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THE THEORY OF PRIMORDIALITY: A TRANSDISCIPLINARY APPROACH TO PARADIGMS IN THE HISTORY OF SCIENCE

A TEORIA DOS PRIMÓRDIOS: UMA ABORDAGEM TRANSDISCIPLINAR AOS PARADIGMAS EM HISTÓRIA DA CIÊNCIA

LA TEORIA DE LOS PRIMORDIOS: UN ACERCARSE TRANSDISCIPLINAR A LOS PARADIGMAS EN HISTORIA DE LA CIENCIA

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ABSTRACT
This is a debate about methodology in the history of science and its correlations with society and culture. Since the work of Thomas Kuhn about paradigms, the vision of historical succession of events in science has changed. Concurrently, Robert Merton incremented his sociological study of science, where he proposed what he named as "multiple in science", to explain the concomitancy of similar discoveries at the same time. Furthermore, before the main event in scientific discoveries and inventions, there are precedent studies or scientific practices which could explain that discovery or invention more as a process than as a single event. Therefore, we propose the Theory of Primordiality to embrace the several primordial events that are correlated with a considered discovery or invention in a historical process even in a long period. That historical process has links among several occurrences surrounding the same aim of the main paradigmatic event, but without substituting it. For this proposal, we studied concepts in methods of history research that tried to reach correlations among processes surrounding scientific discoveries and inventions, including notions of zeitgeist and creativity in science.

KEYWORDS: Methodology**.** Paradigm. Science. Zeitgeist.

RESUMO
Este é um debate sobre metodologia em história da ciência e suas correlações com a sociedade e a cultura. Desde o trabalho de Thomas Kuhn sobre paradigmas, a visão da sucessão histórica de eventos na ciência mudou. Concomitantemente, Robert Merton intensificou seus estudos em sociologia da ciência, onde propôs o que chamou de "múltiplo em ciência", para explicar a concomitância de descobertas similares ao mesmo tempo. Além disso, antes do evento científico principal em descobertas e invenções, há estudos precedentes ou práticas científicas que poderiam explicar a descoberta ou invenção mais como um processo do que um evento isolado. Portanto, propomos a Teoria dos Primórdios para abranger os vários eventos primordiais que estão correlacionados com uma descoberta ou invenção em um processo histórico, mesmo que seja em um longo período. Esse processo histórico tem ligações com várias ocorrências em torno da mesma meta do evento paradigmático, mas sem substituí-lo. Para este propósito, estudamos conceitos em métodos de pesquisa histórica que procuram captar correlações entre processos em torno de descobertas científicas e invenções, incluindo noções de zeitgeist e criatividade em ciência.

PALAVRAS-CHAVE: Metodologia. Paradigma Ciência. Zeitgeist.

RESUMEN
Se trata de un debate sobre la metodología en la historia de la ciencia y sus correlaciones con la sociedad y la cultura. Desde los trabajos de Thomas Kuhn sobre los paradigmas, la visión de la sucesión histórica de los acontecimientos en la ciencia ha cambiado. Concomitantemente, Robert Merton intensificó sus estudios en sociología de la ciencia, donde propuso lo que denominó "lo

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RECIMA21 - REVISTA CIENTÍFICA MULTIDISCIPLINAR
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múltiple en la ciencia", para explicar la concurrencia de descubrimientos similares al mismo tiempo. Además, antes del acontecimiento científico principal en los descubrimientos e inventos, existen estudios precedentes o prácticas científicas que podrían explicar el descubrimiento o la invención más como un proceso que como un acontecimiento aislado. Por lo tanto, proponemos la Teoría de los Comienzos para abarcar los diversos acontecimientos primordiales que se correlacionan con un descubrimiento o una invención en un proceso histórico, aunque sea durante un largo período. Este proceso histórico tiene vínculos con varios sucesos en torno al mismo objetivo que el acontecimiento paradigmático, pero sin sustituirlo. Para ello, estudiamos los conceptos de los métodos de investigación histórica que tratan de captar las correlaciones entre los procesos en torno a los descubrimientos e inventos científicos, incluidas las nociones de zeitgeist y creatividad en la ciencia.

PALABRAS CLAVE: Metodología. La ciencia del paradigma. Zeitgeist.

1. INTRODUCTION

This is a debate about methodology in the history of science and society. By the name "Theory of Primordiality", we propose that any founding event in science can be inserted in a broader process that involves other precedent scientific occurrences. There is some linkage between those occurrences and the paradigmatic event. Nevertheless, those facts are not strong enough to replace the considered capital paradigm.

The purpose of this theory is to achieve a better understanding of scientific founding events, seeing them more as a historical process correlated with several factors in society, than an isolated and just scientific one. Some aspects of this idea are not completely new as we can see in the book by William Whewell, of 1837.

