Protistology 6 (1), 3–13 (2009)

Protistology

Systema Naturae or the outline of living world classification

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Summary

Here we present the short outline of the classification of living things (to the level of classes), given with two main goals: to provide a compact, synthetic overview of the biological diversity; and to supply users with up-todate information of latest taxonomic achievements. The latter is especially important in the recent epoch of "molecular revolution" in the taxonomy.

Key words: living organisms classification, kingdoms, phyla, classes

The era of fundamental works with the depth and breadth of "Systema Naturae" almost ended with the last edition of this great book (Linnaeus, 1767). However, oveviews of the diversity of living things, both collective (Adl et al., 2005, Hibbett et al., 2007) and individual (Corliss, 1984, 1994; Cavalier-Smith, 1998, 2004 and many others) continued to appear regularly until the recent time. Here we present the similar work.

Features

1) Coverage. The classification cover all indisputable living things. This means that viruses, virus-like forms and prions are not included. Author believes that classification should be a "slice" of the recent diversity, therefore fossil taxa also are not listed. We restricted the level of classification with classes.

2) Currentness. The classification presented here is very changeable: when new data (any suggestions about closeness of particular groups) become available, classification is also changed. To approach changeability, we use simple versioning (RCS-based) system. The version presented here has number 5.8020, more recent versions periodically appear on the Web page http://herba.msu.ru/shipunov/os/os-en.htm, older versions are also stored there.

3) Synthesis. The classification is fully synthetic: it is compiling from numerous sources treated as multiple opinions. Any suggestion addresses any triplet of relevant taxa (which could be represented like "A,(B,C)") is taking into account with no selection between scientific sources. Weighting of the opinions is also a major component of classification construction.

4) Concepts. Kingdoms as highest taxa have a special treatment. We use a holistic approach to designate kingdoms according to the three *levels of organization*: (1) prokaryotic cells, (2) eukaryotic cells, (3) tissues/ organs (multitissued organisms sensu Corliss, 1989). On the third level, two kindoms

(*Animalia* and *Vegetabilia*) designated, because their tissue/organ systems of them are not homologous (Ivanov, 1968; Kaiser, 1985a).

5) Lumping. We are holding with large taxa: if the aggregation of taxa is feasible on the given rank level, we treat them as one taxon. This approach follows the simple Occam razor (Swinburne, 1997).

6) Traditions. The classification is traditional from many points of view: (1) it is fully hierarchical, (2) uses only habitual ranks, (3) suggestions based on the morphological material are using with same extent as "molecular", (4) retains traditional names, even in cases where underlying concepts are (slightly) different.

7) Order. Classification presented here is in a form of *hierarchical list*. The order of sub-taxa within the super-taxon group is important. For example, sub-taxa designated as "peripheral" (Ljubarskij, 1996), are usually placing at the beginning or at the end of their part of list.

8) Fuzziness. To represent multiple opinions in one classification, we are using the extended traditional marks:

sed. m. (sedis mutabilis) given if there is a possibility to move the taxon "horizontally" either within super-taxon, or between supertaxa;

stat. m. (status mutabilis) is for the possibility to move the taxon downwards ("stat. m. i."), or upwards ("stat. m. s.") in the hierarchy;

i. s. (incertae sedis) used here only for cases where both previous states are simultaneously applicable;

sed. p. (sedis possibilis) designates the possible alternative location of "sed. m." taxon;

s. str. (sensu stricto) marks "sticky" taxa where the aggregation with neighbor taxa is the alternative;

s. a. (sensu amplo) used here for "fragile" taxa which can be easily split;

s. aggr. (sensu aggregato) when both previous states are applicable;

(**z**) used in case of hemiohomonyms (Kluge, 2000) for ICZN names;

MY (dagger) for "traditional" names introduced here (see below);

"quotes" are for environmental groups which have only DNA sequencebased descriptions; here we list the most prominent of them, but usually not as separate items of the classification list;

***** (asterisk) used for paraphyletic taxa; in general, our intention is to eliminate paraphyly, but some high taxa here are paraphyletic;

/ (slash) used for marginal notes designating domains (see below).

9) Nomenclature. Double nomenclature is used here:

Traditional names which are largely circumscription- and/or volumebased names (Kluge, 2000). We removed the authorship from all names because most of names for higher taxa have been used in various senses (it is especially frequent in protists), therefore, designation an authorship will make situation even less clear. In that regard, we are generally agree with recent proposal of Dubois (2007) abut non-citing authors. In some cases, new names have been created, mostly with changed endings to avoid inter-rank homonymy. These names are marked with dagger (†).

Typified names as simple genus-like uninomials without endings but with rank designated by left-hand superscript (i.e., "Phylum Arthropoda" becomes "Araneus".). The designator is a number with optional decimal part, ranged from 0 (individual) to 7 (kingdom). All intermediate ranks received the unique fraction part: –0.2 (0.8) for sub-, 0.5 for infra-, and 0.2 for super-groups. We hope that from this attempt the list of typified names will finally emerge and become an essential part of higher taxa nomenclature. Types have been chosen types mostly in the accordance with the original descriptions, but for the few taxa we introduced new types. In particular, we chose several type names which sounds similar to the traditional name of taxon (Tatarinov and Shimanskij, 1984).

Kingdoms

If we accept that the highest divisions of organic world should be as broad as possible, we may end up with two different conceptions. We call them "kingdoms" and "domains" (Blackwell, 2004). The first concept is the logical derivate of symbiogenetic theory (Merezhkovsky, 1909) and based on the idea of levels of organization. These levels correspond with four kingdoms: *Monera* (or *Prokaryota*), *Protista, Vegetabilia* (or *Plantae*) and *Animalia* (or *Metazoa*). The third, multi-tissued level is the least stable: it corresponds with two kingdoms and several groups of protists which also reached this level of organization, notably lichenized fungi and higher brown algae like *Fucales* and *Laminariales* (Smith, 1939; Kaiser, 1985b; Buedel and Scheidegger, 2008). These latter groups are usually not considered as kingdoms because of lesser gap between them and their non-multitissued relatives. The other problem of "kingdoms" concept is the absence of positive description for protists. It is possible, however, to

define protists as "eukaryotic organisms with cells forming a homogeneous assemblages or developing independently after the division", but it will not improve our understanding of protists as a paraphyletic group. *Monera* also have problems with paraphyly and non-negative description, which may be at least partly solved (Martin and Koonin, 2006).

The reductionist "domains" conception takes into account mostly molecular characters and better coincides with cladistic way of thought. *Bacteria*, *Archaea* and *Eukarya* are usually considered as "primary" domains, *Panplantae* (aka "bikonts") and *Pananimalia* ("unikonts") may also belong here. In many publications, they are monophyletic, and primary domains appear in every analysis of the environmental DNA. However, recent genomic findings such as "tree of 1%" (Dagan and Martin, 2006) became less supportive for domains; genome-wide data of prokaryotes is also in favor to the *Monera*, then to domains (Koonin and Wolf, 2008). There are also some concerns about strict monophyly of Archaea (Cox et al., 2008; Yutin et al., 2009) and even Bacteria (Lake et al., 2008). In addition, this conception simply ignores morphological diversity of higher groups whereas it is well known that different taxonomic characters may play different roles in the classification of distant taxa (Ljubarskij, 1996).

