Genealogical Classification

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Abstract: Genealogical classification, also described in different contexts as "genetic", "phylogenetic", "historical" or "evolutionary", is the classification of any set of entities according to their origin from pre-existing entities. Entities that share a common ancestry are thus grouped together. Scientific taxonomies of organisms are famously based on this principle, especially after Darwin's introduction of historical methodology in biology. The competing biological schools of cladistic, evolutionary and phenetic taxonomy are good examples of general issues involved in taking genealogy as, respectfully, the only principle, or just one principle along with diversity, or a completely excluded principle. However, a variety of other special sciences have also considered genetic principles for classification, including astronomy, Earth sciences, linguistics, cultural anthropology and musicology; tentative applications of "phylomemetics" to LIS have also been proposed. Many library classifications, notably the Bliss Bibliographic Classification, have applied evolutionary principles to the general order of disciplines. Other authors have suggested that historical relationships among disciplines themselves, or among individual scholars and works, can be represented by an analogous genealogical approach.

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1. Terminological introduction

Genealogical classification is the classification of any set of entities according to their origin from pre-existing entities, so that entities that share a common ancestry are grouped together.

While the term *genealogy* typically refers to relationships between persons belonging to some familiar lineages, here it is taken in a more general sense that can be applied to any kind of entities, as an approach to classification alternative to e.g. logical division or numerical taxonomy. In scientific contexts, the same approach has also been described as "genetic", that is based on the generation of entities from other entities, like in the "genetic classification" of soils; or as "phylogenetic" (Gnoli 2006; Hjørland and Gnoli 2009), that is based on the descent of entities from different ancestral forms through an evolutionary process. Indeed, "[p]edigrees and phylogenies are both genealogies, displaying the historical (evolutionary) connections between generations within biology, rather than contemporary relationships" (Morrison 2016, 456).

In general, classification produces groups of entities that share some set of characteristics. The criteria for selecting these characteristics are known to vary widely according to purposes, but the resulting classes will usually include items that are similar in some respect. In David Hull's words (1988, 272), "[t]wo fundamentally different sorts of classification are those that reflect structural organization and those that are systematically related to historical development". Thus, classifications that account for similarity of structure irrespective of any historical explanation of it can be called *phenetic* or *morphological* or *typological*: such classifications may, for example, lump flies, bats and airplanes together as they all have wings. In contrast to this, genealog-

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ical classifications attempt to explain structures, at least partly, by assuming that certain characters (either similar or not, e.g. wings and arms) share some common origin: they may e.g. lump bats and humans together while splitting them from both flies and airplanes.

As a generated entity may in turn generate other entities, and so on, a genealogical history or lineage is produced. Notice that lineages do not imply just a chronological sequence but also an actual relation of the origin of an entity from some pre-existing one(s). Also, as generated entities may not be identical to their ancestors, a process of evolution can be observed in the long term. Therefore, investigating the origin of entities often implies consideration of some evolutionary process, and genealogical classification can also be described as an evolutionary classification. For example, the main classes of Information Coding Classification (see section 4) have been described as "nine general object areas according to the principle of evolution" (Zeng 2018, section 5.2). Ranganathan listed "Later-in-Evolution" as the second among eight "principles for helpful sequence" arranged in order of priority, only preceded by "Later-in-Time" and followed by "Spatial Contiguity, Quantitative Measure, Increasing Complexity, Canonical Sequence, Literary Warrant and Alphabetical Sequence":

> If the subjects in an array of subjects or the isolates in an array of isolates belong to different stages of evolution, they should be arranged parallel to the evolutionary sequence, except when any other overwhelming consideration rules it out (Ranganathan 1967, 185).

As examples of this principle Ranganathan gives (185-186) the representation, in his and other classification systems, of arrays of plants in botany (*thallophyta, bryophyta, pteridophyta, gymnosperms, monocotyledons, dicotyledons*); of patients in medicine (embryo, child, adolescent, old); of power structures in political sciences (anarchy, primitive, feudal, monarchy, oligarchy, democracy); and of interactions in economics (communication, transport, commerce, credit, public finance, insurance). These examples also make clear how the idea of evolution may be understood in a broad sense, that can be found in both natural and cultural systems.