Whewell (1794-1866) was one of the founders of the "history of science" in a modern concept of it. He also invented designations for fields of sciences and even the word "scientist". So, a part of his referred work named *History of the Inductive Sciences: from the earliest to the present times* is presented as follows:

> "In our history, it is the *progress* of knowledge only which we have to attend to. This is the main action of our drama; and all the events which do not bear upon this, though they may relate to the cultivation and the cultivators of philosophy, are not a necessary part of our theme. Our narrative will therefore consist mainly of successive steps of generalization, such as have just been mentioned. But among these, we shall find some of eminent and decisive importance, which have more peculiarly influenced the fortunes of physical philosophy, and to which we may consider the rest as subordinate and auxiliary. These primary movements, when the Inductive process, by which science is formed, has been exercised in a more energetic and powerful manner, may be distinguished as the *Inductive Epochs* of scientific history; and they deserve our more express and pointed notice. They are, for the most part, marked by the great discoveries and the great philosophical names which all civilized nations have agreed in admiring. But, when we examine more clearly the history of such discoveries, we find that these epochs have not occurred suddenly and without preparation. They have been preceded by a period we may call their *Prelude*, during which the ideas and facts on which they turned were called into action; - were gradually evolved into clearness and connection, permanency, and certainty; till at last the discovery which marks the epoch, seized and fixed forever the truth which had till then been obscurely and doubtfully discerned. And again, when this step has been made by the principal discoverers, there may generally be observed another period, which we may call the *Sequel* of the epoch, during which the discovery has

RECIMA21 - REVISTA CIENTÍFICA MULTIDISCIPLINAR
ISSN 2675-6218

> acquired a more perfect certainty and a more complete development among the leaders of the advance; has been diffused to the wider throng of the secondary cultivators of such knowledge and traced into its distant consequences" (WHEWELL, 1837, p. 12-13).

Thus, Whewell used the word "Prelude" to nominate something similar to our idea of primordiality. Whewell had some "geniality" correlating the context in the big picture with details in science and was also creative finding names and appropriate words for specific aspects of science, as, for example, the word "scientist" that was coined by him (ROSS, 1962, p. 71-75).

Geniality is one of the aspects of creativity in science as we are going to explain later. So, here, the figure of William Whewell is not just of a researcher that wrote about science and is used as a reference, but his own personality is immersed in our aim of study. This is a transdisciplinary look at the issue discussed, when the focus is not just history of science, but also who does it.

What Whewell called Inductive Science is what we use to name today as "science", mainly the field of "hard sciences". In the beginning of the nineteenth century, it was still common to use the words "natural philosophy" for the scientific field. Whewell saw the difference between "science" (or Inductive Science as he wrote) and general knowledge, considering that science derived from "inductive methods". He also pointed the name "Physical Sciences" for his object of discussion (WHEWELL, 1837, p. 6).

This type of geniality of Whewell has common points with contemporary thoughts about the understanding of science and its events. As Whewell was one of the first historians of science, there is singularity and innovation in his ideas about what he called Prelude, seeing a broader context surrounding the main event.

Whewell was contemporary of the foundations of what was characterized as "modern universities" in the nineteenth century Germany. The German model of the University of Berlin, founded in 1810 by Wilhelm von Humbolt, inserted the vision of modern scientific practices in the University, while it still kept some scholastic conformation, aiming at a broader formation of students. Inside, it maintained the traditional freedom of university students and professors.

At the same time, some kind of "renovation" of the French universities after the French Revolution and the Napoleon Empire was paradoxically made under a reinforcement of the rules and controls by authorities with less freedom of its components.

On the other hand, the English universities developed in a way more like the University of Berlin, inserting modern science and keeping some independence of its members (RÜEGG, 2004, p. 3-13).

At the very beginning of the 19th century, the French universities were at the center of continental knowledge and attracted many students. Nevertheless, a few years later, from 1830 onwards, the German universities started to be at the top of a new scientific and human knowledge. In these new conditions, even the French scholars started to go there to find what was considered a kind of 'fresh science'. This model of modern university spread throughout the world.

RECIMA21 - REVISTA CIENTÍFICA MULTIDISCIPLINAR
ISSN 2675-6218

At the time of those university movements, Whewell launched his new concepts. It does not mean that there were direct connections between the two factors. But in any case, the European society was prompted to innovation in knowledge and new institutions of knowledge after the Napoleonic period.

To better establish the proposition of the Theory of Primordiality, we will use the tools: the theory of scientific paradigm of Thomas Kuhn, the sociologic concepts of Robert Merton, some considerations of Gaston Bachelard, Zeitgeist notions, concepts of creativity in science, the long duration concept of Fernand Braudel, the archeology of words of Michael Foucault, and concepts of complexity and transdisciplinarity.

2. KUHN'S PARADIGM, MERTON'S MULTIPLE, AND BACHELARD EPISTEMOLOGY

Since Thomas Kuhn's seminal work on the paradigms in the history of science, we have been able to see scientific innovation as some event that abruptly gives a new way of thinking about certain problems or questions in specific fields of science. Kuhn called "paradigm" that new way of formulating "problems and solutions" in a particular scientific area under specific rules conditioned by a new model of thinking Thomas S. Kuhn, 1962-1970.

The novelty he brought was that the history of science is not something that one can put on a line and watch it evolve from discovery to discovery and from invention to invention in a similar way as a cumulative and progressive number of events. Kuhn used the word "revolution" for such a sudden event because it is a kind of rapid change that causes a great disturbance of thinking in a group of scientists, with practical consequences. In a general way, that change is influenced by social and cultural factors and vice-versa has an influence on society outside the scientific circle. Eventually, it can cause some social impact with even dramatic aspects.

The general acceptance of a new paradigm in science usually lingers years after the breakthrough release. This can be observed, for example, if we look at Nobel Prizes granted in Medicine, Physics, Chemistry. Those prizes signalize recognition by the group of scientists and the society in general several years after that discovery or invention.