It is not an easy task to interbreed these conceptions together (see Table 1). We are accepting here more traditional "kingdoms" conception as having more explanatory power, and also as a better interscience communication tool. However, we designate domains as marginal notes in the outline, and also as "girts" in the classification scheme (Fig. 1). There are the list of accepted kingdoms:

Monera This kingdom corresponds with two domains: Bacteria and Archaea, which are treated here as subkingdoms (Fig. 1). The classification based mostly on the results of sequence comparisons and wholegenome analyses. During the widespread HGT events (Koonin and Wolf, 2008), the stability of higher taxa is lower than for other kingdoms.

Protista This is a good example of paraphyletic but integral (according to the level of organization) taxon. Since the idea (Stechmann and Cavalier-Smith, 2002) about two major eukaryotic branches (here we use names *Pananimalia* and *Panplantae* reflecting the their cross-kingdom nature) is obtaining more support (Hampl et al., 2009), we marked them as domains. Infrakingdom Apusobionta may finally appear as non-natural because the support for the position and unity of this group is quite moderate (Cavalier-Smith et al., 2008). Fungi in our classification belong to protists since they generally lack organ/tissue systems.

Table 1. Two concepts of highest taxonomic categories.

Monera		Vegetabilia	Protista	Animalia
Bacteria	Archaea	Panplantae		Pananimalia

Vegetabilia Only three phyla reflecting the major features of the life cycle (with gametophyte dominance; with sporophyte dominance and free gametophyte; and with a seed) are accepted here. On the Fig. 1, the "girt" shows that with the domain approach this kingdom should be treated as a part of *Panplantae*.

Animalia Historically, animal phyla reflect the traditional idea of "bauplan". However, since sponges, coelenterates, placozoans and acoels are now the "hot spots" of animal classification, groups here should be considered as generally unstable. The position of the latter group in Deuterostomia is based on the recent publications (Deutsch, 2008 and others). The volume of phylum Platyzoa is also discussable. With the domain approach, the kingdom will become a part of *Pananimalia* ("unikonts").

The outline

Regnum Monera [[7]*Bacillus*] */Bacteria*
Subregnum *Bacteria* [[6.8]*Bacillus*]*[1]
Superphylum *Terrabacteria* [[6.2]*Bacillus*] s.a.
Phylum 1. THERMOBACTERIA† [[6]*Deinococcus*] s.a.
Classis 1(1). *Aquificae* [[5]*Aquifex*] sed.m.[2]
2(2). *Thermotogae* [[5]*Thermotoga*] sed.m.
3(3). *Deinococci* [[5]*Deinococcus*][3]
Phylum 2. ACTINOBACTERES † [[6]*Actynomyces*]
Classis 1(4). *Actinobacteria* [[5]*Actinomyces*]
Phylum 3. FIRMICUTES [[6]*Bacillus*] s.a., sed.m.4
Classis 1(5). *Clostridia* [[5]*Clostridium*][5]
2(6). *Bacilli* [[5]*Bacillus*]
3(7). *Erysipelotrichi* [[5]*Erysipelothrix*]
4(8). *Mollicutes* [[5]*Mycoplasma*][6]
5(9). *Dictyoglomia* [[5]*Dictyoglomus*] sed.m.
6(10). *Fusobacteria* [[5]*Fusobacterium*] sed.m.
Phylum 4. OBSCUROBACTERES† [7]

[1]Incl. "Nanobacteria" i.s. et dubitativa

[2]Incl. Desulfurobacteriaceae, Thermodesulfobacteriaceae, Hydrogenothermaceae.

[3]Incl. Thermales.

[4]Incl. "OP9" and probably other environmental groups.

[5]Incl. Symbiobacteria, Thermolithobacteria stat.m., *Sulfobacillus* i.s., *Thermaerobacter* i.s.

[6]Incl. Lumbricincola.

[7]"TM7"–"OP11" group, one of the largest and best delineated environmental groups. Probably includes "TM7", "OD1", "OP11", "WS6", "WWE3" and some other lineages.

