Summary. Human beings are not alone in the Universe. Neither are we alone among ourselves. Between the macrocosmos and the microcosmos we can find our mesocosmos, a unique result of human intelligence. Science, as the combination of accumulated learning, and as a process for achieving knowledge of the environment in which we live, is likewise an exclusive product of human intelligence. It fits in the mesocosmos. However, science as a whole is single, but it is plural in its component parts, and it forms a system, with all its attributes, peculiarities and properties. The different branches of human knowledge, which form the nodes of the general system, are not static. They are dynamic and continually evolve. They change position and content and transmute with varying acceleration both in space and time. The different branches of human knowledge mutually interact within and among themselves, and with the environment in which they are located or in which they locate. A dialectic relation is established. This can be positive or negative, favourable or pernicious, and depend on the evolution of mankind at each given historical moment. A greater acceleration, faster in time, in the development of mankind can produce such a tension in the dialectic relations of the branches of human knowledge, that a deceleration is brought about in science as a whole. An intelligent being can dominate and control dialectic flux and reflux so that influx is positive and helps the human being to advance along his path of discovery.

Introduction.

Today, when systems science, the methodological, coherent and rational study of systems, is so highly developed, we should at least attempt to adapt its basis, fundamentals and applications to the concept of science itself.

Watertight compartments no longer exist in this age of communication and information. We find ourselves in a world of relating organizations, whose communication is by means of information flows. We no longer think in terms of any isolated organization, be it natural, rational or conceptual. The scope of human knowledge has widened and its different branches have spread until they run into each other and intermingle. In other words we are at that point in history when "systems begin to flower".

We can view our world as a network of systems all varying in characteristics, properties and peculiarities. At times a system will exist in its own right, at other times, irrespectively of whether it maintains its individuality, it forms part of a superior systems and is housed and "governed" by this.

Up to the end of the seventies, systems theory was mainly used to study social or socio-cultural systems such as economic systems, trade union movements, mass revolutions, etc.
Some years before, Bertalanffy had already mentioned conceptual systems. Today, we believe that conceptual systems have the same right to exist as any real system, with respect to space and time.

Systems as such have been studied in greater depth and Rafael Rodríguez Delgado, in 1985, supported the idea of considering three main types of system according to their evolution, particularly with respect to internal reactions, space and time. He called these static, dynamic and dialectic systems. Within systems theory, we consider that there are: static, dynamic and dialectic systemics. Of these, the last is the most recent and modern.

In an attempt to apply dialectic systemics, we have turn to science which, as a complex, contradictory product of mankind, is a system in itself. It is a system that does not fit either the statics or the dynamics of systems. Hence our study of the “dialectic interactions in science”.

**Historical Background of System Dialectics**

Without wanting to delve too far into the past, and keeping to the present century, we can mention Jay Forrester who, in 1961 and more so in 1971, discovered that not all the so-called dynamic systems obeyed the established laws. There was some type of relationship, or variable, that influenced and caused anomalous behaviour in the system. René Thom, in his theory on catastrophes, also mentions that certain social systems are unpredictable, if their parameters and variables are considered with respect to system dynamics. In recent years, several others made similar observations. It was clear that something did not tally. It was as if some condition or premise were missing. Gonseth, in 1985, shed light on the matter with his “Scientific Dialectics”. The answer may well lie in the fact that there could be conflicting, opposing and, at the same time, dialectic situations in complex systems. Such situations depend on the moment, situation or state of the system in its evolutionary phase.

The pioneer and promoter of Systems Theory in Spain, Rafael Rodríguez Delgado, proposed his “dialectic systemics” in 1985. One of his innovations consisted, in addition to variables, parameters, flux and reflux vectors and feedback loops, in considering the “transformable” concordant and opposing interactions\(^1\), which promote dialectic situations in the system and affect its behaviour.

Note that these statements give a new meaning to the term “dialectic”. A meaning that does not appear in the usual dictionary. It is a phenomenon and product of our times. Its meaning and area of application have been increased by concepts. Our area of knowledge likewise grows.