The initial mention of that new thinking, when the former paradigm is still in validity, is of difficult reception, and the discoverer is usually rejected by his fellows. For the acceptance of the new idea, it is common that something also happens to the society. It is possible to see it, for example, in the discovery of prions by the physician Stanley Prusiner. He proposed this concept in a publication of 1982, but he was only recognized in 1997, receiving the Nobel Prize, after the epidemic of prion disease in the United Kingdom (PRUSINER, 2014).

William Whewell, in the book aforementioned affirms: "and the history of each science, which may thus appear like a succession of revolutions, is, in reality, a series of developments". In this statement, he already uses the word "revolution", and he seems to oppose the idea of "development" to that of "revolution". In his other text, which he called "Epoch" or "Sequel", there is some similarity to

RECIMA21 - REVISTA CIENTÍFICA MULTIDISCIPLINAR
ISSN 2675-6218

the idea of Kuhn’s paradigm. In Whewell's time, the use of the word revolution for a political or social event was new, having been in use since the French Revolution.

All the surrounding processes that incept from a new scientific paradigm can affect people that work inside and outside that focused field. The social and historical dimension of that occurrence can transform it in a "remarkable fact." This condition makes the discoverer directly involved in it as a kind of "founding father" of something that acquires a new name and a new definition, mainly inside that specific field of science and society. This event finally becomes a consistently new milestone in the history of science, always being associated with the specific founder.

That event can be seen with its contemporary correlations and its connection with past factors. In this case, several people are involved with the occurrence and the new fact may not be alone in that moment in time, but together with other similar events. Robert K. Merton, in his sociology of science, called that simultaneity a "phenomenon of multiple discoveries in science" and it can be evidenced by the quasi-concurrent recording of similar scientific events (STORER; MERTON, 1973, p. xi-xxiv).

One explanation for this kind of coincidence is that it reflects common interests in different social groups under similar political, economic, and cultural conditions. These interests in similar issues may reveal that some factors related to specific situations in science have similarities in the objective of scientists.

Perhaps the first such coincidence in modern history was the discovery of mathematical calculus by Isaac Newton (1643-1727) and Leibniz (1646-1716) at the same time. At first glance, we could say that this phenomenon arrived with modern knowledge in modern European society and with the spread of this modern way of thinking and acting with some similarities among different nations.

When we speak of “modern society”, we can even refer to the society of the 16th, 17th and 18thcenturies in Europe before the development of contemporary media. One could say that the aforementioned coincidence was “inevitable”, even with some different ramifications of their work.

We must also emphasize that Newton and Leibniz were named “natural philosophers” and not yet “scientists”. Maybe they were actors of a historical transition from philosophy to science in a modern consideration. Anyway, what we want to accentuate is that the new paradigm that each of them had founded was probably not an isolated phenomenon and perhaps inevitable in societies with some similar interests.

In this line of deterministic thinking, the French scholar Gaston Bachelard (1884-1962) quoted a phrase by George Bruce Halsted about other mathematical novelty: “the discovery of the non-euclidian geometry, around 1830, was inevitable”.

With the following quotes we do not want to deeply study physical or mathematical conceptions, but to understand methods in the history of science that can help explain the conditions for the Theory of Primordiality.

RECIMA21 - REVISTA CIENTÍFICA MULTIDISCIPLINAR
ISSN 2675-6218

In his work *Le Nouvel Esprit Scientifique,* Bachelard talked about another kind of coincidence in science that he named 'dialectical tendencies' in fields such as philosophy and science in that period of the 19th century (BACHELARD, 2000, p.121-131)

Bachelard cites some sort of 'preparation' for mathematical and geometric discoveries during the 18th century under several scholars such as, for example, D'Alembert, Saccheri, and others, with several consequences years ahead. He also cited the scholars Taurinus and De Tilly in the following century as people correlated with the development of that mathematical thinking.

Bachelard explains the advent of new concepts in physics (as the non-Newtonian mechanics, notions of matter and irradiation, waves and corpuscles, determinism, and indeterminism) in the spirit of modern science in a kind of succession of 'thinking models' similar to that explained in Kuhn's paradigm.

Gaston Bachelard speaks of contemporary science as a very new way of seeing reality, sometimes as an abrupt novelty with no expected events, other times as prepared events in the past. Thus, his thinking is open to seeing connections among different scientific events, while still accepting some abrupt occurrences. Along these lines, he emulated the use of probability studies in science such as the ones used by Heisenberg and Louis De Broglie in corpuscular theories in the 20th century.

For Bachelard, determinism and indeterminism in science seem to be a paradox, but in those new physical situations resolved by the quantum theory. The quantum theory can be considered a transdisciplinary concept which adjusts paradoxical conditions.

While Bachelard had some ideas like Kuhn about new models in science appearing with a rupture, he explains that in non-Cartesian epistemology "there is no simple phenomenon, the phenomenon is a tissue of relationships, there is no simple nature, no simple substance". There is no simple idea, because to be understood, it must be inserted in a complex system of thoughts and experiences.

This mention may be reminiscent of the contemporary Theory of Complexity. Even though he was not completely clear about all the correlations in science, Bachelard had ideas that were similar to transdisciplinary approaches to epistemology and knowledge, which involved complexity.

