The Problem of Scientific Revolutions

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In the dynamics of our scientific knowledge, a special role belongs to development stages connected with reconstruction of investigation strategies, required by foundations of science. These stages were called scientific revolutions. Foundations of science provide growth of knowledge, till common features of system organization of the objects studied are counted in the picture of the world, and methods of their cognition correspond to the existing investigation ideals and norms.

But developing science may come across basically new types of objects, which require other vision of reality, different from that suggested by already developed picture of the world. The new objects may require that the scheme of method of cognitive activity, represented by a system of investigation ideals and norms, should be changed. In this situation growth of scientific knowledge stipulates reconstruction of foundation of science. Such reconstruction can be realized in two variations: a) revolution connected with transformation of the special picture of the world without important changes in investigation ideals and norms; b) revolution which causes radical changes not only in the picture of the world, but also in scientific ideals and norms, as well as in philosophical foundation of science.

In the history of natural science we can find samples of both situations of intensive knowledge growth. An example of the former: transition from mechanistic to electrodynamics picture of the world in physics of the last quarter of the 19th century due to construction of the classical theory of electromagnetic field. This transition, though followed by quite radical transformation of vision of the physical reality, did not change essentially cognitional attitudes of classical physics. It conserved understanding of explanation as search for substantial foundation for phenomena explained and strictly determined links among the phenomena; any indications to observation means and operational structures, which uncover essence of the objects studied etc., are eliminated from the principles of explanation and justification.

An example of the second situation is the history of quantum-relativistic physics, characterized by reconstruction of not only the scientific picture of the world, but also the classical ideals of explanation, description, justification and knowledge organization, as well as corresponding philosophical foundation of science.

The new picture of the reality studied and new norms of cognitional activity, while settling in a concrete science, then can have a revolutionary influence on other sciences. In this aspect we can mention two ways of reconstruction of investigation foundations: first, due to intradisciplinary development of knowledge; second, due to interdisciplinary connections, "grafting" of paradigmatic statements of one science to another.

In real history of science both ways superpose, so in most cases it would be more correct to speak about domineering of one of them in each science at either stage of their historical development.

Intradisciplinary Revolutions

Paradoxes and problem situations as premises of a scientific revolution

Most often science includes new objects into investigation unconsciously, through empirical studies of new phenomena or in process of solving special theoretical problems.

To analyze the peculiarities of this process in details, let us consider the historical situation immediately preceding construction of the special relativity and became one of the premises of the revolution in the 20th century physics[1].That situation was linked with discovery of paradoxes in classical electrodynamics of moving bodies.

When Lorentz developed Maxwell's electrodynamics, and the electron theory was built, it became possible to solve the class of problems considering interaction of moving charges and bodies with electromagnetic field. In the process of solution investigators were to formulate Maxwell's equations in different frames of reference, and then it became clear that the equations were no longer covariant, if we use Galilean transformations. Introduction of new transformations offered the way. The transformations were first offered by Vogt, and then by Lorentz, who has given his name to them for the history of science.

The coordinate transformations (space and time) in transition from one inertial system to another are an important characteristic of such system. Inertial frame of reference is one of fundamental theoretical objects of any physical theory. In Maxwell-Lorentz's electrodynamics it played the role of a component of the theoretical scheme which lay in the foundation of the theory. That scheme presented electromagnetic processes through relations of abstract objects: electric and magnetic fields in a point, elementary point charge (electron, and inertial frame of reference. The scheme was objectified through mapping to the electrodynamic picture of the world: elementary point charge correlated with the image of electron as a charged spherical body of very small size, immersed in ether; space-time characteristics of the frame of reference were connected with features of absolute space and absolute time. This connection was established thanks to the fact that space and time intervals of the frame of reference were seen as unchangeable in transition from one frame of reference to another. Stability of the intervals allowed us to consider them as independent from motion of the body (frames of reference) and, consequently, to present them as absolute space and absolute time. Galilean transformations (which automatically inferred this quality of inertial frames of reference) got this way their physical interpretation.

But when new transformations were introduced into the theory, the frame of reference, in a hidden manner, got new features: from Lorentz's transformations it was inferred that separately space and separately time intervals are not conserved in transition from one frame of reference to another. In mapping to the picture of the world these frame of reference features were objectified, which raised inconsistent definitions of space and time. Relativity of space and time intervals was incompatible with the principle of absolute space and time[2].

Paradoxes are a symptom indicating that science draws into sphere of its investigations a new type of processes, whose essential characteristics have not been reflected in the picture of the world. Formed in mechanics notions of absolute space and time allow consistently describe processes taking place at speeds low compared to the light speed. At the same time, in electrodynamics investigator dealt with fundamentally different processes characterized by light speed or close speeds. If he had implied old notions here, it would have caused contradictions in the very foundation of physical knowledge.

Thus, a special theoretical task became a problem: the system of knowledge could not remain inconsistent (a theory should be consistent, which is a norm of its organization), but to

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1 We are turning to analysis of the mentioned fragment of history of physics because reconstruction of foundations of scientific search in this case was accompanied by change of all components of foundations, including ideals and norms of investigation and philosophical foundations of science.

2 In Russian methodological literature paradoxes of such type were analyzed as "contradiction of meeting" of two different theories (in this case — mechanics and electrodynamics). Some time ago this approach was realized by M. I. Podgoretsky and Ya. A. Smorodinsky (see Podgoretsky and Smorodinsky (1969)). Later this approach was developed by R. M. Nugaev (see Nugaev (1989)). Not denying the importance of all these results, I would like to stress that "meeting" of the physical theories is realized due to mapping of their core (theoretical schemes) on the physical picture of reality, which is the system-forming factor with respect to other components of theoretical knowledge of physics.

eliminate paradoxes, it was necessary to change the physical picture of the world perceived by investigator as adequate reproduction of reality.

Such situations are quite characteristic for science entering the stage of a scientific revolution. Scientific problems emerging at this period appear due to solving special tasks. From our point of view, a task grows to a problem the following way: theoretical schemes and laws, generated by already formed foundations of science, are rebuilt in the process of their empirical justification, are correlated with new facts and so include new meaning. In reverse mapping to foundations (to the picture in the world, in particular) this meaning can come to mismatch with notions of reality introduced into the picture of the world. If the picture of the world does not take into account specificity of new objects, then theoretical scheme, considering some essential peculiarities of such objects, may lead to paradoxes in the system of knowledge[3].

Science solves paradoxes by means of reconstruction of foundations previously formed. Such reconstruction without fail leads to change of the picture of the world. Though, revision of the picture of the world is not at all easy, as at the previous period stimulated theoretical and empirical investigations and was perceived as adequate image of the essence of processes studied.

For instance, it is characteristic that Lorentz, who prepared breakdown of the electrodynamic picture of the world, failed to make a decisive step himself.

He interpreted changes of space and time intervals as fictitious, "local" space and time. What was true, he believed, was absolute space and time of the picture of the world accepted by the late 19th century physics.

As early as deducing his transformations, Lorentz was eager to provide them with physical sense introducing into the picture of the world a number of assumptions, which would preserve ether and absolute space and time. He supposed that electron, moving past ether and interacting with it, can change its own space configuration. This was how Lorentz interpreted change of space and time intervals as a by-effect of electron's dynamics, but not as a real property of space and time. From the same positions did Lorentz interpret the results of Michelson's experiment.

It was Einstein who radically transformed of the electrodynamic picture of the world. The transformation was connected with rejection of the conception of ether and revision of the ideas of absolute space and time.

Characterizing Einstein's transfer to new vision of the physical reality, we could follow Kuhn and use terms of discovery psychology as Gestalt-switching. But such approach would keep from the light logic of cognitive movement, which lay in the foundation of Einstein's works, and which characterizes foundations of the mechanism of reconstruction of science foundation at the period of scientific revolution.