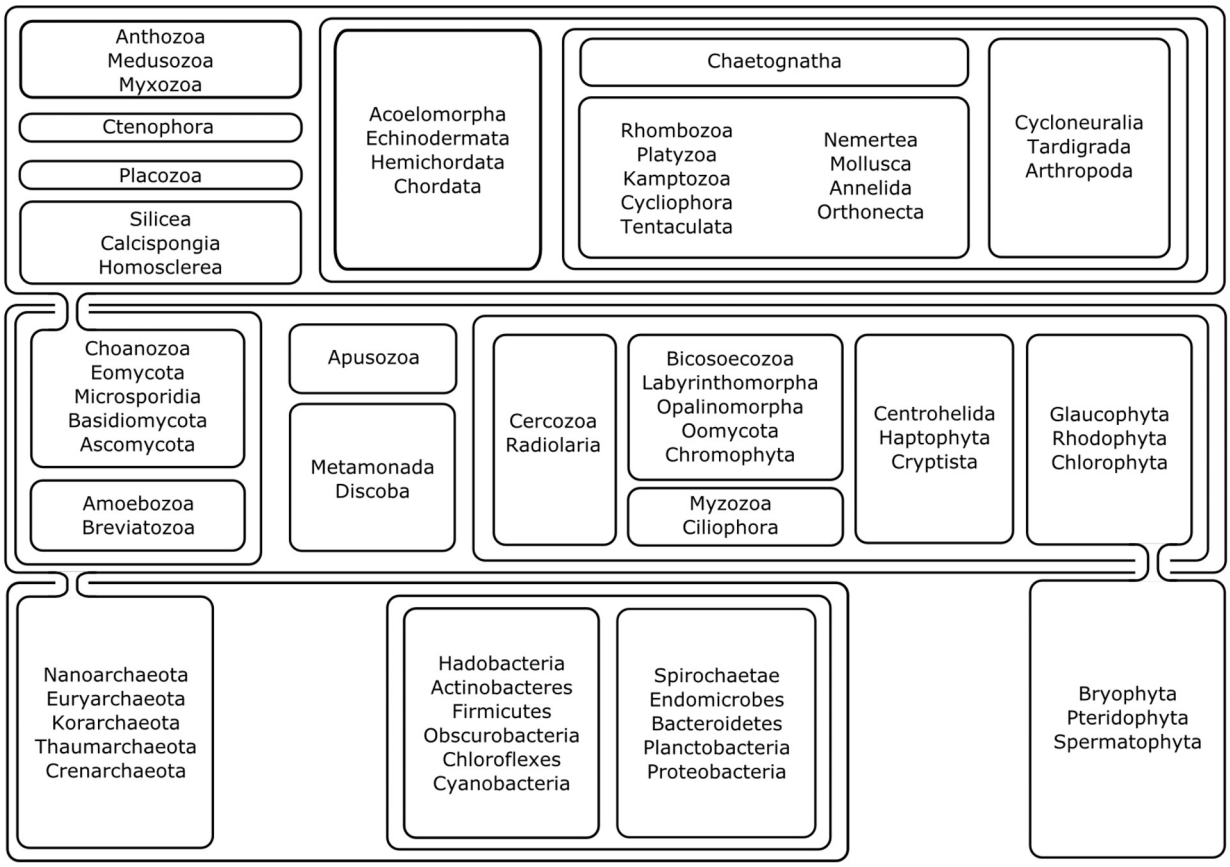

Fig. 1. The schematic view of the classification. This scheme is a variant of nested treemap, a compact alternative to the tree-like presentations (Johnson and Shneiderman, 1991). The most outer squares designate kingdoms, text strings represent phyla, all other squares represent taxa of the intermediate ranks. To make the scheme even more compact, all names of taxa higher than phyla, and squares for the phyla are omitted. "Channels" between squares designate cases of accepted paraphyly on the level of kingdoms.

Phylum 5. CHLOROFLEXES [6*Chloroflexus*][8]
Classis 1(11). *Thermomicrobia* [5*Thermomicrobium*]
2(12). *Chloroflexi* [5*Chloroflexus*]
3(13). *Dehalococcoidetes* [5*Dehalococcoides*]
4(14). *Anaerolineae* [5*Anaerolinea*][9]
5(15). *Ktedonobacteria* [5*Ktedonobacter*]
Phylum 6. CYANOBACTERIA [6*Nostoc*] sed.m.
Classis 1(16). *Gloeobacteria* [5*Gloeobacter*]
2(17). *Oscillatorineae** [5*Oscillatoria*][10]
3(18). *Nostocineae* [5*Nostoc*]
Superphylum *Gracilicutes* [6.2*Rhodospirillum*] s.a.
Phylum 7. SPIROCHAETAE [6*Spirochaeta*] sed.m.
Classis 1(19). *Spirochaetes* [5Spirochaeta] s.a.[11]
Phylum 8. ENDOMICROBES† [6*Endomicrobium*] sed.m.
Classis 1(20). *Endomicrobia* [5*Endomicrobium*][12]
Phylum 9. BACTEROIDETES [6*Bacteroides*] s.a.[13]
Classis 1(21). *Gemmatimonadetes* [5*Gemmatimonas*] sed.m.
2(22). *Fibrobacteria* [5*Fibrobacter*]
3(23). *Chlorobia* [5Chlorobium]
4(24). *Bacteroidia* [5*Bacteroides*][14]
5(25). *Salinibacteriay* [5*Salinibacter*] stat.m.s.
Phylum 10. PLANCTOBACTERIA [6*Planctomyces*][15]
Classis 1(26). *Planctomycea* [5Planctomyces]
2(27). "*Poribacteria*" [5"*Poribacter*"]

[8]Incl. Thermobaculum i.s.
[9]Incl. Caldilineae.
[10]Incl. Synechococcineae stat.m., 'Prochlorophyceae', Acaryochloris.
[11]Incl. Leptospira.
[12]= "TG1".
[13]Incl. "TG3".
[14]Incl. Flavobacteria, Sphingobacteria, Cytophagia.
[15]= "PVC", incl. "OP3".

3(28). *Chlamydiae* [5*Chlamydia*]
4(29). *Lentisphaeria* [5*Lentisphaera*]
5(30). *Verrucomicrobiae* [5*Verrucomicrobium*][16]
Phylum 11. PROTEOBACTERIA [6*Rhodospirillum*] s.a.
Classis 1(31). *Caldiseria*† [5*Caldisericum*] i.s.[17]
2(32). *Aminanaerobia* [5*Deferribacter*] i.s. et s.a.[18]
3(33). *Acidobacteria* [5*Acidobacterium*] sed.m.[19]
4(34). *Desulfobacteria* [5*Desulfobacter*] s.a.[20]
5(35). *Rhodobacteria* [5*Rhodobacter*][21]
Subregnum *Archaebacteria* [6.8*Methanobacterum*]* */Archaea*
Phylum 12. NANOARCHAEOTA [6*Nanoarchaeum*] stat.m.
Classis 1(36). *Nanoarchea* [5*Nanoarchaeum*]
Phylum 13. EURYARCHAEOTA [6*Methanobacterium*]
Classis 1(37). *Thermococci* [5*Thermococcus*]
2(38). *Methanobacteria* [5*Methanobacterium*] s.a.[22]
3(39). *Thermoplasmata* [5*Thermoplasma*]
4(40). *Archaeoglobi* [5*Archaeoglobus*]
5(41). *Halomebacteria* [5Halobacterium][23]
Phylum 14. KORARCHAEOTA [6*Korarchaeum*] stat.m.
Classis 1(42). *Korarchaea* [5*Korarchaeum*]
Phylum 15. THAUMARCHEOTA [6*Cenarchaeum*] stat.m.
Classis 1(43). *Cenarchaea* [5*Cenarchaeum*]
Phylum 16. CRENARCHAEOTA [6*Sulfolobus*]
Classis 1(44). *Thermoprotei* [5*Thermoproteus*]
2(45). *Sulfolobea* [5*Sulfolobus*][24]

