Foundations of biological systematics: history and theory [a fragmentary translation]

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Foundations of Biological Systematics:
History and Theory

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The foundations of biological systematics are considered in full in its historical, theoretical, and partly philosophical aspects. The general context of the consideration is shaped by the nonclassical philosophy of science combined with evolutionary epistemology. The basic taxonomic research programs and theories (scholastic, typological, organismic, evolutionary sensu lato, phenetic, numeric, biomorphological), basic concepts (classification, hierarchy, taxon, homology, trait, kinship, similarity, weighting), and theoretical foundations of nomenclature are characterized. The main causes of their historical dynamics and the main stages and directions of their development are analyzed. Bibl. 3441.

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FOREWORD*

A theory without practice is dead and barren, while practice without theory is useless and pernicious.
P.L. Chebyshev

Whenever a theory appears to you as the only possible one, take this as a sign that you have neither understood the theory nor the problem which it was intended to solve.
K. Popper

Biology has always dealt with and is actually addressing the same global puzzle: why organisms are diverse in general and why they are similar and different in particular (Waddington, 1970). Therefore, the main task of biological science has always been and is uncovering and explanation of similarities and differences between organisms: how these arise, what are their structural, functional, adaptive, evolutionary, etc. meanings. Since recently, the subject area outlined by this global objective is referred to as *biological diversity* (Wilson, 1988; Reaka-Kudia et al., 1997). And although biological science, in the 19–20th centuries, having become largely experimental and focused mainly on the subcellular levels of organization of living matter, tried to "disown" from the above task, the latter remains in fact basically the same: to explain a) how and why organisms are differentiated structurally and functionally, and b) how and why they differ in the ways of their structuring, in their functions, in their role in natural communities.

The study of some fundamental manifestations of biological diversity constitutes the subject domain of the *biological systematics*. Accordingly, the systematics itself, as one of the key branches of biology, is the subject of research related to the analysis of its own theoretical content.

This content includes first of all determining, as exactly as possible, what and how the systematics is exploring. Answers to such questions seem self-evident at first sight, but the whole history of science shows the opposite: the very formulation of these questions and the search for answers to them are far from obvious; they change along with change of the understanding of the structure of the cognizable reality and the correct ways of its cognition. The semantic evaluation of the content of scientific activity is the subject of the philosophy of science; the ways in which these assessments are embodied in the principles of scientific research constitute the subject of the theory of science — more precisely, of different theories in different

*The present text is an authorized English translation of several (of more general meaning) parts of the book to appear by the fall of 2018 as following: I**gor Ya. Pavlinov. Foundations of biological systematics: history and theory. — Archives of Zoological Museum of Moscow State University, 55. Moscow: KMK Sci. Press. 2018. 786 p.** The translation is rather rough and clumsy, but hopefully understandable enough to attract an attention to the entire book. *IYP* branches of science; the embodiment of these theories in practical scientific research give the final result of the latter, namely the practical knowledge.

It can be seen from the preceding that any practical science does not exist without theoretical science, and this latter does not exist without the philosophy of science. This is true in the general case; this is also true for the biological systematics.

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The present monograph examines the theoretical foundations of biological systematics in general scientific and partly in philosophical and historical aspects. Such a look at the subject fits into the general understanding in the non-classical scientific paradigm formed over the past few decades that a) any scientific discipline is "scientific" to an extent that it is "theoretical"— strictly empirical scientific knowledge is impossible; b) the own foundations of the scientific discipline require at least a minimal philosophical interpretation — scientific knowledge is impossible without a general understanding of what exactly and why so and not otherwise, is explored; c) any scientific discipline is a complex developing system, which present state depends on the preceding ones, therefore the content of scientific knowledge cannot be understood out of historical context of its development. As a result, such a way of treating biological systematics as a scientific discipline can be presented in the form of a fundamental triad "*the theory of systematics + the philosophy of systematics + the conceptual history of systematics*".

It is important to emphasize that biological systematics is considered here in its widest scope, encompassing all the conceptual constructs that have ever figured throughout its long history and occur in the present. The main task of the book is to provide a sufficiently complete review of theoretical views in taxonomy, not limited to the current scientific and organizational (ie, "by-scientific") conjuncture. Therefore, as far as it is possible, attention is equally paid to all theoretical ideas, their presentation is made as possible not too biased and not imposing the author's point of view. However, in some cases, the latter is quite noticeable: it is explained by the fact that systematics is regarded here as a biological discipline, therefore the consistency and significance of particular concepts is determined by their biological content and meaningfulness.

Such a broad scope is largely due to the author's commitment to the idea of scientific (cognitive) pluralism and to evolutionary epistemology realizing it in a specific way. This position implies the recognition that there are no "generally good" and "generally bad" theories and concepts in systematics: each of them appears in its time and operates in a certain philosophical and scientific context and dies with it at in respective time time, leaving its trace in the content of this discipline. This position is opposed to scientific (cognitive) monism, which is based on the idea that some particular taxonomic theory (phylogenetic, phenetic, typological, etc.) is "the most correct" and nearly "final", whereas every others are "wrong" or at least "outdated". Therefore, the traditional textbooks on systematics are most often reduced to the presentation of a particular theory pretending to be the "the most correct." However, the entire conceptual history of systematics, especially the change of its scientific and philosophical foundations in the middle of the 20th century, shows that there is nothing unshakable, once and for all established in the theoretical backgrpund of this (as well as any other) scientific discipline. And if so, then one should not be especially zealous with any "final" estimates, remembering that "*everything passes — and this too will pass*";

though not completely, for "*nothing passes completely*" (see versions of the parable of King Solomon's ring).

The underlying task of the book, conditioned by the author's position, is to draw attention of the reader prone to theorizing to the diversity of ideas as such — and to encourage him to realize that the diversity of taxonomic concepts reflects the overlap of two complexities. One of them is a complexly structured diversity of the living matter, another is a complexly organized cognitive process aimed at that diversity; and all this together can not be squeezed into a dull uniformity of the "universal law of everything." Therefore, the conceptual diversity in a cognitive respect is no less remarkable and attractive (for a theorist) than the biological diversity itself. Any concept is interesting and worthy of attention to an extent it reflects a particular manifestation of biodiversity and/or the way of the latter investigation; the analysis of the concepts makes it possible to understand the whole spectrum of these manifestations, without concentrating on any particular one.

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The monograph was prepared on the basis of the author's previous books on the history and theory of systematics (Pavlinov, Lyubarsky, 2011, Pavlinov, 2013a), therefore some fragments of the text represent an inevitable and quite forgivable "self-citation." In this book, in comparison with the two just mentioned, the historical part is reduced while the theoretical and philosophical part is substantially revised and in fact is re-written, and bibliography is significantly updated. Taking into account the criticisms of colleagues about the author's style of the previous texts, I tried to simplify my language as much as possible in order to make the presented ideas more clear, with minimal framing them by considering various kinds of circumstantial considerations. The desire for adequate coverage of the diversity of taxonomic concepts and their historical and philosophical contexts made it possible to present a conceptual history of systematics in the form of a broad stream of different mutually interacting ideas, rather than a linear unidirectional sequence of interlacing dominants.

In the introductory section I, the contents and the basic structure of biological systematics are described in the most general outlines (chapter 1): its main branches are characterized, and relation between systematics as a scientific discipline and taxonomy as its theoretical foundation is defined.

The historical section II presents an outline of the historical development of this discipline in the form of its conceptual history (Chapter 2). The latter means that the main subject of consideration is the history of theoretical concepts, and not particular classifications. According to the above triad, this story is "inscribed" into the development of cognitive systems, from initial pre-scientific to the modern ultra-rational. Readers, accustomed to the traditional arrangement of the main historical landmarks (Aristotle—Linnaeus—Darwin—Hennig), will probably be surprised that the conceptual history may look quite different. Chapter 3 examines the prehistory of scientific systematics: the folk pre-systematics and the proto-systematics (from Antiquity to the Renaissance) are characterized. Chapter 4 presents the initial formation of the scientific systematics proper: considered are the scholastic systematics, the early post-cholastic systematics ("natural systematists", the first typologists, organismists, numerologists), the mastering of the evolutionary idea by systematics. Chapter 5 is devoted to the modern systematics, for which the active interest in onto-epistemic grounds of this discipline is very characteristic.

Theoretical Section III is devoted to the consideration of basic conceptual constructs that constitute a “philosophical frame” and the content of theoretical branch of systematics. Perhaps some readers will be scared off by the abundance of all “isms” in this Section, but believe me — if there is no theoretical science without the philosophy of science, then it does not exist without these “isms.” Chapter 6 describes the cognitive situation in which this discipline is being developed, and its main components (ontical, epistemic, subjective) are analyzed. Chapter 7 briefly describes the scientific (cognitive) categories as regulators of research activity in systematics; of special importance is the ontoepistemic correspondence, emphasizing complex mutual influence of the ontic and epistemic bases of systematics. An important part of this philosophical-theoretical approach to the presentation of the foundations of systematics is a very preliminary outline of one of the possible ways of developing taxonomic theory as a quasi-axiomatics (Chapter 8). Significant attention is paid to the analysis of the basic concepts and notions of biological systematics (Chapter 9): under consideration are approaches to definitions of the taxonomic system (classification), taxon, taxonomic hierarchy, similarity and kinship, homology and character, weighing, taxon- character correspondence.

In Chapter 10, which is included in this section, the main research programs and schools of systematics are described. The task of this chapter is to represent adequately the general structure of the conceptual space of biological systematics, therefore it does not correspond much to the current established views of the “mainstream” and “backwoods” of this discipline. Early taxonomic theories (scholastic, basic “esoteric”) are considered briefly, with more attention being given to those that developed during the second half of the 19th and in 20th centuries. Classification phenetics, numerical systematics, modern versions of typology, “natural” and rational systematics, biomorphics, evolutionary-interpreted systematics (biosystematics, cladistics, evolutionary taxonomy) are considered in a single vein.

Special section IV is devoted to the taxonomic nomenclature, it is based on recently issued monograph of the author (Pavlinov, 2015a). Nomenclature is viewed from the theoretical point of view — as a proposal to comprehend nomenclatural norms and principles, and not as an “instructions for the application” of paticular rules and codes. Chapter 11 briefly considers the history of nomenclature concepts. Chapter 12 describes the main versions of these concepts, shows relationship between them and the taxonomic theory, summarizes the key principles of the nomenclature, which are classified into five main groups, namely regulatory, cognitive, linguistic, juridical, taxonomic.

The chapters and sections of the book are sequentially numbered; the text is supplied with numerous cross-references to the sections where certain theoretical concepts and notions, events in the history of systematics are analyzed in more details. All this perhaps spoils the overall impression of the work, making the text redundantly “technical”, but the combination of numbering and references makes it easier to navigate the book, making it generally more informative. In particular, the reader, having opened any part of the book, thanks to these links, can be guided in its other parts as well. It is also important that reciprocal references from general categories to paticular taxonomic concepts and vice versa make it possible to show that the first are introduced not just out of love for “leisurely theorizing”: it is the categories that largely determine the content of the concepts; accordingly, the latter ones turn out to be but ad hoc (arbitrary) constructs without support of the former.

* * *

More than a vast bibliographic list, including more than 3,400 titles, deserves a brief explanation. Presenting an overview of theories and concepts, I considered it possible not to go into detailed analysis of particular points of view that would increase enormously the already large volume of the book. In most cases, particular positions, which have been being discussed in systematics, are briefly outlined, and bibliographic references redirect interested readers to respective sources, where these positions are detailed, argued or challenged. Thus, the bibliography can be considered as a supplementary reference section. In addition, these references reflect to some extent the level of interest in this or that topics under discussion: the more references, the more brisker is the discussion.

By the way, almost all of this literature I actually studied thus minimizing "relaying quotation". In this regard, it is more than appropriate to praise the open Internet resources (such as Biodiversity Heritage Library, Gallica digital library, Göttinger Digitalisierungs Zentrum, Flora and Fauna, Google Book, CyberLeninka, Library Genesis, JSTORE, BioStor, SciHub, as well as the Internet portals of scientific journals), which made available a colossal amount of published scientific information. In order to make my modest contribution to the network book exchange, I collected about 250 key books on the history and theory of systematics in my own electronic library, uploaded on the Internet portal of the Zoological Museum of Moscow State University (http: // zmmu.msu.ru/musei/struktura_muzeya / sektorteriologii / sotrudniki-sektora / biblioteka).

Igor Ya. Pavlinov

SECTION I — INTRODUCTORY

The surrounding world is phenomenally diverse and, at a first glance, is full of infinite uncertainties. The knowing of this world, so strange (and therefore somewhat frightening) in its diversity, — cognition in general and scientific cognition in particular — means revealing in it some orderliness and, due to this, to reduce the initial uncertainty to some finite set of regularities that can be structural and functional, phenomenological and causal, etc. The main purpose of this knowing is to present a rationally organized picture of a supposedly rationally organized world so that, looking at which, rationally arranged conscious mind would feel comfortable.

The primary and therefore strongly necessary form of rationalization of both the world being cognized and its knowledge is its categorization. Its essence is in the discrimination between "one" and "another": one's own and the other's, the known and the unknowable, the real and the nominal ... This primary phase of cognition is a coarsening categorization, which then goes into the next one connected with detailing and trying to return some elements of the natural continuity to the coarse qualitative cognitive scheme. The movement in this direction gave birth to two different ways of describing natural diversity, namely qualitative classification and quantitative "formula." The essential difference between them is determined not only by the method of cognition, but also by its goal: the main task of classification is the ordering of the diversity of objects themselves compared by their parameters, while the task of "formulation" is the ordering of the variety of object parameters revealed by means of their comparison (Hempel, 1965; Whitehead, 1990; Rozov, 1995; Subbotin, 2001).

This difference has constituted the basis for the fundamental delineation of two basic (from the standpoint of the character of cognitive activity) divisions of the classical natural science laid down by F. Bacon, that is "the natural history" and "the natural philosophy". The method of elaboration and the form of representation of knowledge became classification systems in the former and parametric systems in the latter (see 9.2). Accordingly, within the framework of natural history, mainly classifying disciplines began to develop (biology, geography, geology, etc.), while within the framework of natural philosophy, mainly parametrizing ones did (physics, chemistry, astronomy, etc.). Of course, no complete isolation exists between them, as the both use these two approaches though in different ways; but their ratio is significantly different just because initial tasks are different.

* * *

Biology is one of the most "classifying" disciplines: it has been developing classification systems at different levels and for different aspects of the diversity of organisms. Manifestations of interorganismal diversity are studied and classified by systematics, biogeography, biocenology, etc .; manifestations of intraorganismal diversity are studied and classified by anatomy, histology, cytology, etc. They are effectively supplemented by "parametrizing" disciplines that study the relationships between different properties of organisms: physiology, biochemistry, developmental biology, genetics, ethology, etc. But they just complement and not replace disciplines of the classifying series; the reason is that there are manifestations of the diversity of organisms that cannot be represented by the means of any parametric systems, so there are disciplines investigating by means classification systems.

Biological systematics (biosystematics in the general sense) is one of the key classifying biological disciplines. Its fundamental status is determined by the fact that the classification systems create certain "framework conditions" for other studies of the diversity of organisms. In some disciplines, the results of systematic (taxonomic) research serve as a starting point for conducting, in others as a means of "objectifying" the results of their own research.

Of course (and unfortunately), such status of taxonomy is hardly realized fully: the "effect of the last car in a train" is responded. Looking at the train of scientific biological knowledge leaving for the future, an observer sees the last cars, that is the most recent scientific disciplines and approaches, and does not see the locomotive pulling the entire train. For this reason, at the present stage of the development of biology concerned mostly with the study of organisms at the molecular-genetic level (that "last car"), systematics (that "locomotive") is pushed to the back of the biological sciences. In particular, molecular phylogenetics (genophyletics) promotes actively this trend by declaring itself to be the only scientific way of describing and explaining the diversity of organisms (Felsenstein, 2004; Kondrashov, 2010; Alyoshin, 2013).

Well, as it was noted in the Foreword, "everything passes — and this too will pass away." The reason is quite obvious (Minelli, 2003a, Wheeler, 2008a, Pavlinov, 2013a, Wanninger, 2015): organisms do not boil down to "molecules", the organismal diversity is not reduced to the molecular one, and the historical causes of organismal diversity identified by means of genophyletic research are not the only ones ordering this diversity: there are also structural, systemic, etc. causes. All these are explored on a complex basis and integrated by biological systematics: this means that the latter possesses not only the past, but also the future of biology. And if so, then studying and developing its own theoretical grounds is an important means for ensuring any progress in this development.

* * *

The introductory Section is the shortest in the book. In its single Chapter 1, the content and structure of biological systematics are briefly outlined, the main tasks of this discipline and its main branches are indicated, that are theoretical, practical and applied.

Chapter 1. The content and structure of biological systematics

The content of any cognitive activity aimed at comprehending the "nature of things", in a certain ultimate sense, can be reduced to finding out what the diversity of these "things" is and why they are different. Why are there different cosmic bodies — galaxies, stars, planets? Why are there different microparticles — say, hadrons and leptons? Why are there different chemicals — for example, alkali and acids? Why are there different ethnic groups and different languages? And so on.

Biological science constitutes nothing special in this series. As it was said in the Foreword, cognitive activity in it is connected with the description and explanation of the diversity of biological phenomena: it begins with the questions about how, to what extent and why organisms are different or similar, and ends up with the answers to them. And yet, there is one significant difference: it was only in biology that a separate discipline was formed dealing specifically with the study of the diversity of "things", in this case organisms, namely *biological systematics*.