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3 From these positions we can interpret the problem situation, which emerged in connection with Planck's discovery of the action quantum. Analysis of radiation of absolutely black body first was really a quite particular problem in the course of the investigation program set by the electrodynamic picture the world. The latter also shaped the means of solution of this problem: notion apparatus of thermodynamics and Maxwell — Lorentz's electrodynamics. Application of those means let the investigators construct the model of radiation of absolutely black body, whose adaptation to experiment (and reconstruction in the course of that adaptation) led to Planck's discovery. The radiation law, offered by Planck, was coordinated with all experimental data (in this regard the special problem was solved). But in mapping of the model, relatively to which the law was formulated, to electrodynamic picture of the world, there appeared a paradox: the model supposed that oscillators absorb and emit electromagnetic energy in portions multiple of $h\nu$, while in the picture of the world electromagnetic radiation was regarded as continuous medium. Hence there emerged a problem: what was the real nature of electromagnetic field? The solution of that problem was connected with further reconstruction of electromagnetic picture of the world, with introduction of notions of corpuscular-wave character of electromagnetic field (the idea of photons).

When Einstein's predecessors tried to preserve the previous picture of the world, they did not eliminate paradoxes, but only transferred them to a deeper layer of science foundations.

In this case there usually emerge contradictions between the system of knowledge being created and science ideals, while a theory should be constructed according to the latter. Additional principles, introduced into the picture of the world to explain new phenomena, appear as ad hoc postulates. If we permanently use such postulates when we discover new phenomena, we face with danger of chaotic increase of initial principles of theoretical investigation. In the extreme, such increase may lead to the situation when the number of principles may start equalizing with the number of empirical facts explained through the said principles, which would destroy the very idea of theoretical explanation.

Einstein's criticism of the notions of classical physics was, to considerable extent, stimulated by understanding of the mentioned paradox. In turn, such understanding stipulated the investigator's specific position. He had to leave the limits of especially scientific problems and consider them in the aspect of regularities of cognition process, i.e. turn to the language of philosophical and methodological analysis. Cognitive activity, aimed at reconstruction of science foundations, always stipulates change of investigator's position and turn to philosophical and methodological means (see fig. 1).

Einstein proceeded from the following methodological postulate: a theory should not only fit to normative experimental justification, but also, in the ideal case, it should be organized so that diversity of very different phenomena should be explained and predicted on base of relatively small number of principles which would fix the essence of reality studied.

At later stages of his activity (after the special relativity had been created), Einstein pointed at those methodological criteria, according to which a physical theory should be created, as at requirements of its experimental verification and internal perfection[4]. He justified both requirements as profound characteristics of scientific investigation; and, in effect, he regarded them as explication of invariant contents of ideals of science, which controls creative search at all stages of development of natural science.

Justification of the indicated requirements as universally important characteristics of ideal of natural science theory stipulated analysis of the nature of theoretical cognition. Einstein returned to this analysis many times, at different stages of his career, improving and developing notion of ways of formation of a scientific theory. Theoretical reproduction of essential aspects of reality, according to Einstein, is realized by means of creative search for a moderate number of principles, on base of which all the rest conceptual construction of theory is unfolded. The principles themselves can only be "blown" by experiment, they are not deduced directly from experimental facts by induction. They are the result of active reconstruction of historically collected conceptual means, which are developed in the very cognition process and, to large extent, determine the character of theory created. To be true, a theory should rest on experiment. But one and the same experimental sphere can be described by different theories, and each of them offers its own vision of facts. That is why, according Einstein, experimental verification is necessary, but not sufficient to accept a theory. Internal perfection of a theoretical construction is also needed.

In its developed form, Einstein accounted that conception after the special relativity had been created. It seems that when the special relativity was becoming, many ideas of the mentioned conception were in embryonic state. We have good reasons to believe that Einstein worked out the idea of impossibility to deduce theoretical principles from experiment directly only at the time of creation of the general relativity[5]. But Einstein had always understood the

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4 See Einstein (1965-1967, vol.4, pp.266-267).
5 Holton (1979, pp.218-226).

special role of principles in theoretical cognition. All stages of his works are marked by conviction that there are profound regularities of nature, that science is called to uncover, and that they are reflected in science as principles.

According to Einstein, the indicator of correspondence of theoretical principles to reality studied is not only the fact that some corollaries, confirmed by experiment, can be deduced from them, but also that principles embrace as large diversity of facts as possible. Principles, laid in foundation of physical investigation, should reflect "general features of enormous host of experimentally proved facts"[6].

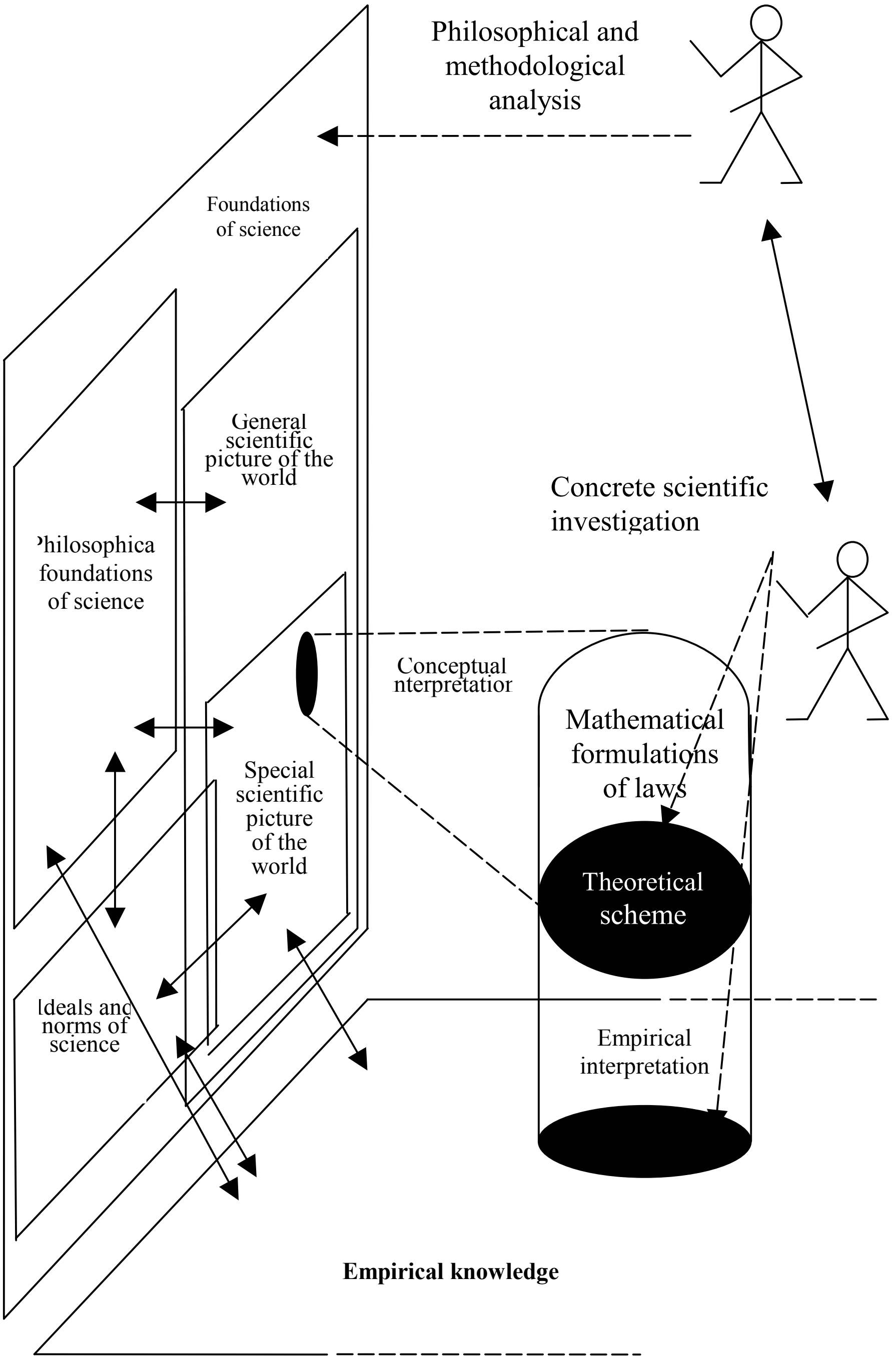

Fig. 1.

6 Einstein (1965-1967, vol.4, pp.15).

Such notions were enough to justify universality of ideal experimental verification and internal perfection of theory. Further evolution of Einstein's epistemological views only made this justification more precise, including new, deeper aspects of understanding of interconnections of theory and experiment.