Thomas Kuhn also wrote about what he called "coincidental events" in science. In his work *The Essential Tension: Selected Studies in Scientific Tradition and Changing* he said that between 1842 and 1847 the energy conservation hypothesis was publicly announced by four different European scientists who were dispersed – Mayer, Joule, Colding and Helmholtz – all of them, except the last one, completely ignoring each other's theories. Kuhn also reports that Said Carnot before 1832, Marc Séguin in 1839, Karl Holtzmann in 1845, and G. A. Hirn in 1854, all wrote of their convictions that the physical phenomena "heat and work" were quantitatively interchangeable. Continuing, Kuhn noted that between 1837 and 1844, the scientists C. F. Mohr, William Grove, Faraday and Liebig described the world of physical phenomena as manifesting just one "force", which could be electrical, thermal, dynamic, and other forms, but could never be destroyed or created. This force is what later became known as "energy" (KUHN, 1977, p. 38-41, p. 95-101).

Thus, Kuhn cited twelve names of scientists who worked with the emerging concept of energy and its conservation. This could explain something about the nature of simultaneous discovery when scientists are looking at the same factors. On the other hand, Kuhn argued that those discourses were all different, and one or another of the twelve knew something about its counterparts' works. He sustained a certain doubt about the "multiple simultaneity" proposed by Merton.

Another question that he asks is "who was the first to discover the conservation of energy?" He asked not just about "energy" specifically but also at the level of discussion about the context of methodology in the history of science. For him, this question about "simultaneity" specifically in this matter has no answer.

In the considerations under the Theory of Primordiality, who or what 'came first' is not a problem. All the correlated scholars participated in the process of this discovery. Kuhn explains 'simultaneity' as something probably 'apparent' in a long digression by several physical studies and experiments since the 18th century that preceded central events.

He passes along what he attributes to social scientists and philosophers, calling it a "comprehensive law model" that put under social conditions the emergence of discoveries almost as something predictable. In his work with the history of science, he says that he could not apply that model of human behavior to the narratives of history.

Under the Theory of Primordiality, we can make a balance between the thinking of Merton and that of Kuhn. The latter establishes factors concerned to the science itself, while the first thinks more about the social conditions for the occurrence of discoveries. We can see that similar social conditions across different countries led to similar scientific interests at the same time.

Looking into a succession of occurrences, we can observe past factors and events in history that generated similar searches for scientific discoveries of correlated fields. But, anyway, the Theory of Primordiality does not focus on predicting future phenomena but looks into events in the face of a scientific paradigm that has connections a little more than mere chance, which already had some trace of the main thinking that becomes recognized.

3. SCIENTIFIC EVENTS AND ZEITGEIST

Thus, among these discoveries or inventions, one of them usually becomes the focus of the prominent people of the scientific field in question. The society involved in the context can contribute to establishing that person as the 'founding father' of some new science. We can look, for example, to Louis Pasteur, known as 'the discoverer of microbes' in the second half of the 19th century. It was indeed an important milestone in the history of science, and he deserves that emphasis. On the other hand, we have registers of men who had made similar propositions or discoveries before Pasteur, but not with the same mark and strength. Girolamo Fracastoro of Verona (1483-1553), a physician that was also 'a poet, classicist, physicist, geologist, astronomer, and pathologist' was one of them. His text *Syphilis sive Morbus Gallicus* (1530) became known, a Latin poem where he gave the name of that disease and suggested its venereal spread. In 1546, Fracastoro wrote *De Contagion,* where we can read already a type of modern theory of infection by invisible germs, which he called *seminaria* (LYONS; PETRUCELLI, 1987, p. 376, p. 439-44).

Other scholars that passed near similar concepts were Robert Hooke (1635-1703), who viewed fungus by microscope, and Antony van Leeuwenhoek (1632-1723), who described microscopic protozoa and bacteria (GUEST, 2004, p. 187-201).

Even though, in an ironic way of speaking, we could say that those discoveries were 'invisible' to the current society, even to the group of scholars. Then, why did Louis Pasteur become the discoverer of microbes? Maybe because he was in the Zeitgeist, or in the spirit of the times appropriate to that discovery. That moment of the 19th century had many other scientific discoveries that were 'beyond the visible' and the scientific society was better prepared to supplant the Galenic paradigm of miasmas as an explanation for the cause of diseases.

We can see another example from another era. In the Ancient Greece, before Hippocrates, there was the Pythagorean school, which was not strictly a medical school, but where there were several physicians among the philosophers. One of them was Alcmaeon, who was the first to declare that the brain was responsible for mental and behavior activities. Until now Alcmaeon is not much known, even because there are only indirect references about him (LYONS; PETRUCELLI, 1987, p. 183-192)

In fact, Hippocrates became known for that affirmation, and one of the reasons for this is that he was in the Zeitgeist for the explanation about correlation of brain, mental, and behavioral activities. Hippocrates lived in the Age of Pericles, known as the Golden Age of Ancient Greek Culture with all its artistic and scientific achievements. In that environment, Hippocrates and his followers were even able to write about their ideas and discoveries in the *Corpus Hippocraticum*, a new way of keeping and spreading medical knowledge that until then was mainly transmitted orally (JOUANNA, 1998, p. 31-44).