* * *

The content of taxonomy as a scientific discipline is determined according to the original question: what kind of diversity does it explore and displays by means available to it. The general response to this question actually means defining the subject area of systematics, namely the one about which more particular questions are asked and how they are responded. From this general answer depends understanding of the problems solved by the systematics in general and by its main divisions, which are theoretical, practical and applied systematics.

In the simplest most empirical variant, the general task of taxonomy is indicated extremely widely as the study of the diversity of organisms without specifying which manifestations of this diversity are taken into account (Sokal, Sneath, 1963; Simpson, 1961; Rollins, 1965; Kerzhner, Korotyaev, 2004). This point of view corresponds to the modern interpretation of biological diversity as a species diversity, which itself fixes only one of the manifestations of taxonomic diversity (see 6.4.4). If this is taken as a definition of the subject of systematics, then it is hardly correct, since it is all-inclusive: all biology appears to be the sphere of its interest. Indeed, as it has just been said, all biological disciplines are engaged precisely and only by studying the diversity of organisms: they differ only in the manifestations of this diversity they fix. At the operational level, it is meant what properties of organisms are taken into account in this fixation and how their diversity is interpreted and generalized (see 6.4.4).

In another version, taxonomy is called the "science of species" (Mayr 1968; Wheeler, 2007, 2009; Epstein, 2009), which, on the contrary, narrows greatly the field of its definition, since it excludes the entire supra-species diversity. Emphasis on phylogenetic and ecological aspects of the diversity of organisms makes it possible to distinguish between *biosystematics* in its general sense (= idiosystematic) and *ecosystematics* (= syntaxonomy) (Griffiths, 1974a; Mirkin, 1985; Korotkov, 1989), but excludes typology, biomorphism and some others important branches of the former. This reproach is true for each particular taxonomic school inclined to absolutize a manifestation of the diversity studied by it, up to declaring it "biological."

As it will be shown elsewhere (see 6.4.4), the task of correct defining of the object of biological systematics (and by this, its tasks) is quite complex and can be solved only in a certain theoretical context. This context is defined in the form of a "conceptual pyramid" (see 6.2), in which the subject area of systematics is defined along with those of other classifying branches of biology by considering all of them in a single general biological context including both theoretical and naturalistic biological knowledge (Pavlinov, 2012a). For this reason, we can limit ourselves here only by emphasizing that: a) the systematics does not deal with all manifestations of the diversity of organisms (biodiversity), but only with some of these manifestations, b) the manifestations of biodiversity studied by it can be collectively designated (by tautology) as *taxonomic diversity* and c) such a definition, to be consistent not only in the content respect (studying *biological* diversity), but also in the theoretical one (studying biological *diversity*), requires immersion in a certain theoretical context.

The latter means that the "stratification" of biological systematics must first of all envisage the delineation of its two main sections, *theoretical* and *practical*; in other terminology they can be designated as nomological and ideographic (Epstein, 2009a; however, he put a slightly different meaning into his division). As the terms imply, the first section develops the theory of systematics, no matter how it is understood, the second realizes this theory in practical studies. The practical section of taxonomy is closely adjointed by its applied section, which is associated with the provision of practical taxonomic research results at the disposal of various users.

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The **theoretical section** of biological systematics is designated in this book as *taxonomy* (Greek τάξις — order and νόμος — law). Philosophers and cognitologists associate taxonomy with the general categorization of concepts, examples are in the doctrine of ontology, in linguistics (Gray, 1978; Gubin, 1998; Cronhaus, 2001; Andreev et al., 2004; Lysyakova, 2006; Shelestyuk, 2007; Shatalkin, 2012). In this general sense this concept was introduced into the systematics at the beginning of the 19th century. A.P. de Candolle (1819; DeCandolle, Sprengel, 1821). Under the understanding of systematics as a science of taxa, its theoretical section can be designated as *taxonology* (Zuev, 1998).

In modern literature, the relation between "systematics" and "taxonomy" is treated quite differently, from their authentication (Mayr, 1947; Borgmeier, 1957; Rogers, 1958; Griffiths, 1974a; Vane-Wright, 2001) to the attribution of essentially different functions to them. Some authors understand taxonomy as the theoretical division of taxonomy (Simpson, 1961; Sokal, 1962; Weinstein, 1981; Simpson, 2006; Pavlinov, 2011a, 2012a, 2013a; Pavlinov, Lyubarsky, 2011); others as its practical section focused on the recognition of taxa (Blackwelder, Boyden, 1952; Blackwelder, 1967; Wheeler, 2001); more others associate taxonomy with the solution of nomenclatural tasks, guided by another etymology (from Latin nomen — name) (Queiroz, Gauthier, 1992; VergaraSilva, Winther, 2009); sometimes taxonomy is reduced to just a list of taxa (Shreider, Sharov, 1982; Dunaev, 2008). In the Meyen–Shreider typology (Mayen, 1975a, 1978a; Panova, Schrader, 1975; Meyen, Schreider, 1976;

Lyubarsky, 1996a) taxonomy is defined as the study of the extensional aspect of the diversity of organisms, complemented by *meronomy* (Greek μέρος — part) as a study the intensional aspect of this diversity: the first classifies taxa, the second classifies merons.

When identifying of taxonomy with the theoretical section of systematic knowledge, it makes sense to distinguish two of its interpretations, universal and biological (Wilkms, 1998a, 2003, 2010a, Zuev, 2015). *Universal taxonomy* develops general formal principles of classifying, so it can be considered as a part of logic; it is about the same as the "philosophical" taxonomy (Humberstone, 1996), or the classiology (Kozhara, 1982, 2006; Pokrovsky, 2002, 2006a), or a "doctrine of any classifications" (Meyen, Schreider, 1976). *Biological taxonomy* is a particular subject taxonomy, a theoretical section of biological systematics. This means that, along with the biological, there are other subject taxonomies, that is, theoretical sections of other classifying disciplines both in biology (biogeography, for example) and outside it.

The main and most general aim of taxonomy as a theoretical branch of biological systematics is the development of the basic *onto-epistemology* of this discipline (see Chapter 6) and its basic thesaurus (conceptual vocabulary) (see Chapter 9) in the context of the general problems of the scientific philosophical foundations of natural science (see Chapter 7). Accordingly, this general aim is divided into two interrelated subtasks, viz ontological and epistemological.

The principal aim of *taxonomic ontology* (in its philosophical, not information theory understanding) is the determination of the subject area of systematics: *what* it studies (see 6.4). In this connection, the key aim is to consider ways to determine the taxonomic reality, both in its general and in particular versions (typological universe, phylogenetic pattern, etc.). Here belongs also consideration of fundamental concepts of taxonomy, namely taxonomic system, hierarchy, taxon, similarity and kinship, homology, character, etc.

The principal aim of *taxonomic epistemology* is to substantiate the general principles of organization of research activity in systematics: *how* it studies its subject (see 6.5). To the sphere of epistemology belongs justification of the scientific status of both the biological systematics itself and the taxonomic knowledge that it develops. Among the most important tasks of epistemology is analysis of general principles of the organization of taxonomic studies, their methodology and methods, conditions for the correct application of different schemes of argumentation, scientific status of the empirical component of taxonomic research, and so on.

The basic "form of being" of theoretical systematics (taxonomy) is the *taxonomic theory* (see Chapter 8). It is rather complex in its structured: there are theories of different levels of generality (general and particular), aspectual (typological, phylogenetic, phenetic, numerological, etc. theories), methodological (numerical, before all), object (about the taxon, about homology, taxonomic categories, etc.).

When distinguishing between general and particular taxonomic theories, the former can be referred to as *metataxonomy* with respect to the particular: it performs mainly a framework function (see 8.2). Particular aspect theories, supplemented by methodological ones, self-organize into basic research programs and paradigms of biological systematics usually called "systematic philosophies" (in the narrow sense). These programs and paradigms, in their turn, serve as the basis for the formation of the *taxonomic schools* of the same name (see Chapter 10). Each of them concretizes and implements general theoretical concepts and notions and brings them to an operational state suitable for use in the practice of systematic research. Theoretical analysis of their content is important for delineating their particular onto-epepistemologies and serves as a key condition for evaluating the possibilities of correct mutual interpretations of the results of taxonomic studies conducted within the framework of different programs (paradigms, schools).

Bearing in mind complex nature of the structure of theoretical taxonomic knowledge, it is important in its development to be able to outline correctly the correlation of its "philosophical" and "biological" components. Without the former, theoretical knowledge in the systematics is impossible; without the latter, it loses its biological content. Therefore, for a full-fledged development of taxonomy, as a theoretical section of biological systematics, a finely tuned interaction of "around-biology philosophers" and "philosophizing biologists" is necessary. In this interaction, the former should not pretend to impose formal schemes and should looking for ways of philosophical understanding of biological taxonomic knowledge; the latter should not insist on biological naturalism and try to reflect on the taxonomic concepts developed by the long history of systematics from the philosophical points of view.

* * *

Practical systematics "realizes" the conceptual constructs developed by particular taxonomic theories based on various kinds of their operational interpretations. These theories form the context of empirical systematic studies, serving as a prerequisite for determining their tasks, methods, the choice of characteristics, ways of representing the structure of the diversity of organisms, etc. Empirical systematists are not likely to agree with such an assessment of the relationship between theoretical and empirical sections; for them, practical studies are self-sufficient and form the very basis of this biological discipline. Nevertheless, it is appropriate to emphasize here that practical systematics can not be empirical in a strict (philosophical) sense (see 7.2): the practical studies can be considered as development of taxonomic hypotheses based on a certain theoretical biologically sound foundation (cf. 6.5.5). Without such understanding of the nature of systematic studies, they really boil down to "stamps collecting."

The main task of the practical systematics, with the solution of which, strictly speaking, it begins, is the development of concrete taxonomic systems (classifications) and their presentation in a format that makes them available for further use. This task is decomposed into the following components: a) carrying out particular systematic studies, including testing (revision) of previously proposed taxonomic hypotheses and developing new ones, including description of new taxa; b) elaboration of identification keys that allow to correlate previously uninvestigated organisms with existing classifications (see 9.2.7); c) publication of the results of these studies in the form of concrete classifications and keys in the articles or in the taxonomic checklists.

One of the most important areas of practical research is *comparative systematics* (Mayr, 1971; Bock, Farrand, 1980), which studies the structure of different classifications in a comparative aspect. Its main substantive tasks are as follows: a) generalization of information on the structure of taxonomic diversity in different groups of organisms obtained in the course of concrete taxonomic studies, b) uncovering general and specific features in this structure, c) analysis of the latter's dependence on the biological (evolutionary, ecological, etc.) specificity of organisms, characters used, classification algorithms applied, etc.

Apparently, pedagogical activity should be attributed to practical systematics: it is associated with the reproduction of scientific personnel involved in systematic research. No science can do without it; for systematics, ensuring a continuous “relay” of transferring practical knowledge about the diversity of organisms between generations is of particular importance. The reason is that such knowledge is largely idiographic (descriptive), it has a large portion of personal knowledge (accumulated experience, etc.) about particular groups of organisms, so familiarity with such knowledge is not reducible to algorithmized learning of taxonomic research skills (although such skills are undoubtedly needed). This activity is now becoming especially relevant in connection with the total “molecularization” of systematics: many practical classification tasks are now solved by biochemists and biomedicians who, due to the specifics of education, hardly understand the deep biological meaning of the ultimate goal for which their studies are conducted.

Among important tasks of practical taxonomy is the development of its *empirical basis* in the form of research systematic collections. The strategy of this development is determined on the basis of theoretical understanding a) of the structure and manifestations of taxonomic diversity and b) that the structure of the worldwide collection poll should be adequate to the structure of diversity of organisms studied by systematics (Cotterill, 2002, 2016; Pavlinov, 2016).

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Applied systematics is at the junction of the systematics proper and all those spheres of human activity that somehow come into contact with manifestations of taxonomic diversity. It relies on the results of practical systematics, its main and most general task is the *information support* of that activity. The significance of this branch is determined by the fact that, figuratively speaking, the various users look at the diversity of organisms through the eyes of the practical systematists: what the latter distinguish in their classifications, all others take for certain “taxonomic given.” In expanding the spheres of competent (sic!) applications of the systematic knowledge, are interested not only users but systematists themselves: demonstration of the practical importance of the results of their research in the eyes of the inhabitants serves as an “justification” for the development of systematics as a scientific discipline.

Within the biology itself, in some of its branches, the concrete results of systematic studies constitute something like an empirical basis. The list of such branches includes first of all biogeography (comparative analysis of the distribution of taxonomic groups), ecology (analysis of taxocene structure in the local natural communities), meronomy (comparative analysis of meronic structures in representatives of different taxa), evolutionics (evolutionary explanations of the structure of taxonomic diversity). In other branches of biology, classifications serve as a means of *objectifying* their results: correct indication of the taxonomic allocation of objects of physiological, genetic, biomedical, etc. research is one of the indispensable conditions for the scientific validity of these results. Classifications at the species/subspecific level are of fundamental importance for the elaboration and application of strategies and plans of nature conservation, control of the export/import of biomaterials of all kinds (the organisms themselves and their derivatives), and so on.

It is worthy to indicate importance of educational sphere of the applied systematics. The presentation of the orderly and annotated results of practical systematic studies to the common public is aimed not only at transferring knowledge about phenomenal diversity of organisms, but also in the upbringing of certain attitude (and the respective style of thinking) towards its perception. The core of this attitude is understanding of the diversity of living nature as its fundamental property (attribute) resulted from biological evolution and deserving detailed study and conservation.

SECTION II — HISTORICAL

The *history of science is a part of science* — this is one of the key theses of modern non-classical science formulated by the principle of historicism (Grushin, 1961, Kuznetsova, 1996, Rozov, 2002) and actively developed by evolutionary epistemology (see 2.2 on it). The meaning of this statement is as follows.

Science is a developing non-equilibrium system, so its historical development is non-Markovian, that is, with a sufficiently high level of past influence on the future. Therefore, in its development there is always a historical continuty, putting the scientific knowledge attained to a certain moment into certain dependence on previous ideas and concepts. Both new theoretical ideas and concepts and concrete classifications realizing them arise not de novo “out of thin air”, but as a kind of superstructure over previously developed ones. Therefore, the science, like any developing system, is to a certain extent a “victim of its history”: this general idea is formalized by Niels Bohr’s *correspondence principle*. If it is ignored, the movement of knowledge along the time scale turns into “Brownian”, that is into a chaotic wanderings in search of some kind of unimaginable “novelty”, which denies all “antiquity.”

From this point of view, the study of the history of the formation of taxonomic knowledge is very important for understanding how the biological systematics functions as a developing system, how and why key ideas developed and changed at different stages of its development. An appeal to the past of systematics — to the manner in which and why this, and not the other way, formation of its basic concepts proceeded, allows one to see traces of the past in the present and serves as one of the prerequisites for understanding this present and, at least to some extent, to look into the near future. Therefore, the newest interest in the theory of systematics inevitably generates an interest in its history (Hull, 1988), which obliges to consider theoretical questions in the general context of the fundamental triad “*the history of systematics + the theory of systematics + the philosophy of taxonomy*” (see the Foreword): this corresponds generally to the modern understanding of the relation between history, theory and the philosophy of science in its non-classical version (Kuznetsova, 1996, 1998, 2010, Rozov, 1997, 2008; Wilkins, 1998; Flek, 1999; Maienschein, 2000; Lennox, 2001; Lakatos, 2003; Styopin, 2003).

* * *

The present section of the book describes the main stages and directions of the development of biological systematics throughout its history. Two general phases of the historical development of the classifying activity are distinguished in it: a) a “prehistory”, to which pre-proto-systematics is allocated (Chapter 3), and b) a “conceptual history” proper encompassing the development of scientific systematics in its strict sense, beginning with the scholastic systematics and ending with more advanced theories and schools. In Chapter 4, taxonomical concepts that developed throughout the 19th century are discussed in a great detail: some of them are mainly of historical interest ("esotericism"), others served as a "seed" for the subsequent conceptual development of biological systematics (early versions of the typology, "natural systematics", evolutionary concepts). Chapter 5 briefly describes the main trends in the development of theoretical views in the 20th century; a detailed analysis of the content of the conceptions formed during this period is given in the theoretical Section III.

Chapter 2. Conceptual history of systematics

One of the deep meanings of the conceptual history of systematics is that the basic elements of the triad "*history* + *theory* + *philosophy*" indicated in the Foreword are interrelated and mutually conditioned. This is just the *inter*connection and *inter*dependence, so that this triad can be built in the form of a special conceptual "triangle" (see 6.1 on this). On the one hand, without a knowledge of the history of the development of ideas, it is hardly possible to understand fully their current content, which explains the great attention paid to the history of systematics in this book. On the other hand, an important conclusion for this Chapter, which can be extracted from this interdependence, is that the general scientific position of the modern reenactor of the history of systematics largely determines his/her ideas not only about the scientific content of this discipline, but about its history as well.

The latter means that, although the realized history is unique and therefore integral, in its analysis we are dealing actually not with it in its suchness, but with its outlines, interpretations, explanations. There is no "history in general" in them, but rather its personal versions advocated by adherents of different concepts of both the history and particular scientific doctrines (Rozov, 2002). In the extreme case, this position is expressesed by aphorism of an historian Marxist M.N. Pokrovsky (1928): "history [is] does not represent any more but a politics overtaken in the past"; in our case, "politics" is the taxonomic theory, from the perspective of which the history of systematics is examined. With this, it should be emphasized that each of the proposed interpretations (unless this is, of course, intentional falsification and not "sincere delusion") is true to an extent that it reveals some aspect of the historical development of this discipline.