The genealogical principle can be applied in the knowledge organization systems (KOS) developed in many special sciences, such as taxonomies of organisms, languages, etc. It can be applied as well in the KOSs aimed at organizing the bibliographical outputs of the sciences in libraries and other information centers. Thus, genealogical classification is relevant both to the special sciences and to library and information science (LIS).

2. The genealogical approach in scientific taxonomies

The most famous example of a genealogical classification, although not the only relevant one, is in biological systematics. Aristotle, Linné, Buffon and Kant had already considered some genealogical criteria, e.g., by classifying very different male and female forms in the same species because both are generated by parents of that species. Despite this, at the time of Linné plants and animals used to be classified mainly according to morphological characters, and one main question was which characters were the most important for classification; for example, Linné claimed that sexual organs are especially meaningful for this purpose.

However, since the 19th Century theories of biological evolution have started to explain morphological diversity by descent from common ancestors. It was especially Charles Darwin who introduced a view of all organisms as being connected among them through genealogical relationships, in what is known today as the Tree of Life.

> All the foregoing rules and aids and difficulties in classification are explained, if I do not greatly deceive myself, on the view that the natural system is founded on descent with modification; that the characters which naturalists consider as showing true affinity between any two or more species, are those which have been inherited from a common parent, and, in so far, all true classification is genealogical; that community of descent is the hidden bond which naturalists have been unconsciously seeking, and not some unknown plan of creation, or the enunciation of general propositions, and the mere putting together and separating objects more or less alike. (Darwin 1859, 420).

Darwin adopted a historical perspective in natural history, which he applied to various classes of phenomena including not just organism species but also such other processes as the formation of atolls (Darwin 1874). In this approach, the different kinds of phenomena that we can observe today are viewed as different stages in a historical process, so that the synchronic dimension is complemented by a diachronic one. "Darwin was, above all, a historical methodologist [... who] taught us why history matters and established the methodology for an entire second style of science" (Gould 1986, 60).

A similar logic is applied, for example, in current theories of the evolution of stars through different stages, where each stage corresponds to a class of stars that can be observed today. Genetic approaches to classification have also been introduced in geomorphology (Davis 1915), climatology (Oliver 1970) and soil science (Buol et al. 1980), where they have been competing with morphological approaches. Avery (1962, 236) presented an example of a discussion in soil science:

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> [...] fundamental objections to the classical 'genetico-geographical approach' arose [...A]ppreciation of the shortcomings of previous schemes has led to a general reaction in favour of descriptive systems, with categories described in terms of intrinsic properties rather than in terms of inferred genetic factors or processes. The most extreme advocate of this approach is Leeper [1956] [...]. This proposal has, however, gained only limited acceptance, and most soil taxonomists in western countries are now concerned with the formulation of what may be called 'morpho-genetic' systems, informed by the two guiding principles [Duchaufour 1960; US Department of Agriculture 1960].

Interestingly, this account was published in the LIS journal *Aslib proceedings*, as part of an interdisciplinary conference on classification also attended by scholars in LIS, philosophy, biology, anthropology and linguistics (Kyle 1962). More recently, Nikiforova and Fleis list the genetic approach as one of the basic requirements for classification of soils: "from the perspective of the General Theory of Classification, a universal soil classification system should be natural, genetic, 'fundamental-and-specific', and hierarchical" (Nikiforova and Fleis 2018, abstract).

Another prominent example of genealogical approaches can be found in linguistics, where "genetic" classifications of languages into "families" of supposedly common origin are alternative to "typological" classifications, which are based on the similarity of phonological and grammatical features in different languages irrespective of their origin (Michalove et al. 1998). Indeed, Ruhlen (1994) observes that all diversity among languages, as well as all diversity among proteins, among animals or among religions, has to be explained ultimately in terms of three possible causes:

- convergence (e.g. a language developing a grammatical structure similar to another due to external factors),
- borrowing (a language deriving a structure from another through cultural contacts between their speakers) and
- common origin (a language sharing a structure with another as it historically derives from it, like French from Latin).

While convergence and borrowing are processes that lead to similarities between genealogically unrelated entities, common origin depends on genealogical relationships.