Having distinguished universal characteristics of ideal theoretical explanation and theoretical organization of knowledge (experimental verification and internal perfection), Einstein then analyzed the situation, to which physics had come till the early 20th century.

Einstein estimated hypotheses introduced in Lorentz's electrodynamics ("explaining" change of lengths and time intervals) as typical ad hoc postulates, which help to only formally eliminate contradictions between theory and experiment and are only "artificial means to save theory"[7]. Lorentz's electrodynamics of moving bodies was not up to the mark of ideal theoretical organization, and so required radical reconstruction. But such reconstruction was impossible without change of fundamental notions and ideas, on which the physical picture of reality was based.

Since these notions were ontologized, their revision raised the question of their relation to reality. So, again we had a situation, when philosophical analysis was a necessary preliminary condition for solving concrete scientific tasks.

The relativity theory creator many times emphasized that scientific notions are to describe reality, which exists independently from us. We see reality through a system of notions and, due to this, often make these notions absolute, identify them and reality. But the development of science proves that even most fundamental notions and ideas of science "can never be final". "We must always be ready to alter them, that is, to alter the axiomatic basis of physics, in order to take account of the facts of perception with the greatest possible logical completeness"8.

Such philosophical criticism of notions and principles of the picture of the world is a premise for its further radical reconstruction.

But the role of philosophical and methodological analysis in the period of reconstruction of science foundations is not reduced to critical functions only. This analysis has also a constructive, heuristic function, as it helps to work out new foundations of investigation. The new picture of the world cannot be obtained from new empirical material in a purely inductive way. This material itself is organized and explained in concordance with certain ways of its vision, and this is specified by the picture of the world. That is why empirical material can only discover contradiction between old vision and new reality, but it is unable to indicate by itself, how this vision should be changed. Forming the new picture of the world claims special ideas, which would let us regroup elements of the old ideas of reality, eliminate a part of them, include new elements, so that we could solve paradoxes existing and assimilate collected facts. Such ideas are formed in the sphere of philosophical and methodological analysis of cognitive situations in science and play the role of quite general heuristics, which provides intensive development of investigations.

Scientific Revolutions and Interdisciplinary Interactions

Scientific revolutions are possible not only as the result of intradisciplinary development, when the investigation sphere absorbs new types of objects, assimilation of which requires that foundations of the scientific discipline should be changed. They are also possible due to interdisciplinary interactions, based on "paradigmatic graftings" — transfer of notions of the

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7 Ibid, Vol. 1, p.66.
8 Einstein (1931, p.66).

special scientific picture of the world, as well as investigation ideals and norms, from one scientific discipline to another. Such transplantations are able to cause transformation of the foundation of science without paradoxes and crises connected with its inner development. The new picture of the reality studied (disciplinary ontology) and new investigation norms, emerging as the result of paradigmatic graftings, discover another field of scientific problems, different from the one which existed previously, stimulate discoveries of phenomena and laws, which were completely out of the sphere of scientific search before "paradigmatic grafting".

Generally speaking, this way of scientific revolutions has not been analyzed deeply enough neither by T. Kuhn, nor by other investigators in the Western philosophy of science.

Still it is the key for understanding the processes of appearance and development of many scientific disciplines. Moreover, without taking into account features of this way, based on paradigmatic transplantations, we cannot understand that great scientific revolution which was connected with forming of disciplinarily organized science.

The majority of sciences, which are now considered as classical disciplines — biology, chemistry, technical and social studies — date back to ancient times. Historical development of knowledge accumulated facts about separate features of objects studied. But for a long time facts were systematized and explained through natural philosophic schemes.

After there had appeared the first theoretically formed sphere of scientific knowledge — physics, and the mechanistic picture of the world had got status of universal scientific ontology, a special stage of history of sciences began. In most of them investigators made efforts to apply principles and ideas of the mechanistic picture of the world to explain facts.

The mechanistic picture of the world, though formed within physical investigation, at that historical period functioned as both natural scientific and general scientific picture of the world. Justified by philosophical attitudes of mechanist materialism, it put reference points not only for physicists, but also for scientists who worked in other spheres of scientific cognition. No surprise that investigation strategies in those spheres were formed under direct influence of the ideas of the mechanic picture of the world.

In this respect a quite characteristic example is development of chemistry of that historical period (the 17th — the 18th centuries)[9].

In the middle of the 17th century, when chemistry was not yet constituted as independent science, it was either included in the system of alchemic notions, or was presented as set of knowledge used in medicine. The first steps of becoming chemistry as science was, to a great extent, connected with atomic-corpuscular ideas entering chemistry. In the second half of the 17th century R.Boyle put forward a program translating principles and models of explanation, formed in mechanics, into chemistry. Boyle suggested that all chemical phenomena should be explained through notions of movement of "minute particles of matter" (corpuscles). According to Boyle, this way could allow chemistry to separate itself from alchemy and medicine, and transform into independent science. Proceeding from universality of laws of mechanics, Boyle concluded that the principles of mechanics should be also applied the hidden processes taking place between the smallest particles of bodies[10].

Functioning of the mechanistic picture of the world as an investigation program can be traced not only in interaction of chemistry and physics. Analogous mechanism of development of scientific knowledge can be found also in analysis of relations of physics and biology at the stage of predisciplinary natural science (the 17th — the 18th centuries).

On the face of it, biology had no such close contacts with physics as chemistry had. But

9 See more details in Stepin and Kuznetsova (1981. pp.260-279).
10 Dorfman (1974, p.188).

still the mechanistic picture of the world in several situations quite strongly influenced the strategy of biological investigations. In this respect it is interesting to consider investigations made by Lamarck, one of the founders of the idea of biological evolution.

Trying to find natural reasons of development of organisms, Lamarck, to considerable extent, was guided by the principles of explanation taken from mechanics. He based on the 18th century's variation of the mechanist picture of the world, which included the idea of "imponderable" fluids as carriers of various types of forces, and believed that it was imponderable fluids that were sources of organic movements and changes in architectonics of living beings.

The nature, in Lamarck's vision, was field of permanent motion, transfer and circulation of innumerable fluids, among which the main "stimuli of life" are electric fluid and thermogen[11].

The development of life, from his point of view, raised as "growing influence of motion of fluids", which made organisms more and more complicated. He wrote: "Who cannot see here the historical motion of organization phenomena, observed in animals considered, who cannot see it in this growing complication in the common row in transfer from the simple to the more complicated"[12]. According to Lamarck, it was the exchange of fluids between environment and organisms, growth of this exchange in strengthening of the organs' functions that led to changes in the latter. Adaptation of organisms to living conditions strengthens functions of some organs and weakens other ones. The corresponding exchange of fluids with environment causes small changes in all organs. In turn, such changes are inherited, and that, in Lamarck's opinion, could lead to quite considerable reconstruction of organs and appearance of new species in case of long accumulation of changes.

As we can see, the explanation used by Lamarck, to a great extent was initiated by principles, translated from the mechanistic picture of the world.

The function of the mechanist picture of the world as investigation program common to all sciences was displayed not only in studies of various natural processes, but also in knowledge of man and society which attempted to form the science of the 18th century. Certainly, consideration of social objects as simple mechanical systems was a greatest simplification. These objects belong to the class of complicated, developing systems including man and his consciousness. They require special investigation methods. But, to work out such methods, science had to go a long road of development. In the 18th century there were no objective premises for that yet. At that epoch scientific approach was identified with those its samples which were realized in mechanics, and so it seemed natural to build studies of man and society as some kind of social mechanics on base of application of principles of the mechanistic picture of the world.

Quite a characteristic example of such approach is Lamettrie's and Holbach's thoughts about the nature of man and society.

Basing on ideas developed in the mechanistic picture of the world, Lamettrie and Holbach widely used mechanical analogies in explanation of social phenomena and in discussion of problems of man as a natural and social being.

Considering man as, first of all, a part of nature, a special natural body, Lamettrie presented him as a certain type of mechanistic system. He wrote that man can be presented as a "clockwork", but of enormous size and built so skillfully and ingeniously, that if the second wheel stopped, the minute one would gear and work as if nothing had happened. In the same sense, choking up of several vessels is not enough to destroy or stop the action of the lever of

11 Lamarck (1807).
12 Lamarck (1959, p.148).

all motions in the heart which is the working part of human machine...[13]

Then Lamettrie indicates that human body is a self-winding machine, the main embodiment of continuous motion[14]. At the same time he denoted singularities of this machine and its complicity in comparison with technical devices studied by mechanics. He wrote that man can be regarded as a very smart machine, so complicated that it is absolutely impossible to form a clear idea of it and, consequently, to give it an exact definition[15].