It is clear from the previous that it is necessary to distinguish between two "histories". One of them is the *history as such*, as a realized process of the historical development; as it has just been said, this history (according to the initially accepted condition of the "historical monism") is the only one and therefore the integral. Another "history" is a *narration of the history* based not only on facts as such (sources, documents, etc.) but also on their interpretations. It is clear that these two "histories" are not identical: one is what was objectively proceeding "in reality", the other is what is subjectively described and interpreted based on some or another reasons; so the latter is not history but *historiography* (Bloch, 1973). The problem here is that the second "history" stands often out for the "first" one, so a possible reconstruction is taken for the only "real" history. It would certainly be better to distinguish terminologically between them; this is however not done here just to avoid terminological conglomerations; but an important difference should be kept in one's mind.

2.1. The content of conceptual history

Coarsening the entire situation to an extent, one can identify two main ways of positing the historical development of biological systematics corresponding to two ways of understanding its main content, namely *empirical* and *theoretical* ones.

Empiricism sees in systematics mainly generalized facts, which are particular classifications. Accordingly, *empirical history* of systematics is constructed as a chronicle, the main events in which are successive updates of these classifications. Obviously, such an approach gives little to understand why these events happened and how they affected the further development of systematics — and the more it does not give an understanding of why there are different classifications at all, including those that do not fit a general trend of elaboration of more and more "complete" and "perfect" systematic knowledge.

In contrast, a theoretical view of the systematics assumes an equally theoretical view of its historical development, which in this case appears as a *conceptual history*, that is as a process of the development of ideas, which is regular to some extent and causally conditioned, directed not so much by the accumulation of the facts (classifications), as by the development of theoretical constructs — theories, concepts, etc. As the zoologist of Ernst Mayr rightly noted, "the most important aspect of the history of systematics is that it is, like the history of evolutionary biology, a history of concepts rather than of facts" (Mayr, 1982, p 144.). These taxonomic concepts, in their turn, arise not spontaneously but in a certain general scientific (more broadly, socio-cultural) context, which itself is also subject to changes. Thus, this is the historical dynamics of the general scientific cognitive context that serves as the main driving force in the development of the theoretical ideas in any scientific discipline, including systematics (Grene, 1987a, Putnam, 2002; Rozov, 2002; Ilyin, 2003).

Conceptual and empirical understanding and presentation of the history of systematics can be presented as an emphasis on the *intensive* and *extensive* ways of its development, respectively. In the language of classical systematics, the first way implements theoretical research program, the second one is practical program, or "methodical" and "collection" ones, respectively (Long, 1996; Zuev, 2002, 2009, 2015; Pavlinov, Lyubarskiy, 2011; Pavlinov, 2013a, 2015a; see beginning of the Chapter 10). Intensive development is a *problem* one: a transition from one stage of this history to another is always caused by the solution of the previous and the posing of new problems (Mayr, 1982a). It is associated with a deepening of ideas about how the wildlife in general and the diversity of organisms in particular are organized, and how to describe their diversity. Extensive development expands these ideas by providing an empirical basis for the application of concepts and stimulating their development to certain extent. It is obvious that these two modes of development and the corresponding "histories" do not exclude, but complement each other: one does not exist without the other (although supporters of empirical systematics are unlikely to agree with this).

The general theoretical position adopted in this book, set forth in the Foreword, means that the content of the conceptual history of systematics consists of the significant changes in its cognitive situation (see 6.1 about it), which are marked by changes in the key cognitive models, the problems they generate and the ways to solve them. Obviously, these changes are not spontaneous, but are caused by the development of the science-philosophical and natural-scientific contexts. In the 16th century, that was the development of the "classification paradigm" stimulated by the birth of the new European science, at the turn of the 18th and 19th centuries that was mastering the ideas of "natural systematics" (in its both general and particular understanding) under influence of the philosophy of empiricism, in the second half of the 19th century that was mastering of the evolutionary idea. In the first half of the 20th century. systematics developed mainly under the influence of positivism ideas, and in its second half under influence of the postpositivism philosophy of science, according to which the metaphysical component of systematic knowledge was expelled from it or again legitimized in it.

It follows from the previous, in particular, that in order to understand and expose the conceptual history of systematics, unlike the empirical one, it is not important what particular taxa the leaders of one or another of its scientific schools distinguished and named, but what ideas they introduced into its development, making the latter intense. Thus, A. Cesalpino was an Aristotelian — and the first to applied the classification method in systematics based on genus-species deductive scheme. J. Ray was influenced by the ideas of an empiricist philosopher J. Locke — and first to begin a turn towards inductive understanding of classification method. C. Linnaeus was an agnostic — and this was the reason for distinguishing by him between the Natural System and artificial classifications, partly reproducing Locke's idea of the artificiality of any particular classifications. The theory of evolution (as it is understood at the present time), before being argued by biologists Ch. Darwin and E. Haeckel, has been actively developed by philosophers I. Kant and G. Spencer in the form of the historically understood natural-philosophical idea of transformism. Kant can be considered a precursor of numerical systematics, because it was him who said that in every knowledge there is exactly as much of science as there is of mathematics in it. Positivist philosophy formed the basis of classification phenetics, as one of its first ideologists, J. Gilmour, directly stated; ontoepistemic reductionism, rooted in positivism, forms the basis of the newest genosystematics. Well, and so on, examples can be multiplied and multiplied.

An important part of such a vision of conceptual history is the emphasis placed on which ideas some of its actors have introduced into the formation of the theoretical foundations of systematics; it is often found that the accepted opinions appearing in the textbooks are fundamentally untrue on closer examination. So, it is important to know that Aristotle was not an "essentialist" in the modern (Popperian) sense and that the essentialism of the early systematizers did not at all mean "stagnation in taxonomy" (Balme, 1987a; Winsor, 2003, 2006a; O'Rourke, 2004; Pavlinov, 2013a, b; Richards, 2016); that the beginning of scientific systematics, as just mentioned, was laid by Cezalpin, who first put it on a solid methodological basis, and not by Linnaeus (Pavlinov, Lyubarskii, 2011; Pavlinov, 2013a, b, 2015a, Lyubarsky, 2015); that the "Linnean reform" of the descriptive systematics language was carried out not by Linnaeus himself, but mainly by his students and opponents (Pavlinov, 2013b, 2015a); that Darwin did not "destroy the species as a natural unit", but simply equalized its evolutionary (and thereby taxonomic) status with that of subspecies, geographical races, etc. (Stamos, 1996, 2013; Sloan, 2009; Pavlinov, 2013a); finally (as a curiosity) that E. Mayr denoted his first contribution to the development of the theory of evolutionary systematics by negating the species as a significant taxonomic unit, but later changed his position to the opposite one (Greene, 1992, Chung, 2003); or that D. Hull first declared essentialism in taxonomy "two millennia of stagnation" (Hull, 1965), but subsequently abandoned such an interpretation (Hull, 2006).

* * *

In connection with the necessity (because of inevitability) of the laying down certain accents in the study and reconstruction of the conceptual history, a serious controversy appears between *presentism* vs. *antiquarianism*, as these two oblige to assess in different ways the theoretical constructs that were being formed at different times (Demidov, 1994; Rozov, 1994; Foucault, 1994; Kuznetsova, 1996, 2009, 2010). In the case of presentism, some theory having arosed in the past is considered in the context of a modern understanding of the conceptual core of a scientific discipline, through the prism of the nowadays problems and tasks existing in it. In the case of antiquarianism, that theory is considered in the scientific and sociocultural context that existed at the time of its emergence and, in general, gave rise to it. For example, present-day science obliges modern biologists, which are devoted to the evolutionary idea, to evaluate the history of the systematics of the 17–18th centuries from the point of view of the extent to which the taxonomic theories and concepts that arose then contributed to the development of this idea. But from an antiquarian point of view, for an understandable reason, such an analysis is hardly correct: the naturalists laying the foundations of taxonomic science at that time were thinking about creation and not about evolution, so they worked out concepts as they saw them then. And only later on their concepts did receive evolutionary interpretation; for example, the alchemical affinity of "everything with everything" turned to the genealogical relationship of organisms.

A combination of prezentism and antiquarianism makes it possible to view the conceptual history as a kind of scientific-social relay, within which development of cognitive situation proceeds that combine elements of continuity and novelty (Rozov, 1997, 2002, 2008; Rozova, 2014). At the heart of continuity is conservatism of the key cognitive problems and themes, making each subsequent appeal to them just another "variation on a theme", just another "one more time on an issue..." (Holton, 1975). At the heart of the novelty is the dynamics of research programs and paradigms that determine differently the main content of scientific knowledge in the given discipline.

Consideration of the conceptual history of systematics in the context of sociocultural dynamics as such kind of "relay" (McKelvey, 1982; Zuev, 2002, 2009, 2015; Pavlinov, 2013a) allows us to understand many external factors acting on the development of the cognitive situation in our discipline, first of all the change of both worldviews and general scientific contexts related to it. It also gives a dual understanding of the significance of changing ideas and concepts over time, both on their own ("here and now") and as making a certain contribution to the formation of theoretical knowledge at subsequent stages of the development of systematics. As a result, links and continuities can be identified at the level of these programs and onto-epistemic concepts, which may elude attention under a different angle of view (Pavlinov, Lyubarskii, 2011; Pavlinov, 2013a; Lubarsky, 2018).

Thus, modern interpretations of the taxonomic hierarchy appear simply as a variety of philosophical representations about hierarchies of essences and categories, which go back to the scholasticists, to Neoplatonists, and further to the confrontation between Plato and Aristotle. The modern taxonomic monism, which affirms the right to existence of just one "most true" classification theory (for example, phenetic or cladistic), appears to be but one of the manifestations of the monistic cognitive doctrine of the antic and/or biblical sense. Very clear is the long chain of continuity of natural philosophical ideas in the development of numerism — from Pythagoras through Galileo and then through Descartes and Kant to Gauss and finally to modern numerical taxonomy, whose ideologists believed it to be the "newest revolution" in the history of this discipline. Another example is the influence of the natural philosophical doctrine of organismism on the formation of the phylogenetic theory: E. Haeckel considered phylogenesis as the development of a "genealogical individual", now this influence is implicit in the acknowledge of the partonomical nature of phylogenetic classifications.

2.2. Hystory of systematics as a process

According to one of the key ideas of evolutionary epistemology, the historical development of scientific knowledge can to some extent be likened to biological evolution (Tulmin, 1984; Hull, 1988; Gaidenko, 1991; Merkulov, 1996, 2003; 2006; Hachleig, Hooker, 1996; Follmer, 1998; Campbell, 2000; Popper, 2000, 2002; Abachiev, 2004; Denisova, 2005; Haitun, 2014). Within the framework of this model of science development, if in the biological evolution the key act is speciation (species formation), in conceptual evolution, respectively, it is "conceptiation" (concept formation) encompassing both the concepts proper and the theories that include them. With such a consideration of the development of science, theoretical knowledge, which constitutes the core of research programs, is analogous to the genotype, while practical results (in our case these are particular classifications) are an analogue of the phenotype, and the selective agent is the scientific community built into the general socio-cultural context (Hull, 1988; Hachleig, Hooker, 1996). From this point of view, specific accents are placed in the understanding of some mechanisms of the formation of research programs and schools in biological taxonomy (McKelvey, 1982, Mishler, 1990, 2009; Pavlinov, 2011a, 2013a).

With consideration of the historical development of systematics as a specific "conceptual evolution", two basic components, *anagenetic* and *cladogenetic*, can be quite naturally recognized in it. In the first case, it is the progressive evolution of taxonomic theories from less to more developed (actually, something like Aristotelian Scala of Perfection); in the second case, it is their fragmentation and multiplication yielding a branching scheme of historical development of theoretical systematics. As the science develops as an open system, this two-component model, very similar to the one that phylogenetics develops in biology, should be cmplemented with a *network* component. It corresponds to the "horizontal transfer" in biological evolution, that is the exchange of ideas, their borrowing and combining. In general, it turns out that the conceptual history of systematics can not be laid in a single trend of a sequential change of the dominant paradigms. Although all this is subordinated to the fundamental idea of the cognition of the System of Nature in its most general sense (*unification tren*d), the interpretations of this idea are very different (*diversification trend*), and different interpretations can anastomize to some extent and form due to interchange by particular treatments (*combinatorial trend*) .

* * *

Two general concepts of the philosophy of science mentioned above, classical and non-classical, differently assess contribution of each of these three components to the overall process of the historical development of scientific knowledge. Accordingly, both the entire process of conceptual evolution can look and particular “assessments” of appearing theories can set substantially different.

The “classics” gives special importance to the anagenetic component: the development of taxonomic science is represented as a steady progress of knowledge from less to more complete, directed successively by sequentially replacein one another more and more consistent theories within the framework of a single guiding idea — for example, the above idea of the Natural System. At the empirical level, it looks laike developing a more and more perfect overall classification as a form of representing an increasingly complete taxonomic knowledge. This main historical trend is complemented by certain local conceptual branches and related classifications, which are of secondary importance. According to this point of view, both the outdated theories that formed the core of taxonomy in the past, and the side ones, all of them are discarded over time as unnecessary (Shatalkin, 2012).

The main problem, unsolvable within the framework of the classical paradigm, is that, as the whole history of taxonomy shows, it is impossible to specify in some unique way a constant guiding and directing idea, except perhaps the most general i*dea of the Natural System* that can be represented today as elaboration of more and more complete knowledge of the structure of the taxonomic diversity. The driving force behind this trend can be regarded as the *law of growth of intensionality of classifications*, which means more and more complete reflection of the properties of that diversity by means of classification (Subetto, 1994). But the very idea of what taxonomic diversity is, and thus the idea of the completeness of the knowledge about it, depends on the developing cognitive situation, in the context of which the subject area of systematics is examined.

Thus, for the scholasts (Turnefort, Linnaeus) and early ideologists of the “natural systematics” (Adanson, Jussieu, Candolle), this completeness was determined by the approximation of specific classifications to the Natural System in its natural philosophical understanding, that is as the universal law of Nature. To achieve this goal they were perfecting the “natural method”, filling it with a specific content according to their understanding of what the “nature” is. For supporters of the empirical history of systematics, this view of latter’s ultimate goal means that the main development trend is set by elaboration of more general and comprehensive classifications (Turrill, 1938, Davis, Heywood, 1963, Blackwelder, 1964). For the rationalists, the key idea determining the progress of systematics is the subordination of its own general theory to those concepts that are borrowed from some “general logic”: the more in the taxonomic theory of this logic, the more advanced and progressive it is (Lyubishchev, 1966, 1982; Kozhara, 1982, 2006). Within the framework of “numeristics” (another variant of the rational idea), the main trend of progressive development of systematics is determined by how effectively it masters numerical methods for assessing similarity and kinship relations, tigether with constructing classification schemes based on them (Cain, 1959a, Sneath, 1961, 1995). And so forth ...

Such a diversity in understanding of the main trend in the historical development of systematics is caused by the fact that not only the taxonomic theories and concepts themselves change over time, but also those general scientific paradigms that shape a conceptual scaffold for this history. Such paradigms, according to the general idea of the “social relay”, are formed by the scientific community in a certain local socially and historically conditioned cognitive context. Accordingly, quite local ideas are formed about what is scientific and unscientific in systematics, on the basis of which accents are placed in understanding of what is driving force for and what is the direction of the dominant trend in the evolution of taxonomic science.

* * *

The "non-classics" gives equal importance to both ana- and cladogenetic components of the evolution of taxonomic knowledge: including both of them on an equal footing in the general historical picture means that the diversification of theories is as immanent to this evolution as the sequential progression. This means that the evolution of theoretical systematics is not strictly determined and narrowly directed linear process. Its development is associated, among other things, with the growing understanding that taxonomic diversity is complexly structured and multidimensional — and this changing understanding over time is also added to a general assessment of what the completeness of taxonomic knowledge is. Accordingly, as the understanding of the structure of taxonomic diversity is complicating, the conceptual space that makes up it becomes more complicated as well, and due to this the number of particular taxonomic theories increases, each with its own specific subject area.

The evolutionary epistemology basically adopted here allows us to draw attention to the fact that the concept of adaptive zones, borrowed from the biological theory, is quite organically embedded into the model under consideration as an important external factor that diversifies developing systems. In the biological evolution, such are the groups of organisms and their properties, in the "conceptual evolution" these are taxonomic theories and concepts. In the latter case, both general onto-epistemic ideas, as well as particular ideas about the subject area and methods of systematics that open opportunities for its development in one direction or another, are acting as the "adaptive zones": moreover, by virtue of the action of scientific-philosophical regulators they direct this development. As a result, an "adaptive radiation" of particular theories and concepts proceeds that, over time (and for some time), can be transformed from side branches into dominant ones. So, in the second half of the 19th century, a new very large "adaptive zone" was opened by the evolutionary idea that has generated now dominating evolutionary (in a broad sense) systematics. At the beginning of the 20th century, as already noted, this "zone" was formed by the positivism philosophy of science (especially by its physicalist version), which forced the main trend in the development of systematics toward phenetic, "numeric" and (for some time) experimental directions. At the end of the 20th century, a new direction of development was provided by molecular genetic factology, which supplemented the evolutionary idea, and as a result, more than a popular genosystematics (genophyletics) was erected.