Regnum Protista [7*Euglena*]*

Infraregnum Panmycota† [6.5*Agaricus*]* */Pananimalia*
Superphylum *Myconta*† [6.2*Agaricus*]* s.a.
Phylum 17. CHOANOZOA [6*Codosiga*] s.a.
Classis 1(46). *Filasterea* [5*Capsaspora*][25]
2(47). *Choanomonadea* [5*Codosiga*]
3(48). *Ichthyosporea* [5Ichthyophonus][26]
4(49). *Cristidiscoidia* [5*Nucleraria*][27]
Phylum 18. EOMYCOTAY [6Mucor]* s.a.
Classis 1(50). *Chytridiomycetes* [5*Chytridiopsis*][28]
2(51). *Blastocladiomycetes* [5*Blastocladium*]
3(52). *Rozellomycetes* [5*Rozella*][29]
4(53). *Kickxellomycetes* [5*Kickxella*][30]
5(54). *Mucoromycetes* [5*Mucor*]*[31]
6(55). *Glomeromycetes* [5*Glomus*]
Phylum 19. MICROSPORIDIA [6*Microsporidium*]
Classis 1(56). *Microsporea* [5*Microsporidium*][32]
Phylum 20. BASIDIOMYCOTA [6*Agaricus*]
Subphylum *Ustilagomycotina* [5.8*Ustilago*]
Classis 1(57). *Exobasidiomycetes* [5*Exobasidium*]
2(58). *Ustilaginomycetes* [5*Ustilago*]
Subphylum *Pucciniomycotina* [5.8*Uredo*]
Classis 3(59). *Pucciniomycetes* [5*Uredo*]
4(60). *Atractiellomycetes* [5*Atractiella*]
5(61). *Cystobasidiomycetes* [5*Cystobasidium*]
6(62). *Agaricostilbomycetes* [5*Agaricostilbum*]
7(63). *Microbotryomycetes* [5*Microbotryum*][33]
8(64). *Mixiomycetes* [5*Mixia*]
Subphylum *Agaricomycotina* [5.8*Agaricus*]
Classis 9(65). *Wallemiomycetes* [5*Wallemia*] sed.m.[34]
10(66). *Bartheletiomycetesy* [5*Bartheletia*]
11(67). *Tremellomycetes* [5*Tremella*]
12(68). *Dacrymycetes* [5*Dacrymyces*]
13(69). *Agaricomycetes* [5*Agaricus*]
Phylum 21. ASCOMYCOTA [6*Ascomyces*][35]
Subphylum *Taphrinomycotina* [5.8*Ascomyces*]*[36]
Classis 1(70). *Taphrinomycetes* [5*Ascomyces*][37]
2(71). *Schizosaccharomycetes* [5*Schizosaccaromyces*][38]
3(72). *Saccharomycetes* [5*Saccaromyces*]
4(73). *Neolectomycetes* [5*Neolecta*]
Subphylum *Pezizomycotina* [5.8*Tuber*]

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[16]Incl. Opitutae, Spartobacteria.
[17]="OP5", the formal name is not yet published.
[18]Incl. Synergistetes, Chrysiogenetes i.s., Nitrospira i.s., *Calditrix* i.s.
[19]Incl. Halophagae, Solibacteres.
[20]Incl. Deltaproteobacteria, Epsilonproteobacteria.
[21]Incl. Alphaproteobacteria, Betaproteobacteria, Gammaproteobacteria.
[22]Incl. Methanobacteriales, Methanococcales stat.m., Methanopyrales i.s.
[23]Incl. Methanomicrobiales, Methanosrcinales, Halobacteriales.
[24]Incl. Desulfurococcales, Caldisphaerales.
[25]Incl. *Ministeria*.
[26]Incl. *Amoebidium*, Eccrinales, Aphelidea sed.m., *Corallochytrium*.
[27]Incl. Nucleariidae, Pompholyxophryidae sed.m.
[28]Incl. Neocallimastigales, *Thalassochytrium* sed.m.
[29]Incl. *Olpidium* et *Caulochytrium* sed.m.
[30]Incl. Basidiobolaceae, Harpellales, Asellariales, Zoopagales, Entomophthorales, *Nephridiophaga*.
[31]Incl. Endogonales, Mortierellales.
[32]Incl. Metchnikovellidea sed.m., *Mikrocytos mackini* sed.m.
[33]Incl. Cryptomycocolacales, Classiculales.
[34]Incl. *Entorrhiza* stat.m.i.
[35]Incl. *Spirogyromyces* i.s.
[36]Incl. "SCGI" group.
[37]Incl. *Saitoella*.
[38]Incl. Pneumocystis.

Classis 5(74). *Orbiliomycetes* [[5]*Orbilia*]
6(75). *Pezizomycetes* [[5]*Tuber*]
7(76). *Dothideomycetes* [[5]*Dothidea*][39]
8(77). *Eurotiomycetes* [[5]*Penicillium*]
9(78). *Lecanoromycetes* [[5]*Lecanora*][40]
10(79). *Laboulbeniomycetes* [[5]*Laboulbenia*]
11(80). *Leotiomycetes* [[5]*Leotia*]
12(81). *Sordariomycetes* [[5]*Sordaria*]
Superphylum *Sarcobionta*† [[6.2]*Amoeba*]
Phylum 22. Amoebozoa [[6]*Amoeba*][41]
Subphylum *Lobosea* [[5.8]*Amoeba*][42]
Classis 1(82). *Tubulinea* [[5]*Amoeba*]
2(83). *Flabellinea* [[5]*Vannella*]
3(84). *Acanthopodida* [[5]*Acanthamoeba*][43]
4(85). *Thecamoebida* i.s.[[5]*Thecamoeba*]
5(86). *Mayorellida*† [[5]*Mayorella*] i.s.[44]
Subphylum *Conosea* [[5.8]*Physarum*]
Classis 6(87). *Variosea* [[5]*Filamoeba*] sed.m.[45]
7(88). *Mastigamoebidae* [[5]*Mastigamoeba*][46]
8(89). *Mycetozoa* [[5]*Physarum*][47]
Phylum 23. Breviatozoa† [[6]*Breviata*] i.s.
Classis 1(90). *Breviatea* [[5]*Breviata*]
Infraregnum Apusobionta† [[6.5]*Apusomonas*] i.s. / *Panplantae*
Phylum 24. Apusozoa [[6]*Apusomonas*]
Classis 1(91). *Apusomonadea* [[5]*Apusomonas*][48]
2(92). *Planomonadea* [[5]*Planomonas*] sed.m.[49]
Infraregnum Excavata [[6.5]*Euglena*]
Phylum 25. Metamonada [[6]*Trichomonas*] s.a.
Classis 1(93). *Preaxostyla* [[5]*Oxymonas*][50]
2(94). *Parabasalea* [[5]*Trichomonas*][51]
3(95). *Fornicata* [[5]*Hexamita*][52]
Phylum 26. Discoba [[6]*Euglena*] s.a.
Subphylum J*akobozoa*y [[5.8]*Jacoba*]
Classis 1(96). *Anisomonadea* [[5]*Collodictyon*] i.s.[53]
2(97). *Malawimonadea* [[5]*Malawimonas*] sed.m.
3(98). *Jakobea* [[5]*Jakoba*][54]
4(99). *Heterolobosea* [[5]*Naegleria*][55]
5(100). *Hemimastigea* [[5]*Spironematella*] i.s.[56]
Subphylum *Euglenozoa* [[5.8]*Euglena*]
Classis 6(101). *Euglenophyceae* [[5]*Euglena*]* s.a.[57]
7(102). *Kinetoplastea* [[5]*Bodo*]
Infraregnum Chlorobionta [[6.5]*Volvox*]*
Superphylum *Rhizaria* [[6.2]*Cercomonas*]
Phylum 27. Cercozoa [[6]*Cercomonas*] s.a.[58]
Subphylum *Monadofilosea* [[5.8]*Cercomonas*]
Classis 1(103). *Chlorarachniophyceae* [[5]*Chlorarachnion*]
2(104). *Metromonadea* [[5]*Metromonas*] stat.m.
3(105). *Granofilosea* [[5]*Heliomorpha*][59]
4(106). *Sarcomonadea* [[5]*Cercomonas*]* s.a[60]
5(107). *Thecofilosea* [[5]*Coelodendrum*] s.a.[61]
Subphylum *Endomyxa* [[5.8]*Gromia*]
Classis 6(108). *Foraminifera* [[5]*Rotalia*][62]
7(109). *Gromiidea* [[5]*Gromia*]
8(110). *Proteomyxidea* [[5]*Filoreta*][63]
9(111). *Plasmodiophorea* [[5]*Plasmodiophora*][64]
10(112). *Ascetosporea* [[5]*Haplosporidium*][65]
Phylum 28. Radiolaria [[6]*Acanthometra*]
Classis 1(113). *Acantharia* [[5]*Acanthometra*]

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[39]Incl. Arthoniales.