Evolutionary thinking has important implications for classification (Richards 2016, 88-89), as Darwin himself realized. Indeed, while he still considered similarity as a useful tool for assessing relationships, he now viewed genealogy to be the basis for classification (Padian 1999).

This insight has eventually led to a "Darwinian turn to a genealogical or phylogenetic classification" (Richards 2016, 101) in biology. In a Darwinian world, indeed, the Linnaean hierarchies' trees of relationships between organisms can now be interpreted as phylogenetic trees rather than just as similarity trees (dendrograms). This leads some, like Ereshefsky (2001), to advocate for entirely new methods of classification that abandon the categories originally based on Linné's essentialist ideas, such as the fixed ranks of phylum, class, order, genus and species. Anyway, it is noticeable that phylogenetic trees often resemble the corresponding dendrograms at least in their general lines, which seems to work as a confirmation of the soundness of both. On the other hand, many details may change depending on whether priority is given to genealogy or to morphology, as it will be discussed in the next section.

Another issue is that genealogical classification is inherently more demanding than morphological one, as it requires not only observation or measurement of the items on hand, but also historical reconstruction of their origin. Often such historical knowledge is simply not available, so that classification has to start with a morphological approach, waiting to be improved later as more information on genesis becomes available. This process can be observed in many domains. For example, Ritter (2006, emphasis original) observed that "though atmospheric science is progressing everyday, we still have a long way to go before we have a *complete* understanding of the workings of our climate. [Genetic ones] are inherently the most difficult classifications to create and use because of the multitude of variables needed"; while "completion" is only an ideal aim in science, this case shows how genealogical knowledge is regarded as a sign of maturity in a domain.

Despite these difficulties, genealogical approaches are increasingly exported from the study of organisms to other domains of biological and human sciences. For example, "[p]hylogenetic paleoecology is a new research paradigm that promotes the explicit incorporation of 'tree-thinking' in studies of deep-time ecological processes" (Lamsdell et al. 2017, 452). Types of cells can also be investigated and organized with evolutionary approaches (Arendt et al. 2018).

Some years ago, prominent evolutionary biologist Niles Eldredge, also a jazz player in his spare time, started to play with the idea of applying phylogenetic systematics to his personal collection of cornets (Eldredge 2000). Although cultural artifacts clearly inherit their characters from ancestors in ways very different from those of organisms, the resulting classification trees share some general properties (Tëmkin 2016). As Eldredge noticed, artifacts may include the sudden appearance of new inventions, which is unlikely in organisms. Additionally, non-"vertical" inheritance from specimens other than parents is usually considered to be much more important in cultural artifacts or in languages (as with borrowing processes discussed above) than in organisms. However, in recent years various mechanisms for

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"horizontal" or "oblique" inheritance outside genome are being identified in organisms too (Gontier 2015), so that even the graphs connecting organisms can be said to be "reticulating networks not just divergent trees" (Morrison 2016, title; cf. Quammen 2018), not unlike trees of artifacts (Kressing 2016). Cultural evolution is a field increasingly researched by phylogenetic approaches (Gontier 2016; Suman 2018), and "[t]he spectrum of cultural entities analyzed phylogenetically is rapidly growing, comprising languages, texts, artifacts, concepts, social institutions, and entire cultures" (Tëmkin 2016; cf. section 5).

3. Cladistics vs. phenetics

As it has been mentioned, only part of similarity may be explained by common origin; however, in many cases, convergence and borrowing also matter. While *homology* is common origin of characters that have a similar structure, even if they now perform different functions, such as bat wings and human arms, *analogy* is similarity of characters having a different origin, such as bat wings and airplane wings.

Analogy is often explained by evolutionary convergence, that is, selective pressure by similar factors on structures of different origin: bat wings and airplane wings have become similar because both have to fit the laws of aerodynamics in order to perform flight. Criteria for distinguishing homology and analogy have been developed especially in biology (Minelli and Fusco 2013), although recent advances in developmental genetics are making the picture more complex (Gilbert and Eppel 2015). In Darwin's view, only homologies are relevant to classification, because they show genealogical relationships with other organisms, while analogies should not be considered. This was a key achievement in theory of classification:

> This is the significance of the Darwinian revolution for classification. Darwin gave us a theoretical foundation that in turn provided a framework for determining which traits were relevant to classification and explains why a nested hierarchy is appropriate (Richards 2016, 97).