Accordingly, if an idea loses its relevance, the "adaptive zone" formed by it narrows and the taxonomic theory developed within it tends to get extinct; the fates of organismic natural philosophy of the 19th century (see 4.2.3.2) and classificatory phenetics (see 10.2) of the 20th century exemplify such "evolutionary events" in the conceptual history of systematics. And yet, both of them, figuratively speaking, did not "sink into oblivion": the first gave birth to the classical (Haeckelian) phylogenetics and is now embodied in the general idea of partonomic systems (see 9.2.2); while some important ideas were borrowed from the second by numerical philetics (see 10.3.2).

Developing further the evolutionary metaphor with reference to the history of theoretical systematics, one can see in it a manifestation of the principle of progressive specialization. In this case, it means that some particular taxonomic theory begins with more general ideas and proposals and then turns into a fairly formalized classification approach, in which an initial key idea is strengthened up to its hypertrophy. A striking example is the evolution of numerical systematics: at its inception are general considerations on the possibility of quantifying the similarity and difference between organisms and the need for development of an "exact taxonomy", at its (at the moment) end is the "mathematical taxonomy", in which consistency of biological classifications are determined by how much they correspond to the conditions of a particular mathematical method (see 10.3).

Finally, it seems possible to talk about macro- and microevolutionary trends, about parallelisms and convergences, about the iterative and reticular evolution of taxonomic theories (Pavlinov, Lyubarskii, 2011; Pavlinov, 2013a). This evolution at the macro- level is directed by the shift and diversification of cognitive models and programs: such was a transition from scholastic to post-cholastic systematics at the end of the 18th and the beginning of the 19th centuries, the growing influence of the evolutionary idea throughout the 19th century (phylogenetics), the development of systematics under the strong influence of positivism philosophy in the first half and middle of the 20th century (dominance of microsystematics, phenetics). Obviously microevolutionary are all sorts of "character and" "methodical" (in a narrow sense) particular taxonomic concepts: examples are division of botanists into "fructuists" and "corollists" in the 17th–18th centuries, those associated with various quantitative methods in numerical systematics in the 20th century. An example of iterative evolution (see Rautian, 1988) can be the revival of the scholastic principle of the single fundamentum divisionis in the most recent genosystematics (Pavlinov, 2011b) or repeated attempts to integrate into systematics of multicellular animals the data on their individual development (Pavlinov, 2013c). An example of reticular evolution can be seen in the formation of a "new phylogenetics" in the second half of the 20th century resulted from combining some basic ideas of cladistic theory, molecular factology and numerical methodology (Pavlinov, 2003; Pavlinov, 2004a, 2005a, b).

An interesting manifestation of the "biological" nature of the evolution of taxonomic theories is the competitive relationship between them (more precisely, between schools implementing them) as a result of two kinds of causes, subjective and objective (Hull, 1988; Pavlinov, Lubarsky, 2011; Sterner, Lidgard, 2017). On the one hand, of importance is a pretension of respective scholars adherent to the classical monistic idea to possession of the "truth in the last resort", which motivates them to treat all other taxonomic theories and schools as "untrue". Thus, in the scholastic systematics, heated disputes were waged between the above "fructuists" and "corallists"; in the second half of the 19th century, the sharpest controversy broke out among the adherents of the "natural" and phylogenetic systematics; in the second third of the 20th century, the same thing occurred between ideologists of phenetic, cladistic and evolutionary taxonomy theoris. On the other hand, the serious factor that stimulate competition among schools is the limited available resources for conducting taxonomic studies. And the competition for these resources is currently exacerbated by the increase in both the cost of such research and innovations in the organization of the whole of science (Haitun, 2014).

* * *

When discussing the conceptual history of systematics, classifications and schools that replace one another are most frequently meant, and attention is focused on their novelty and implied progressiveness (Stafleu, 1969, Mayr, 1971, 1982a, Hull, 1988, Quicke, 1993). In this regard, the tendency to declare almost every nascent classification approach as a "*new systematics*" revealing new perspectives for the development of taxonomic knowledge is noteworthy. The early post-cholastic systematics of the turn of the 18–19th centuries was designated this way. (Stafleu, 1969, 1971). During 20th and 21th centuries, such status was assign by "populationists" (Hubbs, 1934, Huxley, 1940a, Mayr, 1942, Mayr, 1947), several times by "numerists" (Smirnov, 1923, 1938, Sneath, 1958, Cain, 1959a), typologists (Lubarsky , 1996a, Vasilyeva, 1999), essentialists (Rieppel, 2010a), cladists (Nelson, 1971, Queiroz, 1988), supporters of molecular approache (Hawksworth, Bisby, 1988, Olson et al., 2016) and their opponents (Wheeler, 2008a, b), ideologists of ontogenetic systematics (Martynov, 2009a, b, 2011) and even just working with large data sets (Schram, 2004).

However, with this, another fundamental property of the evolutionary development of systematics emphasized above is lost, namely the inertia generally inherent in the process of development of any complex system, including cognitive. Aconservative basic element is built into the development of systematics, ensuring its unity as a scientific discipline (see above about Bohr's correspondence principle). This means that systematics is doomed to discuss essentially the same "eternal problems", trying to solve them differently at different stages of its conceptual history.

The inertia of the historical development of systematics as a scientific relay is ensured primarily by sufficiently stable worldviews that constitute the ontological basis of various research programs in it. Thus, the holistic ontology first appeared in ancient times, in modern times it was the basis of the natural philosophy from which it penetrated into classical phylogenetics, some of its important elements, as already noted above, are seen in the newest ideas about partonomic divisions (Woodger, 1952; Tversky , 1989; Mahner, 1993; Gerstl, Pribbenow, 1995; Mahner, Bunge, 1997; Chebanov, 2007; Calosi, Graziani, 2014; Lyubarsky, 2016, 2018). Opposite to it reduction ontology, formalized in scholasticism as nominalism, is the same for the natural philosophical system of supporters of the idea of the "Scala of Perfection" of the second half of the 18th century, as well as for modern phenetics and, in part, for population taxonomy. This kind of obvious inertia can be traced in the framework of particular taxonomic theories; for example, in the evolutionarily interpreted systematics, the common integrating factor is the acknowledging some connection between evolution and classifications: it determines the unity of the evolutionary idea from Lamarck (early 19th century) and Haeckel (second half of the 19th century) to the contemporary cladistics (the turn of the 20th–21st centuries), the differences are reduced to the particular interpretations of the relationship between similarity, kinship and history (see 10.8).

An external more than obvious manifestation of the known conservatism of systematics is the stability of its conceptual apparatus and partly of the methodology: the concepts of taxon, character, homology, similarity, etc., the general principles of classification as one of the forms of comparative (in a broad sense) method are uniform for practically entire systematics. Different interpretations of them give rise to a diversification trend; but the fact that these interpretations are just the particular manifestations of certain common ideas sets unquestionable unification trend, ensuring the inertial character of the conceptual history of systematics.

* * *

It should be reminded once again that the history, understood as actualized developmental process, is single in the sense that the historical events undoubtedly took place and each of them was really unique. This is true with respect to both particular classifications, the development process of which constitutes an empirical history of systematics, as well as classification theories and concepts, the dynamics of which form the conceptual history of systematics. All this is obvious — but it is also obvious that, when considering and describing this single realized history, accents on the events can placed differently, so that the history can be presented in a variety of versions. At the same time, as already mentioned above, the arrangement of accents in the consideration of directions and stages of the historical development of systematics largely depends on the general scientific position of a researcher. Thus, resorting to the figurative language of the philosopher-historian R. Collingwood, one can say that every systematist writes his "own" history of this scientific discipline in accordance with his/her views and inclinations (Collingwood, 1980).

Thus, within the framework of empirical history, the selection of three main stages designated as *alpha*-, *beta*-, and *omega*-systematics is popular: the first (initial) corresponds to the study of local fauna and flora, the second — to the construction of common systems, the third (final) — to the development of a omnispective classification (Turrill, 1938; Mayr, 1947, 1971; Mayr et al., 1956; Davis, Heywood, 1963; Blackwelder, 1964; Stace, 1989). V.V. Zuev (2002, 2009) distinguishes two main stages of the history of taxonomy, namely *empirical* and *theoretical*, indicated by the dominance (in the Linnaean terminology) of collection and methodological programs, respectively. In a more general sense I.Ya. Pavlinov (1996a) singles out the *irrational*, *rational narrative* and *rational hypothetical-deductive* stages of its development.

Researchers committed to some particular taxonomic theory believe it is the latter that finalizes the development of the entire systematics and structure the latter's history accordingly. For example, botanists usually distinguish two main stages in the history of systematics, the epochs of *artificial* and *natural* systems (Sprengel, 1808; Maksimovich, 1827; Sachs, 1906). In turn, proponents of the evolutionary idea divide the entire systematics into *pre-evolutionary* and *evolutionary* (Mayr, 1947, 1971, 1982a; Mayr et al., 1956). A variant combining these two versions divides history of systematics into artificial, natural and phylogenetic stages (Starostin, 1970). Theoreticians of population (bio)systematics distinguish the *descriptive*, *systematic* and *biosystematic* stages of the development of taxonomic science (Valentine, Löve, 1958). Phenetichian-numerist P. Sneath (1995) believes that the development of numerical systematics in the second half of the 20th century became the most significant achievement in this science from the times of Linnaeus, the cladist K. de Queiroz (1988) argues that it is the cladistics (the same second half of the 20th century) that is most important, as it made the systematics truly evolutionary. An amusing scheme (in the form of a cladogram) of sequential formation of the basic classification concepts from Aristotle to Henning was presented by M. Christoffersen (1995).

Considering, from the point of view of evolutionary epistemology, the claims of the ideologists of every "new" taxonomy to its exclusiveness, “finality” and therefore unconditional leadership, we have to admit that they go against the general principle of historicism, according to which: a) any scientific theory is transient, b) historical development is inertial, so c) there are neither completely true (“final”) nor completely false (“forgotten”) theories. All this means that there is neither completeness and absolute novelty nor complete obsolescence of classification ideas in systematics. Every “new” taxonomic theory is just another version of the solution of the eternal questions of this scientific discipline, which, as the course of its conceptual history proceeds, will find eventually an appropriate place among other versions.

Indeed, almost every taxonomic theory makes its specific contribution to the development of general ideas about the structure of diversity of the biota and the ways of its understanding and representation — and as such becomes and remains a part of the entire conceptual history. Even quite “esoteric” theories usually scolded by “progressists” of various kinds are not exceptions. For example, the essentialist division of the properties of organisms into essential and random ones within the framework of quinarism was turned into dividing the similarity into essential and analogous corresponding to different aspects of the affinity of organisms; this became subsequently a prerequisite for the formation of general concept of homology (see 9.6.1).

Since the history of systematics considered here is conceptual, to remain in it means to remain its actual “actor” preserving a creative potential and ablility to become integrated, with its old ideas, into new ones. Examples of this from the recent history of systematics are the aforementioned revival of the scholastic principle of the single fundamentum divisionis in genosystematics (Pavlinov, 2011b) or the revival of interest in essentialism in the discussion of the ontological status of taxa (see 6.4.5).

* * *

Within the framework of the conceptual history of systematics, it is assumed that the general integration-diversification trend of its development is set by a three general causes corresponding to the three basic components in the overall cognitive situation (Pavlinov, 2011a, 2013a; Pavlinov, Lyubarsky, 2011; see 6.1.). Some of them relate to the ontological foundations of systematics and are associated with the development of different ideas about the structure and causes of the taxonomic reality. Others refer to its epistemic grounds: they are associated with the development of cognitive constructs corresponding to different understandings of the principles of scientific research. The transition from less to more developed conceptual apparatus, from less to more sophisticated research methodologies and classification methods implementing them — all these constitute a global historical trend of the development of theoretical systematics. The cuases of the third category refer to the subject component of the cognitive situation: here we mean the changing social factors of the development of science, the styles of research thinking, and so on.

2.3. Principal stages

Taking into account the changes in the structure and content of the general cognitive situation in which classification activity was and is carried out during the long history of systematics, four main stages are naturally enough distinguished: pre-systematics, proto-systematics, scholastic and post-scholastic systematics (Pavlinov and Lyubarsky, 2011; Pavlinov, 2013a). Of these, the first two are united in the “prehistory” of scientific systematics, the other two correspond to the development of the actual scientific systematics.

A transition from one stage to another has the character of a scientific revolution. Such revolutions are quite local, since they concern mainly the content of research activity in the systematics. But in part they are global, as far as they are related to the development of the cognitive situation in natural science as a whole (Lubarsky, 2018).

* * *

Pre-systematics begins the history of the whole classification activity of mankind, it is characteristic primarily of communities of primitive people (see 3.1); it is represented by *folk-systematics.* It is largely empirical and pragmatic, and not an abstract cognitive. Its basis is an intuitive ontology with a large admixture of mythology, which is of a local nature. In the cognitive situation of pre-systematics, there are no methodologies and methods that establish a connection between the intuitive perception of the diversity of living beings, on the one hand, and some primitive classification schemes, on the other. The common basis for such schemes (folk classifications) is most often something like a primitive essentialism based on the evaluation of the significance of the properties of living beings from the point of view of their importance and interest to people.

* * *

Proto-systematics is immersed in the broader context of ideas about living matter as a part of the ordered Cosmos: the latter means that these ideas, unlike folk-taxonomic ones, are global rather than local ones. Within the framework of this context, two key tasks are solved, laying the two main cognitive programs in systematics (see the beginning of Chapter 10): a) *theoretical* (methodical) program is related to the rational development of the first onto-epistemic principles of cognitive activity, b) *empirical* (collector) program is related to generalization and primary systematization of information about living nature, partly in "cosmic" and partly in utilitarian understanding of it.

In the proto-systematics, three stages are distinguished quite naturally, namely the *antique*, the *scholastic* (medieval), and the *herbal* (Renaissance) (see 3.2). During the first stage (from the 4th century BC up to the 5th century AD), general principles of logical classification and related basic concepts are developed, which were genus, species, essence, difference, etc. In the writings of the scholastics (6–14th centuries), the basic cognitive categories of onto-epistemology (realism, nominalism, conceptualism, rationalism), basic methodologies (deductive and inductive argumentation schemes) and classification methods (the generic-species scheme of notions division) receive clear understanding. Herbalism (14–16th centuries), in contrast to medieval scholasticism, develops basically the collection program: it lays the foundations of descriptive systematics, including compilation of diagnostic characteristics, the ways of formation of taxonomic names, etc.

* * *

Scientific systematics began to develop together with the modern science (16th century), a prerequisite for which was formation of a new cognitive situation in the natural science: it separated the scientific systematics from the preceding herbalistics. The attention of the systematizers is now focused mainly not by pragmatic but by cognitive intention: the main goal is the rational understanding and learning of Nature from the point of view of the universal natural law organizing it as the Systema Naturae. Accordingly, in the development of classifications, the key task is to reveal natural groups of organisms in which the above law is manifested, according to their own nature; utilitarian significance now excluded from the latter.

By the way this general cognitive intention is realized in the scientific systematics, the latter's conceptual history can be divided into two main stages, *scholastic* and *post-scholastic*. The first of these covers the 16th-18th centuries, the second begines in the second half of the 18th and early 19th centuries. In its turn, post-cholastic history can be divided into three main stages — early, mature and modern taxonomy — depending on what key ideas determine its scientific content.

* * *

The initial stage of the development of systematics as a science is largely connected with the development of the methodology of classification activity, borrowed from medieval scholasticism (see 4.1.1). This became the basis of its initial rationalization as a scientific discipline, which is busy systematization, and not simply enumeration of facts. This circumstance makes it possible to designate the systematics corresponding to this stage as **scholastic** (Pavlinov, Lyubarsky, 2011; Pavlinov, 2013a,b, 2014). Classification of organisms (in Linnaeus, of all natural bodies in general) is based on logical generic-species scheme, the development of the latter constitutes the main content of the early systematics, one or several pre-selected anatomical structures are used as the basis for logical division. Closer to the end of this stage, there is a noticeable modification of scholastic rationality: instead of the rankless hierarchy of the above scheme, a hierarchical system with fixed rank is introduced.

* * *

Post-scholastic systematics begins to develop as a kind of postponed "Renaissance protest" against domination of the scholastic approach to development of the Natural System (see 4.2.1). The main emphasis is shifted from the method of cognition of Nature and the classification of organisms according to individual characteristics to Nature itself in the whole variety of its manifestations: this means the *biologization* of systematics and makes it "natural" in a broad sense. An important part of this understanding is the desire to classify organisms not by a few essential properties, but by the totality of their various characteristics. This turn is connected with the empiricization of taxonomic studies and with the transition from a predominantly deductive ("top-down") to a predominantly inductive ("bottom-up") method of developing classifications. Empiricization was the main content of the "new rationality" of early post-cholastic systematics, which largely determined the direction of its further development.

However, this direction can not be considered strictly linear: within the framework of the early post-cholastic ("natural" in a broad sense) systematics, a significant variety of taxonomic theories appears over a fairly short period of time (Pavlinov, Lyubarsky, 2011; Pavlinov, 2013a, 2014). They differ in the content of particular cognitive situations — there are different natural philosophies (from "systemic" to "scalar", from typological to transformational, from organismic to numerological, etc.), different methodologies (the ratio of inductive and deductive elements, different approaches to weighting characteristics) — and all of them, of course, generate natural systems according to their ideologists. Among them, "natural systematics" (in the narrow sense, ie, mostly botanical), typology, early organismic and transformational theories have the greatest significance in their consequences.