[40]Incl. Lichniales.

[41]Incl. 'X-cells' i.s.

[42]Incl. *Trichosphaerium* i.s., *Vermistella* i.s., *Cochliopodium* i.s., *Corallomyxa* i.s, *Stereomyxa* i.s.

[43]Incl. *Balamuthia*.

[44]Incl. *Dermamoeba*.

[45]Incl. [[5]*Phalansterium*], *Acramoeba, Multicilia, 'Arachnula'* sensu Tekle et al., 2008.

[46]Incl. *Pelomyxa, Entamoeba, Endolimax, Endamoeba*.

[47]Dictyostelia, Protostelia, Copromyxidae sed.m., *Ceratiomyxa* sed.m., *Semimorula*.

[48]Incl. *Amastigomonas, Apusomonas*.

[49]Incl. "*Ancyromonas*" = *Planomonas, Micronuclearia* sed.m.

[50]Incl. Oxymonadida, *Trimastix*.

[51]Incl. Trichomonadida, Hypermastigida.

[52]Incl. *Carpediemonas, Hicanonectes, Dysnectes*, Retortamonadida, Diplomonadida.

[53]Incl. *Diphylleia* (z), *Collodictyon, Sulcomonas*.

[54]Incl. *Andalucia*.

[55]Incl. *Pleurostomum, Acrasis, Guttulinopsis* sed.m., *Fonticula* sed.m., *Stephanopogon* stat.m.i.

[56]Sed.p. juxta Thecofilosea; incl. *Hemimastix, Stereonema, Paramastix* sed.m.

[57]Incl. Diplonemea (= Diplosonematea) stat.m., Symbiontida stat.m. (*Calkinsia, Postgaardi*), *Notosolenus, Petalomonas*.

[58]Incl. *Meteora* i.s.

[59]Incl. *Massisteria, Limnofila, Nanofila, Mesofila*, Desmothoracida, Gymnosphaeridae sed.m., Heliomonadida, *Microcometes* sed.m., *Boveemonas* sed.m., *Pseudodimorpha* sed.m., *Kibisdytes* sed.m.

[60]Incl. Cercomopnadida sed.m., Glissomonadida, Pansomonadida, *Metopion* sed.m., *Allantion* sed.m.

[61]Incl. Cryomonadida, Phaeodarea, Ebriida, *Protaspis, Pseudodifflugia*, Spongomonadida, Thaumatomonadida, *Pseudopirsonia, Auranticordis*, Euglyphida.

[62]Incl. Xenophyophorea, *Reticulomyxa, Komokiacea, Schizocladus*.

[63]Incl. Vampyrellidae sed.m., Biomyxidae sed.m., *Pseudospora* sed.m., Rhizoplasmidae s.aggr., *Leucodictyon* sed.m., Reticuloamoeba sed.m.

[64]Incl. *Phagomyxa*.

[65]Incl. Paramyxidia, *Bonamia, Claustrosporidium, Paradinium*.

2(114). *Taxopodida* [[5]*Sticholonche*] [66]
3(115). *Polycystinea* [[5]*Collosphaera*]
Superphylum *Heteroconta* [[6.2]*Fucus*]
Phylum 29. Bicosoecozoa [[6]*Bicosoeca*]
Classis 1(116). *Bicoecea* [[5]Bicosoeca][67]
Phylum 30. Labyrinthomorpha [[6]*Labyrinthula*]
Classis 1(117). *Labyrinthulea* [[5]*Labyrinthula*][68]
Phylum 31. Opalinomorpha† [[6]*Opalina*]
Classis 1(118). *Blastocystea* [[5]*Blastocystis*]
2(119). *Opalinea* [[5]*Opalina*][69]
3(120). *Actinophryida* [[5]*Actinophrys*] sed.m.[70]
Phylum 32. Oomycota [[6]*Saprolegnia*]
Classis 1(121). *Oomycetes* [[5]*Saprolegnia*] [71]
Phylum 33. Chromophyta [[6]*Fucus*] [72]
Classis 1(122). *Bacillariophyceae* [[5]*Diatoma*] s.a.[73]
2(123). *Dictyochophyceae* [[5]*Dictyocha*] [74]
3(124). *Pelagophyceae* [[5]*Pelagomonas*] [75]
4(125). *Eustigmatophyceae* [[5]*Eustigmatos*]
5(126). *Chrysophyceae* [[5]*Chrysococcus*] s.a.[76]
6(127). *Pinguiophyceae* [[5]*Pinguiochrysis*]
7(128). *Raphidophyceae* [[5]*Rhaphidomonas*]
8(129). *Phaeophyceae* [[5]*Fucus*] s.a.[77]
Superphylum *Alveolata* [6.2*Paramecium*]
Phylum 34. Myzozoa [[6]*Peridinium*]
Subphylum Apicomplexa [5.8Plasmodium] s.a.
Classis 1(130). *Apicomonadea* [[5]*Colpodella*][78]
2(131). *Chromerida* [[5]*Chromera*]
3(132). *Gregarinea* [[5]*Gregarina*] [79]
4(133). *Sporozoa* [[5]*Plasmodium*] s.s.[80]
Subphylum *Dinozoa* [[5.8]*Peridinium*]
Classis 5(134). *Perkinsida* [[5]*Perkinsus*][81]
6(135). *Ellobiopsea* [[5]*Ellobiopsis*][82]
7(136). *Syndinea* [[5]*Syndinium*][83]
8(137). *Oxyrridea* [[5]*Oxyrris*]
9(138). *Dinoflagellata* [[5]*Peridinium*][84]
Phylum 35. Ciliophora [[6]*Paramecium*]
Subphylum *Postciliodesmatophora* [[5.8]*Spirostomum*]
Classis 1(139). *Karyorelictea* [[5]*Trachelocerca*]
2(140). *Heterotrichea* [[5]*Spirostomum*]
Subphylum *Intramacronucleata* [[5.8]*Paramecium*]
Classis 3(141). *Spirotrichea* [[5]*Oxytricha*][85]
4(142). *Armophorea* [[5]*Clevelandella*]
5(143). *Litostomatea* [[5]*Spathidium*]
6(144). *Phyllopharyngea* [[5]*Podophrya*][86]
7(145). *Nassophorea* [[5]*Nassula*][87]
8(146). *Colpodea* [[5]*Colpoda*]
9(147). *Prostomatea* [[5]*Prorodon*]
10(148). *Plagiopylea* [[5]*Plagiopyla*]
11(149). *Oligohymenophorea* [[5]*Paramecium*]
Superphylum *Cryptobionta* [[6.2]*Cryptomonas*]
Phylum 36. Cryptista [[6]*Cryptomonas*] s.a.[88]
Classis 1(150). *Cryptophyceae* [[5]*Cryptomonas*][89]
2(151). *Katablepharidea* [[5]*Katablepharis*] sed.m.[90]
3(152). "*Biliphyta*" [[5]"*Biliphyta*"][91]
4(153). *Telonemia* [[5]*Telonema*] stat.m.
Phylum 37. Centrohelida [[6]*Acanthocystis*] sed.m.
Classis 1(154). *Holosea* [[5]*Luffisphaera*] i.s.[92]
2(155). *Centrohelea* [[5]*Acanthocystis*][93]
Phylum 38. Haptophyta [[6]*Prymnesium*]