At the same time, many scholars are also interested in describing and explaining the diversity of evolved forms, that is, to account for their similarities and dissimilarities. Both common origin and similarity can thus be considered as important criteria for classification. In some cases, these two criteria can conflict, and reconciling them to produce a single consistent system is not always trivial (Gnoli 2017). For example, classes of musical instruments, e.g., in the Hornbostel-Sachs classification (Lee 2020), are mostly based on their structural characteristics which determine the way they produce sounds (by their body, by membranes, by wind, by strings or by electricity). However, there are cases where instruments of one class are actually derived from ancestors of a different main class, thus posing the problem whether the structural or the genealogical criterion should prevail:

> *Lyres* are defined as yoke lutes where "the strings are attached to a yoke which lies in the same plane as the sound-table and consist of two arms and a cross-bar". Crowth, a Medieval instrument documented in iconographical sources, in its initial form fell under the definition of lyres; but later it got a neck, so that it is no more a lyre, though being the development of a lyre. A more familiar example is piano, which is classified among table zithers, as in first pianos strings were just tightened on the sound-table; however, later pianos contain a cast iron frame, on which strings are now tightened, so that strictly it should be considered as a frame zither instead. In the latter case, the genetic criterion prevails in the classification, while in the former what prevails is morphology (Gnoli 2006, 144, italics original)

Even more radical cases can be identified, including an exotic musical bow from Kenya that can be classified as either a lute, on a morphological basis, or as a zither, "so giving priority to the genetic criterion, in the same way as cladists say that birds are reptiles" (Gnoli 2006, 144).

During the 20th century competing schools have developed in systematic biology, each emphasizing different criteria (Richards 2016): cladistics, phenetic taxonomy and, as a middle way, evolutionary taxonomy. Cladistics, founded by entomologist Willi Hennig (1999) under the name of "phylogenetic systematics", emphasizes common origin as the unique basis for classification: the only classificatory branches (termed *clades*) allowed in cladistics must be strictly monophyletic, that is, must include all and only the entities derived from a common ancestor, while leaving related branches that do not share that ancestor out. This involves adoption of a specific set of complex terms, such as *plesiomorphy* (ancestral form) and *synapomorphy* (shared form deviating from the ancestral one). Reconstruction of the optimal trees (cladograms) involves a principle of parsimony — a term also adopted by Ranganathan as a classification principle, as noticed by Montoya (2018).

Cladistics has much developed since Hennig and has been accepted by more systematic biologists in recent years. On the other hand, its dependence on knowledge of the evolutionary history of every character means that many cladograms are largely hypothetical until more evidence is found on the origin of specific characters. To base classification on characters that can be measured objectively irrespective of their supposed evolution, an alternative ap-

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proach is that of numerical or phenetic taxonomy, founded by Sokal and Sneath (1963) — the latter also a speaker at the interdisciplinary conference cited in section 2. These authors, although well aware of the evolutionary framework of modern biology, observed that hypotheses about phylogeny should be a result, rather than a premise, of classification, otherwise the argument would be a circular one. Phenetic taxonomy thus emphasizes similarity of characters over phylogeny for methodological reasons. Large numbers of characters are compared in different organisms simply by statistical methods, irrespective of their supposed origin; calculations produce trees that optimally group the organisms sharing most characters.

The approach of phenetics can be described as empiricist: in its view classification should start from empirically observed characters without being influenced by a priori assumptions, like the assumption that characters that look more meaningful for reconstructing genealogy should be preferred. On the other hand, theories do affect classification in any science, including biology:

> In fact, except for the purely practical criteria such as easy identification and high variability, it is unclear why any particular trait would be better than any other for classification. We can understand this problem relative to modern evolutionary thinking about classification. On the now standard approach, biological classification represents phylogeny and the evolutionary tree. This theoretical basis gives criteria for determining which traits should be used in classification. As we shall see, homologies — shared traits based on common ancestry — are better traits for generating a classification on this theoretical basis. There is a theory, evolutionary theory, that gives us operational guidance here about which traits to use (Richards 2016, 68).