* * *

In the second half of the 19th century, a new important step in the development of the post-scholastic systematics occurred that transferred it from an early stage to a more mature one, corresponding to the common understanding of living nature as part of the self-developing Cosmos (see 4.2.6). It is marked by the active development of transformational natural philosophy in its modern evolutionary content, and introduction of the genealogical interpretation of the Natural System on this basis. According to this, alchemically understood affinity, expressed through an essential similarity, is replaced by blood relationship, which is revealed on the basis of characters with minimal relation to the important vital sentiments (essences) of organisms. Of particular importance is the Darwinian model of evolution (the natural selection of random variations), which attracted the interest of taxonomists mainly to intraspecific categories and thereby deprived the "Linnean" species of its particularly distinguished status. Haeckel's evolutionary model (phylogenetics), which absorbed significant elements of the organismic natural philosophy, focuses mainly on high-ranking groups and, along with typology, gives the advantage to developing macro-classifications.

* * *

The development of biological systematics throughout the 20th century, considered in the context of its conceptual history, is largely due to the search for responses to new challenges of scientific rationality that emerged at that time: it refers to the impact first of positivistic and then (and mostly) post-positvistic philosophy science (see Chapter 5). Positivistic philosophy, with its domination of the physicalistic scientific paradigm (science is the physics, everything else is "stamps collecting"), has led to the loss of the former prestigious status of systematics. This encourages the latter to try to fit into science in its new understanding, to justify its onto-epistemology by direct appeals to the actual scientific and philosophical developments. The movement in this direction becomes the content of the next "new rationality" of biological systematics, which allows it to hope for the acquisition of the status of a full-fledged natural science discipline. This hope, for reasons not depending on the systematics, is justified only partially; and yet, such an active form of the rationalization of taxonomy makes it *modern* in the full sense of the word.

The search for possible responses to the new challenges leads to further fragmentation and multiplication of taxonomic theories and schools. This process includes the development of both earlier theories ("natural", typological, evolutionary), largely snubbed by new ideas, and attempts to master these new ideas and build new classification theories on them. At the beginning, the development of biology in general and the systematics in particular under direct influence of reductionist ideas of the positivist philosophy of science acquire special significance: in a certain sense, in the first half of the 20th century, *positivist taxonomy* dominates. Its development leads, on the one hand, to the formation of *population* (*bio*)*systematics*: here the specific trend of the biologization of taxonomy is manifested in a specific way on the basis of the Darwinian evolutionary model. Somewhat later, on the other hand, the *classification phenetics* and *numerical systematics* are conjointly begin, which to a certain extent lead to a "debiologization" (formalization) of the positivist systematics. In both cases, the traditional "museum" systematics (primarily typology and classical phylogenetics) is declared "morally obsolete" and pushed to the secondary position.

In the second half of the 20th century, active development of the phylogenetic concept begins, marking another significant step in the history of modern taxonomy. At this stage, this concept is developed in the form of two taxonomic theories: evolutionary taxonomy that has preserved many traditional traits, and more radical cladistics. Toward the end of the 20th century, the latter begins to incorporate actively molecular genetic data and new numerical methods, which leads to an absolute dominance of genosystematics (more commonly known as molecular phylogenetics = genophyletics).

* * *

Along with these "mainstream" schools, during the two centuries of post-cholastic history of systematics, several taxonomic theories appears that have a more particular significance. In the 19th century, these are "esoteric" theories like numerology and organismism. In the 20th century, there are several specific variants of rational taxonomy realizing the general idea of its nomotetisation; besides, biomorphics is developed that classifies life forms (bio- or ecomorphs). Those who are inclined to reduce everything to the "mainstream" also refer typological systematics to those "marginals" of the 20th century.

* * *

In the meronomic part of post-cholastic systematics, the dominant "de-essentialization" of characters as a classifying basis becomes an important feature. Their essentialist interpretation remains noticeable only in some early versions of "natural systematics". In other taxonomic theories, either their diagnostic interpretation (especially among "genealogists") begins to dominate, or individual characters "dissolve" in the holistic understanding of the organism as a plan of structure or as archetype (organismists, typologists) or in phenetic hyperspace (phenetics).

Among the basic ideas of meronomy developed by post-cholastic systematics is the general concept of homology. Initially, it develops on a typological basis, then on a phylogenetic one. Its significance for taxonomy lies in the fact that it radically changes the general approach to the choice of classifying characters, excluding both their essential and phenetic interpretations and placing homologization of characters as the main principle of assessing their significance ("weight").

A remarkable manifestation of the differential weighting of the characters, that was inherited from the Scholastic and constitute the basis for classification, is the development of many "character" theories. They are entirely based on giving particular importance to certain classification characteristics and appear as the technical base of taxonomic research develops. Thus, if the early botanical systematists are divided into "fructuists" and "corallists", among modern approaches occur, for example, karyosystematics, chemosystematics (including molecular genetic), ontogenetic taxonomy, etc.

* * *

Toward the end of the 20th century, the systematics begins to abandon some of the dogmas of the classical philosophy of science and master its nonclassical philosophy. The main turning point is the recognition of the significance of scientific pluralism, implying the meaningfulness of different conceptual means of describing the diversity of organisms. This marked the *newest* (current) stage of development of biological systematics.

The content of the new trend is mainly the recognition of the multifaceted structure of the diversity of the biota and the ways it is represented. On this basis, significance of recongition of different aspects, fragments, levels, etc. of taxonomic diversity is acknowledged (see 6.4.4); it is proposed to distinguish taxonomic and meronomical aspects of considering this diversity (see 6.4.3); two basic ways of representing the structure of the first of these basic aspects, namely based on set theory (taxonomical in narrow sense) and system theory (partonomical, holistic) are fixed (see 9.6). All this becomes a prerequisite for the formation of ideas about the cognitive equivalence of both different manifestations (aspects, levels, etc.) of the diversity of organisms and the taxonomic theories studying them (see 8.2).

SECTION III — THEORETICAL

Science is impossible without theoretical knowledge: this is true both in the most general case, and in rwspect to any branch of natural science, claiming the status of a scientific, including, of course, biological systematics. Therefore, the structure, functioning and development of the latter as a scientific discipline is largely determined by the content and dynamics of its theoretical component. For the same reason, an understanding of what is the scientific systematics is largely determined by the understanding of this component.

The basic content of theoretical knowledge is (by tautology) the theory (Greek θεωρία — consideration, contemplation) in the most general sense, ie, some conceptual construct which purpose is a) to generalize the object of knowledge, b) to explain it, and c) on this basis to regulate the cognitive activity directed at it. By the level of generality and the nature of the tasks solved in the course of implementing these three "assignments", theoretical knowledge is structured hierarchically, with a number of functional strata of different levels of generality being singled out in it.

The theorizing at the lowest level includes the primary generalizations of empirical data, including all kinds of judgments (hypotheses) about specific regularities that establish some connections between facts and indicate possible causes of these links; in the systematics, these are classifications. Though, such generalizations are often considered empirical and deprived of theoretical status, but this is hardly correct: in any generalization there is an element of theorizing as far as it operates with general notions. Indeed, in order to develop empirical generalizations about the diversity of organisms that are more advanced than folk-systematic ones, one must have sufficiently developed general concepts of taxa as well as of homology and characters as the bases of meaningful comparison, etc.

The next level is given by particular subject theories and concepts, within the context of which these primary generalizations are developed. In taxonomy, they include various sorts of specific classification theories (phylogenetic, typological, "natural", etc.) and concepts (species, homology, etc.).

Higher levels include scientific theories and concepts of general order that determine the subject areas of scientific disciplines and the principles of their study. They form that part of theoretical knowledge, within the framework of which onto-epistemic bases of the subject/aspect branches of natural science are developed. This level includes elaboration of the ideas about structure of the diversity of biota and about those of its manifestations that are studied by classifying biological disciplines, namely systematics, biogeography, biocenology, etc. In particular, this includes theoretical constructs that separate the taxonomic and meronomical aspects of organismal diversity. In the systematics itself, general taxonomic theory belongs to this level, which determines the subject area of the entire discipline and its own branches, basic concepts (classification, taxon, character, etc.), the principles for development of taxonomic hypotheses, etc. (see Chapter 8).

Metatheoretical level consists of conceptual constructs of the most general order, performing a basic regulatory (framework) function concerning organization of the cognitive activity in the natural sciences, which are obviously also relevant for systematics. They include the principles of the formation of the cognitive situation and its conceptual carcass, the development of the principles of cognition, the criteria for scientific knowledge and research methodologies and methods, etc. Such constructs relating to this level shape what is commonly called the *philosophy of science*, or *metascience* (Whewell, 1847; Carnap, 1971; Stepin et al., 1999; Ilyin, 2003; Mikeshina, 2005; Moiseyev, 2008; Voytov, 2016), as well as private philosophies of different branches of science in its general understanding and its separate subject areas — logic , mathematics, physics, chemistry, biology, etc. (Bureyko, 1970; Grene, 1974; Ruse, 1977; Mayr, 1988a; Heisenberg, 1989; Mahner, Bunge, 1997; Sober 2000; Perminov, 2001; Schumann, 2001; Ellis, 2002; Bunge , 2003; Samsin, 2003; Garvey, 2007; Yurchenko, 2008; Kurashov, 2009; Maddy, 2012; Pozdnyakov, 2015a). If not to fear exaggeration, it is permissible to talk about "philosophies" of specific branches of biology, including biological systematics and some of its key concepts. Such exaggerations were not feared by the theoreticians of the second half of the 18th and early 19th centuries (Linnaeus, 1751; Fabricius, 1778; Link, 1798; Lamarck, 1809; Fleming, 1822; Geoffroy..., 1830), this understanding is explicitly stated in some modern meta-scientific studies of systematics and its sections (Gilmour, 1940; Rogers, 1958; Volkova , Filyukov, 1966; Mahner, Bunge, 1997; Epstein, 1999–2009; Zuev, 2002; Brigandt, Griffiths, 2007; Richards, 2011, 2016).

The recognition of the complex nature of the entire cognitive situation inherent in modern science makes the close interaction of the science and the philosophy of science itself highly relevant. This means that a serious discussion of the scientific validity of any discipline (including systematics), including an assessment of the scientific nature of its content, is impossible without resorting to scientific criteria that do not exist on their own, outside the philosophy of science. Of course, this connection is not recognized by all; an opinion is expressed, including authoritative scientists (for example, Weinberg, 2008), that "digging" in the philosophical principles of cognition impedes the progress of knowledge about what Nature "actually" is; such a position can be called "anti-principle" (Schwab, 1960). However, at the present time an opinion prevails among theorists that this connection is fundamentally significant for the credible functioning and development of science (Kun, 1977; Popper, 1983; Mahner, Bunge, 1997; Ilyin, 2003; Koyre, 2003; Styopin, 2003; Ivin, 2005; Feyerabend, 2007; Moiseev, 2008).

Concluding these general comments, I would like to note the following. Neither the theoretical constructs that make up the content of taxonomy as a theoretical section of systematics, nor their philosophical framing, are not homogeneous. They exist in the form of diverse particular concepts and interpretations, each with its own justification, historical destiny, specific place in the general cognitive situation, with their adherents who develop and apply them in specific cognitive situations. This philosophical-scientific pluralism is very rarely presented in the systematic reviews; on the contrary, many "philosophizing" biologists are often excessively categorical in their assessments of the superiority of accepted (and implicitly imposed) particular scientific and philosophical ideas, thus leaving behind hot discussions between philosophers around these ideas.

According to the author's position stated in the Foreword, in the following chapters the variety of these ideas is reflected as far as possible fully, — of course, very briefly and only to an extent that would make it possible to show how diversity of philosophical positions influences the variety of theoretical concepts in the biological systematics.

* * *

As can be seen from the foregoing, the scientific status of both systematics itself and the taxonomic knowledge that it develops in particular can not be understood outside the general philosophical and theoretical context (Bock, 1974; Griffiths, 1974a; Wiley, 1975; Kitts, 1977; Platnick, Gaffney, 1977; Hull, 1988, 1999; Rieppel, 1988b, 2003; Mahner, Bunge, 1997; Epshtein, 2002; 2003; Zuev, 2002, 2016a; Hołyński, 2005; Wägele, 2005; Williams, Ebach, 2008; Pavlinov, 2010b, 2011a, 2013a; Richards, 2011, 2016; Pozdnyakov, 2015). This context deserves to be designated as the *philosophy of taxonomy* (Mahner, Bunge, 1997; Epstein, 1999-2009a), or, if not so pathetically, the *general taxonomy* (Lyubishchev, 1975), *methodological taxonomy* (Gregg, 1954), *metataxsonomy* (Subetto, 1994; Mahvin, Bunge, 1997; Pavlinov, Lubarsky, 2011; the latter term is also used with different meanings, see: Akhmanova, 1966; Van Valen, 1973; Marchesi, Ravel, 2015) or (not too well) *metaclassification* (Meyen, Schrader, 1976). This circumstance reflects a significant modern interest in general theoretical problems and questions of biological systematics.

A full theoretical knowledge of the latter can be imagined as a complexly organized conceptual construct, the core of which is *taxonomy* as its theoretical division proper, while its enclose is *metataxonomy* as a philosophy of systematics. Together they constitute a fundamental dyad "*theory of systematics + philosophy of systematics*", which provides a general understanding of the theoretical content of this discipline. This means that the theory of systematics can not be built without philosophy of systematic: actually, it is one of the most "philosophizing" biological disciplines. As E. Mayr emphasized, in it "every basic biological concept is also a philosophical concept [they] run one into each another" (after Greene, 1992, p. 259). Moreover, every "biological classification [is] a place where philosophy is practically applied" (Lubarsky, 2018, p. 287).

The just-named dyad is a fragment of a more general triad, which also includes a conceptual history of systematics (see Foreword). This section presents a review of only this dyad; concepts are considered as such outside their historical context. The content of this section can be divided into two blocks.

The first block includes materials of a theoretical and philosophical nature. In this case, one of the main tasks is to demonstrate that if one considers systematics as a science, then the practice of systematics is inconceivable outside the theory of systematics, which is developed in the context of the philosophy of systematics, and this latter, in turn, is sahped by the general philosophy of science. Chapter 6 examines the structure of the cognitive situation in which biological systematics operates. Chapter 7 provides a brief overview of the main scientific (cognitive) categories as applied to systematics.

It should be stipulated here that, since the author is a "philosophizing biologist" and not a "near-biological philosopher", the philosophical aspects of metataxonomy set forth herein are not intended for philosophers (by whom the method of submitting the materials relevant to their competence is likely to seem quite canonical and not especially correct), but for biologists who are interested in scientific and philosophical foundations of the biological systematics.

The second block includes materials on the theory of biological systematics proper. Chapter 8 shows how the taxonomic theory can be substantiated and developed if it is understood as an implementation of scientific and philosophical ideas with reference to the study of the structure of biological diversity. Chapter 9 examines in more detail the main concepts and concepts of taxonomy, namely classification, taxon, character, etc. Chapter 10 describes the main research programs and schools of systematics, mainly recent ones.

Chapter 8. Taxonomic theory as a quasi-axiomatics

Not any scientific discipline can function normally without more or less developed theory; accordingly, the development of a scientific discipline is perhaps before all the development of its theoretical component. The latter is elaborated as a conceptual system containing generalized theoretical knowledge about the subject under investigation; this was briefly mentioned at the very beginning of the theoretical section of the book.

Systematics, regarded as a scientific discipline, is not an exception. It is based on a taxonomic theory briefly considered in this Chapter under a rather specific and partly formal point of view — as a quasi-axiomatics.

8.1. General consideration

The main purpose (function) of any theory is to develop generalizations about the phenomenon under investigation, however the latter is understood. The theory indicates regularity in this phenomenon that are treated as essential from some cognitive point of view, and presents them in the form of a set of internally consistent conceptual constructs — generalizations (laws or hypotheses), concepts, etc. Accordingly, since science deals with the uncovering of such regularities, and not simply by stating and enumerating certain facts, the theory plays in it a key role.

When considering what a scientific theory is, it is important to keep in mind the following principal points. The basis of the its entire construction is the unity of ontology and epistemology: one does not exist without the other, they are interrelated, this reflects the metaphor of the "cognitive triangle" and the general principle of onto-epistemic correspondence (see 6.1, 6.3). A theory is always local to some extent: it is limited to a certain area of application, including a certain level of generality, so a substantial scientific "universal theory of everything" is impossible. The theory is not a complete product but a living developing cognitive system "in statu nascendi"; the vector of its development is directed towards a more complete understanding of what and how it reflects. Some concepts (partial) can be defined within the framework of this theory, others (more general) so only in a metatheory including this one. In any sufficiently developed theory, one can single out a solid core and a labile periphery: the first contains the basic meaning of the theory, which does not change in the course of its development, the contents of the second can vary to some extent (clarifications, shifts of accents, etc.) by influence of various kinds of "external circumstances".

There are no qualitative differences between theory and concept: both represent ways of formulating theoretical knowledge of different degrees of "maturity". In this pair, a theory corresponds to a more developed and in this sense a more "mature" and fundamental generalizing knowledge, while a concept corresponds to its initial shaping. Therefore, a general theoretical (conceptual) construct elaborated within the biological systematics can be called both a taxonomic theory and a taxonomic concept. Considered from the point of view of systematics proper, such a construct looks like the "theory" (and sometimes even as a "philosophy"); froma more general standpoint of natural science, especially loaded with a physicalist paradigm, it is rather a “concept”.