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[66]Incl. *Larcopyle.*

[67]Incl. Placidiales (incl. *Wobbia*), Borokales, Anoecales (incl. *Cafeteria, Caecitellus*), Bicoecales, *Commation* sed.m., *Discocelis* sed.m.

[68]Incl. *Diplophrys, Sorodiplophrys*, Thraustochytridiales, Labyrinthuloideales.

[69]Incl. Proteromonadida.

[70]Sed.p. juxta Pedinellales.

[71]Incl. *Developayella, Pirsonia*, Hyphochitriomycetales, "MAST-4, 7, 8" groups.

[72]Incl. *Leukarachnion.*

[73]= Khakista, incl. *Bolidomonas* stat.m.

[74]Incl. Pedinellales, Rhizochromulinales.

[75]Incl. Sarcinochrysidales.

[76]Incl. *Picophagus, Synchroma, Chlamydomyxa, Leukarachnion, Oikomonas, Paraphysomonas*, "MAST-1, 2, 3, 6" groups sed.m.

[77]= Fucistia, incl. Chrysomeridophyceae stat.m., Schizocladiophyceae, Xanthophyceae stat.m., Phaeothamniales, Aurearenophyceae.

[78]Incl. *Colponema* sed.m. *Algovora, Voromonas, Aplphamonas, Chilovora, Colpodella, Acrocoelus.*

[79]Incl. *Rhytidocystis* stat.m., *Cryptosporidium* sed.m., *Selenidium.*

[80]Incl. Coccidia sed.m., Piroplasmida, Haemosporidia, *Nephromyces.*

[81]Incl. *Perkinsus*, P*arvilucifera, Rastrimonas, Phagodinium* sed.m.

[82]Incl. *Ellobiocystis, Parallobiopsis, Rhizellobiopsis, Thalassomyces.*

[83]Incl. "Marine Alveolate Groups I and II".

[84]Incl. *Noctiluca.*

[85]Incl. *Protocruzia, Phacodinium, Lycnophora.*

[86]Incl. Suctoria, Synchimeniida.

[87]Incl. Nassulina, Microthoracina.

[88]Incl. *Palpitomonas* sed.m.

[89]Incl. *Goniomonas, Tetragonidium, Bjornbergiella.*

[90]Incl. *Leucocryptos, Platychilomonas, Hatena.*

[91]Incl. "Picobiliphyta"

[92]Incl. *Paraluffisphaera.*

[93]Incl. 'Microheliozoan'.

Classis 1(156). *Prymnesiophyceae* [[5]*Prymnesium*][94]
Superphylum *Archaeplastida* [[6.2]*Volvox*]
Phylum 39. Glaucophyta [[6]*Glaucocystis*]
Classis 1(157). *Glaucophyceae* [[5]*Glaucocystis*]
Phylum 40. Rhodophyta [[6]*Bangia*]
Classis 1(158). *Cyanidiophyceae* [[5]*Cyanidium*][95]
2(159). *Rhodellophyceae* s.a.[[5]*Rhodella*][96]
3(160). *Compsogonophyceae* [[5]*Compsopogon*]
4(161). *Bangiophyceae* [[5]*Bangia*]
5(162). *Florideophyceae* [[5]*Palmaria*]
Phylum 41. Chlorophyta [[6]*Volvox*]* s.a.
Subphylum *Chlorophytina* [[5.8]*Volvox*]
Classis 1(163). *Prasinococcophyceae* [[5]*Prasinococcus*] stat.m.s.
2(164). *Nephroselmidophyceae* [[5]*Nephroselmis*]*[97]
3(165). *Tetraphyceaey* [[5]*Tetraselmis*]
4(166). *Pedinophyceae* [[5]*Pedinomonas*] stat.m.s.
5(167). *Chlorophyceae* [[5]*Volvox*]
6(168). *Trebouxiophyceae* [[5]*Chlorella*][98]
7(169). *Ulvophyceae* [[5]*Ulva*]
Subphylum *Charophytina* [[5.8]*Chara*]*
Classis 8(170). *Mesostigmatophyceae* [[5]*Mesostigma*]
9(171). *Charophyceae* [[5]*Chara*]*[99]
Regnum Vegetabilia [[7]*Magnolia*]
Phylum 42. Bryophyta [[6]*Bryum*]*
Subphylum *Hepaticae* [[5.8]*Marchantia*]
Classis 1(172). *Haplomitriopsida* [[5]*Haplomitrium*][100]
2(173). *Marchantiopsida* [[5]*Marchantia*][101]
3(174). *Jungermanniopsida* [[5]*Jungermannia*][102]
Subphylum *Bryophytina* [[5.8]*Bryum*]
Classis 4(175). *Takakiopsida* [[5]*Takakia*]
5(176). *Sphagnopsida* [[5]*Sphagnum*][103]
6(177). *Andreaeopsida* [[5]*Andreaea*][104]
7(178). *Polytrichopsida* [[5]*Polytrichum*]*[105]
8(179). *Bryopsida* [[5]*Bryum*][106]
Subphylum *Anthocerotophytina* [[5.8]*Anthoceros*]
Classis 9(180). *Anthocerotopsida* [[5]*Anthoceros*][107]
Phylum 43. Pteridophyta [[6]*Pteris*]*
Subphylum *Lycopodiophytina* [[5.8]*Lycopodium*]
Classis 1(181). *Lycopodiopsida* [[5]*Lycopodium*][108]
Subphylum *Pteridophytina* [[5.8]*Pteris*]
Classis 2(182). *Psilotopsida* [[5]*Psilotum*]
3(183). *Ophioglossopsida* [[5]*Ophioglossum*]
4(184). *Equisetopsida* [[5]*Equisetum*]
5(185). *Marattiopsida* [[5]*Marattia*]
6(186). *Pteridopsida* [[5]*Pteris*]
Phylum 44. Spermatophyta [[6]*Magnolia*] s.a.
Classis 1(187). *Cycadopsida* [[5]*Cycas*]
2(188). *Ginkgoopsida* [[5]*Ginkgo*]
3(189). *Gnetopsida* [[5]*Gnetum*]
4(190). *Pinopsida* [[5]*Pinus*][109]
5(191). *Angiospermae* [[5]*Magnolia*]
Regnum Animalia [[7]*Araneus*] [110] / *Pananimalia*
Subregnum Spongia [[6.8]*Spongia*]
Phylum 45. Silicea [[6]*Spongia*] stat.m.s.
Classis 1(192). *Hexactinellea* [[5]*Euplectella*]
2(193). *Demospongia* [[5]*Spongia*] s.aggr.
Phylum 46. Calcispongia [[6]Sycetta] stat.m.s.
Classis 1(194). *Calcarea* [[5]*Sycetta*]
Phylum 47. Homoscleraea [[6]*Oscarella*] stat.m.s.
Classis 1(195). *Homoscleromorpha* [[5]*Oscarella*]
Subregnum *Phagocytellozoa* [[6.8]*Trichoplax*]
Phylum 48. Placozoa [[6]*Trichoplax*]
Classis 1(196). *Trichoplacoidea* [[5]*Trichoplax*]
Subregnum *Ctenophora* [[6.8]*Ctenoplana*]
Phylum 49. Ctenophora [[6]*Ctenoplana*]
Classis 1(197). *Ctenophoroidea* [[5]*Ctenoplana*][111]
Subregnum *Cnidaria* [[6.8]*Hydra*]
Phylum 50. Anthozoa [[6]*Actinia*]
Classis 1(198). *Zoantharia* [[5]*Actinia*]
2(199). *Alcyonaria* [[5]*Alcyonium*]
Phylum 51. Medusozoa [[6]*Hydra*]*
Classis 1(200). *Staurozoa* [[5]*Lucernaria*]
2(201). *Cubozoa* [[5]*Carybdea*]
3(202). *Scyphozoa* [[5]*Aurelia*]
4(203). *Hydrozoa* [[5]*Hydra*]
5(204). *Polypodiozoa* [[5]*Polypodium*] stat.m.
Phylum 52. Myxozoa [[6]*Myxidium*]
Classis 1(205). *Malacosporea* [[5]*Tetracapsula*][112]
2(206). *Myxosporea* [[5]*Myxidium*][113]
Subregnum *Bilateria* [[6.8]*Araneus*]
Infraregnum Deuterostomia [[6.5]*Felis*] s.a.