Adoption of the framework of evolutionary theory suggests that common origin of characters (homology) should indeed matter in classification. At the opposite side of the issue, however, exclusive focus on common origin may also produce questionable, counterintuitive results. A famous example is that, according to cladistic criteria, birds would be a kind of reptiles, as the common ancestor of birds and crocodiles is more recent than the common ancestor of all reptiles (see Figure 1). Should these extreme consequences be accepted in classification in name of the methodological strictness of cladistics?

The reason for such apparent paradoxes is that the cladistic approach does not take diversity into account. Although birds have indeed developed from reptiles in relatively recent times, hence are close relatives of them, they have diverged morphologically from ancestor forms more

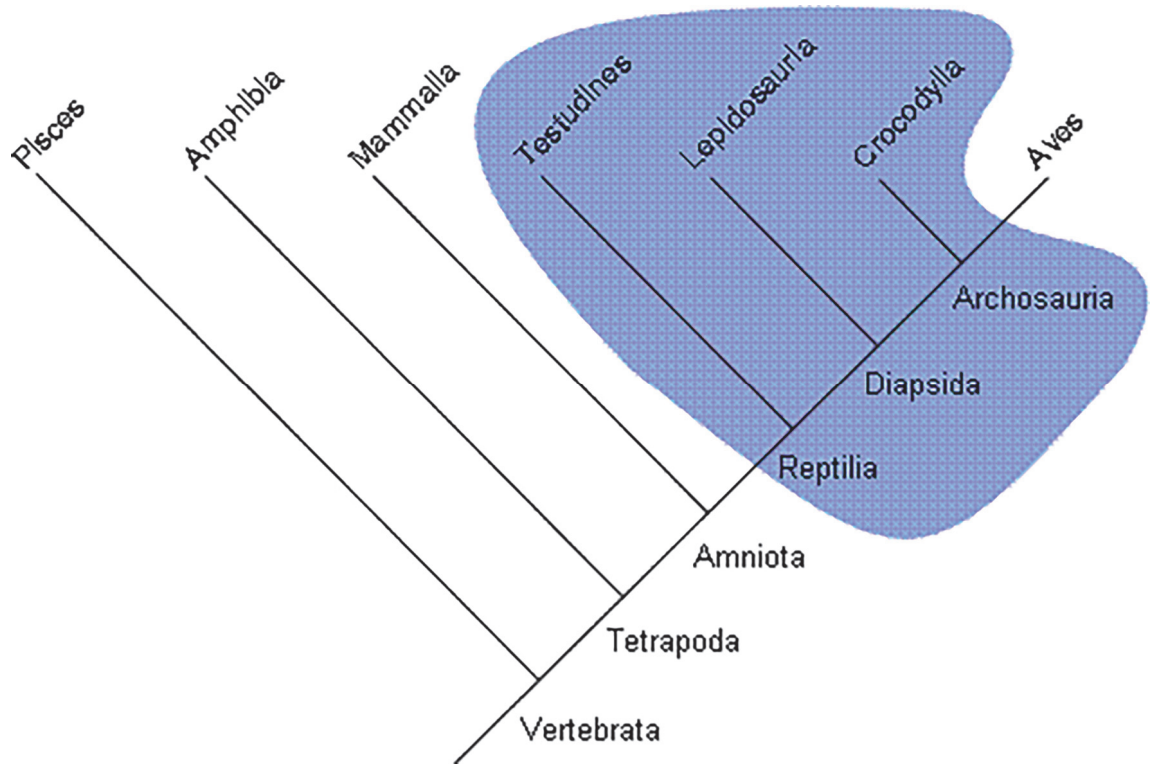

Figure 1: Phylogenetic tree showing how Aves, the class of birds (top right), should be part of reptiles (blue area) according to cladistic rules (from *Wikipedia*, GNU license).

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strongly than any other reptiles. This may still justify the classification of birds in a separate taxon.

