/2011; I. Prigogine, 1996; V. v. Weizsäcker, 1939/1997). This subject is very well exposed in Niklas Luhmann’s book “*Complexity and modernity. From the unity to the difference”,* where, among other things, he states: “We live installed in the difference, not in the unit” (1982/1998, p. 25).

Goethe’s concepts of **metamorphose** and of **augmentation (***Steigerung)* are the opposite of a blind determinism. Nature is always creating new forms, each time more complex, where nothing is predetermined. In his *Aphorisms and Fragments,* Goethe states several ideas to describe the indeterminism reigning in nature, like, for example, when he says: “Nature has reserved so much freedom for itself that we will never be able to embrace it in a consistent way with our knowledge and our science” (*NWS*, Volume II, p. 708). Or when he states: “Fantasy is more proper of nature than sensibility” (*NWS*, Volume II, p. 699), alluding to that creativity of nature, whose products or results are always unpredictable.

5. ***Subject/object separation vs. primordial unity of both***: in the previous paradigm the absolute division between subject and object gave rise to aporias without solution, such as those of the theory of knowledge, of the body-world or soul-body relationship. Heidegger’s being-in-the-world (1927), Maturana and Varela’s constructivism (H. Maturana, 1980; H. Maturana and F. Varela 1990; F. Varela et al.,1991 and F. Varela & J. Shear, 1999) or Hans Jonas’ (2001) theory of life have contributed to putting an end to the duality subject/object. The same occurs with the concept of the lived body from the French philosophy (M. Merleau-Ponty, 1945/1957/1966; G. Marcel, 1955) and of the “worldly” body (*welthafter Leib*) from the German phenomenological psychiatry (W. Blankenburg, 1971/2013, 1989; C. Kulenkampff, 1958; J. Zutt, 1963). How the act of knowing makes both the object and the subject arise, as well as, at the border between both, “the mental” is developed in the work of well-known neurobiologists, like G. M. Edelman and G. Tononi in their book *A Universe of Consciousness. How matter becomes imagination*, where they state, among other things, that “Consciousness is a dynamic property of a special form of morphology (...) to the extent in which it interacts with the environment” (2000, p. 216). Shortly before they had pointed out that: “Without movement there is no informative acquisition” (143), referring with this not only to the sense of touch, where it was always evident, but also to the sense of sight, which does not seize structures of immobile forms, since the permanent ocular scan with its eye-saccadic movement is necessary for a form to appear in the vision. These

new developments of cognitive sciences show evident coincidences with what, decades before, Viktor von Weizsäcker stated in this capital work “The Circle of the Form” (*Der Gestaltkreis*, 1939).

One of Goethe’s greatest ideas was that of the introduction of the subject to scientific research, something that since Werner Heisenberg’s (1927) “Uncertainty or indeterminacy principle” and Niels Bohr’s (1927) “complementarity principle”, Viktor von Weizsacker’s (1939/1997; 1956/2005) theory of the *Gestaltkreis* (circle of the form) and the new development of cognitive sciences starting from the eighties, has become inescapable (H. Jonas, 2001; P. L. Luisi, 2010; H. Maturana, 1980; Maturana and F. Varela, 1990); J. Piaget, 1967/1969; K. Popper & J. C. Eccles, 1985; F. Varela et al., 1991; F. Varela, 1997/2010). Viktor von Weizsäzcker, almost simultaneously with Heisenberg and Bohr, and starting from neurology and psychiatry, explicitly based on Goethe, postulated **the introduction of the subject in medicine**: “I believe biology will not be able to be constituted in a formal science if it refuses to include the subjectivity proper of the living beings”. And he adds: “... Even physics has concluded that processes exist that cannot be observed without the fact that, at the same time, observation modifies them… The relative indetermination of sensory processes is the presupposition of this new and different unit we call ‘biologic unity’. Between the lability of the elemental functions and the synthetic improvisation, a necessary indeterminacy relationship exists which guarantees the possibility of the biological act. What we call subject consists precisely of this indeterminacy, which, in turn, makes room for the creative act.” (1939/1997, p. 295).