To understand the situations above, we can introduce the concept of Zeitgeist, or "spirit of the times". The German word *Zeitgeist* was first cited by Johann Gottfried von Herder (1744-1803) in a literary review. After Herder, someone attributes the term to the philosopher Georg W. F. Hegel (1770-1831), who correlates "spirit" and "time" in his works "Phenomenology of Spirit" and "Reason in History". It seems that the use of that term was correlated with movements in the European society relating to the French Revolution, the Napoleonic Wars and what came after that as national spirit spurred on by the revival of the Gothic Culture (OERGEL, 2019, p. 1-5, 8-15).

Nowadays, one concept of Zeitgeist strictly related to science is the one that links a scientific event with its own time and the social and cultural conditions that favored it. We can see this use of the word Zeitgeist, for example, in the book of 2004 "Creativity in Science – Chance, Logic, Genius, and Zeitgeist" by Dean Keith Simonton. The author works with those concepts influencing creativity in science. About Zeitgeist, he wrote that "sociologists of science have argued that discoveries and inventions are the inevitable product of the sociocultural system." (SIMONTON, 2004, p. 10-11).

RECIMA21 - REVISTA CIENTÍFICA MULTIDISCIPLINAR
ISSN 2675-6218

Here we argue that Zeitgeist is also related to the reception of the new ideas or the new paradigms by the contemporary scientists of the proponent, as we can see in the writings of Thomas Kuhn.

Let us go back to Louis Pasteur and the last decades of the 19th century. We can find social, scientific, even economic factors that converged in ideal conditions for his explanations to be accepted. He first understood that he discovered microbes, using techniques to solve problems with fermentation in wine cultures. The world of science and medicine was prepared for his discoveries. We can even see that in 1871 Joseph Lister applied these notions to make sterilized procedures. Although cleaning was already an ancient process, now with the concept of germs, it acquired a new vision. We can say that the 'Microbial Paradigm' or 'Pasteurian Paradigm' was founded. A strong link was made between Pasteur and microbes. This is what happens under a strong Zeitgeist condition.

The other scholars related to microbial concepts, Fracastoro, Hook, Leeuwenhoek, lived before the social and scientific conditions for the understanding and deep acceptance of their ideas. However, if we look at this occurrence in the history of science as a 'process,' we may consider all of them related to that discovery, yet still keeping the central role for Pasteur. In a certain way, they can be seen also as counterexamples of the Zeitgeist factor. If the thinker were outside the Zeitgeist, even having formulated a correct scientific hypothesis, his idea would be ignored until the scientific society was prepared for it, which would only happen if the Zeitgeist was strong enough to receive the new paradigm.

To better understand the concept of Zeitgeist, we can recall the story of the physician Ignaz Philipp Semmelweis (1818-1865), who realized the connection between dirty hands and puerperal infections. After intuitive observations of students in action, in 1847 he proposed hand hygiene before procedures. He was very criticized and suffered a lot because of that affirmation. He was not in a proper Zeitgeist for the reception of the new idea and the new practice. And we must point out that it was a 'scientific' reaction against him. He suffered greatly from the rejection not of only of his ideas, but of himself (LYONS; PETRUCELLI, 1987, p. 550-553).

It is an example that the historical concept of Zeitgeist also encompasses the conditions of the scientific society or group of scientists involved in receiving and accepting or rejecting the new proposition. As this example, there are several others in the history of science. As Thomas Kuhn said, the proponent of a new paradigm is often taken for a dreamer, a poet, or even a 'lunatic'.

In this line of thinking, some discoverers and inventors make the discovery of what would later become a new paradigm only when the Zeitgeist came along. Nonetheless, they persist in their ideas. Therefore, the recognition is delayed, as we can see in the time that goes between a great discovery and the Nobel Prize for that discovery, which is a way of general acknowledgement of a new paradigm. This can be observed, for example, in the discovery of *Helicobacter pylori* by Robin Warren and Barry Marshall in 1982. At that moment, the paradigm for the cause of gastritis was stress related and the scientific community did not accept the new 'strange' explanation. Marshall even infected himself with the bacterium in order to prove the existence and action of *Helicobacter pylori*. In 2005

RECIMA21 - REVISTA CIENTÍFICA MULTIDISCIPLINAR
ISSN 2675-6218

they received the Nobel Prize for that discovery, when the public and the scientific community were in the *Zeitgeist* to accept the new paradigm (THE LANCET, 2005).

Another emblematic example of the Zeitgeist is the Copernican theory of heliocentrism. Copernicus' book was published in the year 1543, the same year as his death. The publication of this book in those times was not the same as a contemporary publication under strong mediatic diffusion. Thus, even with precursors since the ancient Greeks, we cannot say that the reception of the Copernican paradigm was instantaneous and fit to the Zeitgeist around that date. The problem of the acceptance of the theory was not just religious but mainly an issue of paradigm. The ancient Aristotelian and Ptolemaic paradigms were difficult to surpass because they were so strongly embedded in the scholars' minds. The problem of Aristotelian paradigms was what constituted the issues concerning Galileo Galilei in the 17th century together with the debate about heliocentrism, and the so called 'Copernican revolution' can be seen as a construction of the scholars (KUHN, 1957, p. 13 a 16).