**Science as a System.**

Whenever referring to science, we like to think of its two main meanings: the result of collected knowledge and that of a methodically formed body of doctrines that enables us to achieve a coherent knowledge of the world in which we live. A real, material world, or an abstract world of ideas.

\(^1\)Author’s comment
With both meanings, science can be considered as a system. For our purposes, we will refer to the latter. The reasonings we are going to develop could possibly be applied, by extrapolation, to science as a collection of accumulated knowledge.

To think of science as a system is not a modern idea. In "Criticism of Pure Reason", Kant defines a system to be the uniting of the different forms of knowledge under a single idea, implicitly involving the concept of science in that "uniting of different forms of knowledge". Descartes considers "modern science" to be a set of simple, but not isolated, mutually interacting elements. In the present century, Bertalanffy considers the system, among other definitions, to be a conceptual correlation of certain universal features of observable objects, that can be applied to science. Shannon, in "Information Theory" refers to science as a morpho-genetic process in which there are a series of phases in knowledge that can assimilate and filter information to reach that true knowledge of external data. What is implicit here is the meaning of system. Aquilino Morcillo Corvettto defines science as a symbolic system that translates reality. Finally, we have to succumb to the temptation and give one of Ashby’s definitions of a system. He considers it to be a set of variables chosen by an observer from amongst those that are available and possible from the area of the real world. A set of variables and a part of the world he wants to study and whose behaviour he wants to observe when changing the values of those variables according to pre-established rules. This can perfectly apply to science.

We still feel it is necessary to give further opinions on "science as a unit" in its totality, despite its being made up of more or less adjoining parts. Raimundo Lulio in "Ars Magna" considers science to be a unit. Back to the present century, Voltes Bou believes that one of the aims of the General Systems Theory is to establish the unit of science. Sadowskij considers systems...of knowledge...as the totality of the set of...that knowledge.

Following the opinions of such well known and qualified authors, I will attempt to give my idea of science as a system and, in particular, with respect to this article. Science is a complex system, evolving in time, comprising a network of elements, or nodes, which mutually interact in concordance or in opposition according to conditions established by Man or Nature.

Nodes are not simple elements, and in turn they contain other complex systems, or subsystems of real or conceptual dismorphic elements.

In mutual interactions one has to consider the variables, parameters, flux and reflux, feedback loops and transformable features. These arise through the influence of mutual relationships between elements of different characteristics, either real or conceptual. This likewise explains the dialectic behaviour of science as a systems, where one of the transformable characteristics is time.

The vectors that distinguish the mutual reactions do not all follow a single direction. They often change direction and can even change and reverse their direction.

If we were to represent science as a system graphically we would have to use a three dimensional diagram with vectors in all possible directions, in which primary elements,
C = Science System
N = Nodes = First category Subsystems
S = Subsystems
T = Time

SCIENCE SYSTEM WITH ITS NODES MUTUALLY INTERACTING IN CONCORDANCE
such as nodes (first class subsystems), are not equidistant. A time vector would have
to be included, its direction being unique but its duration variable. (Figure 1). Casual
diagrams such as those by Jay Forrester could not be applied here, because variables and
transformable features do not always occur in sequence. New types of working diagram will
have to be thought up, a possible line of study I leave to the experts. Further study could
involve the application of systemography to the science system, with attractic graphical
representations which could describe it in topographical terms.

Likewise, a new area of research appears, which involves the possibility of measuring
these types of system either qualitatively or quantitatively, by means of a new branch of
study which, in other articles, I have ventured to call “systemometry”. This could be an
interesting line of research for systems theory specialists.

Mental Outline of the Science System.

We could perhaps better understand the science system if we had a mental outline.