As a way of conclusion

I do not want to end this daring attempt of exposing, in a few pages, the scientific thinking of that universal man who Johann Wolfgang von Goethe was and the interesting coincidences with what has been called “the new paradigm of sciences", without referring to the historical, sociological, and political implications which science could have had on Goethe's style had it not been completely overshadowed by the empirical sciences of Newtonian cut and the spectacular technological development they brought along. Because it would be legitimate to ask whether a less substantialist, more dialectic, more systemic, less mechanistic, less determinist thinking which did not pretend to separate subject/object and person/world like that of Goethe, could perhaps have avoided the development of nuclear weapons of mass destruction and of fanatical ideologies like those which ravaged Europe in the 20th century, and, anyway, also prevented the destruction of our natural environment. This is exactly what the great physicist and Nobel Prize winner, quoted several times in these pages, Werner Heisenberg, indicated in the lecture he gave during the Annual Meeting of the Goethe Society in May 1967 and published in 1990, together with other essays, in the form of a book, in which he says among other things, the following:

"In science as in art, the world since Goethe's day has gone the way he warned us against, since he considered it too dangerous. Art has withdrawn from the immediately real into the interior of the human soul, while science has taken the step into abstraction, has conquered the huge expanse of modern technology, and has pushed on to the primal structures of biology and the ground forms that correspond in modern science to the platonic solids. At the same time, the dangers have become fully as threatening as Goethe foresaw. We have in mind, for example, the soulless depersonalizing of labour, the absurdity of modern armaments, the flight into insanity that took the form of a political movement. The Devil is a powerful fellow. But the lucid region we spoke of earlier in connection with romantic music, and which Goethe was able to discern throughout all nature, has also become visible in modern science, at the point where it yields intimations of the mighty unity in the ordering of the world. Even today we can still learn from Goethe that we should not let everything else atrophy in favour of the one organ of rational analysis; that it is a matter, rather, of seizing upon reality with all the organs that are given to us and trusting that this reality will then also reflect the essence of things, ‘the one, the good and the true’. Let us hope that the future will be more successful in this regard than our own day, than my own generation, has found it possible to be.” (“Goethe’s View of Nature and the World of Science and Technology”, in *Across the Frontiers*, 1990, pp. 140 y 141).

References

Aristotle: “Metaphysics”. In: *Great Books of the Western World 7, Aristotle: I.* Oxford: Encyclopaedia Britannica, Inc. (1966), Paragraph 994, pp. 512 and 513.

Auersperg A v. & Oettingen-Spielberg Th zu: “Wahrnehmung und Offenbarung”. In: *Poesie und Forschung*. Stuttgart: Enke Verlag (1965), S. 60-66.

Auersperg A v. & Oettingen-Spielberg Th zu: “Die rückläufige Bestimmung im genetischen Denken”. In: *Poesie und Forschung*. Stuttgart: Enke Verlag (1965), S. 40-56.

Auersperg A v. & Oettingen-Spielberg Th zu: “Versuch einer anthropologischen Deutung des Selektionsprinzipes im Sinne Teilhard de Chardins Phénomène Humaine”. In: *Poesie und Forschung*. Stuttgart: Enke Verlag (1965), S. 56-59.

Bachelard G (1970): *Estudios*. Buenos Aires: Amorrortu (2004).

Bachelard G (1971). *Epistemología. Barcelona*: Anagrama (1973).

Bertalanffy L von (1949): *Concepción biológica del cosmos*. Santiago: Ediciones de la Universidad de Chile (1963), pp. 10-24; 124-129.

Bertalanffy L von (1968): *Teoría general de los sistemas*. México-Madrid-Buenos Aires: Fondo de Cultura Económica (1981), pp. 30-53.

Blankenburg W: *Der Verlust der natürlichen Selbstverständlichkeit*. Stuttgart: Enke Verlag (1971). Traducción castellana de O Dörr y E Edwards: *La pérdida de la evidencia natural*. Santiago: Ediciones Universidad Diego Portales (2013), pp. 227-256.

Blankenburg W: “Phänomenologie der Leiblichkeit als Grundlage für ein Verständnis der Leiberfahrung psychisch Kranker”. In: *Daseinsanalyse* 6: 161-93 (1989).

Bunge M. *Causalidad*. Buenos Aires: Eudeba, 3ª Edición (1972).

Bunge M: *Emergencia y Convergencia. Novedad cualitativa y unidad del conocimiento*. Barcelona: Editorial Gedisa (2004).