[94]Incl. Pavlovophyceae.
[95]Incl. *Cyanidium, Galdieria, Glaucosphaera.*
[96]Incl. Stylonematophyceae, Porphyridiophyceae.
[97]Incl. Pyraminomonadales, Mamiellales, Nephroselmidales, Picocystis.
[98]Incl. *Helicosporidium, Geminella* and *Microspora* i.s.
[99]Incl. Conjugatophyceae.
[100]Incl. Treubiales.
[101]Incl. Blasiales, Sphaerocarpales, Monocleales.
[102]Incl. Pelliales, Fossombroniales, Pallaviciniales.
[103]Incl. *Ambuchanania.*
[104]Incl. *Andreaeobryum* stat.m.i.
[105]Incl. Oedipodiales stat.m.i., Tetraphidales stat.m.i.
[106]Incl. Buxbaumiales sed.m., Diphysciales, Timmiales.
[107]Incl. Leiosporocerotales.
[108]Incl. Isoetopsida stat.m.
[109]Incl. Cupressopsida.
[110]Incl. *Salinella* i.s. et dubitativa.
[111]Incl. Tentaculifera, Nuda.
[112]= *Tetracapsula, Buddenbrockia.*
[113]= Actinomyxidia.

Phylum 53. ACOELOMORPHA [[6]*Convoluta*] sed.m.
Classis 1(207). *Acoela* [[5]*Convoluta*]
2(208). *Nemertodermatida* [[5]*Nemertoderma*]
3(209). *Xenoturbelloidea* [[5]*Xenoturbella*] stat.m.
Phylum 54. ECHINODERMATA [[6]*Echinus*]
Classis 1(210). *Crinoidea* [[5]*Metacrinus*]
2(211). *Ophiuroidea* [[5]*Ophiura*]
3(212). *Asteroidea* [[5]*Asterias*][114]
4(213). *Echinoidea* [[5]*Echinus*]
5(214). *Holothurioidea* [[5]*Holothuria*]
Phylum 55. HEMICHORDATA [[6]*Balanoglossus*]
Classis 1(215). *Enteropneusta* [5*Balanoglossus*]* [115]
2(216). *Pterobranchia* [[5]*Rhabdopleura*]
Phylum 56. CHORDATA [[6]*Felis*] s.a.
Subphylum *Cephalochordata* [[5.8]*Branchiostoma*]
Classis 1(217). *Leptocardii* [[5]*Branchiostoma*]
Subphylum *Vertebrata* [[5.8]*Felis*]
Classis 2(218). *Cyclostomata* [[5]*Myxine*]
3(219). *Chondrichtyes* [[5]*Squalus*]
4(220). *Actinopterygii* [[5]*Perca*]
5(221). *Dipnoi* [[5]*Protopterus*][116]
6(222). *Amphibia* [[5]*Rana*]
7(223). *Reptilia* [[5]*Gecko*]*
8(224). *Aves* [[5]*Gallus*] stat.m.s.
9(225). *Mammalia* [[5]*Felis*]
Subphylum *Tunicata* [[5.8]*Ascidia*] stat.m.i.
Classis 10(226). *Ascidiacea* [[5]*Ascidia*][117]
Infraregnum Protostomia [[6.5]*Araneus*]
Superphylum *Chaetozoa*† [[6.2]*Sagitta*]
Phylum 57. CHAETOGNATHA [[6]*Sagitta*]
Classis 1(227). *Sagittoidea* [[5]*Sagitta*]
Superphylum *Spiralia* [[6.2]*Nereis*]
Phylum 58. RHOMBOZOA [[6]*Dicyema*] sed.m.
Classis 1(228). *Dicyemida* [[5]*Dicyema*]
Phylum 59. PLATYZOA [[6]*Fasciola*] s.a.
Subphylum *Gastrotricha* [[5.8]*Macrodasys*] stat.m.i.
Classis 1(229). *Gastrotrichoidea* [[5]*Macrodasys*]
Subphylum *Gnathostomulea*† [[5.8]*Gnathostomula*] stat.m.i.
Classis 2(230). *Gnathostomulida* [[5]*Gnathostomula*][118]
Subphylum *Gnathifera* [[5.8]*Rotifer*] s.s.
Classis 3(231). *Micrognathozoa* [[5]*Limnognathia*]
4(232). *Diurodrilidae* [[5]*Diurodrilus*] sed.m.[119]
5(233). *Syndermata* [[5]*Rotifer*][120]
Subphylum *Platyhelminthes* [[5.8]*Fasciola*]
Classis 6(234). *Catenulida* [[5]*Catenula*]
7(235). *Rhabditophora* [[5]*Planaria*]*[121]
8(236). *Neodermata* [[5]*Fasciola*][122]
Phylum 60. KAMPTOZOA [[6]*Pedicellina*]
Classis 1(237). *Cycliophora* [[5]*Symbion*] stat.m.
2(238). *Entoprocta* [[5]*Pedicellina*] sed.m.
Phylum 61. MOLLUSCA [[6]*Limax*]
Classis 1(239). *Aplacophora* [[5]*Neomenia*] s.a.[123]
2(240). *Polyplacophora* [[5]*Chiton*]
3(241). *Monoplacophora* [[5]*Monoplacophorus*]
4(242). *Bivalvia* [[5]*Mytilus*]
5(243). *Scaphopoda* [[5]*Dentalium*]
6(244). *Gastropoda* [[5]*Limax*]
7(245). *Cephalopoda* [[5]*Octopus*]
Phylum 62. TENTACULATA [[6]*Lingula*] s.aggr.
Classis 1(246). *Gymnolaemata* [[5]*Flustra*] stat.m.[124]
2(247). *Phylactolaemata* [[5]*Plumatella*]
3(248). *Phoronida* [[5]*Phoronis*]
4(249). *Linguliformea* [[5]*Lingula*]
5(250). *Craniiformea* [[5]*Craniscus*]