Expressing his agreement with Lamettrie in understanding man as a machine[16], Holbach concentrated his attention at the ideas of universality of mechanistic laws, believing it to be possible to describe human society by means of them.

For him man is a product of nature submitted, on the one hand, to the general laws of nature, on the other hand, to special laws[17].

According to Holbach, man's specific feature is his desire to self-preservation. Here man resists destruction, feels the force of inertia, is drawn towards himself, is attracted to objects alike and repelled by the ones opposite to him...Everything he does and everything that happens in him is consequence of the inertia force, inclination to himself, attraction and repulsion forces, aspiration for self-preservation, in a word, energy he shares with all beings observed[18].

When Lamettrie and Holbach use the notions of machine, force, inertia, attraction, repulsion to characterize man, here we can clearly trace the language of the mechanistic picture of the world, which, during a long period, determined the strategy of nature, man and society. This strategy can be quite easily found also in later stages of development of knowledge, for instance, in social conceptions built by H. Saint-Simon and Ch. Fourier. In his "Work on Newtonian Attraction" Saint-Simon said that progress of human mind came to the situation when the most important discourses on politics can and should be deduced from knowledge obtained in higher sciences and the sphere of physics[19].

In Saint-Simon's opinion, the law of gravity was to become basis of new philosophy, which, in turn, can become foundation of new political science. He wrote that the force of European scientists, joined in a common corporation and linked by philosophy, based on the idea of gravity, will be immeasurable[20].

Saint-Simon thought that the ideas of gravity could become a base for such a discipline as history. He said that history "still is a collection of facts, more or less exactly known, but in future it should become a science, and, as the only science is classical mechanics, history, in its structure, should approximate to celestial mechanics"[21].

Ideas of the same kind can be found in Ch. Fourier's works; he believed that principles and approaches of mechanics allow us to disclose the laws of social movement. He wrote that there existed two types of laws ruling the world. The first one is the laws of material gravity, and the priority of its disclosure belongs to Newton. Regarding himself as successor of Newtonian ideas and disseminating the gravity doctrine to social life, Fourier thought that there was the second type of laws, which regulated social movement. He defined them as laws of gravity by passion, which occupied the central place in his conception as decisive property

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13 Lamettrie(1796).
14 Ibid.
15 Ibid.
16 Holbach (1770).
17 Ibid.
18 Ibid.
19 Saint-Simon (1966).
20 Ibid.
21 Saint-Simon (1948, p.234).

of human nature[22].

As a matter of fact, here we face a kind of analogy between existence of gravity of natural bodies and people's bent for each other. To great extent, it is done due to the fact that man is considered as a part of nature, though having some distinctions from other natural objects, but still submitting to general principles of motion formulated in mechanics. The idea of common mechanics of nature and human relations for the most part was initiated by the mechanistic picture of the world, which domineered in the science of the 18th century and partly preserved its positions in the early 19th century.

The role of the ideas of the mechanistic picture of the world was so considerable that they not only determined the strategy of development of scientific knowledge, but also had influence upon political practice. The idea of the world as a regulated mechanical system evidently sufficed over the minds of creators of American constitution, who worked out the structure of state machine, whose all links were to act as smoothly and exactly as clockwork[23].

All this presents us evidences of a special place of the mechanistic picture of the world in the culture of technogenic societies of the epoch of early industrialism. Mechanism was one of important origins of formation of corresponding worldview structures, which struck roots in the culture and exerted influence upon various spheres of functioning of social consciousness.

In turn, the spread of mechanist worldview confirmed the belief that the principles of the mechanical picture of the world are universal means of cognition of any objects.

Thus, we may state an important feature in functioning of the mechanistic picture of the world as fundamental investigation program in the science of the 18th century: Synthesis of knowledge, realized within it, was connected with reduction of various processes and phenomena to mechanical ones. The correctness of such reduction was justified by all system of philosophical foundations of science, where mechanistic ideas prevailed.

But, as the mechanistic picture of the world expanded to new and new subject spheres, science more and more often had to take into consideration peculiarites of those spheres, which required new, non-mechanistic ideas. More and more facts hardly could be conformed to the principles of the mechanistic picture of the world.

Up to the late 18th — the early 19th centuries a new situation started to arise; it led to appearance of disciplinary natural science, and within it the scientific picture of the world got its special characteristics and functional signs. It was a revolution in science, connected with reconstruction of its foundations, emerging of new forms of its institutional organization and its new functions in the dynamics of social life.

The history of chemistry, biology, technical and social disciplines cannot be understood, if we do not take into account "paradigmatic graftings" which were connected with expansion of the mechanistic picture of the world into new subject spheres.

Let us trace special features of that process. As we have already stated, the first attempts to apply notions and principles of mechanics in chemistry were connected with R. Boyle's program. Analysis of its historical fate shows that Boyle's desire to explain chemical phenomena from positions of notions of motions of "minute particles of matter" (corpuscles) required account of specificity of chemical processes. Under pressure of accumulated facts about chemical interactions, Boyle had to modify the ideas of the mechanistic picture of the world transferred to chemistry, and, as a result, chemistry started to form the picture of specific for chemistry picture of the processes studied.

According to Boyle, the primary corpuscles were to be considered as elements replacing former Aristotle's and alchemic elements. Basing on facts proving that changes of substances

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22 Fourier (1953).

23 See Toffler (1986, p.14).

allows a scientist both to turn some of the substances into others, and to restore some of them in their initial shape, Boyle concluded that elementary corpuscles, determining properties of the corresponding compound substances, should be preserved in reactions[24]. These corpuscles are presented as qualitatively different elements, which form chemical compounds and mixtures.

Here it is evident enough that Boyle's picture of chemical processes, though conformed to the mechanistic picture of the world, included also specific features. In embryonic state it contained notion of chemical elements as corpuscles, having individuality, which, being physical particles, were as well were carriers of properties which let them form various kinds of chemical substances in their compounds[25].

Mechanics could ignore these properties, considering corpuscles as only as masses subject to influence of forces, but in chemistry the properties of corpuscles, which make the chemical elements, are to be the main object of studies.

The mechanist picture of the world (if we take its developed forms), along with elementary objects — corpuscles, picked out the types of bodies built of them: liquid, solid, gaseous. In the picture of chemical reality, offered by Boyle, typology of chemical substances was not entirely reduced to typology of physical objects: together with distinction of liquid, solid and gaseous (volatile) substances Boyle picked out two classes of compopund chemical objects — compounds and mixtures, and it was presumed that inside each of them there are special subclasses. Boyle gave these notions in non-developed and, in many respects, hypothetical form, since concrete empirically fixed features, distinguishing compounds from mixtures, were not yet defined. "A long time yet was taken by the difficult question: what is a chemical mixture and what is compound, what are their nature, properties and differences; it caused contradictory statements of various kinds"[26].

Boyle's program offered atomistic picture as basis for experimental and theoretical work in chemistry. In its main features it anticipated future Dalton's discoveries, though in the 17th century there were no sufficient conditions for its realization.

At Boyle's time chemistry did not dispose of experimental possibilities to decide which substances are elements, and which are not[27]. Boyle also did not worked out the idea of atomic weight as a characteristic, which could allow chemists to distinguish substances from each other[28].

Nevertheless, despite the fact that Boyle's program was not realized, for methodological analysis it can serve as a good example which lets us determine of transfer of principles (in this context, principle of the mechanist picture of the world) from one science to another. The example of this program shows that translation into chemistry normative principle, fixed in the mechanist picture of the world (like the following normatives: all bodies consist of corpuscles, all phenomena can be explained by interaction of indivisible corpuscles which submit to mechanical laws), did not eliminate specificities of chemical investigation. What is more, to apply new principles in a new sphere, they were to be delivered in a special way, with due regard for specificity of objects, studied in chemistry. And that led to construction of a special picture of the reality studied (in this case — the picture of chemical reality), guided by which, investigator could experimentally find and explain chemical phenomena.