Firstly, science comprises the different branches, or nodes, of science, i.e. History (his-
torical sciences), Geography (geomorphic science), Chemistry (chemical sciences), Physics
(physical sciences), Medicine (medical sciences), Economics (economic sciences)... These,
in fact, are the conjoint branches of science, and are ever increasing due to the expansion
and evolution of science itself.

These nodes are not equidistant. With respect to a given node, others might be
closer or further. We realize that historical sciences are closer to geomorphic sciences than
chemical or spiritual sciences. Nevertheless, they exert a mutual influence of differing
intensity according to the given point in “time”.

It is fairly easy to see how the different nodes, or branches, of science are, or can be,
influenced. For example, a better historical knowledge of human relationships in past ages
can influence developments in psychology or sociology. The discovery of a new chemical
compound can transform the car industry, which has ecological consequences, etc.

These “nodes”, or branches of human knowledge, that comprise science, form complex
subsystems, in which there are what we might consider other, second class, subsystems. In
turn, these are complex and can be divided up into third class subsystems, etc., until we
reach a single element, which I do not think can be simple although its complexity is not
so great. As second class subsystems we can consider the branches of chemistry: organic
chemistry, inorganic chemistry, quantum chemistry, analytical chemistry, etc. Not all are
on the same conceptual level, something which is easily proved.

Another example is that of historical sciences: ancient history, ... modern history,
... the history of civilizations, ... the history of ceramics, etc. These also are concepts at
different levels. The complexity of these subsystems is evident.

On the other hand, we must remember that, in science and its components, we cannot
just consider these objects of study, in a more or less realistic way, we also have to consider
the lines of reasoning followed to achieve science’s aims, something that requires a knowl-
edge of the world in which we live. These lines of reasoning form a network in which the
gifts of reason, observation, reasearch and information all play their part. In other words, we are referring to elements belonging to a conceptual world, varying in characteristics and origins, of widely differing intensities and directions.

In the nodes, or first class subsystems, of the science system, there are two basic, complex elements that are real and conceptual and mutually interact. We can now see why science should be studied from a systemic dialectic point of view.

**TAXONOMY IN THE SCIENCE SYSTEM.**

Having attempted to define the science system and split it into primary and secondary nodes, with real and conceptual components, we can go a step further and attempt to classify the system using the taxonomy of systems theory.

The science system
- belongs to our noosystem;
  - and fits in the mesosystems;
- complex,
- nonlinear,
- open,
- dissipative,
- cyclic,
- plurivalent $\leftrightarrow$ univalent,
- infinite (in our time dimension),
- adaptable,
- social $\leftrightarrow$ ecological,
- natural $\leftrightarrow$ artificial,
- real $\leftrightarrow$ conceptual,
- continuous $\leftrightarrow$ discontinuous,
- hierarchical $\leftrightarrow$ nonhierarchical,
- universal $\leftrightarrow$ particular.

Looked at from a human dimension, the human being is in the centre, he is the agent, the being who manages his world and his environment of relationships. He takes external vectors, which reach him as information vectors, by means of his intelligence he transforms them so as to construct his noosystem. As a typical human product, science belongs to the noosystem. As regards to its dimension, between the macrocosmos and the microcosmos, it fits in the mesocosmos which is likewise composed of products of human intelligence.

Out of all the taxonomic classes in which we have incorporated the science system, special mention should be made of those in which the system appears to belong to a class and to its opposing one, e.g.

natural $\leftrightarrow$ artificial, continuous $\leftrightarrow$ discontinuous, real $\leftrightarrow$ conceptual.

It is precisely here, with contradictions like this, that a dialectic behaviour appears, in the contraposition of opposites implying a constantly, but not continuously, developing transformative evolution.
S = System
I = Information
V = Semaphore-Vector
In = Research
C = Science
t = Time

INFORMATION'S INFLUENCE- RESEARCH- SCIENCE SYSTEM

FIG. 2
We feel that the contraposition of the above mentioned classes is sufficiently clear so as not to merit further discussion.