It is interesting that this year of 1543 was the same of the publication by Andreas Vesalius of his book *De Humanis Corporis Fabrica,* the masterwork that made him the 'Father of Modern Anatomy' and supplanted many Galenian paradigms. Vesalius was well received as a professor at the University of Padua, having several successors. It seems that it was an ideal Zeitgeist for his ideas within that group where he was received. But maybe we cannot say the same for the ideas of Copernicus, or even for Vesalius outside his own environment, because when he was in the University of Paris, before Padua, he was confronted by his professor, who was sedimented in the Galenian paradigms. So, the Zeitgeist is not just a matter of time, but also of place and space, under social and cultural conditions. As we can see, the 16th century was a time of change for ancient paradigms of Greeks such as Aristotle, Ptolemy and Galen. Maybe there were certain conditions in the European society that led to major changes related to the Greek heritage in the understanding of human and cosmic nature (LYON; PETRUCELLI, 1987, p. 416-419).

So, what we call the Zeitgeist are not exactly forces that conditioned inevitable discoveries, but conditions that became favorable to recognize someone's discovery in new understandable ways.

In this line of thinking, we propose the Theory of Primordiality. The word 'primordiality' is derived from 'primordial' as it is used to indicate, for example, some supposed event that happened in 'primordial times', as we can see in anthropology texts, for example. So we are not using the word 'primordiality' as a synonym for 'priority'. The word 'primordiality' intends to express the events that precede a recognized scientific discovery or invention and have a correlation with it in a more than casual way, but not strong enough to replace that main occurrence of the Zeitgeist.

Therefore, some essential factors for the theory of primordiality have already been mentioned: Kuhn's notion of paradigm, the phenomenon of multiple discoveries of Robert Merton with considerations by Bachelard and Kuhn, and the Zeitgeist.

It is useful to add something about what is called 'Mertonian Paradigm' about the 'structure and dynamics' of a scientific community. This paradigm works under two factors: the normative structure of science and a distinguishing system of rewards. Thus, not only does innovation in science come from ideals, but also from rewards, even symbolic, and under rules and protocols that can restrict or expand ideas and proposals.

The structure and dynamics of a scientific community bear some similarity with the explanations that Kuhn attributes to 'casual simultaneity' in the discoveries in science, although he restricts that simultaneity to scientific conditions. Merton's angle of vision goes beyond that and emerges from the social sciences. Bachelard's vision is something between or even embracing both positions.

4. CREATIVITY IN SCIENCE

Creativity in science is discussed by the author Simonton. At first glance, the word 'creativity' seems more appropriate for the Arts than for the Sciences. However, the impulse that comes from the human mind in search of new solutions to new or old problems comes as a hunch in the scholar's mind. The experience of that is like a feeling of creating something new, a feeling of creativity. In Science, creativity can appear by chance, also called 'serendipity', or by logical explanations, or by some peculiar circumstance of a genius personality.

Any of these ways can happen in or out of the Zeitgeist. If it happens in the Zeitgeist, they are more likely to be accepted at that moment. As mentioned earlier, William Whewell was creative in the use of language in science and created names that helped to characterize new scientific concepts and fields which are still useful.

In his study of creativity in science, Simonton used the term 'metasciences' to refer to the following fields: history of science, philosophy of science, sociology of science, and psychology of science. These areas have distinctive interests and methodological techniques. Historians prefer narratives; philosophers work with analyses; sociologists focus on institutions, and psychologists look at individuals. Following these considerations, creativity in science can be studied from Logic, Genius, Chance and Zeitgeist. Each of these factors has some influence on different kinds of discovery in order for it to actually occur. But we think that, even with these factors, to become a 'new paradigm', this event is likely to succeed when some kind of Zeitgeist is favorable to it. Simonton relates 'disciplinary Zeitgeist' and 'sociocultural Zeitgeist' as different conditions to generate the scientific event. The reception of a new idea by scientists and society can be added to Zeitgeist.

Thus, the production of a new paradigm is necessary but not enough for the reception of this discovery by the related communities. If the scientists and/or the society is not prepared to receive the new paradigm, they will not understand it and will not be receptive to it. So these three factors (chance, logic, and genius) can influence creativity, but only Zeitgeist can help the main event to become a historical landmark in time.

From a sociological point of view, Robert Merton mentioned factors that can influence creativity in science in a way that can be related to contemporary science. He cites several kinds of rewards, of different levels and symbols to the academic life and to the society in general. Those rewards can be the considered the pinnacle of science as the Nobel Prize. Sometimes it can be, for example, a promotion to the job of scientist. That stimulus of reward could not be imagined in the 17th or 18th century; the word 'scientist' was created by Whewell only in the 1830s, and there was not a professional named 'scientist' yet.

In a certain way, it is possible to say that 'scientific paradigms' existed centuries before that designation the word 'science' was used to characterize a particular part of knowledge. At any time in history, what we now call 'science' followed specific conditions by that concerning society. Each society, at each moment, has changing Zeitgeist conditions, even to create new paradigms or receive new paradigms.

5. THE LONG DURATION

The French historian Fernand Braudel (1902-1985) was a member of the *École des Annales*, initiated by Mark Bloch and Lucien Febvre, with new ways to think about history, shedding light on events that were ignored by the traditional history, and giving space to psychologic witness of the events. In a text of 1958, Braudel proposed new ways of thinking about the different times of different sections of historical studies. He explained that what can be called 'short duration' in history is correlated to the time of the news, the time of the historical event itself, or a succession of contemporary events, or an immediate historical narrative. In opposition to this short duration, he proposes to work with the concept of 'long duration'. That conception can be applied to certain conditions and contexts that give more 'space' to the work of the historian through times. He exemplifies by citing a part of the history of science which deals with "built universes with imperfect explanations, that had centuries of duration." In this matter, for example, there was the 'Aristotelian Universe', only contested after Galileo, Descartes, and Newton, and this one was supplanted by the ideas of Einstein (BRAUDEL, 1958, p. 7-22).