Using the material of history of science, we can state that becoming of most new disciplines was connected with both intradisciplinary development of science and with

24 Jua (1975, p.93).
25 Dorfman (1974, p.188).
26 Solovyov (1971, p.24).
27 Ibid, p.24.
28 Jua (1975, p.93).

translation of normative principle from one science to another. In this respect, Boyle's program can be regarded as an attempt of revolutionary transformations in chemistry by transplantation of cognitive directions and principles, taken from the mechanist picture of the world, into it.

Failure of that attempt was connected first of all with the fact that the picture of chemical reality, offered by Boyle, did not include such features of its key object (chemical element), which could be experimentally justified and stimulate new investigation ways in chemistry. That picture also had no experimentally verifiable features, which could allow investigators to clearly distinguish the basic types of chemical objects (element, compound, mixture).

A century and a half later, when chemistry had stored corresponding knowledge, it repeated Boyle's attempt in a more successful variation.

The process of reconstruction of foundations of chemistry in the 18th — the 19th centuries was also conditioned by not only inner factors of its development (interaction of theory and experiment). The decisive role here still belonged to the mechanist picture of the world, prevailing at that time. As a universal scheme of explanation of physical phenomena, it introduced the idea of interaction of material corpuscles (bodies) by means of various types of forces. Analogically to this approach, in chemistry there began to establish the notion of "forces of chemical affinity"[29], which determined interaction of chemical elements. This notion was included into the picture of chemical reality, first as a hypothesis, then, in Lavoisier's works, as a thesis justified by experiment.

As Lavoisier noted, probably, one day the exactness of data available will be brought to such degree, that a geometrician will be able to calculate in his study phenomena, accompanying any chemical compound, in the same, say, way, in which he calculates movement of celestial bodies. Laplace's views in this respect and experiments, which we have projected on base of his ideas, to express forces of affinity of various bodies, now do not let us not regard such hope as some chimera[30].

Lavoisier himself even created a table of oxygen's affinity with various substances and supposed possibility of quantitative measuring affinity[31].

In his works special attention is paid to working out notions of the main objects — elements. He suggested that the idea of the ultimate limit, reached by analysis, should be connected with the names of elements. In this respect all substances indivisible, in his opinion, at the contemporary state of knowledge, were elements. Before there appear means to divide them, and experiment proves us the contrary, — said he, — we cannot regard them as compound[32].

Classifying compound substances, Lavoisier, on the one hand, reckoned for these evidently hypothetical substances (such as thermogen), on the other hand, he brilliantly foresaw that a number of substances, which appeared as simple ones, in the nearest future would not be reckoned for simple ones.

Lavoisier's new notions of elements were a decisive "progress of the problem" in forming of scientific picture of the chemical reality. The results, obtained by Lavoisier, were essential for proof of the law of conservation of substance (1789) which made possible quantitative study of chemical reactions. They exerted influence upon investigations carried out by Dalton, which finished Lavoisier's program of forming new system of chemistry principles, which would coordinate with domineering physical ideas and base on chemical experiments. The

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29 I. Newton was one of the first to put forward this idea; it was justified by J. Biot and P.Laplace, then it directed investigations of J. Richter, A. Lavoisier, L. Proust, C. Berthollet et al. See Solovyov (1971, pp.90-99).
30 Solovyov and Kurashov (1983, p.108).
31 *A Becoming of Chemistry as Science* (1983, p.108).
32 Lavoisier (1943, p.362).

works of Dalton and his followers led to construction of the picture of chemical reality, where chemical elements were presented as atoms different in their form and atomic weight. The latter allowed chemists to explain not only phenomena observed in experiments, but also many laws, discovered at that time and confirmed by experiment (for instance, stehiometry laws discovered by Richter, Proust and Dalton).

Investigators of Dalton's works truly say that Dalton came to construction of stehiometry laws, basing on the atomist hypothesis, and from the position of it he generalized experimental facts. That hypothesis had its premises in philosophical atomist doctrines, but its direct source was in Newton's atomist views, the notions of the mechanist picture of the world of indivisible and indestructible corpuscles.

Dalton's atomist picture, in the process of its development (here the decisive role belonged to A. Avogadro and Ch. Gerhardt), was enriched by the ideas of molecules as integral systems of atoms, and of chemical processes as interaction of molecules when they exchanged atoms. In turn, the notions of atomic-molecular structure of substance started exerting reverse influence upon physical investigations. It is characteristic that the molecular-kinetic theory of heat, which replaced the thermogen theory, was mainly based on the idea that substance consists of moving molecules.

In one of his first works on kinetic theory of gases (1857), R. Clausius created a mathematical model of thermal movement of gas particles and prefaced it with account of the ideas of molecular structure of substance. In that account, beside translational movement, he singled out also rotating and intramolecular oscillatory movement[33]. Mentioning of the latter is interesting only because it means that a molecule from the very beginning is imagined as a complicated thing, consisting of atoms (this idea entered the scientific picture of the world under the influence of development of chemistry). It is also quite characteristic that in A. Kroenig’s work (1856), which preceded Clausius's investigation and gave start to the investigation cycle, which led to construction of molecular-kinetic theory of heat, the key moment of justification of hypothesis of heat as kinetic movement of molecules is inference of Avogadro's law. That law, deduced in 1811, was then so entirely forgotten that physical dictionaries did not even include Avogadro's name[34]. But in chemistry Avogadro's law was not only well known, but also it played the decisive role in development of atom-molecular conceptions. Later it was returned from chemistry to physics and there actively used in construction of molecular-kinetic theory of heat.

Thus, we may conclude that in translation of the principles of the mechanist picture of the world into chemistry, they were not just transplanted into the "body" of chemistry, stipulating purely mechanical view of chemical objects, but were confronted with the features proper to objects studied in chemistry, and that stimulated becoming of chemistry as science, with its specific object part, and forming a new picture of the reality studied, now not reducible to the mechanist one. And though investigators still went on considering transformation of chemistry into a section of applied mechanics or appearance of independent chemical mechanics (D. I. Mendeleev), really one could say that chemistry was becoming constituted in an independent science, under influence of the mechanist picture of the world and regarding specificity of chemical objects. And the most important aspect of that process was becoming of a special picture of the reality studied. The physical picture of the world and the picture of the chemical reality got subordinational connection, and that connection did not abolish relative independence of each of them.

Similar processes of becoming of special scientific picture of the world also can be traced

33 Dorfman (1979, p.127).
34 Ibid.

in the history of biological knowledge.

Above we have mentioned that Lamarck, explaining causes of appearance of life, resorted to the ideas, developed in the mechanist picture of the world of the 18th century, in particular, notions of thermogen and electric fluid as carriers of special forces, which were regarded by the scientist as the main stimuli of life. Though Lamarck did not transfer mechanically the ideas of those hypothetical substances into the field of knowledge developed by him. He emphasized that thermogen and electric fluid, entering a living organism, are transformed into a specific fluid — nerve fluid, proper only to living beings. The nerve fluid, in Lamarck's opinion, was an acting force, as a sort of instrument that produced feelings, ideas, and acts of reason. It is nerve fluid that is able to cause such amazing phenomena, and, to deny its existence and its properties, we would have to give up any investigation of physical reasons of phenomena and again turn to vague, groundless notions to satisfy our curiosity toward this object[35].

Explaining the nature of living organisms this way, Lamarck, though in a hidden form, accentuated his attention at specificities, proper to living beings, and that circumstance laid foundation for specification of biological science and forming of its special picture the reality studied. Lamarck not only emphasized specificity of biological objects, but also pointed out their interaction with the environment as source of their changes. According to Lamarck, these changes happen due to permanent extraction of fluids from the environment and their transformation inside a living organism. Accumulation of corresponding fluids inside organism causes changes of separate organs and the whole organism, and these changes can be traced, if we consider a row of generations for long enough time. "In the course of time, and under influence of unlimited diversity of permanently changing circumstances, living bodies of all classes and all orders were created"[36].

Thus, the principles of explanation, taken from the mechanist picture of the world, were transformed by Lamarck into the principle of evolutional explanation of features of organisms and species, the principle, fundamental for biology.