Cremer Ch: “Vom Farbenkreis zum Supermikroskop: Goethe – Dilettant oder Fachmann?“. In: *Jahrbuch 25, Bayerische Akademie der schönen Künste* (Hg.). Göttingen: Wallstein Verlag (2011), S. 74-96.

D’Espagnat B (1981): *En busca de lo real*. Madrid: Alianza (1983).

Deutsch D (1997): *La estructura de la realidad*. Barcelona: Anagrama (1999).

Eckermann JP: *Conversaciones con Goethe.* Barcelona: Editorial Océano (2016), p. 197.

Edelman GM & Tononi G: *A Universe of Consciousness: how Matter becomes Imagination.* New York: Basic Books (2000, pp. 216 y 143.

Goethe JW von: “Entwurf einer Farbenlehre” (1808). In: *Naturwissenschaftliche Schriften.* Gedenkausgabe*,* Band I. Zürich-Stuttgart: Artemis-Verlag. 2. Auflage (1964), S. 19-244; S. 20.

Goethe JW von: “Schriften zur Wissenschaftslehre”. In: *Naturwissenschaftliche Schriften*. Gedenkausgabe, Band I. Zürich-Stuttgart: Artemis-Verlag. 2. Auflage (1964), S. 839-926.

Goethe JW von: “Polarität”. In: *Naturwissenschaftliche Schriften*. Gedenkausgabe, Band I. Zürich-Stuttgart: Artemis-Verlag. 2. Auflage (1964), S. 863-864.

Goethe JW von: “Die Natur”. In: *Naturwissenschaftliche Schriften*. Gedenkausgabe, Band I. Zürich-Stuttgart: Artemis-Verlag. 2. Auflage (1964), S. 921-924.

Goethe JW von: “Aphorismen und Fragmente”. In: *Naturwissenschaftliche Schriften.* Gedankenausgabe, Band II. Zürich-Stuttgart: Artemis- Verlag. 2. Auflage (1964), S. 685-781.

Goethe JW von: “Selige Sehnsucht”. In: *Werke*. Band I. Frankfurt am Main: Insel Verlag (1965), S. 248.

Goethe JW von: “Vermächtnis”. In: *Werke*. Band I. Frankfurt am Main: Insel Verlag (1965), S. 231-232.

Goethe JW von: Theory of Colours. Cambridge, Massachusetts: The MIT Press (2000).

Goethe JW von: *Viaje a Italia*. Barcelona: Ediciones B, S. A. (2001), pp. 17-25.

Heisenberg W (1967): “Goethe’s View of Nature and the World of Science and Technology”. In: *Across the Frontiers*. Woodbridge: Ox Bow Press (1990), pp. 122-141.

Holm-Hadulla RM: *Leidenschaft: Goethes Weg zur Kreativität*. Göttingen: Vandenhoeck & Ruprecht. 3. Auflage (2019), S. 172-174.

Jonas H: *The Phenomenon of Life*. Evanston: Northwestern University Press (2001), pp. 26-33; 58-63; 81.

Kulenkampff C: “Das paranoide Syndrom, anthropologisch verstanden”. In: *Das paranoide Syndrom in anthropologischer Sicht*. Berlin-Göttingen-Heidelberg: Springer Verlag (1958), pp. 9-16.

Levy-Strauss C (1958): *Antropología Estructural*. Buenos Aires: Editorial Universitaria (1968), pp. 29-50; 211-218.

Lewin K (1941): “Analyse der Begriffe Ganzheit, Differenzierung und Einheitlichkeit”. In: *Feldtheorie in den Sozialwissenschaften*. Bern-Stuttgart: Verlag Hans Huber (1963), S. 330-361.

Lewin R (1992): *Complejidad: el caos como generador de orden*. Barcelona: Tusquets (1995).

Luhmann N (1982): *Complejidad y Modernidad*. Madrid: Editorial Trotta (1998).

Luisi PL: *La vida emergente. De los orígenes químicos a la biología sintética*. Barcelona: Tusquets Editores (2010).

Marcel G: *Être et Avoir* : Paris: Aubier Montaigne (1955).

Maturana H: “Biology of Cognition”. In: *Autopoiesis and Cognition*: The Realization of the Living. Dordecht: D. Reidel Publishing Co. (1980), pp. 5-58.