* * *

Although the notion of theory is one of the key and basic in the science, it has no sufficiently clear and unified definition; and probably the latter can not exist because of the qualitative heterogeneity and dynamic nature of the whole system of scientific knowledge. Aspiration to unified understanding of the theory ingeneral sense is an ideal of the classical monistic paradigm, acknowledging impossibility of this is an attribute of the scientific pluralistic “nonclassics”.

The main parameters of a theory (Ilyin, 2003; Stepin, 2003; Ushakov, 2005) are its content, structure, construction method, application area (including the level of generality). From the point of view of the main theme of this book, it is most important to single out the following main categories of theories that differ in these parameters:

— *informal* (concrete, about a phenomenon studied by particular discipline) and *formal* (abstract, including the method of studying this phenomenon),

— *deductive* (axiomatic) and *inductive* (empirical),

— *metatheory* (theory about theories) and the *object* theories proper,

— *explanatory* (causal) and *descriptive*.

By their **content**, the theories can be divided into two main groups depending on what kind of generalizations they develop. Some of them relate to ontology, others to epistemology: the former can be considered object theory (for example, theory of phylogeny, theory of homology), the latter are methodological theory (for example, the theory of calculus of kinship on the basis of similarity estimates).

The **method of constructing** a theory in its general basis can be *deductive* (in particular, hypothetically-deductive) or *inductive-deductive*. A strictly deductive method is most effective in the case of formal systems, where it is called *axiomatic*: in it, all particular assertions are logical consequences of initially introduced general ones. In *semi-axiomatic* method all initial conditions are given quite formally, but not strictly enough to meet the criteria of proper axiomatics. Strictly inductive construction of a scientific theory does not presuppose any prior assumptions, therefore it is impossible in the natural sciences (see 6.2): the formulation of empirical generalizations requires prior introduction of some basic ontology, for example, in taxonomy this is postulated objective existence of diverse organisms. Therefore, a *hypothetico-deductive* method of constructing theory is most suitable for natural theories such as taxonomy, which (with some reservations) can be designated as *quasi-axiomatic*. With this, initial notions of such theory considering to its own ontology are meaningfully interpreted, and the rest are derived from them taking into account some boundary conditions (such as onto-epistemic correspondence).

The **structure** of scientific theory includes two basic components, “horizontal” and “vertical”.

The “*horizontal*” *component* of theory is first and foremost an ordered system of generalized judgments about a) about ontology, i.e. properties of some manifestation (fragment, aspect, etc.) of the reality being explored, and b) about epistemology, ie principles and methods of studying and representing this reality in a cognitive system. In constructing the theory as quasi-axiomatics, judgments relating to its ontological part appear as *axioms* or *presumptions* depending on their truth status (see 6.5.5), and judgments of its epistemic part appear as *inference rules*. Specific elements of ontology and epistemology are mapped (fixed) in the *basic thesaurus* of the theory through appropriate concepts and notions; this thesaurus stands out as another part of the theory, equivalent to the two just outlined. Together they form the *conceptual carcass* of the cognitive situation in which this theory is being developed and functioning. With specification of the "horizontal" component, various secondary judgments of a more particular order about the reality under investigation are included here: these are verifiable consequences, prognostications, etc.

Axioms (postulates) or *presumptions* shaping ontology of the theory are relevant to the very subject of research: they answer the question "*what*?" (phenomenological models) and also "*why*?" in the expanded interpretation (causal models). Together they define the subject area of the theory, namely the reality under investigation and its fundamental properties; so they form a substantial background knowledge of the research conducted in the context of this theory. Thus, the axioms/presumptions actually "construct" the reality under investigation in the form of its basic conceptual model: by this, they reduce the general "*Umgebung*" to a particular "*Umwelt*", define the basic elements of this reality as special kind of ideations (for example, the organism, the property of the organism, etc.), and basic relations between them (structural, functional, genetic, etc.). Axioms (postulates) are introduced as a "credo", the truth-status assessment of which is equal to one; they are not questioned within the framework of this cognitive situation and therefore does not change at the end of the research; such cognitive status of them provides the rigidity of the entire conceptual carcass. Presumptions do not have such unconditional truth status: the latter is given probabilistically, with the probability being significantly less than one and can change (including decrease) as a result of the research (Rasnitsyn, 1983, 1996, 2002, 2005; Pavlinov, 2005b,c, 2010b, 2011a, Pavlinov, Lyubarsky, 2011).

For example, for systematics in its general sense, an unconditional axiom is the assumption of the real existence of a diversity of organisms and their properties; all the rest, including reasoning about causes of this diversity, is presumptions. In the evolutionary-interpreted systematics, the axiom is the assertion that the structure of the diversity of organisms is a consequence of the evolutionary development of the biota; of presumptive nature are the judgments about homology of the structures, which form the basis for recognizing characters and comparing organisms. The boundary between the judgments of these two categories, axioms and presumptions, is not strictly defined. For instance, the basis for the elaboration of any hypothetical-deductively built nomological system is the assumption that there is certain regularity in the structure of the diversity of organisms (for example, periodicity). This assumption can be considered both an axiom and a presumption: in the first case, intellectual efforts will be aimed at confirming the alleged regularity, in the second it is possible to demonstrate its absence. The development of the premise knowledge on a quasi-axiomatic basis is the subject of active criticism from adherents of the inductive way of developing taxonomic knowledge: the initial assumptions are equated with "ideologems" (Gilmour, 1940, 1961; Sokal, Sneath, 1963; Sneath, Sokal, 1973; Oskolsky, 2007; Chaikovsky, 2010). This type of criticism proceeds from classical (Baconian) inductive scheme of the development of scientific (including theoretical) knowledge; this cognitive attitude is however untenable from the point of view of "non-classics" (see 7.3).

The *inference rules* that shape epistemology of quasi-axiomatically constructed natural-science (including taxonomic) theory are relevant to the exploration procedure: they answer the question "*how*?" — exactly, how explorations should be conducted. These rules regulate principles and methodology of elaboration of those explorations, and in fact represent ways to "translate" the general statements about the reality into concrete cognitive models applied to available facts. For example, the axiom of phylogenetically determined structure of the diversity of organisms is translated into phylogenetic classifications on the basis of the analysis of empirical data by means of such rules (in cladistics, this is the principle of synapomorphy). The rules of inference include the basic argumentation schemes (see 6.5.3), the principles of organization of research activity based on them or added to them (for example, the principle of economy, the use of comparative or experimental techniques, general schemes for the elaboration and testing of hypotheses, etc.), the optimal ways to represent particular cognitive models, for example, in the form of classification system.

The "*vertical*" *component* of the theory (in its most general sense) is determined by the ratio of its constituent conceptual constructs of different levels of generality, connected by a single unifying ordering parameter, above all a concrete onto-epistemology. According to this, theories are usually divided by their levels of generality into those of higher (metatheory), middle (generalizing "object" judgments) and lower (revealing empirical patterns) levels. Theories proper, united by a single metatheory, can be considered conceptually connected; otherwise, they are conceptually disconnected. The frmer collectively shape the "conceptual pyramid" (see 6.2): its upper part is metatheory (in taxonomy, it is general taxonomic theory), it regulates particular theory "s. str." addressed to the actual reality being explored (in taxonomy, for example, typological or phylogenetic, species theory, homology theory, etc.). The top of the "pyramid" is occupied by axiomatic statements that define a rigid carcass of the cognitive situation, at the middle level are assertions of the presumptive (optional) character, which are mandatory in some versions and are not in others. Levels of the hierarchy of this "pyramid" are not strictly fixed; it can similarly be arranged for the entire systematics, and for each of its sections. For example, in evolutionary-interpreted systematics, a theory that connects the diversity of organisms with the evolutionary process belongs to the higher level, the Haeckelian and Hennig versions of phylogenetics belong to the middle level, the versions of cladistic (economical, etc.) belong to the lowest level. With the expanded understanding, two more levels are introduced into the "vertical" structure of the theory, in a certain sense "external" with respect to it: at the upper one is the conceptual enclosure, which is formed by the main scientific categories of cognitive activity, developed by the philosophy of science (see 6.7); at the lower one is placed empirical basis formed by the elements of the reality under investigation (in the taxonomy, a research sample).

The **basic properties** (characteristics) of the scientific theory can be somewhat provisionally divided into two groups (Ilyin, 2003; Styopin, 2003). Of them, "internal" ones reflect its properties as quasi-axiomatics; "external" reflect the properties of the theory as a natural-scientific construct, somehow relating it to the object reality being studied.

Among the "internal" properties of the theory are the following:

— *completeness*: the totality of basic assumptions (axioms and presumptions, inference rules) should allow to derive all the judgments about the investigated reality required in the given cognitive situation, without resorting to any additional reasoning (i.e., to judgments not defined in framework of this theory); this property corresponds to the constructive condition (see 7.4) and makes every quasi-axiomatic system "closed". As it can be supposed, this condition is not strictly feasible from the point of view of the principle of theory incompleteness (see 6.2);

— *independence*: assumptions of each of the categories should not "overlap" in the conceptual space, that is, they should not duplicate each other and/or be derived from each other. This condition does not probably extends to the interrelation of judgments relating to different basic components of the cognitive situation postulated by the principle of onto-epistemic correspondence (see 6.3);

— *consistency*: basic assumptions should not provide for the possibility of mutually exclusive judgments about the reality under investigation. This property corresponds to binary logic, whereas it is not so significant in multivalued or fuzzy logics relevant for natural science disciplines, and should be considered in conjunction with the complementarity principle (see 7.9);

— *solvability* (efficiency): the basic assumptions of onto-epistemology, provided that it is complete, should allow development of research procedures (methods, algorithms), through which it is possible to elaborate meaningful hypotheses about the reality under study for a reasonable number of steps (time). In particular, this property implies indispensable operationalizability of concepts and notions that shape the basis of ontological epistemology.

As can be seen from the foregoing, the "rigid" interpretation of these properties of scientific theory, which was formed within the framework of the classical concept of science, in its non-classical version is softened, in one form or another. In this way, the built natural-science (including taxonomic) theory is actually a quasi-axiomatics, and not an axiomatics (and not even a seven-axiomatics) in its strict sense. In particular, the methods of building quasi-axioms are based not on formal logic, but on substantive judgments about the reality under investigation. From this point of view, one of the basic properties of the natural-scientific theory is its systemacy, which reflects interrelation of its basic assumptions on the level of onto-epistemology (see 7.4).

The "external" properties (characteristics) of the natural-science theory in the majority of them also appear as its main functions. Almost all of them directly correlate with the criteria of the scientificity of knowledge (see 6.5.1), therefore here it suffices just to list them: verity (adequacy, likelihood), rationality, explanatory power, prognostic (heuristic) possibility. To them it can be added the level of universality of the theory outlining the scope of its applicability; since, as was emphasized above, there are no universal theories, it may be more correct to talk about the level of locality.

8.2. Content and structure of taxonomic theory

The main task of biological systematics is to study the structure of taxonomic reality; or, which is almost the same, the structure of taxonomic diversity (see 6.4.4 for the content of these notions). Accordingly, the main purpose of the *taxonomic theory* (TT) is the formation of the theoretical context of the cognitive situation in which this general task is solved; based on this assignment, its main parameters considered in the previous section are determined (Pavlinov, 2011a).

These parameters for TT can be determined as follows. It is built as a taxonomic quasi-axiomatics, in which judgments about taxonomic reality (the ontical component) appear as (quasi)axioms or presumptions, and the principles of its study (the epistemic component) are the inference rules. The area of its application is the taxonomic reality, as it was outlined above, ie, it is a object (informal) theory. Its main content is the theoretical comprehension of knowledge about this reality and the principles of its investigation and representation. As part of this comprehension, TT does not explain the mechanisms generating the structure of the reality under study, although it allows for a possibility of taking them into account in the development of onto-epistemology: thus, it is mainly a *descriptive* theory. With this, TT describes not the dynamics, but the *statics* of the structure of the diversity of organisms; therefore, taxogenesis (taxonogenesis), if it is understood as the evolution of real groups of organisms (Krasilov, 1986; Pozdnyakov, 2005; Zuev, 2015, 2016b), is not within its competence. However, it can be assumed that representation of an ordered picture of taxonomic reality is not just a description of it, but also an explanation by the means available to taxonomy (Zarenkov, 1976, 1988). In this case, if taxogenesis is understood epistemically — as a "generation" of taxa in the process of elaboration of classification, — then it can be said that TT explores and explains the *principles of taxogenesis*. Thus, TT can be considered causal in some sense.

The basic structure of the TT thus constructed is represented as a "conceptual pyramid" (see 6.2), the top of which is occupied by a *general* TT, at the middle level are *particular* TTs of various levels of generality, at the lowest level are their operational interpretations. The "shell" of the TT consists of conceptual constructs of a higher level of generality, formed both by general scientific categories (see 6.7) and by basic ontical models (about the objective reality of the surrounding world, etc.). Its empirical basis is the manifestation of biological diversity investigated by systematics (taxonomic reality).

The need to develop TT in such form is dictated by the general scientific *principle of rationality* (see 7.4): its representation as a system of quasi-axioms and inference rules makes the underlying assumptions both deducible and verifiable. An additional requirement imposes the principle of constructiveness: these assumptions must be explicit (not "implied") and constitute a totality of necessary and sufficient conditions for delineating the "Umwelt" studied by systematics. On the other hand, the uncertainty principle (see 7.9) means that this requirement is not feasible completely: the content of natural science knowledge is not completely formalizable and therefore not definable "without a residue". So in a quasi-axiomatic system there will always be some unconscored "gaps", and the thesaurus formed on its basis will contain incompletely defined notions (see 9.1).

* * *

Elements of quasi-axiomatics can be found in a sufficiently large number of issues that examine theoretical bases of systematics, both in general and in particular schools. They are evidently present in the works of the scholastic taxonomists, where the fundamental statements are framed as "canons" or "rules". For example, C. Linnaeus' "Philosophy of Botany ..." is presented almost entirely in such format (see 4.1.3): in particular, the axiom of "we count as many species as different forms was created from the beginning" relates to the basic ontology (Linnaeus , 1989, § 157), wile the inference rule "a character exist not to establish a genus, but to learn it" (op. cit., § 169) relates to epistemology. A.-P Candolle (1819) declared (but not derived) three "theorems" considering the coupled classifying significance of different anatomical structures (see 4.2.5). In many treatises of both "classical" period and modern, such statements appear as "axioms" or (more often) "principles" in their fairly common understanding (for example, Lindley, 1836; Engler, 1898; Ferris, 1928; Mayr et al., 1955, Simpson, 1961; Sokal, Sneath, 1963; Lines, Mertens, 1970; Mayr, 1971; Pratt, 1972; Sneath, Sokal, 1973; Militarev, 1988; Rasnitsyn, 1992, 2002; Kluge, 1998; Schuh, 2000; Epstein, 2002, 2003); they actually represent (in the terminology adopted here) actual "axioms" and "inference rules", whereas this latter notion is not used at all. There are many fundamental books entitled not "principles" but "foundations" (for example, Hennig, 1950; Wägele, 2005; Williams, Ebach, 2008; this book). There are examples of attempts to present dush foundations of a phylogenetic theory, claimed and designed as drafts of respective quasi-axiomatics (Løvtrup, 1973, 1975, 1977; Wiley, 1981; Pavlinov, 1990a, 1997, 2005; Mayden, Wiley, 1993; Wägele, 2005); some of them are detailed enough. For example, the theory of evolutionary taxonomy of V. Epstein (2002, 2003, 2009b) in the nomothetic section includes more than two dozen "laws" (foundation of phylogenesis) and 6 postulates (rules of natural classification); they are generalized in the form of 12 "axioms". The rationale for the phylogenetic concept of S. Lövtrup includes more than a dozen axioms, more than 15 definitons and more than 50 theorems (Løvtrup, 1975). Other "phylogenetic" quasi-axiomatics are more concise: with reference to the methodological principle of economy, only those properties of biological evolution indicated that are necessary to substantiate the cladistic concept (for example, Bonde, 1976; Wiley, 1981; Pavlinov, 1990a, 1992a, 2005b).

Apparently, it is hardly appropriate to consider here in any detail the variants of the proposed quasi-axiomatic and more formalized systems. The former, like the just mentioned, are largely particular and fragmentary, indistinctly structured; the latter appealing for comprehensiveness (Woodger, 1937; Gregg, 1950; Jardine, 1969; Mahner, Bunge, 1997) are too formal for systematics as a natural science discipline. In addition, none of them has been investigated for completeness, independence, applicability, and other key properties of any quasi-axiomatic (see above).

All this means that the development of TT in this way is in its infancy and requires special detailed studies: for the time being it is not so much a taxonomic theory in the proper sense, even if "immature" (Zuev, 2015, 2016a), but rather some preliminary sketch of a general taxonomic concept. Therefore, there are only a few preliminary nodal positions, which outline a) the general direction in which a rationally and constructively developed TT can be construed, and b) the general theoretical context in which the main concepts and schools of biological systematics will be considered in the next chapters.