The diversity of living organisms, different levels of their organization were foundation to their arrangement in a certain order, from simple to complicated ones, and the gradation principle, which Lamarck assumed as basis of his evolutional conception. Though, insisting on smooth, imperceptible transitions between species, Lamarck came to conclusion that there were no real borders between them and, in the final analysis, denied their reality, his idea of changeability and inheritance of accepted changes were the basis of further development of biological knowledge, when it accumulated empirical material which stimulated development of evolutional notions.

Taking into account the fact that ideas of objects and their interactions are one of aspects of forming of the picture of the world, we may say that Lamarck introduced new vision of biological reality.

Lamarck's evolutional ideas were heuristically important not only for development of biological knowledge, but for other natural sciences, such as geology, as well.

In his conception, Ch. Lyell strove to solve a difficult and actual (for that time) problem of correlation of modern natural forces and the forces of the past. Solving this problem, Lyell took notice of the ideas, already developed in biological science. He was not satisfied with approaches, applied by "the catastrophists", but in Lamarck's conception he found answers to arising questions. We mean the principles which lie in the foundation of Lamarck's conception: first, the principle of similarity of acting natural forces and those which acted in

35 Lamarck (1809).
36 Lamarck (1959, p.365).

the past; second, the principle, according to which radical changes are results of gradual small changes, accumulated for a long time.

Lyell employed these principles in his doctrine of geological processes[37]. He transferred normative principles, formed in biology, into geology, and thus constructed a theoretical conception, which later exerted reverse influence upon biology and, along with Lamarck's evolutional ideas, became one of the premises for becoming of scientific picture of biological reality connected with the name of Darwin.

When Darwin's conception appeared, biology got the status of independent branch of natural science of full value. At that period the picture of biological reality got clear features of autonomy and acted as a system of scientific notions disclosing properties of living nature.

Settling of biology as an autonomous branch of knowledge did not mean that its further development took place exclusively owing only to its inner factors. Appearance of new knowledge in disciplinarily organized science always is a complicated and multilateral process, which includes both intradisciplinary and interdisciplinary interactions. An example of this would serves Mendel's discoveries. They were results not only of development of biology, but were realized through translation of ideas, developed in other sciences, into biology. In his work "Experiments on Plant Hybrids" Mendel formulated his theory of discrete heredity carrier, the "heredity factor", and demonstrated that separate features and properties of organism can be connected with these "heredity factors"[38].

Mendel's experiments became possible due to development of hybridization in biological practice of the time. At the same time, the empirical material, accumulated in biologists' and practical selectioners' research works, did not by itself lead to the idea of "heredity factors". To formulate this idea, Mendel had to preliminarily dispose of some theoretical vision and accumulated empirical material under it.

That theoretical vision was being formed not only on base of developing biological knowledge, but also under influence of principles of explanation translated from other spheres of knowledge, from mathematics, for instance. Investigators of Mendel's works said that he "joined methods of two branches: mathematics — the probability statistical method (Doppler), and biology — hybridization method (Unger)"[39].

In fact, Mendel ran his experiments as base of the new, only being formed at that stage, picture of biological reality, which was constructed thanks to interrelation of intradisciplinary and interdisciplinary knowledge. Gradually did that picture settle the notion of a new biological object — "heredity factors". Exposure of that object and including the idea of it into the picture of the biological reality, on the one hand, let investigators interpret accumulated facts in a new way, on the other hand, contributed to further justification and development of Darwin's theory of evolution and formation of new theories in biology (for instance, the synthetic theory of evolution as joint of the evolution theory and population genetics).

In turn, the new theories and facts exerted reverse influence upon the picture of biological reality, which was corrected and developed under influence of theoretical and empirical material. In the first third of the 20th century Darwin's picture of the biological world was replaced by a new one; there not organism, but population was regarded as the basic unit of evolution, and it introduced the basic organization levels of living nature — molecular heredity carriers, cell, multicellular organisms, populations, biogeocenoses and biosphere (the ideas of the two latter levels were included into the picture of the biologic world mostly due to works of Sukachev and Vernadsky).

37 See Ravikovich (1976, pp.42-43).
38 Mendel (1959).
39 See Pastushny (1981, p.17).

Interaction of organisms with each other and with environment was regarded in the contexts of including over-organism structure of the living nature into this interaction. The base of biological processes was reproduction of life structures in concordance with their genetic code (heredity) and their changes caused by mutations and natural selection.

Finally, there appeared new ideas of space-time characteristics of biological processes. Even Darwin's picture of the world introduced the notion of evolution time (unlike the mechanist picture of the world, which had extratemporal character), it consolidated the idea of historicism. Further development of biology corrected these ideas and formed the notion of special space-time structures of the living nature, not reducible to physical space and time. There appeared the idea of biological time of separate living organisms and populations; it became clear that the notions of physical time continuity are not enough to characterize biological systems, and later it contributed to introduction of the idea of "anticipatory reflection".

As the result, the picture of the biological reality became not only autonomous referring to the physical picture of the world, but alternative to it, to some extent. Physics remained non-evolutional science, while biology, starting with consolidation of Darwin's ideas, was based on the evolutional picture of the world of processes studied.

In the historical development of social disciplines we can see similar features of forming of disciplinary knowledge, connected with specificity of the object studied, taken into consideration. The mechanist paradigm, extended to include the sphere of social cognition, was modified, and, in the process of such modification, break with the mechanist principles became visible. Here a most important part again belonged to new "paradigmatic graftings" in the sphere of social knowledge from biology (as it developed the ideas of evolution), and then, in the 20th century, from the system theory, cybernetics and the information theory.

The first steps to constitution of social studies as a special sphere of disciplinary knowledge entailed modernization of the images taken from the mechanist pictures of the world. Au. Comte, acknowledged as one of the founders of sociology, included the notion of historical development, fundamental, in his opinion, characteristic of society, into his picture of the social reality. Furthermore, his conception first regards society not as a mechanism, but as a specific organism, whose parts form an integrity. At this point we can clearly see the influence of biological ideas upon Comte's sociological conception.

Further development of these ideas was connected with H. Spencer's general evolution theory and ideas of social development as a specific phase of evolution of the world. Spencer not only transfers the ideal of biological evolution to the sphere of social knowledge, but also tries to single out some general principles of evolution and their specific concretization as applied to biological and social objects[40]. The idea of society as an integral organism, according to Spencer, should take into account that people as social elements possess consciousness, as if spread over all social aggregate, and not localized in some centre.

The further steps, connected with reconstruction of primary paradigmatic images transferred from natural science to social knowledge, were connected with discussions referring to methodology of social cognition. These discussions are still lasting, and their centre is the thesis (formulated by Dilthey) of fundamental difference of knowledge of spirit and knowledge of nature. W. Dilthey, W. Windelband and H. Rickert gave this definition to that difference through opposition of understanding and explanation, individualization and generalization, ideographic method, connected with description of unique historical events, and nomothetic method, aimed at finding generalization laws. There emerged two extremes in interpretation of the methods of social and humanitarian cognition: one of them treated them

40 See Spencer (1997, pp.282-299).

as identical, the other sharply opposed them. But the real scientific practice developed in the space between these two extremes. That development revealed features of the scientific ideal and their specification referring to singularities of the events studied. Reflection over such kind of scientific practice causes methodological approaches, which takes away sharp opposition between explanation and understanding, individualization and generalization. Weber, for example, emphasizing importance of understanding of directions and motives of the active subjects for sociology, also developed the idea of ideal types as generalizing scientific notions which help us to construct explanatory models of social processes.

We should also mention that in the natural scientific cognition it is possible to trace links of understanding and explanation, though in a different accentuation than in social and humanitarian cognition. In particular, understanding is built into the very acts of natural scientific observation and formation of facts. When a modern astronomer observes shining points in the sky, he understands: these are stars, massive plasm bodies analogous to the Sun, while an ancient astrologer could understand the same phenomenon differently: for instance, as celestial light shining through slits in the dome of the sky.

The understanding acts are determined by the cultural tradition, ideological directions, the picture of the world, openly of hiddenly accepted by the investigator. These are common features of understanding in any area of cognition.

In principle, the idea which declares that only in people's activity does the investigator deal with mentalities included into it, and, studying nature, he faces nonliving and spiritless objects, — this is a worldview attitude of the technogenic culture. In other traditions, for example, in traditionalist cultures, which recognize the idea of soul reincarnation, cognition of the nature and man are not opposed as sharply as in the culture of technogenic civilization.