While to cladists, the purpose of classification is just to reconstruct the history of phylogenetic relationships, many biologists believe that diversification should also be represented in classification. This balanced approach is recommended by evolutionary or Darwinian taxonomy, championed by Ernst Mayr, which takes into account both evolutionary history and morphology (Mayr 1942; Simpson 1961; Mayr 1991; Mayr and Bock 2002; for a polemical criticism see Ghiselin 2004). In this approach, groups should be monophyletic in the broader sense that they include only, but not necessarily all, descendants of a common ancestor: indeed, descendants that have differentiated widely from the original forms, such as birds from ancestral reptiles, deserve the creation of new separate groups. Such groups, like reptiles not including birds, are called paraphyletic groups by cladists and are not accepted by them as valid groups (Richards 2016, chapter 4).

A notion related to these problems is that of evolutionary grade, proposed by biologist and philosopher Julian Huxley (1959). In Huxley's view, evolutionary trees should be analyzed not just in terms of their clades, that is the branches that represent origin relationships, but also by grades, the successive levels reached by every branch that represent innovations in structural organization. In this sense, while birds belong to a clade originating from certain reptiles, they have formed a new grade of sophisticated adaptations to life in the air, which represents an evolutionary novelty.

On the same basis, Huxley (1955) proposed that humans, although clearly derived from a clade of apes, should be classified in a new taxon of *psychozoa* having the same rank as all animals as a whole, given the exceptional adaptative novelties introduced with the human brain, language and cultural skills. This idea raises the usual warnings about considering any life form "higher" than another, which is not justified in Darwinian biology. On the other hand, in the perspective of knowledge organization, the idea may be relevant as it connects genealogical classification as applied in biology with a wider view of arranging entities in orders of increasing organization (e.g. unicellular life, plants, animals, men, ...), as is done in many general classifications since at least the times of the Medieval *scala naturae*. This is discussed in the next section.

4. Evolutionary series in general classifications

Besides taxonomies of the individual sciences, the genealogical approach can also be applied to the whole of knowledge. This implies that items in a general KOS can be arranged in some evolutionary order.

"Evolutionary" usually refers to the order of objects that are typically studied by the listed disciplines, so that disciplines studying less evolved objects are listed before disciplines studying more evolved ones: e.g. chemistry is listed before biology because molecular structures precede cells and organisms in the evolution. However, it may also refer to the evolution of the disciplines themselves: this leads to historicist approaches discussed in the next section.

The idea of a general order of objects, or phenomena, implies views of a cosmical evolution encompassing not just life forms or other specific classes of entities, but the whole of reality. Such views are common among philosophers of different schools, from Hegel to Bergson, Peirce and Hartmann, though not shared by other philosophical traditions, e.g., all dualist traditions (Descartes, most Christianity) for which matter and spirit are distinct, irreconcilable realities.

Classifications of the sciences also influence library classification systems. An early application of such evolutionary views to the order of main classes was in James Duff Brown's Subject Classification:

> Matter, force, motion and their applications are assumed to precede life and mind, and for that reason the material side of science, with its applications, has been selected as a foundation main class on which to construct the system. Life and its forms, arising out of matters, occupy the second place among the main classes [...] Human life, its varieties, physical history, disorders and recreations, follows naturally as a higher development (Brown 1906, 12).

Classification theorist Ernest Cushing Richardson explicitly claimed that disciplines should be arranged in the evolutionary order of appearance of phenomena: "the order of the sciences is the order of things," and "the order of things is lifeless, living, human, superhuman" (Richardson 1930; cf. Dousa 2009). However, this main sequence is not followed in the library classification Richardson produced for Princeton University, whose main classes are: Bibliography, Government documents, Periodicals, encyclopedias, History, Language and literature, Oratory, Sports, Photography, Religion, Philosophy, Psychology, Education, Political science, Law, Science, Medicine, and Technology (Princeton University 2002).

