THE TOTAL SCIENTIST

The essay ***Language Problems in Mathematics*** *is a revised version (probably for the publication in [25]) of a paper presented at the Romanian Academy in 1940. We find in it Onicescu's main points of interest in the field of natural sciences, just as* ***Reflections on an Economy of the People*** *can serve as an introduction to his ideas on social sciences. Indeed, the former refers to mathematics, logic, mechanics, probabilities and even a philosophy of all these, while the latter reveals his tendency to break away from the framework of the too abstract theories.*

Characteristic for his outlook is the fact that he considered the theory of probability a science of nature, subordinated logic to mathematics (without falling into the trap of formalism), and used mechanics as a "pilot science" (whose evolution was supposed to serve as guide – not as absolute norm – to the other sciences). Even mathematics can learn from mechanics, especially geometry –, to from mechanics, from quantum mechanics. However, all have to put their assertions to the test of experience, because logical coherence and rigor are not enough to guarantee scientific truth. Every science has a language, but it is not reduced to it. Truth is not reduced to language correctness; it implies the adequacy of the theory to the reality in view. On the other hand, the complete mathematization of knowledge is not possible either.

Onicescu could not give up the organic unity of knowledge, expression and experience (both individual and collective). He had developed this belief by approaching the great physicists and mathematicians, and had consolidated it through his activity as an exceptional statistician and organizer, with a great sense of social-scientific interactions and human relations. It is this sense that accounts for the special kind of friendship and collaboration relations he had with his disciples.

Onicescu is one of the few Romanian scientists in the field of natural sciences who described extensively and entirely their philosophical outlooks ([6], [7], [18]). We shall take this description as a basis, but we shall associate it with some of his more concrete writings. A general presentation of his scientific activity accompanied by a complete bibliography was published by M. Iosifescu in ***International Statistical Review****, 54 (1986), pp. 97-108.*

According to Onicescu, the goal of science, like the goal of philosophy, is the complete knowledge of the world; but while science is dynamic (and therefore infinite) knowledge, philosophy is the study of the already established (therefore, finite) structures of knowledge, i.e. a sort of metatheory. Scientific knowledge is oriented towards (real or theoretical) objects and their relations, and its main goal is to find and predict the evolution of their adequate characteristics. If he militated for a common goal of sciences and for their cooperation, Onicescu was nevertheless careful to emphasize their specific autonomy, as well as the necessary pluralism of approaches. He thought it impossible to completely mathematize sciences, or to reduce mathematics to axioms or logic.

The essence of mathematics is, in his opinion, to construct mathematical theoretical objects and maneuver them by mathematical reasoning, which takes a variety of forms, apart from the deductive and the inductive ones. Demonstration itself is only one form of reasoning. By firmly preserving the unity of objects and reasoning in mathematical thinking (separated by Plato and Aristotle, the former focusing the object-ideas, the latter, deductive reasoning), Onicescu considers it necessary – under the assault of formalism and logic – to lay emphasis on developing a theory of mathematical objects. These are free – but not arbitrary – constructions (as they are supposed to be coherent and mainly consistent), made by *analogy with the real objects. They go beyond concepts, which are analytical (in a Kantian sense, i.e. they are reduced to definitions), while the mathematical objects are synthetic (as they produce new concepts and problems, that are not contained by definitions). Thus, besides the points and sides that define it, the plane triangle also has angles (whose total sum imposes itself as a problem), and marks the limits of an internal surface (with a certain area), etc.etc.*

Theoretical objects – mainly the mathematical ones – are of two kinds: epistemological (unique) and ontological (multiple instances of materialization of the ontological objects, but sharing all their characteristics). Various ontological mathematical triangles are obtained from the epistemological one, for instance, by changing the coordinates of its points. Mathematical objects are not geometrical only, but also arithmetical (like the natural whole number), algebraic (like the abstract group or the category) or physical (like the material point or even the Universe). A partial or total system of characteristics of the object makes up a structure. Objects may have a simple or a complex structure (the latter consisting of several correlated simple structures). Thus, fluids have a macroscopic structure described in phenomenological thermodynamics in terms of body volume, pressure and temperature, while in statistical thermodynamics, they have a microscopic structure, characterized by the position, speed, etc. of its particles.

According to this outlook, paradoxes eliminate themselves from the field of mathematics, because they lead to contradictory mathematical objects, i.e. to pseudo-objects. Still, this is, in my opinion, only a local solution to the problem of paradoxes, and we should leave it to other fields of knowledge (to logic, according to A. Dumitriu) to study their causes and the possibility to predict them. Onicescu does not adhere to the intuitivonist philosophy, aiming at the elimination of the mathematical infinite; on the contrary, he shows that, besides its negative, limiting character, it also has a positive one: that of belonging to an unlimited set (as it appears in the limit of convergent sequences of numbers).