The problem of opposition of individualization and generalization, ideographic method, on the one hand, and nomothetic method, on the other hand, also requires correction. Events, irreproducible individually, occur not only in the history of society, but also in the processes of natural historical development: history of life on the Earth, the history of our Universe.

At the level of separate, empirically fixed events, both social and natural phenomena are irreproducible. But science cannot be reduced to ascertaining irreproducible events empirically. When we speak about historical processes, the aims of science consist in discovering tendencies, logic of their development, connections based on laws, which would allow scientists to reproduce the picture of the historical process on base of the "point-events", uncovered by historical description. In other words, here we deal with historical reconstruction. Each such reconstruction seems purely ideographic knowledge only in outward appearance. In fact, it combines ideographic and nomothetic elements in a specific way, which discloses logic of the historical process, not separated from the gist of its individuality, but woven into it. Historical reconstructions can be regarded as a special type of theoretical knowledge of unique, never repeated historical processes. Weber's studies of Protestant ethics and birth of capitalist spirit are an example of historical reconstruction dealing with theoretical comprehension of history. The same words can be said about K. Marx's works dedicated to revolutionary events of 1848 — 1852 and 1871 in France. The results of Marx's investigations, presented in his works "Louis Bonaparte's 18th of Brumaire", "The Civil War in France" represent reconstructions which demonstrate theoretical view through the material of historical description. In principle, one and the same fragment of history can be presented in different reconstructions. In this case each of them presents as a kind of theoretical model aimed at describing, understanding and explaining the historical reality. They compete with each other, and this neither is an extraordinary situation in science. Each new historical reconstruction wants to assimilate larger and larger diversity of accumulated facts and predict the new ones. Prediction as retro-diction (discovery of unknown facts of the past) plays as important role as in historical investigations as in any other types of theoretical cognition.

Certainly, there is specificity of historical reconstructions in sciences and social and humanitarian studies. When an investigator is reconstructing some fragments of spiritual history, he has to understand the corresponding type of cultural tradition, which can radically differ from that of existing in his own culture. In this case the frontier is occupied by the procedures of understanding, movement in hermeneutic circle, when understanding passes from a part to the whole and then from the whole to a part many times, perceiving specificities of other cultural tradition[41].

At the same time, the very acts of understanding and procedures of historical reconstruction in humanities (though, in natural science as well) are determined by the investigator's disciplinary ontology, the special scientific picture of the world, introducing scheme-image of the object sphere studied. Discussions of ideals and norms of investigation in humanities in many respects refer to the ways of construction of such picture and its philosophic justification. The general principles, commonly accepted, evidently or in hidden form, are three fundamental theses: any notions of man and society should take into consideration historical development, integrity of social life and the fact that social processes include consciousness. The said principles mark the scope within which pictures of social reality are constructed.

Their becoming as specific images of the social world, different from paradigmatic models taken from natural science, took place in the second half of the 19th — the early 20th centuries. During that time Spencer, Marx, Dilthey, Durkheim, Simmel, Weber offered variants of disciplinary ontologies of social and humanitarian subjects. Though they competed with each other, determining the sphere of acceptable problems and means of their solution, they also interacted. They had common problems, discussed by all investigators, though from different positions. Each of them promoted his ideas of society, correlating with rival investigation programs. All this served as evidence of the final stage of the scientific revolution, which started by transfer of natural scientific paradigms to the sphere of social processes and finished by their reconstruction and forming of social and humanitarian disciplines.

When disciplinary organized science is formed, every discipline gets its specific foundations and its own impulse of inner development. But sciences do not become absolutely autonomous. They interact, and exchange of paradigmatic principles is an important feature of such interaction. That is why revolutions connected with "paradigmatic graftings", which change the strategy of development of disciplines, at this stage are also traced distinctly enough.

In this respect, a characteristic example can be found in transfer from physics into chemistry of a fundamental principle, according to which processes of molecular transformations, studied in chemistry, can be presented as interaction of nuclei and electrons, and therefore chemical systems can be described as quantum system characterized by certain ψ-function[42]. That idea made the foundations of a new trend — quantum chemistry, the appearance of which marked a revolution in modern chemical science and birth of fundamentally new investigation strategies.

We may find examples of translations of paradigmatic attitudes in most different sciences. Thus, notions of self-organization, developed in cybernetics and theory of systems, translated into modern physics, considerably stimulated development of ideas of synergetics and

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41 See Rorty (1985, p.67).
42 Kuznetsov V.I. (1973, pp.289-293, 295).

thermodynamics of non-equilibrium systems.

No less productive was the union of biology and cybernetics, based on the ideas of living objects as self-regulating systems with transition of information and reverse connections.

Among numerous examples, which would confirm effectiveness of such interaction, we can mention the theory of biological evolution as a self-regulating process, created by I. I. Shmalgauzen in the 1950s — 1960s.

The first step toward the new theory was consideration of biological objects — organisms, populations, and biocenoses — as self-regulating systems. Shmalgauzen wrote: "All biological systems are characterized by greater or smaller ability to self-regulation, i. e. homeostasis. With the help of self-regulation each of these systems maintain its very existence, its composition and structure with its characteristic inner connections, appropriate transformations of the whole system in space and time. Certainly, homeostatic systems are, first of all, a separate individual of each species of organisms, then population as a system of individuals of one species, characterized by its composition and structure with specific intercommunications of its elements, and, finally, biogeocenosis, also having its composition and structure with its intercommunications, often very complicated ones"[43].

Translation of the new paradigm from cybernetics into biology required certain correction of the notions introduced. It was necessary to take into account specificity of biological objects, which belong to a special type of self-regulating systems. It was important to pay attention to their historical evolution. As a result a problem emerged: to what extent we can apply notions of homeostatic systems, which conserve their qualitative stability, to systems which are historically developing, changing qualitatively in the process of evolution.

Shmalgauzen proceeded from the assumption that the basic principles of self-regulation can be used also in description of historically developing systems. He wrote: "Mechanism of control and self-regulation are, naturally, different in different systems. But general principles of regulation can, in all cases, be considered from one point of view, from the standpoint of the doctrine of regulating devices"[44]. In principle, it was an nontrivial step, since systematic working out notions of mechanisms of self-organization in historically developing objects in natural science started later. Essential aspects here were I. Prigogine's investigations of dynamics of non-equilibrium processes, R. Thom's theory of catastrophes, development of synergetics (H. Hacken, M. Eigen, G. Nicolis et al.). Shmalgauzen's ideas of regulation processes in historical development of biological systems can be regarded as one of preliminary versions of this investigation program, which is now actively being developed.

Using the ideas of self-organization in analysis of interaction of biological systems and considering evolution as a process automatically regulated, Shmalgauzen includes the new notions into the picture of biological reality. Interaction of the main structural units of living beings — organisms, populations and biocenoses — was considered from the point of view of transfer and transformation of information and processes of management.

Applying the ideas of information codes and feedbacks to already formed synthetic theory of evolution, Shmalgauzen introduced essential transformations and additions. He uncovered regulating mechanism of evolution with regard for levels of organization of living organisms, considering them as an entity, which includes direct and reverse connections of organisms, populations and biogeocenoses.

Considering each individual as a complicated communication, recoding genetic information of molecular level into a set of phenotypic features, Shmalgauzen presented it as a whole information block, and specific for each individual activity in biogeocenosis regarded

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43 Shmalgauzen (1968, p.103).
44 Ibid.

as a means of transmission of reverse information[45].

Translating the theory of evolution into language of cybernetics, he demonstrated that "the very transformation of organic forms is regularly realized within a relatively stable mechanism, lying at biogenetic level of organization of life and acting according to statistic principle"[46]. It was "the highest synthesis of the idea of evolution of organic forms with the idea of stability of species and the idea of stability of geochemical function of life in the biosphere"[47]. This approach allowed the investigator to formulate the principle of group selection, indicated the role of competition of whole population with each other as condition of creation and maintenance of over-organism systems (species and biogeocenosis)[48]. Shmalgauzen's conception also explained many facts of noise-immunity of transmission of hereditary information, opening new ways to apply mathematical methods in the theory of evolution.