6(251). *Rhynchonelliformea* [[5]*Rhynchonella*]
Phylum 63. NEMERTEA [[6]*Nemertes*]
Classis 1(252). *Archynchocoela* [[5]*Archynchonemertes*]
2(253). *Nemertini* [[5]*Nemertes*][125]
Phylum 64. ANNELIDA [[6]*Nereis*]
Classis 1(254). *Myzostomida* [[5]*Myzostoma*] sed.m.
2(255). *Sipunculida* [[5]*Sipunculus*] stat.m.[126]
3(256). *Polychaeta* [[5]*Nereis*] s.a.[127]
Phylum 65. ORTHONECTA [[6]*Rhopalura*] sed.m.
Classis 1(257). *Orthonectida* [[5]*Rhopalura*]
Superphylum *Ecdysozoa* [[6.2]*Araneus*]
Phylum 66. CYCLONEURALIA [[6]*Ascaris*] s.a.
Subphylum *Scalidomorpha* [[5.8]*Priapulus*] s.s.
Classis 1(258). *Kinorhyncha* [[5]*Kinorhynchus*]
2(259). *Priapulida* [[5]*Priapulus*]
Subphylum *Nematoidea* [[5.8]*Ascaris*]
Classis 3(260). *Nematoda* [[5]*Ascaris*][128]
4(261). *Nematomorpha* [[5]*Gordius*]
5(262). *Loricifera* [[5]*Nanaloricus*]
Phylum 67. TARDIGRADA [[6]*Macrobiotus*]
Classis 1(263). *Tardigradoidea* [5*Macrobiotus*][129]
Phylum 68. ARTHROPODA [[6]*Araneus*] s.a.

[114]Incl. *Xyloplax*.
[115]Incl. *Planctosphaera*.
[116]Incl. *Latimeria* sed.m.
[117]Incl. Thaliacea, Larvacea stat.m.
[118]Incl. Filospermoidea, Bursovaginoidea.
[119]Sed.poss. juxta Polychaeta.
[120]Incl. Hemirotifera stat.m. (*Seison*, Acanthocephala et Bdelloidea), Monogononta.
[121]Incl. Macrostomida, Polycladida, Neoophora s.s.
[122]Incl. Monogenea, Trematoda, Cestoda.
[123]Incl. Caudofoveata stat.m.i.
[124]Incl. Stenolaemata.
[125]Incl. Anopla, Enopla.
[126]Incl. Sipunculoidea, Phascolosomatidea.
[127]Incl. *Lobatocerebrum* sed.m., *Jennaria* sed.m., Aelosomata, Clitellata, Echiura stat.m., Sibolginida (Pogonophora et Vestimentifera).
[128]Incl. Adenophorea, Secernentea.
[129]Incl. Heterotardigrada, Mesotardigrada i.s., Eutardigrada.

Subphylum *Lobopoda* [[5.8]*Peripatus*] stat.m.
Classis 1(264). *Onychophora* [[5]*Peripatus*]
Subphylum *Cheliceromorpha* [[5.8]*Araneus*]
Classis 2(265). *Chelicerata* [[5]*Araneus*][130]
3(266). *Pantopoda* [[5]*Pycnogonum*]
Subphylum *Myriapoda* [[5.8]*Scolopendra*]
Classis 4(267). *Chilopoda* [[5]*Scolopendra*]
5(268). *Pauropoda* [5*Pauropus*]
6(269). *Diplopoda* [[5]*Julus*]
7(270). *Symphyla* [[5]*Symphylella*]
Subphylum *Pancrustacea* [[5.8]*Scarabaeus*]
Classis 8(271). *Branchiura* [[5]*Argulus*] stat.m.
9(272). *Pentastomida* [[5]*Cephalobaena*] i.s.
10(273). *Ostracoda* [[5]*Cypris*]
11(274). *Cephalocarida* [[5]*Hutchinsoniella*]
12(275). *Hexapoda* [[5]*Scarabaeus*] s.a.[131]
13(276). *Branchiopoda* [[5]*Daphnia*]
14(277). *Copepodoidea* [[5]*Cyclops*] [132]
15(278). *Thecostraca* [[5]*Lepax*] [133]
16(279). *Remipedia* [[5]*Speleonectes*]
17(280). *Malacostraca* [[5]*Cancer*][134]

Acknowledgments

Author is very grateful to books which initiated his child-born interest of global taxonomy, first of all to "Homunculus" of N. Plavilschikov, and famous Russian popular encyclopedias "Zhizn' rastenij" and "Zhizn' zhivotnykh". There were many fruitful discussions with A. Aleshin, I. Mirabdullaev, A. Mylnikov, K. Mikrjukov, Th. Cavalier-Smith, L. Margulis, D. Patterson, S. Glagolev, A. Rautian, N. Kluge, A. Chernyshev, V. Filin, D. Sokoloff, anonymous reviewer and many others which were the sources of significant improvement of the classification.

Selected References

Nearly 1700 references (mostly articles from 1980s, but also some important books and older works) have been used for the construction of classification. Here we list only references cited directly in the introductory text; the full list is available for download as a BibTEX file from http://herba.msu.ru/shipunov/os/current/synat.bib.

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