In the same years, Henry Evelyn Bliss (1929; 1933) published a wide enquiry comparing many systems of the sciences based on evolutionary ideas according to different authors, and proposed that both classifications for education and classifications for library arrangement should essentially follow their principle of "gradation in speciality", even if with some adaptations. In particular, his Bibliographic Classification is based on the evolutionary arrangement of sciences proposed by Auguste Comte (cf. Trompf 2023), as still reflected in its second, faceted edition (BC2):

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> Gradation in speciality [...] reflects a notion held by a number of philosophers and particularly by the French philosopher Comte of the dependence of the special sciences on the general sciences. For example, Physics deals with the most fundamental phenomena – the nature of matter and energy itself. Chemistry deals with matter and energy as organized in different substances. For the explanation of chemical phenomena, the concepts of physics will often be drawn on; e.g. the valency or combining power of the elements is explicable in terms of their electronic structure. In this view, Chemistry is more 'special' than Physics (Mills and Broughton 1977, section 6.213.3).

The order of main classes is not very different in other general systems, such as Colon Classification (Satija 2017), Library-Bibliographical Classification (Sukiasyan 2017, section 3.1), Broad System of Ordering (Kawamura 2018, section 3) or Information Coding Classification (Ohly 2018, section 5). These have been described as "serial classifications" by Bhattacharyya and Ranganathan (1974).

While disciplines can be arranged in such an order based on the order of their objects of study, the principle can be applied in an even more direct way in phenomenon-based classifications, such as the CRG-NATO draft (CRG 1969) or the Integrative Levels Classification (ILC), where classes of phenomena are listed from the most primitive to the most derivate.

> Gradation is a theoretical order of the sub-disciplines of science. It correlates quite strongly with another theoretical order, that of → integrative levels [...] Integrative level theory refers to phenomena. It arranges physical entities in a sequence beginning with elementary particles or energy forms (or even, it has been suggested, mathematical structures) and proceeding through successively higher levels (atoms, molecules, molecular aggregates, minerals, mineral aggregates, land masses, celestial bodies ...) whereby at each new level new emergent properties are discernible (Mills and Broughton 1977, section 6.213.3).

For example, the main classes of ILC second edition (cf. Gnoli 2017, 47) are:

aWc	information
a	forms
b	spacetime
c	branes
dWj	matter
d	particles/waves
e	atoms
f	molecules
g	continuum bodies
h	celestial objects
i	rocks
j	land
kWn	life
k	genes
l	bacteria
m	organisms (eukaryote)
n	populations
oWp	minds
o	instincts
p	consciousness
qWv	societies
q	languages
r	rituals
s	communities
t	polities
u	enterprises
v	technologies
wWy	works
w	artifacts
x	artworks
y	knowledge

5. Genealogy of domains and the historicist approach

Hjørland (2017, section 4.2c) lists "hermeneutics" or "historicism" as one among the possible basic approaches to LIS-KO and classification, also including empiricism, rationalism and pragmatism. In his view, "historicism" can be applied to either the subjects or the objects of knowledge (Hjørland and Gnoli 2009). While the genealogical approach as described to this point is applied to objects,

> [t]here is also a subjective side of classification, and this subjectivity has developed historically. The classifying subject is influenced by his or her culture, paradigms, and tradition. This may be termed, for example, hermeneutics, historicism, or social epistemology. (Hjørland 2017, section 4.2c)

This suggests that an evolutionary approach can also be applied to the ways knowledge is obtained and developed. For example, Michael Kleineberg has proposed to apply Ken Wilber's scheme of "levels of knowing" to represent increasing degrees of awareness in epistemological approaches (Kleineberg 2014), or Lawrence Kohlberg's scheme of developmental stages of moral consciousness for representing viewpoints adopted by authors in different documents (Kleineberg 2018). Edward Craig has proposed a theory of knowledge described as "genealogical" among other terms. He considers knowledge as the evolution of a "state of nature" where "protoknowledge" has to fit the basic needs of

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identifying reliable informants about practical situations within a small-scale society (Craig 1990; Kunsch and McKenna 2020).

As for the cultural products of knowledge, a genealogical approach can lead to order disciplinary fields according to their historical relationships. For example, religion and epic poetry could be listed among the most ancient fields; philosophy could be presented as the parent field of—in chronological order—natural history (in turn giving birth to physics and biology), sociology, psychology... This is just a hypothetical example, while others claim that psychology is to be reconnected more to physiology: so that even in this case genealogical classification is demanding, as it presupposes knowledge of past relationships between the classified entities.