8.2.1. General taxonomic theory

General taxonomic theory (GTT) is a metataxonomy developed and functioning as a general framework for p*articular taxonomy theories* (PTTs). It may well claim the status of a "systematic philosophy", which is usually (though not especially legitimately) assigned to PTTs — phenetic, cladistic, etc. (Mayr, 1965a,b, 1969; Hull, 1970, 1988; Pesenko, 1989, 1991b; Epshtein, 1999–2009a; Ereshefsky, 2001a). This causes some duality of GTT. On the one hand, considered from the point of view of the general construction of theoretical knowledge, it is an object one: its ontic basis is made by judgments about certain fragment of Nature as such. On the other hand, the GTT understood and built up in this way is not intended to solve specific classification problems that are dealt with by PTT: it generally considers possible ways of formulating such problems and possible solutions to them — and therefore, generally speaking, it is "divorced from reality" (however, empiricists of all kinds accuse any conceptual construct in this "sin"). Taking into account this duality, in developing the GTT, we must try to avoid the two extremes — both extreme formalization detaching it from the biological reality (Gregg, 1950; Mahner, Bunge, 1997) and the reduction to some PTT, to which its ideologists attribute a priority status (Hennig, 1950; Simpson, 1961; Mayr, 1971; Sneath, Sokal, 1973).

The main purpose of GTT as meta-taxonomy is the development of a conceptual carcass of a three-component cognitive situation in which biological systematics operates in a sufficiently broad treatment (see 6.1). In a general sense, it can be defined as "the conceptual system [...] providing the ontological, epistemological, semantical, and logical bacground for [systematics]" (Mahner, Bunge, 1997, p. 248). By bringing this definition into a line with the terminology adopted in this book, GTT can be interpreted as an *interrelated set of general judgments about the subject area* (*ontology*) *of biological systematics and the principles of its study* (*epistemology*) *reflected in the system of basic concepts and concepts* (*thesaurus*) (Pavlinov, 2011a). Elaborations of GTT as a quasi-axiomatics encompasses all three of its sections.

As far as the biological systematics is engaged in the study of the real diversity of organisms, GTT is significant not in itself, but as a means of developing specific TPTs dealing with this diversity. GTT forms something like a "space of logical possibilities", with those "possibilities" appearing in the form of concrete PTT, some of which are actually implemented, some are not. Therefore, bearing in mind the requirements of the derivability condition (see 8.1), the GTT must be built in such a way that the statements within a particular PTT can be formulated as specific explications (concretization, detailing) of the GTT statements themselves. This, among other things, means that the volume of the above space must be sufficient to encompass all possible PTT s as its derivable consequences (interpretations).

It is possible to structure GTT on various bases. For example, within the framework of classical scientific rationality, the division of TT into nomological and ideographic categories is popular. After the adoption of the idea of evolutionism, its supporters divide the entire systematics into evolutionary and non-evolutionary. It is shown further in this section that a more general and substantial structuring is carried out quite naturally taking into account the following main parameters: a) the emphasis on any one of the basic components of the cognitive situation (see 6.1) and b) the method of considering the taxonomic reality, which can be aspectual or object (see 6.4.3).

* * *

The **ontological part o**f the GTT includes quasi-axioms and presumptions about taxonomic reality, as it was defined above (see 6.4.4), and answering the question "*what*?": what biological systematics (in its general sense) exactly explores. According to this, this part begins with the *axiom of existence*: biological organisms with their properties do exist, they constitute an objective "biological reality". It is presumed that the properties of organisms that outline the taxonomic reality and distinguish it from other biological realities (ecological, etc.) are already given (intensionally) by some "shell" metatheory of a more general nature; as an option, they can be indicated (apparently extensionally) within the GTT itself. Probably, the *axiom of potential infinity* of biological diversity as a cumulative pool of organisms and their properties must be separately fixed: in it, the reduction of "Umgebung" to some finite "Umwelt" finds its justification.

Next, the *axiom of diversity* is introduced: organisms with their properties are diverse, with some of them being similar and others different; this makes diversity structured. Also, axioms are needed to fix relations between organisms and their properties significant for the systematics: these are taxonomic (similarity, kinship, etc.) and meronomical (primarily homology and again similarity) relations, respectively. Apparently, it makes sense to introduce the axioms of *systemity* and *common cause* on the basis of the same general scientific principles (see 7.4): they indicate the non-random nature of the structure of the diversity of organisms and make the epistemic principle of classificability meaningful (see below).

Acknowledge of the existence of a) the diversity of organisms with their properties, b) the relations between them and c) the non-random nature of the both, makes meaningful and necessary the fixation of various manifestations of the structure of this diversity. Of these, the most important is delineation of the aspects of diversity, carried out at several levels. Initially, a division of the taxonomic and meronomic aspects is determined on the basis of the distinguishing organisms and their properties, respectively: a formalism necessary for this can be designated as an *axiom of taxono-meronomization* of the taxonomic reality. Within the first of these aspects, an *axiom of aspectedness* fixes distinguishing similarity, kinship and other possible ways of preset aspects of diversity based on recognition of the respective relations between organisms. Within the framework of the meronomic aspect of diversity, such formalization (through the introduction of the corresponding axiom) fixes the possibility of distinguishing various properties and establishing relationships between them within the organisms: this serves as the basis for procedures for homologization and the recognition of characters. In addition, an *axiom of connectivity* is introduced that relates both the properties and relations of organisms and the aspects of diversity recognized on their basis so that one can, say, judge about kinship by similarity. It is required a "formal" (axiomatic) fixation of a possibility of recognition of the superorganismic structural units of diversity on different bases, namely according to particular aspect, level, fragment, etc. It seems reasonable to fix the *fractal nature* of the structure of the diversity of organisms, which makes it possible to judge about the properties of the whole ("Umgebung") by the properties of its fragments, aspects, etc. ("Umwelts").

This part of quasi-axiomatics also includes general judgments about the ontolic status of structural (aspectual, etc.) units of diversity, the mechanisms that generate this diversity, etc. This "fragmentation" of the GTT's ontological bases distinguishes in it different versions of general categorization — realistic or nominalistic, descriptive or causal, etc. Apparently, to ensure this, it is necessary to introduce corresponding axioms that fix these divisions and admit subsequent ones. For example, the *axiom of causality* can further break down by indication of various causes of the diversity of organisms, generating the corresponding PTT — creationist, evolutionary, structural, etc.

It is possible that statements about some of the above manifestations of the structure of biological diversity have logical status not of axioms or presumptions, but of deducible judgments ("theorems"). This important issue requires special consideration as the GTT will be being developed further.

Epistemic part of the GTT includes the inference rules, which most appropriately be called principles in the proper sense; their main purpose is to justify organization of research activities in taxonomy. One of the primary tasks in this case is to introduce general scientific principles into the quasi-axiomatics of GTT by a suitable way, giving them a meaningful (from a taxonomic point of view) interpretation: an example is the inversion of the principle of cognition into the *principle of classifiability* (see 6.5). At the same time, general principles are introduced that allow to elaborate a taxonomic system as a meaningful representation of taxonomic reality — for example, the *principle of adequacy*. On the other hand, quite formal principles, such as *logical consistency*, are important, taking into account the multiplicity of the underlying logical systems (see 6.5.2).

The most important task of epistemology, which ensures solvability of the entire quasi-axiomatics of GTT, is the development of methodology for empirical taxonomic studies. This includes, among most important, the principles of *interpretational homogeneity* vs. *interpretational variability* of the taxonomic system, according to which the latter is based on the same or different interpretation in different fragments and at different levels (see 9.2.1).

The methodological part of GTT includes analysis of applicability of different argumentation schemes — inductive, deductive, hypothetical-deductive — for elaboration of taxonomic systems (see 6.5.3). This is closely linked with the development of ideas about the epistemic status of these systems, first of all the question of whether they can be attributed the status of scientific hypotheses developed and tested according to certain procedural standards (see 6.5.5).

Very important is the *principle of selectivity*, based on the same general scientific principle (see 6.5.4.2). It (with reference to fractality) indicates a way of shaping the empirical reality that serves as a basis for solving any research task in practical taxonomy.

A system of classifying principles that govern the development of a taxonomic system is necessary, taking into account the requirements of meaningfulness (adequacy) and formality (logic consistency); in this case it is important to distinguish between general and particular principles. The *principle of taxonomic unity* is one of the most general and the most significant ones as an explication of the axiom of identity of indistinguishable entities in the logic. It formalizes a general way of structuring taxonomic reality, regulates recognition of taxa based on their intensional and extensional characteristics. At a lower level of generality, particular interpretations of this principle appear according to which relations between organisms are taken as a basis: this leads to shaping aspectual PTT (see below).

Here belongs a set of *principles of optimality* in their epistemic sense (see 7.4). Of these, for example, the *principle of optimal diagnosability* of taxa (Starobogatov, 1989, 1994), which is connected to the principle of taxonomic unity, directly concerns elaboration of taxonomic systems.

An important part of the methodology of taxonomic studies is general *principle of non-equivalence of characters* (Zarenkov, 1983, 1988). In an extended interpretation, not only the properties of organisms, but also the relationships between them, fall under its effect (see 9.6.3).

Bearing in mind that GTT in the actual cognitive situations is realized in the form of specific PTTs, the development of its epistemic part requires introduction of the following general principles. One of them

— let it be the *principle of interpretability* — determines the conditions for particular interpretations of axioms/presumptions and inference rules in GTT into those in different PTTs. Another is the *principle of translatability* that determines the conditions for mutual "translation" of the statements of different PTTs and, thereby, mutual interpretation of specific taxonomic systems developed on their bases. The *principle of taxonomic uncertainty* fixes the inability to develop a unified PTT and respective omnispective taxonomic system based on it that would be adequate to the etire taxonomic reality in its full extent.

Subjective component of the cognitive situation is not specified in standard versions of axiomatic systems (including semi- and quasi-) for the simple reason that their format was formed at the time of the dominance of classical science. This component clearly appears, for example, as an *anthropic principle* introduced along with others in the taxonomical concept of V.M. Epstein (2002, 2003). Obviously, it can not be correlated with any of the other above mentioned basic categories; perhaps in order to reflect it in a quasi-axiomatic system, it is necessary to designate another category in the structure of the latter that would fix regulatory function of the subject in constructing conceptual carcass of the cognitive situation, an example is *axiology* developed within the framework of modal logic (Ivin, 2016).

The influence of this component is clearly manifested in the fragmentation of taxonomic reality: the selection of its various aspects (fragments, etc.) is given by certain themes (tasks) of taxonomic research, which are formulated on a subjective basis (see 6.6). Here it is permissible to talk about different kinds of subjectocentrism that determine the choice of one or another PTT in the general space of their "logical possibilities". This means that such a choice is not accidental with respect to the characteristics of the subjects of cognitive activity in systematics, from specific schools with their particular PTTs to individuals with their own personal knowledge. On this basis, the general statements proposed in the GTT are selected, refined, supplemented and thus made applicable to the solution of those specific research tasks, which the "actors" of biological systematics deal with.

Not pretending to formalize the subjective component of taxonomic quasi-axiomatics, it is possible at the present stage of development of GTT just to state that it really occurs in the cognitive situation, performs an important regulatory function and therefore is implicit in all theoretical developments. The latter means that consideration of the theoretical grounds of both systematics in general and each of its schools is impossible without taking this component into account. The question of how the statements about this component within the framework of the GTT are implemented in each of the PTTs also requires special analysis.

8.2.2. Particular taxonomic theories

Particular taxonomic theories (PTTs), as their name implies, are specific interpretations of GTT: it is governed by the general principle of interpretability and is achieved by introducing specific particular interpretations of those statements of the basic quasi-axiomatics that such interpretation implies and admits. For example, the axiom of existence and the principle of classifiability can hardly be splitted by particular interpretations: they are the same for all PTTs. In contrast, the axioms fixing specific properties/relationships of organisms, and the principle of taxonomic unity certainly imply such interpretations, with each of which generating a specific PTT. Thus, the latter principle is clarified by indicating those relationships between organisms that are significant in the context of accepted substantive assumptions (primarily similarities and/or kinship).

Understanding GTT as a common framework concept for the development of PTTs makes the metaphor of the *conceptual space* (“space of logical possibilities”) a suitable representation of the interrelations between. Its axes are formed by the components of the cognitive situation and formalizing its quasi-axiomatic system, these are ontic, epistemic and subjective (Pavlinov, 2011a, see 6.1). Particular interpretations of these components are representable as fixations of different values on the corresponding axes. Each such fixation distinguishes in this space a certain local area, which is a particular cognitive situation and a PTT implementing it. This means that the latter, like GTT, can be fully determined only taking into account all three components of the cognitive situation. It is clear that the ways of fixing those values can be quite a lot: this generates plurality of local areas in the general conceptual space, to which different PTTs correspond. These latter overlap to some extent depending on the degree of coincidence of particular interpretations of the basic models (fixed values of the corresponding axes); this aspect of the structure of the GTT is considered by the previously mentioned principle of translatability.

Since the basic onto-epistemology is of decisive importance in the development of any quasi-axiomatics, the structure of the conceptual space, formed by particular interpretations of the GTT, is determined primarily by that component of the cognitive situation, which is the main emphasis in the formation of a particular quasi-axiomatics (Pavlinov, 2011a). According to this, the potential set of different PTTs is divided into three main categories, intersecting in one or another form, which key features are reflected in their names.

The *ontologically-oriented* PTTs focus on the ontical component: they are addressed to reality as such, their main task is to develop conceptual constructs that are adequate to certain understandings of the structure of biological diversity. This category includes those PTTs, the basis of which is given by the fragmentation of taxonomic reality according to different manifestations of the diversity of organisms: these are, first of all, aspectual, object, level, fragment theories; relational theories constitute a separate group.

In the *epistemologically-oriented* PTTs, the key task is to solve the methodological problems associated with the development of classification algorithms: these are methodological theories.

In case the *subjectively-oriented* PTTs, we are talking about the fact that the concrete individual with his/her personal knowledge is placed at the forefront of taxonomic research. In this case, it is hardly possible to talk about formalized PTTs; However, one should not forget that denial of any theory is also a kind of “theory”.

These main categories and groups of PTTs are considered in more detail below.

Aspectual block is composed of PTTs, which differently interpret the basic ontology. They are divided primarily into phenomenological (descriptive) and causal (explanatory) theories: in the former, the structure of diversity is determined without specifying the causes that generate it, in the latter its causal justification is presumed. This justification can be, for example, creationist, structuralist or evolutionary; structuralist PTTs are numerological, typological, phenetic; evolutionary PTTs are divided according to the level of consideration of the evolutionary process (micro- or macro-), by inclusion (evolutionary taxonomy) or exceptions (cladistics) of the adaptive interpretation from the basic evolutionary model, and so on.

The basic ontologies on which such PTTs are based (evolutionary, organismic, etc.) are probably not parts of them. Rather, they should be viewed as “shell” informal metatheories borrowed from other knowledge areas, which are biological, in general natural sciences, or worldviews. They are introduced into the cognitive situation at the level of GTT and further detailed.

On the basis of a certain ontological model, in one way or another, the most significant aspects of diversity are fixed (with reference to the axiom of aspect) that are manifested in specific relations between organisms — similarity, kinship, etc. These aspects are fragmented by the introduction of corresponding specifying axioms: for example, similarity can be defined as phenetic, typological, biomorphological, etc.; kinship can be defined as a general “evolutionary”, cladistic, etc. In the evolutionary-interpreted systematics, the axiom of similarity-kinship correspondence is of key importance at the level of ontology; it allows to judge about kinship relations by similarity relations at the level of epistemology.

According to the refined aspects introduced in this way, the inference rules that form the epistemic component of the corresponding TPTs are formulated; they are developed on the basis of the general principle of onto-epistemic conformity. These include, first and foremost, clarification of the principle of adequacy: it indicates: a) to which aspect of diversity should be adequate the taxonomic system developed by this PTT and b) what are the most reliable ways to ensure the required adequacy. According to the point (a), the principle of taxonomic unity is refined to (by tautology with refined interpretations of relations) phenetic, typological, phylogenetic, etc. unity. According to the point (b), methodological principles (mathematical, experimental, etc.) and methods of taxonomic studies (see 6.5.4) are elaborated. An important part of the PTT’s methodologies is the refinement of the general principle of the inequalities (weighting) of characters and similarities in accordance with specific definitions of taxonomic unity: examples are the concepts of equivalent or differential weighting of characters, general or special similarities, etc.

The **methodological** block is composed of PTTs, the main task of which is the development and/or justification of the classification methods outside the context defined by the onto-epistemic correspondence. This includes classiology (and “logical” taxonomy in general), numerical systematics (see 10.7.1, 10.3).

Object (elemental) PTTs study individual units recognized in the general structure of the diversity of organisms. They provide a meaningful interpretation of the general concepts of the taxon (monophyletic groups, species, etc.), (arche)type, meron, taxonomic rank, etc. (see 9.3, 9.4).

Relational PTTs investigate and interpret intra- and intergroup relations that structure taxonomic reality. Their competence includes the study of similarity, kinship, homology, etc. (see 9.5, 9.6).

The PTTs comprising aspectual and methodological blocks are the most notable in taxonomy, it is they that are sometimes ascribed the above-mentioned status of “systematic philosophies”. They form separate research programs and schools (in the general sense) of the same name — phenetic, typological, evolutionary-interpreted, biomorphological, etc. (see Chapter 10). Each of them can be represented as some local conceptual space fragmented according to the details of the corresponding specific quasi-axiomatics: for example, population, phylogenetic, and cladistic schools are quite naturally distinguished in the evolutionary-interpreted systematics; stationary, dynamic, epigenetic schools are individuated in typology; numerical phenetics and phyletic are specific schools in the numeric systematics.