The concept of long duration applied to the Theory of Primordiality can extend apparently long-standing primordial links to certain scientific paradigms. For example, in the history of medicine, some paradigms of Galen endured for fifteen or seventeen centuries, through a 'long duration' process.

When Braudel wrote about long duration, he was in a kind of Zeitgeist appropriate to certain studies of methodology for what he called a "crisis of the human sciences" crushed by its own progresses under new organizations and techniques. Therefore, he proposed the "long duration" as a tool that historians could apply to bring new contributions to the human sciences. Beyond a simple correlation of causes and effects, a longer time with a longer chain of events could help to understand certain historical processes. Braudel cited Benedetto Croce for whom it is possible to incorporate even "all the history" to a specific event since it can be helpful to add some explanation. Braudel wrote about a new kind of historical narrative that can add new actors, new factors, beyond the near circumstances of a new conjunctural condition.

6. ARCHEOLOGY OF WORDS

Michel Foucault starts the introduction of his book *Archeology of Knowledge* writing about 'long duration' in history. As he says, this methodological tool can help historians to look beyond the episodic events in a kind of "vertical" trespass that allows seeing multiple layers within a given matter of study. It can help to search deeper meanings instead of just indicating an isolated linear succession of events. Foucault cited Canguilhem, who studied the transformations of concepts in the history of science and talked about "microscopic and macroscopic scales" of the history of medicine at different levels of events and discoveries (FOUCAULT, 1969).

Foucault writes that there is an archeology for monuments, and another archeology of documents and discourses. In the history of science, there is a research of deeper layers with the tool of "archeology of words" that can bring new meanings to the "long duration primordiality".

He emphasizes the historian's work to constitute the elements of study from the mute monuments, apparently contextless objects, and other things left over from the past. Like this elaboration, the historian must restore "historical discourses", mainly with documents, like an archeology of the "past knowledge".

Foucault calls it "new history" when he talks about how to treat documents analyzing the greatest number of representatives, defining levels of analysis and the elements concerned, the delimitation of sets under material and time conditions. In this context, he says that the philosophy of history can bring knowledge from and to linguistics, economics, literary analysis, and mythology. By this way, the level concerned, or the layer of the analysis plays a role in here, in a kind of epistemological approach to the history of science.

In this line of thinking, he talks about notions around the theme of "continuity" included in the long duration, something opposed to a condition of "rupture". This continuity gives a special statute to an ensemble of phenomena that have "succession and similarity". He understands that some kind of "influence" gives support to transmission and communication of those processes.

This influence links across distance and time what can be called "unities" in a general way. The unities can be defined as individuals, works, notions or theories. Thus, it is possible to regroup a succession of dispersed events, which can be joined under "a principle of organization".

At this point Foucault speaks about notions of "mentality in community" under simultaneous or successive circumstances in what he calls as a "collective consciousness". Long duration in history and collective consciousness can have some connection if we go from one event to another with each of them linked to the former.

There is a question about "enunciations" compounding a continuity by centuries or even millennia. Could we say that, for example, the brain diseases analyzed by Thomas Willis and the one by Charcot were explained under different discourses? Or that the several discourses about mental diseases seemed different but were of the same kind?

Foucault said that there is connection among different discourses when they are related to the same object. But it is necessary to see if that object changes or becomes subdivided in various other objects. This progression could lead the discourses towards changing processes.

Another thing is the changing of the discourse construction. The change in vocabulary, or in metaphors, could point out that perhaps there were, for example, two types of medicine in history: an older one and a newer one. Each of them with a different kind of discourse.

But the set of enunciations made at the same time or at different times may have some level of connection in ways that we could say that they are still parts of the same process. It can work as a connection among different discourses from different sciences, in different times and places, like a transdisciplinary connection.

On the other hand, the distance in time and space could be enough to say that there are different processes, discourses and sciences.

The elaboration of this “new history” of Foucault must navigate among discourses and sciences and establish proximities and distances. Perhaps considering each scientific paradigm.

Likewise, the scientific language takes on words from the colloquial world and vice-versa, the common language takes on words born strictly in the scientific environment. This kind of interchangeable discourse also happens across scientific fields. The concepts of long duration and archeology of words can help to build the Theory of Primordiality.

7. TRANSDISCIPLINARITY AND COMPLEXITY

In the year 1994, Edgar Morin and Basarab Nicolescu made the Manifest of Transdisciplinarity, delineating this specific kind of approach to knowledge. Before that, during the second half of the 20th century, some scholars developed an epistemological way to look at how the different fields of knowledge can be organized together (NICOLESCU, 1999).

“Multidisciplinarity” is a name that corresponds to the traditional scheme of disciplines since Aristotle, as it can be found in conventional schools, with few connections among the different areas. “Interdisciplinarity” is established among disciplines that use common language and common methods to teach or to do research. Although transdisciplinarity has similarities with the words multi and interdisciplinarity, it has a more significant epistemological difference. In transdisciplinarity, we look at the disciplines in an overview or in a transversal way. When talking about science in transdisciplinarity, one can say that is using “metalanguage” to study the discourses of the different disciplines, or “metamethod” to study their methods.