Maturana H., Varela F: *El árbol del conocimiento*. Madrid: Editorial Debate (1990).

Merleau-Ponty M (1945): *Fenomenología de la percepción*. México: Fondo de Cultura Económica (1957). Translation into German: *Phänomenologie der Wahrmnehmung*. Berlin: Walter de Gruyter & Co. (1966), S. 89-96; 165-171.

Murphy M & O’Neill L (Eds.): *La biología del futuro.* Barcelona, Tusquets (1999), p. 53

Pelegrina H: *Fundamentos Antropológicos de la Psicopatología*. Madrid: Editorial Polifemos (2006), pp. 89-147.

Piaget J (1967): *Biología y Conocimiento*. Madrid: Siglo XXI (1969).

Piulats O: “J. W. Goethe: El Newton del Idealismo”. Manuscript: pp. 1-20. Later published in *Goethe y Montserrat*. Solsona: Solsona Comunicación (2010), pp. 38-54.

Popper K & Eccles JC: *El yo y su cerebro*. Barcelona: Editorial Labor (1985).
Popper K (1988): El universo abierto: Un argumento a favor del indeterminismo. Post Scriptum a La lógica de la investigación científica. Sevilla: Editorial Tecnos (2011).

Prigogine I: “Una nueva formulación de la teoría cuántica”. En: *El Fin de las Certidumbres*. Barcelona-Buenos Aires-México D. F. – Santiago de Chile: Editorial Andrés Bello (1996), pp. 143-165.

Prigogine I: “Las leyes del caos”. En: *El Fin de las Certidumbres*. Barcelona-Buenos Aires-México D. F. – Santiago de Chile: Editorial Andrés Bello (1996), pp. 97-141.

Prigogine I: *¿Tan solo una ilusión?: Una exploración del caos al orden*. Barcelona: Tusquets. 4ª Edición (1997).

Teillard de Chardin P (1955): *El fenómeno humano*. Madrid: Taurus Ediciones, S. A. (1965), pp.134-141; 178-185; 189.

Thom R (1988): *Esbozo de una semiofísica*. Barcelona: Gedisa (1990).

Varela F, Thomson E, Rosch E: *The embodied mind*. Massachusetts: MIT (1991). Traducción al castellano: *De Cuerpo Presente. Las Ciencias Cognitivas y la Experiencia Humana*. Barcelona: Editorial Gedisa (1997).

Varela F & Shear J. "First-person Methodologies: What, Why, How?" *Journal of Consciousness Studies*, 6, No. 2-3: 1-14 (1999).

Varela F (1997): *Fenómeno de la vida.* Santiago de Chile: JC Sáez Editor (2010), pp. 188, 189, 190, 195, 196, 201.

Wagensberg J: *Ideas sobre la complejidad del mundo.* Barcelona: Tusquets Editores (1985).

Waddington CH (1968): *Hacia una biología teórica*. Madrid: Editorial Alianza (1976).

Weizsäcker V. von (1939): "Der Gestaltkreis: Theorie der Einheit von Wahrnehmen und Bewegen". In: *Gesammelte Schriften*, Band 4. Frankfurt am Main: Suhrkamp (1997), S. 83-334.

Weizsäcker V. von: *Pathosophie.* Göttingen: Vandenhoeck & Ruprecht (1956), S. 180-183.Translation into Spanish: *Patosofía*. Buenos Aires: Libros del Zorzal (2005).

Whitehead AN (1929): *Proceso y realidad*. Buenos Aires: Editorial Losada (1956).

Zubiri X.: *Inteligencia sentiente*. Madrid: Alianza, Trilogía. Inteligencia y Realidad (1980), Inteligencia y Logos (1982), pp. 22-25, e Inteligencia y Razón (1983).

Zubiri X: *Escritos menores 1953-1983.* Madrid: Alianza Editorial (2006), pp. 179 y 181

Zutt J: "Über den Stand des in Erscheinung stehenden Menschen". In: *Auf dem Wege zu einer anthropologischen Psychiatrie*. Berlin-Göttingen-Heidelberg: Springer Verlag (1963), S. 410-416.

Note: The translations of quotations from German and Spanish into English were carried out by one of this study's authors (O. Doerr-Zegers).