Another eloquent example, which demonstrates productivity of translating notions of cybernetics into biology, can be working out of intercellular interaction (A. Turing, 1952; M. Tsetlin, 1964; V. Volterra, 1968; M. Apter, 1970). Comparison of interaction of cells with interaction of a group of automatic devices, where there is no common centre, which would delivered commands, allowed the investigators to discover a number of singularities of intercellular regulation. Later it was found out that this model is applicable to description of processes of regulation not only at the level of cells, but also at organism and population levels[49].

We may ascertain that notions translated into biology then returned to cybernetics enriched. Elucidation of singularities of regulation of biosystems under decentralized control led to development of the model of intercellular regulation and prepared further use of it in other spheres (its application to systems of developed market economy, to some social systems etc.).

In the 20th century we can see considerable activation of exchange of paradigmatic attitudes not only between various natural sciences, but also between them and social disciplines and humanities.

For instance, we may ascertain that many achievements of modern linguistics were obtained because of application of images of cybernetics, ideas of the theory of information and notions of genetics.

Thus, consideration of natural language in terms of cybernetics and the theory of information, as well as application of notions of genetic code as special language of heredity, turned out quite productive in discussions of the problem of generative grammar. Analogy between sociocode and genetic code (with regard for connections phenotype — genotype) opened new possibilities to generalize the theory of generative grammar developed by N. Chomsky's school. Linguists used to criticize Chomsky's theory from the position that it gave not description of generative models of natural languages, but only description of general conditions for generative models. Application of analogy phenotype — genotype let investigators put the problem in a new way and to consider under new angle the results already obtained. They put forward the hypothesis that real generating process in functioning of languages is analogous to elucidation of the connection phenotype — genotype in development of organisms. In accordance with this new vision, they formulated the problem:

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45 Ibid, p.147.
46 Berg and Lyapunov (1968, p.13).
47 Ibid.
48 Ibid.
49 *The History of Biology from the beginning of XXth century to nowadays* (1975, pp.591-592).

to create the theory of generative grammar as two-level system[50]. The first level is to generate ideal linguistic objects, which form, in their entity, ideal language (genotypic language). The second one — to provide transformation of objects of genotypic language into objects of a real language (phenotypic language). From that point of view Chomsky's theory was regarded as attempt to construct conception of genotypic language. Many critical objections to this theory, from the new point of view, were not only disproof of the problem offered, but more statement of a problem — to find a link between it and the theory of generating models of phenotypic type[51].

Intercommunication of linguistics, biology and the theory of information, characteristic for development of these disciplines, emerged in the 20th century, to large extent, due to development of semiotics and new interpretation of linguistics as part of semiotics.

Linguistics was sort of proving ground for establishing ideas of semiotics as discipline studying signs and sign communications. Disciplinary ontology of linguistics (picture of language as a special object of investigation) was modernized, when natural languages started to be regarded as a variation of semiotic systems. Then linguistics presented as a special part of semiotics and included investigation of not only natural, but also artificial languages.

Such modernization of object sphere of linguistics, in turn, opened new ways for its interaction with other disciplines which used ideas and notions of semiotics.

The images of language as a complicated sign system transmitting information are widely used in zoosemiotics, which studies language of animals.

In turn, the results obtained here, make it possible to find new formulations of many linguistic problems. According to prominent linguist Roman Jakobson, "language and other means of people's communication in their various interactions — mutatis mutandis — gave a lot of instructive analogies with transmission of information in other species of living beings. "The adaptive nature of communication", in all its diversity, the essence of which was uncovered by Wallace and Srb, is reduced to two mutually connected classes: adaptation to environment and adaptation of environment to its own needs. Really it became one of "the most disturbing" biological problems, it is hard to overestimate its meaning for modern linguistics. Similar processes in the life of language and in animals' communication are worth thorough investigation and comparison, useful for both ethology and linguistics. In the period between the world wars there appeared the first concord of investigators of the two disciplines, aimed at study of two aspects of evolution: adaptation and convergent evolution. Namely then the linguists' attention was attracted to biological notion of mimicry, and at the same time biologists started examining different types of mimicry as method of communication. Divergent development, as opposed to convergent tendency in spread of communication...draws more and more attention of both linguists and biologists. The known methods of manifestation of language non-conformism, peculiarity or "narrowness", get interesting ethologic analogies, and biologists study and describe what they call "local dialects", according to which animals of the same species, crows or bees, are distinguished"[52].

R. Jakobson emphasizes that parallels between code system, which make up the array of biological information, and human language open broad possibilities to transfer notions and methods. Referring to the works F. Crick, Janovsky, G. and M. Beadle, F. Jacob, he says that these authors-biologists consider hierarchical structure of "genetic language", similar to the one discovered by linguists in natural languages, as its most important feature. Jakobson wrote: "Both linguists and biologists attribute hierarchical structure of language and genetic

50 See Shaumian (1965, pp.97-135, 370-373).
51 Ibid, pp.370-373.
52 Jakobson (1985, pp.389-390).

communications to fundamental scientific principles. As Benveniste showed, linguistic unit has only that status which it gets inside a unit of higher level. Transfer from lexical units to syntactic groups of different ranges is parallel to transfer from codons to "cystrons" and "operons"; the two latter levels of genetic sequences are compared by biologists to syntactic groups of different degree of complexity, and limitations for distribution of codons inside such constructions were called "syntax of DNA-chain". In genetic communication "words" are not separated from each other; special signals inside constructions indicate beginning and end of the operon and borders of cystrons inside operon; these signals are metaphorically called "punctuation marks" or "commas". They really correspond to delimitative means used for phonologic distinguishing of phrases inside speech, and simple sentences and word combinations inside phrase"[53].

As one more example of productivity of exchange of paradigmatic models between linguistics and biology, R. Jakobson points out at discovering of similarity of synonymy in natural speech and changes "in meanings of codons, caused by their position in genetic communication". He stresses that biologists, investigating singularities of peptide translations, found some kind of "synonimic codons", and that opened new possibilities to understand flexibility in recording hereditary information[54].

All these exchange processes of paradigmatic attitudes, notions and methods between various disciplines stipulate some generalized vision of object spheres of each discipline, vision that lets us compare different pictures of reality studied, find there common blocks and identify them, considering as the same reality.

Such vision is determined by general scientific picture of the world. It integrates notions of objects of different sciences and forms, on base of their achievements, a integral image of the Universe, which includes notions of non-organic, organic and social worlds and their connections. That same picture allows us to determine similarity of object spheres of different disciplines, identify different notions as vision of one and the same object or connections of objects and thus justify translation of knowledge from one discipline into another.

For example, application of notions of atoms in physics, transferred from physics into the general picture of the world, in biology preliminarily stipulated working out a general principle: the principle of atomic structure of matter.

In his lectures on physics, R. Feynman said that, if a world catastrophe destroyed all scientific knowledge, and future generation received only one sentence, carrying most information of disappeared science, that would be sentence: "all bodies consist of atoms"[55].

However, to use this principle in biology, we are to accept one more notion: to consider biological organisms as a special type of bodies (as living matter). This notion also belongs to the general picture of the world.

But if investigator would put forward hypothesis that, through notions of atoms and their structure, developed in physics, we could explain, for instance, phenomena of human spiritual life — meaning of works of art, religious and aesthetic principles, — this hypothesis could not find its base in modern scientific picture of the world, as it does not include spiritual phenomena in the class of bodies and does not regard them as matter.

Thus, the general scientific picture of the world can be regarded as such kind of knowledge, that regulates putting fundamental scientific problems and directs translation of notions and principles from one science into another. In other words, it functions as global investigation program of science, on base of which its more concrete, disciplinary

53 Ibid, pp.393-394.
54 Ibid, pp.394.
55 Feynman, Leighton and Sands (1963).

investigation programs are formed.

By analogy with already considered process of intradisciplinary integration of knowledge, we may suppose that its interdisciplinary integration is inseparably linked with heuristic role of the general scientific picture of the world and is provided by processes of translation of ideas, principles and notions from one science into another and further including obtained here new, most fundamental results into the general picture of the world.

High degree of generalization of such results and aspiration for constructing integral system of notions of the world, including man, his natural and social life, make this picture that special link of developing scientific knowledge, which most closely contacts with meanings of cultural universalities and, consequently, possesses clearly expressed worldview status.