**Dialectic Interactions in the Science System.**

Having considered science as a system and having mentioned its composition, classifications and peculiarities, we shall now look at which, in general terms, are the “variable” elements that exert an influence on the behaviour and hence the evolution of the system.

Firstly, let us consider those “variables” that are external - exogenous, to the system, and those that are internal - endogenous.

Of the external “variables”, information is one of the most important and is essential to the running of the science system. Information, in turn, is produced within the system and serves as a communications channel between the system and its environment. A cyclic process begins, in the form of a spiral loop, that is irreversible and continuous, that moves in time and that can be represented by a semaphore-type vector or information bearer. Information activates science; science produces information and this, in turn, activates science. To prevent destruction of the system, information influx and flux - semaphore vectors - have to maintain a metastable equilibrium within certain limits so as not to exceed the assimilation possibilities of the system. A large increase in information influx can, however, bring about a transmutation of the system, since dialectic influence situations can occur inside. The present point in history, characterized by a large amount of information, characterizes this point: science is in a moment of conceptual and methodological transmutation.

Of the internal “variables” acting on the science system, we shall look at three that are specific to the system: research, inventions and discoveries. All three exert a mutual influence. They are influenced by information that is internal and external to the system and they influence both the working and behaviour of science.

Research plays a decisive role in science and in each of its subsystems. Science would not exist without research. It is its origin, cause and effect. If research goes in a certain direction, science immediately follows. If research decreases, science diminishes. With an increase in research, science follows suit. This occurs, however, within the context of science and not outside it. It is this peculiarity that gives the system its “transformable” characteristic.

Research also needs information for its development. At the same time it produces information which science then assimilates to once again become information. (Figure 2.)

A chain reaction occurs, which is cyclic, spiral in form, constant and discontinuous in intensity and time which affects the science system’s evolution and behaviour.

Discoveries and inventions together form a pair, or doublet. When one is produced, sooner or later the other is produced as a consequence. They are linked, internal “variables” of the system. They also exert a decisive influence on the behaviour and development of the science system, with the peculiarity that they are systemic-type “variables”. They are not merely flux vectors. They themselves are systems and are complex and evolitional. They take part in the same taxonomic categories as the science system. Their
S = System
I = Information
D = Discoveries
IV = Inventions
IN = Research
C = Science
V = Semaphore-Vectors
T = Time

INFORMATION - RESEARCH - DISCOVERIES - INVENTIONS - SCIENCE SYSTEM
influence is widely varied. A given invention can cause a sharp, total change in science, involving an important conceptual transmutation. Well known examples have occurred on various historical occasions. The same happens with discoveries.

If we tried to draw a small diagram such as in Figure 2, we would have to start with the exterior information, through research, discoveries and inventions, to a new output information. At each intermediate phase, information produced should be taken into account, for this is re-used, forming an endless chain of similar characteristics as before, but more complicated, because there are more intermediate stages with their mutual influence. Both discoveries and inventions are transformable and cause a dialectic behaviour of the system. (Figure 3.)

We have here a new subject for research in systemic dialectics: that of studying the behaviour of such complex systems. There will be a need for graphic and conceptual diagrams. Interaction relations will have to be established, as will the equations governing them. These equations will have to be solved in order to study the future behaviour of the systems. Systemography and systemometry would be applied. Remember that science is not the only system to be so complex. Science, however, is sufficiently important, in the evolution of the human being as a rational being, for time to be spent by specialists on its study.

Final Consideration.

With all these lines of reasoning when thinking about science, we have perhaps, instead of providing a ray of light, left uncertainty and pessimism. The scope of human knowledge is so great that it will never be dominated. It is also true that, if we knew everything, study, research and intellectual curiosity would hold no interest and we would have lost one of the principal reasons for living.

According to systemic dialectics, science appears to be attractive and suggestive, full of un-knows to be unveiled, of lines of research that should lead us somewhere. Somewhere better, with better living conditions, better human relationships, and us as better people. It is certainly worth carrying on studying with an eye to the future.

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