It must be noted that disciplines did not emerge historically in the same order as the one proposed by Bliss, which rather is the historical order of emergence of their objects. The theory of relativity was developed since the 20th century, well after other branches of the natural sciences, despite spacetime and particles precede molecules or plants in the cosmic evolution. Thus, a genealogical classification of disciplines according to their historical development conveys knowledge about disciplines inasmuch as socio-cultural phenomena, rather than knowledge about their objects. This may be studied from various philosophical perspectives, not just the historicist one. However, in the historicist approach it is of special interest.

Foucault (1972) investigated how knowledge develops under the influence of the cultural paradigms of a certain period. New paradigms do not just accumulate over existing ones, but can replace previous paradigms through scientific revolutions, as discussed by Kuhn (1962). This suggests that genealogical KOSs could not simply list them as sister classes in an array, like *530.11* relativistic mechanics precedes *531* classical mechanics in the Dewey Decimal Classification; but it should present them as fundamentally alternative options, in practice providing a KOS based on relativistic mechanics and a separate one based on classical mechanics. Each of them would then be useful to index documents of a specific epoch in which the corresponding paradigm was dominant (Eugenio Gatto, pers. comm.), although cross references would be needed for the sake of information recall and interoperability.

On a smaller scale, the genealogical approach can investigate the influence of particular schools of authors on one another, thus reconstructing cultural phylogenetic trees. Genealogical relationships between researchers have indeed been described as "academic genealogy", that is "the quantitative study of intellectual heritage operationalized through chains of students and their advisors" (Sugimoto 2014). Campbell and Mayhew (2017) apply "a phylogenetic approach" to relationships between documents, e.g. the novels of Jane Austen and their successive adaptations, as an alternative to the "Platonic" relationships between an abstract work and its instantiations as represented in the FRBR model. Sims (2018) proposes to apply "a contemporary biological classification approach based on common origin" to book classification itself, by producing dendrograms based on their contents.

More generally, Howe and Windram (2011) propose to designate as "phylomemetics" the application of phylogenetic methods to the human sciences, including historical relationships between different manuscript versions or other cultural artifacts. Macedo (2017) introduces this notion into LIS and KO by proposing its application to trace relationships between archive metadata.

These recent developments suggest that the genealogical approach has an interesting potential of application to the study and classification of knowledge schools themselves, besides its application to the study and classification of the objects of knowledge.

6. Conclusion

The variety of approaches and applications that have been reviewed in this entry shows how genealogical classification is an important method in knowledge organization. Despite this, it has been acknowledged and discussed in explicit ways in a very limited number of sources yet. Its action can rather be detected in KO studies invoking related ideas and principles, such as those of evolution, of levels of reality or of levels of knowing.

It has been shown how genealogical classification can be applied to various contexts. These include taxonomies of special sciences, the most famous example being biology but other important cases covering Earth sciences, linguistics and recently cultural artefacts and mentefacts; general classification systems of the sciences or of the academic disciplines as ordered in libraries; and the historical development of disciplines and scholarly approaches themselves.

Genealogical classification is based on knowledge of the evolutionary history of the classified entities. In this sense genealogical classification, and especially its extreme form, cladistics, have been contrasted with such other approaches as phenetics, which starts instead from an empirical observation of similar and dissimilar characters, recommending avoiding any previous theoretical assumption—provided this is possible at all. Genealogical classification can also be contrasted with the top-down, rationalistic approach of logical division as applied in Porphyry Tree, which was an illustration of Aristotle's logic. On the other hand, in his zoological works Aristotle seemed to recognize that animals can be classified in different ways depending on the scientific purpose (Henry 2011).

In general, this author agrees with Szostak's opinion that both top-down and bottom-up approaches can be inte-

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grated in the development of optimal knowledge organization systems, as part of a pluralistic approach (cf. Szostak 2015). Indeed, knowledge organization is a complex endeavor which involves several components, both ontological (multiple levels at which knowledge is produced, including organic, psychic, social, and cultural) and epistemological (alternative approaches, including rational, pragmatist, etc.). As the same objects can be addressed by a variety of methods, theories and categorial frameworks (Körner 1970), it makes sense that each of them is considered. Explicitly discussing every principle as a separate component, as done in this encyclopedia, is an important requisite for the maturation of the KO field.

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