The mathematical model is a "non-contradictory descriptive construction, whose characteristic features correspond to those of the [concrete or theoretical] object, according to a set of rules of correspondences suitable to our understanding". In its turn, theory "makes the model intelligible and integrates it into the general experience, into its rational unity". Theory is universal, therefore valid for an ensemble of models, just as Newton's mechanical theory explained both Kepler's solar system model and Galilei's model for the falling of objects onto the Earth. Researchers need to be familiarized with the history of natural sciences, in order to notice the richness in nuances of the theoretical concepts and to be inspired as to the future directions of research. Onicescu himself followed this path, which resulted in a series of memorable portraits of scientist, collected in [21] and [25].

In contemporary sciences, emphasizes Onicescu, models are the direct expression of a theory and, in the case of the models in statistical mechanics, there are as many as two explanatory theories: one on a microscopic level (mechanics), and another one on a macroscopic level (the theory of probabilities). The various ways of harmonizing these theories result in the variety of models displayed by statistical mechanics. The most adequate model cannot be chosen on a purely logical basis, but on an experimental one. A strange case is that of the general theory of relativity, in which, says Onicescu, "the model itself wants to express the theory", an anomaly he will feel entitled to correct.

Noticing that, in principle, all the statements of an established scientific theory are true, Onicescu succeeds in building for them a logic with one single value: truth; in fact, two types of logic, corresponding to the two types (theoretical and ontological) of theoretical objects I have already mentioned.

I think that the "invariance mechanics" created by Onicescu in an attempt to reform Newtonian mechanics, and as an alternative to Einstein's relativistic revolution, was the result of the same wish for getting closer to the concrete and to experience.

As I was saying above, Onicescu considered the theory of probabilities not a branch of pure mathematics, but a science of nature that studies those processes in which achieve-

ments of uncertain forecast are represented by random events, to which probabilities can be attached. The significance of the probability depends on the specificity of the experience and on the structure of the system in which it appears. In the first part of his life, by laying the foundations of the Romanian school of the probability theory, Onicescu had the opportunity to study such processes (together with G. Mihoc). He generalized the Markov chains, which reflect the statistical dependence of the immediately successive events, by introducing the chaims with complete connections (for the dependence of events on their entire past) ([3], [5]). On this basis, he then formulated a principle of stochastic determinism, analogous to Laplace's classical dynamic determinism, but applicable to the objects of quantum mechanics, statistical mechanics, as well as to the economic and social phenomena. This analogy was based on the common representation through algebraic chains and differential equations (emphasized by Gr. Moisil), but it asked for a change of the concept of object, understood now as a structure with adequate values and probabilities.

In order to apply statistics in social sciences, Onicescu developed in 1931 (starting from the ideas of R. von Mises and of statistical mechanics) a theory of collectives, as synthetic objects entailing two aspects: on the one hand, sets of relatively homogenous interactive elements that can be studied on the basis of typical (average) values; on the other hand, unitary, indivisible objects. Typical values lead to the idea that there is a relatively stable type, corresponding to a concrete reality. Evolution appears then as a structural change towards the materialization of the typical form, which is the most probable and stable structure. As evolution thus seemed predetermined for a unique goal, he subsequently detailed his approach. In 1972, he contended that the possibility of alternative evolutions could be explained by the possible existence of several stable structures of the same collective, and by the passage from one course of evolution to another through a leap, i.e. through a "break" in the evolution of the collective. It should however be said that, usually, such an evolution is applied to closed systems and heads towards a state of maximum homogeneity, which means "thermal death" for the Universe and death proper for organisms. As biological and social evolution aim at structures of greater complexity and dissimilarity, researchers such as I. Prigogine have suggested as the goal of evolution the states of maximum improbability, achievable by open systems.

Attracted by the informational approach of human action and communication, Onicescu, together with S. Guiaşu, introduced the idea of random automaton. If Moisil had studied the phenomena of involuntary hazard related to the functioning of automata with the help of polyvalent logic, the new concepts reflected the existence of an essential – and possibly, intentional – stochastic structure of automata (important in learning processes). On the other hand, in 1972, he started working on informational statistics, in which the basic idea was to replace Shannon's entropy with informational energy [24].].

Finally, in his last years, Onicescu worked together with M. Botez on devising a "demo-economic" model of a national system, whose principles were presented in several studies, among which the one reproduced above. Unlike the models devised by the Club of Rome Club, this one was centered on man and his creative abilities. The systems were considered super-objects of science, whose behavior was related to structures. The frames of the model were to be (in the increasing order of their variability): nature, ecosystem, man and society, state and legislation, as well as other states. The main characteristic feature of processes was the conservation of total matter, accompanied however by a value decrease (due to degradation, as N. Georgescu-Roegen has argued in his studies).

With this last model, he seems to have aimed to prove that mathematics is capable of getting closer to the concrete aspects of life, evolution and culture. Just as he had tried, throughout his activity, to preserve the unity of that European culture, originating in the Renaissance, in which art and science blended in the works of the authors guided by a Faustian spirit, enriched by the nostalgia for Helen and Hellenism.

(L. B.)