Transdisciplinarity has three pillars: levels of reality, complexity, and a third one that includes paradoxical conditions. There is an extra fourth condition related to Culture. There are no oppositions among transdisciplinarity, multidisciplinarity and interdisciplinarity. Each of them approaches knowledge and epistemology from some respective point of view.

From those pillars of transdisciplinarity, we want to emphasize “complexity”, which is another tool for Primordiality. To explain it, we can remember the Aristotelian concept: "the whole is greater than the sum of its parts." It means that when some organization (biologic or not) achieves the level of a “whole”, it gains an appropriate name and meaning that results from the connection of its parts. Thus, it is not just a matter of randomly mixing the parts, but the linkages among those parts are essential in constructing the whole and its meaning. Complex thinking goes in the opposite direction of reductive thinking. It opens the mind to perceive patterns in different levels of organization.

Melanie Mitchell in her book about Complexity quotes a text by her advisor, Douglas Hofstadter, mentioning reductionism in which he ironically says that “Reductionism is the most natural thing in the world to grasp. It’s simply the belief that ‘a whole can be understood completely if you understand its parts, and the nature of their ‘sum’. No one in her left brain could reject reductionism” (MITCHEL, 2009, p. ix-xiii).

Therefore, Mitchell explains that reductionism has been dominant in science since the 17th century when René Descartes established his scientific method thus “dividing the matter in question into as many parts as possible and establishing an order going from the simplest to the most complex object”. Since then, other scholars developed that kind of vision so that, in 1894, the physicist Albert Michelson proclaimed, in a reductionistic way, that “it seems probable that most of the grand underlying principles have been firmly established and that further advances are to be sought chiefly in the rigorous application of these principles to all the phenomena which come under our notice” (MITCHEL, 2009, p. ix-xiii).

But, as Mitchell writes, the 20th century marked the demise of the reductionist dream with the emergence of “the theory of relativity and the quantum mechanics”. However, not all sciences followed this non-reductionist path of physics. Ironically, in biological sciences, where the interesting “theory of systems” appeared, there is still a paradoxical and strongly reductionist thinking, mainly in health sciences. In environmental sciences, on the other hand, there is a field open to complexity, where biological, populational and other factors are mixed in a non-reductionist vision (MITCHEL, 2009, p. ix-xiii).

As John H. Holland says, a tropical rainforest is an example of a “complex system”. He claims that each complex system has a distinctive property called ‘emergence’ described by a phrase similar to the complexity concept, “the action of the whole is more than the sum of the actions of the parts”. Thus, this field can be explored by focusing on the levels of complexity of different problems and how the systems exhibit “emergence”. As he says, like life and consciousness, complexity does not have a rigorous definition, and complexity is different from complicated. In complex thinking, emergence is a property without a sharp demarcation, and it is correlated to each level of reality (HOLLAND, 2014, p. 2-11).

The property of emergence follows a higher degree than a given whole that goes beyond the sum of its parts. For example, in a living multicellular organism, a tissue is more than the sum of cells because the tissue has some properties that are unique to that tissue itself, beyond the isolated cells, even if they are together but not linked. That tissue also has characteristics that give it a name generally related to its own function. Likewise, we can see the organs, which are formed by several tissues. In the next step, the organs feature a system, and the systems together configurate the whole organism. But in each step of that scale, a new structure appears with its own function. And we could say that a person is more than the biological organism.

In our context, what matters about the complexity theory is that the process of a scientific discovery is more than the sum of its parts, and the connections of that and other parts play an important role in the Theory of Primordiality. The dynamic vision of the action of the whole, or the phenomenon of emergence, can give certain consistency to the process surrounding a scientific event.

8. CONCLUSION

This text is a debate on methodology in the history of science and society. It does not intend to close the proposed discussion, but to start reflections about the idea of the Theory of Primordiality.

The Theory of Primordiality has those different tools to organize its structure: Kuhn's paradigm, Merton's multiple, Bachelard's considerations, the Zeitgeist, creativity, Braudel's long duration, Foucault's archeology of words, transdisciplinarity, the theory of complexity. This Theory proposes that in the history of science, every paradigmatic event has connections with several other events, configuring a whole process concerning a specific discovery or invention that becomes consecrated in a way that it receives a specific designation linked to a specific discoverer or inventor. Therefore, there is a "primordial historical process" that culminates in what is considered to be the main event. Such process can be seen as a whole in a way that several names of discoverers or inventors could be related to a same event, concomitantly or in temporal sequence, without taking off the consecration of the scholar that became famous in the paradigmatic Zeitgeist. The primordial period can have different durations depending on the factors correlated with that paradigmatic one and the society involved; it can be years or centuries. Being out of the Zeitgeist condition, history could relegate some scholars to oblivion or see them only as "predecessors" of the consecrated discovery or invention, signaling that with a mark of "passive" characteristic.

The Theory of Primordiality can bring meaning and understanding to certain historical circumstances that seem isolated or unexplained, connecting them to some complex process, bringing new meaning to what was simply considered a trivial event. A transdisciplinary vision of that process gives fundaments to the Theory, including several cultural and social factors beyond the scientific context. Therefore, it can shed light on scientific historical events and processes that could otherwise remain in the shadows.

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