The PTTs belonging to the above main categories can be considered primary; it makes sense to designate secondary ones, namely a) level theories considering taxonomic reality at micro- or macro-levels of the biodiversity structure; b) fragment theories adapting positions of specific PTTs to biological specificity of the particular groups of organisms (for example, the species concept for higher eukaryotes and prokaryotes).

Chapter 10. Principal research programs in systematics

Any scientific discipline differentiates as it develops: this is the obvious consequence (and evidence) of its normal functioning as a conceptual nonequilibrium system. This differentiation is caused by the impossibility of "embracing the immensity" and of reducing knowledge about some complexly organized phenomenon to its sole knowledge model. Hence the emergence and coexistence of different research programs and paradigms offering different ways of posing cognitive problems and solving within their framework research problems addressed to the same phenomenon. These programs and paradigms are somehow embodied in research practice by scientific schools.

Analysis of structuring (splitting and so on) of common conceptual space in which cognitive situation of biological systematics is being shaped and develops, should be started with designation of the key ideas that unite and guide all this discipline. A general (global) integrating factor for it can be thought about as an idea of the natural system, which can be understood in different ways but remains the focus of attention of all (or the overwhelming majority) of taxonomists. It is complemented by two other fairly general ideas that give some interpretation to the natural system and the ways of its cognition, these are rational and empirical ideas. The first is connected with the theoretical interpretation of what is the natural system and what are the ways of its cognition: it prompts the development of theoretical (onto-epistemic) and methodological bases of systematics. The second is related to the development of practical classifications: in this case no theory is implied, but usually there is an understanding that any sufficiently meaningful classification has something to do with what is "in Nature", that is, ontologically loaded to some extent; however, in the extreme case this load can be rejected (Stekolnikov, 2003, 2007).

A more specific structuring and regulating factor is the formation of *research programs*, each of which is related to the development of certain scientific problem and the conceptual carcas that shapes it (Lakatos, 2003; Styopin, 2003; Rozov, 2008). The two above mentioned ideas, rational and empirical, are put sometimes in correspondence with the *theoretical* (methodical) and *practical* (collection) programs (Long, 1996; Zuev, 2002, 2009, 2015). However, this is hardly correct: they are not associated with certain clearly defined solvable scientific problem, nor with its conceptual design — these are just the general "ideas". This should obviously be a more "narrow" and concrete understanding of what research programs in biological systematics are.

A partricular scientific problem, which constitutes the "ideological core" of each such program, arises in systematics not by itself; actually, it is generated by a particular problem of a more general order formulated within the scientific-philosophical context of the natural science. Such general problem, introduced from the outside, can again be considered as a more or less concrete "idea" that somehow realizes a general rational "superidea": it is a concretization of the latter, thanks to which it acquires constructive status of the scientific problem. Since such "superidea" is quite extensive, its concretizations can be different. In this capacity, phenetic idea appears that rationalizes and thereby makes empirical "superidea" scientifically meaningful (see 10.2). Comparable with it by its importance is rational "numerical" idea, which goes back to a natural philosophical idea that "the Book of Nature is written in the language of mathematics" (see 3.2.2). Typological idea is generated by a combination of organismic and "scala" natural philosophies, suggesting that Nature is a kind of integrity of interrelated parts (see 4.2.4). The natural philosophy of transformism introduces an evolutionary idea into systematics (see 4.2.6).

The stability of any particular research program is ensured by the invariability of the scientific problem that forms its stable "core", whereas the conceptual carcass that is built on this problem can vary according to changes in the general scientific-philosophical context of systematics. The specific forms, in which the conceptual framework is embodied as the problem develops, can be designated as paradigms, the transition from one paradigm to another is a scientific revolution (Kun, 1977). A good example is the development of phylogenetic systematics: its key problem is the development of a natural system as the one adequately reflecting phylogenetic pattern, all its onto-epistemology is aimed at solving this problem, with understanding of the latter varying from classical (Haeckelian) phylogenetics to Hennigian cladistics, and from the latter to the "new phylogenetics" (Nelson, 1971; Hull, 1988; Queiroz, 1988; Funk, Brooks, 1990; Queiroz, Gauthier, 1992; Pavlinov, 2004a, 2005a, b, 2009b; Mishler, 2009; Schmitt, 2014; Lyubarsky, 2018).

Of course, as emphasized above (see 2.1), the significance of specific research programs and paradigms formed in the course of their implementation can be evaluated in different ways. For example, revolutionary character is attributed to the formation of numerical systematics (Sokal, Sneath, 1963, Sneath, Sokal, 1973, Vernon, 2001, Sterner, 2014) or population (bio)systematics (Mayr 1942).

In a recent article (Podani, Morrison, 2017), one can find a kind of classification of taxonomic concepts in a "personified" form (that is, labeled by the names of their ideologists).

10.1. Review of principal programs

In biological systematics, differentiation of research programs, if the latter is not treated especially rigidly, is noted from the earliest stages of its conceptual history. The first was the division into "fructists" and "corollists"; differently interpreted was the meaning of essential status of characteristics, either for the object itself (the organism) or for the subject (the systematizer) (see 4.1.2). By the end of the 18th century, there was a sharp split between "Linneists" and supporters of other interpretations of the meaning of the natural system and the ways of its disclosure (the natural method). At first it was marked by confrontation between the proponents of "System" and "Scala" natural philosophies; then the ideas of "natural systematics" (in its narrow sense), early typology, numerology, organismism, early transformism began to form: this marked the beginning of the post-scholastic phase of the conceptual history of systematics (see 4.2.1). In the second half of the 19th century, evolutionary-interpreted taxonomy proposed its interpretation of the natural system, claimed in two versions — as classification Darwinism and systematic phylogeny (see 4.2.6). At that time, one of the notable manifestations of the confrontation between supporters of different taxonomic theories was the division of taxonomists concentrated on the species into "splitters" and "lampers".

With the beginning of the 20th century, the systematics entered the modern phase of its conceptual history indicated by attempts of a more serious scientific-philosophical justification of the same idea of the natural system, which gave rise to a noticeable wave of conceptual splitting (see Chapter 5). In part, the new design received the previous concepts (typology, classical phylogenetics), its position denoted nomological (onto-rational) taxonomy; the most loud were declarations of population (bio)systematics, classification phenetics and "numeristics", each declared itself as a "new taxonomy", called (each in its own way) to discard all previous ideas as "remnants of the past". Promoted by technological progress, classification concepts began to appear focusing on special character systems: chemosystematics, serology, karyosystematics. In the second half of the 20th century, the confrontation between the evolutionary taxonomy and cladistics was identified; closer to its end, it was replaced by a confrontation between the Hennigian cladistics and the "new phylogenetics", the latter claiming absolute leadership in the study of taxonomic diversity and treating systematics as a whole, but actively using its descriptive language. On this general background, there was a differentiation of object taxonomic theories: the concepts of species and homology, which were fundamental for the whole biology, began fragmented. The same is true for relational theories, the fragmentation of which began earlier: these are concepts based on different interpretations of taxonomic unity, namely natural-philosophical affinity, similarity as such, genealogical relationship, evolutionary unity.

* * *

Development of general ideas about the structure of the cognitive situation in which biological systematics operates, including the formation and structuring of its conceptual carcass, is one of the key tasks of the general taxonomic theory (GTT, see 8.2). Accordingly, part of this task is the identification of specific research programs as the main forms of implementing the basic rational "superidea".

At present, there is no definite understanding of the general grounds for recognition of these programs and, accordingly, what the programs themselves are, how they relate to each other, etc., for the simple reason that there is no GTT sufficiently detailed and elaborated as quasi-axiomatics. Therefore, it hardly makes sense here to dwell in any detail on this not very simple question; it is sufficient, based on the above, to indicate the main research programs (they are also partly concrete "ideas") in the systematics as they are understood here:

— **phenetic program**: the main content is the reductional (deontologized) representation of the structure of taxonomic reality, stimulated by positivist philosophy, as a "sum" of similarities/differences between organisms detected by the whole pool of available attributes;

— **epistemological rational program**: the main content is determined by the accent on the classification method as such, therefore the biological content of the scientific problem is secondary to the technological problem and is "adjusted" to it; this program begins with the scholastic systematics and is most fully realized by the classiology and numerical systematics;

— **numerical program**: actually represents a version of the previous, but can be considered a separate program due to the specificity of its toolkit; two subprograms are distinguished in it, namely phenetic and phyletic, they defined at the level of the basic ontology by the phenetic and phylogenetic concepts, respectively;

— **ontological rational program**: the main content is an ontological substantiation of the subject and tasks of systematics by reference to certain fundamental laws of Nature, structuring it and ordering the variety of its manifestations; this includes the “Scala”, the organismic and numerological concepts, the rational concept of Drish-Lyubishchev, the systematics of “natural kinds;

— **typological program**: the main content is an ontological justification of the subject and tasks of systematics by reference to (arche)type as the organizing principle of the diversity of organisms; can be considered as a variant of the previous program; this program is strongly structured, with stationary, dynamic and empirical versions of the typology being distinguished; a somewhat isolated position is occupied by the evolutionary-typological and epigenetic concepts, the latter at present is represented by ontogenetic systematics;

— **biomorphological program**: the main content is an ontological substantiation of the subject and tasks of systematics as a reflection of the bio(eco)morphological aspect of the diversity of organisms; it is close to typological by its meaning;

— **program of “natural systematics”**: the main content is the focus on the reconstruction of the natural system as a kind of “natural law” of the orderliness of Nature, that system is identified by a combination of significant characters; ininially is a combination of typological and phenetic programs, in the 20th century with a significant admixture of evolutionary interpretations;

— **biosystematical (population) program**: the main content is the identification of the structure of taxonomic diversity at the intraspecific level, taking into account the evolutionary mechanisms that generate it (classification Darwinism) by means of different methodologies and characters; these latter distinguish in it different subprograms, namely chemo-and cytosystematics, experimental systematics, etc .; modern integrative systematics probably belongs here;

— **phylogenetic program**: the main content is an ontically defined understanding of the structure of taxonomic diversity as a result of phylogenetic processes; the main task is to reflect the phylogenetic pattern generated by these processes; classical phylogenetics (Haeckel), more reductional cladistics, the most ontologically loaded evolutionary taxonomy (Simpson) are distinguished.

Obviously, the list given here is neither final nor exhaustive. A more detailed presentation of the structure of research programs is possible by increasing rank of some subprograms, to which they are split according to how the key problem is treated in each of them. So, the research program of ontogenetic taxonomy (here it is listed as a typology) can be considered at the same level with those listed above, if it will be able develop a sufficiently developed PTT related to the general concept of “evo-devo”.

The issue of recognition of not only the research programs themselves, but also those specific paradigms that are formed within their frameworks (for the differences, see the preliminary comments on Section 4) deserves a separate careful analysis. For example, the latest (cladistic) version of phylogenetic systematics (see 10.8.2) may well claim the status of a paradigm, but hardly the status of a special research program. The currently dominant (by number of publications) numerical molecular phylogenetics (see 10.3.2) does not seem to be attributed to either one of these statuses: it lacks its own biologically sound problem, but rather formed and functions as a kind of technical tool applied to a particular factology (though the adherents of this approach are unlikely to agree with this assessment).

* * *

The main way to implement a research program and a paradigm in taxonomy is the particular taxonomy theory (PTT), that is a specifically organized conceptual carcass built onto a relevant scientific problem (see 8.2). The main purpose of PTT, considered in the context of the research program, is the reduction of its core problem to a certain set of solvable scientific tasks due to its more rigorous conceptualization (definitions, etc.) and operationalization. Since it is a matter of reduction, a multiplicity of its possible ways arises at once. For example, different interpretations of the basic concept (arche)type are given within the typological program, different methods for assessing similarity are developed within the framework of the numerical program, different interpretations of phylogenesis, the relation between similarity and kinship, the relation between phylogeny and the taxonomic system are manifestations of the phylogenetic program.

As can be seen from the above list of main research programs in systematics, they all are related to the PTTs of aspectual and methodological blocks (see 8.2). Each of them defines a particular "systematics" — phenetic, numerical, "natural", etc .; they are usually called (not very critically) "systematic philosophies" (Hull, 1970). Accordingly, object, relational and other PTTs are not considered here as organizing forms of research programs and paradigms. Perhaps, in the further detailed elaboration of the GTT, they will also be considered as particular research programs; for example, a proposal to establish special scientific discipline about of general species concept (see 9.3.2) may serve as an argument in favor of such development.

SECTION IV — NOMENCLATORIAL

Cognitive activity, the basic part of which is classification activity driven by a "classification instinct", is closely associated with language activity internally stimulated by a kind of "linguistic instinct" - the desire to identify the identifiable one way or another (Pinker, 2004). Recognition of the fundamental nature of this contingency can be considered a Taoist aphorism, according to which "every thing becomes what it is, when it is called" (Sages ..., 1994). Not so aphoristically, but no less rigidly it (contingency) is manifested in an idea of linguistic cognitivists that the presence of a word in a language is an evidence that this word designates some distinctly identifiable "thing", whether it be an object, a phenomenon, a process, etc. On this basis, the general concept of the "language picture of the world" is developed (Uryson, 2003; Popova, Sternin, 2007; Subetto, 2007; Russo, 2012; see 9.1).

In systematics, classification activity includes necessarily not only the recognition of organisms and their groups in Nature, but also their designation by certain names. With this, the language of taxonomic descriptions inevitably develops together with entire systematics in order to be adequate to that conception of a taxonomic reality that constitutes the subject area of taxonomic research.

One of the important issues of the language of taxonomic descriptions, which directly concerns the naming of objects studied by the systematics, is the *nomenclature*; it has two meanings. One of them combines a set of designations of objects studied by the systematics: this is *nominating nomenclature* in the latter's narrow sense. Nomenclature in a more broad sense is a set of *regulators* (principles and rules), regulating various manipulations with notations: this is the *regulatory nomenclature*. Nomenclature in the regulatory understanding is the main subject of this Section.

A discipline examining the principles of organization and functioning of the nomenclature (in its general sense) is called *onomology*, or *nomonomy*, or *taxonimy* (Dubois, 2000, 2005; Dunaev, 2008; Pavlinov, 2013b, 2015a). Etymologically, they go back to the classical terminology: nomen (lat.) and νυμος (Greek), both meaning *name* (not to be confused with the Greek νόμος – law), and τάξις –- taxon. From a theoretical point of view, the main task of this discipline is not the analysis of and commenting on particular sets of rules, but the "explanation" of the taxonomic nomenclature considered in the general case. To do this, it is necessary to find out what are the main reasons for the dynamics and statics of the nomenclature operating at different stages of its development.

Often, the nomenclature developed by biological systematics is called *biological* by tautology; this designation probably first appeared in the last third of the 19th century (Cope, 1878). Such an extended interpretation of the nomenclature is partly justified by the fact that the classification of living organisms developed by the systematics, in which those organisms appear under specific names, is relevant for the whole of biology. But, on the other hand, taxonomy studies only one of many aspects of biological diversity; other classifying biological disciplines study its other aspects, the development of which and the designation of their elements (biogeographical excretions, syntaxa, taxocenes, etc.) also has broad biological significance. Accordingly, the nomenclatural sections of these disciplines are exactly the same "biological" as in the taxonomy.

On this basis, the nomenclature in the systematics is generally better designate as *taxonomic*; the term "biological" can be assigned to the nomenclatorial system developed recently in the form of "Biocode" (Pavlinov, 2014, 2015a, b). For the subject sections of the taxonomic nomenclature, one could preserve their traditional designations, namely zoological, botanical, bacteriological, virological. Specific designations are also used for some other versions of the nomenclature (numericlature, phylonomenclature).

The taxonomic nomenclature (in both of its above indicated meanings) has been given great attention since the very beginning of the development of biological sistematics as a scientific discipline. This is particularly noticeable in the works having finalized the development of scholastic systematics (see 4.1.3): J. Pitton de Tournefort wrote that "knowledge of plants is equivalent to knowing their names [therefore] the study of plants should begin with their names" (Pitton ..., 1694, p. 1); Linnaeus singled out in the systematics two equally important "grounds", namely classification ("disposition") and naming (Linnaeus, 1737, 1751).

The great importance attached to the taxonomic nomenclature is reflected in many modern guidelines on biological systematics. In addition to setting out the principles of taxonomic research, a significant place is given to the consideration of nomenclatural codes (Blackwelder, 1967, Mayr et al., 1956, Mayr, 1971; Shipunov, 1999; Glushchenko et al., 2004; Korobkov 1971; Barskov et al., 2004). In addition, several books dedicated specifically to the nomenclature have been published (Jeffrey, 1980; Alekseev et al., 1989; Turland, 2013; Pavlinov, 2015a). Recently, the importance of the nomenclature as a regulator of taxonomic names is increasing due to the involvement of systematics in the overall pool of information resources related to the study of biological diversity (Pullan et al., 2000; Garrity, Lyons, 2003; Kennedy et al., 2005; Page, 2006; Minelli et al., 2008; Patterson et al., 2008, 2010; Pyle, Michel, 2008; Schindel, Miller, 2010).

This present Section briefly provides the historical and theoretical issues on taxonimy (onimology). Chapter 11 outlines the conceptual history of the taxonomic nomenclature. Chapter 12 is devoted to the theory of nomenclature proper: a brief overview of its basic concepts and principles is given.