Commentary

One-Dimensional Systematist: Perils in a Time of Steady Progress

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This commentary offers a critical assessment of the molecular age of biological systematics and deals with certain basic tendencies that seem to indicate a new phase of the discipline. These tendencies have engendered a prevalent one-dimensional thought that undermines the very foundation of systematics. This new phase has produced an advanced state of conformity with its consequent stifling of criticism, restricting the legitimization of problems and methods, research priorities, and last but not least, job opportunities and modes of organization of institutions.

Biological systematics is a multidimensional scientific discipline that describes, names, classifies, and determines relationships among the Earth’s biota. It accomplishes these deeply interdependent tasks through surveys, inventories, collections, description of species, phylogenetic reconstruction, hierarchical classifications, monographing, and application of rules of nomenclature. All these activities, except phylogenetic reconstruction, are encompassed by the sub-discipline named taxonomy (Wilson 2003).

Systematics provides a reference system for the whole of biology and therefore can be seen as both the most basic and the most wide-ranging area of biology. It is the most basic because organisms cannot be discussed or treated in a scientific way until some classification has been achieved to recognize them and give them names. It is the most wide-ranging because it gathers together and summarizes everything that is known about the characteristics of organisms, whether ecological, morphological, physiological, genetic, or molecular.

Beneath the fundamental scientific importance of systematics for biology, lies a growing urgency. The roughly 1.7 million species known to science to date probably represent at best fewer than 15% of the actual number. Of the named species, it is estimated that less than 1% have been studied beyond the essentials of geographic location, habitat preference, and diagnostic morphology. At the same time, thousands of species (known and unknown) are threatened by imminent extinction (Raven 2002).

Were we required to characterize the current age of systematics by any single epithet, we should be tempted to call it “the molecular age.” Molecular data have provided a new class of features that allow not only phylogenetic reconstruction of closely related taxa, but also broad scale comparisons across all organisms from bacteria to mammals and plants. Unquestionably, we are witnessing an extraordinary time when molecular systematics is generating an unprecedented revolution within the discipline (Daly et al. 2001).

Despite the tremendous advances, there are profound perils in the molecular age of systematics: 1. An unbalanced emphasis favoring phylogenetic reconstruction based on molecular data at the expense of taxonomy; 2. A narrow research program that ignores many aspects of organismal biology and fragments systematics; 3. An unbalanced education of the new generation of systematists; 4. A depreciation of natural science collections as part of a broader trend away from organismal biology; 5. A slowdown of taxonomic work that will affect the conservation of biodiversity; and 6. An intellectual climate that marginalizes those with different views. I will briefly elaborate on these perils and their consequences.

An Unbalanced Emphasis. Taxonomy was once the proud flagship of the natural sciences. Charles Darwin, the founder of the theory of natural selection, working in Cirripedia (barnacles) in the 19th century and Willi Hennig, the founder of modern phylogenetic reconstruction, working in Diptera (flies) in the 20th century, were both practicing taxonomists. However, in the last 30 years taxonomy has seen a gradual loss of credibility among fellow scientists. This image problem is based on misconceptions of how taxonomy works. The view that taxonomy is a purely descriptive branch of knowledge that consists only of observations (Anonymous 2004) is a clear example of these misconceptions. In fact, taxonomy is a scientific discipline that requires description, but also theoretical, empirical and epistemological rigor, a hypothesis-driven approach, and field and lab expertise (Stuessy 1990; Carvalho et al. 2005).

Furthermore, classification systems are hypotheses. A taxon, the basic unit of taxonomy, is a classification system and as such is a scientific hypothesis about order in nature (Thiele and Yeates 2002). Like every scientific hypothesis, a taxon goes beyond the evidence (observations) for which it purports to account. That is, a taxon has greater scientific content (e.g., predictive capability and explanatory power) than the empirical
propositions it covers. This taxon-hypothesis, once its scientific content is tested and corroborated, permits scientists to study aspects of biology other than systematics (ecology, biogeography, comparative physiology, comparative morphology, genetics, conservation, etc.).

Simultaneous with the image problem of taxonomy and linked to it, there has been an overwhelming focus on molecular-based phylogenies among funding agencies, research institutes, universities, and journals that publish high-profile systematic research, which has led to tremendous advances. However, these advances have come at a cost: a lack of interest (funding, job opportunities, and publication venues) in the general area of taxonomy (Kruckeberg 1997; Lammers 1999; Wilson 2000; Landrum 2001; Wortley et al. 2002; Scotland et al. 2003; Wheeler 2004).

Reliance on the Science Citation Index (SCI, or Impact Factor) as a measure of “good science” contributes to this unbalanced drive (Valdecasas et al. 2000), since fewer and fewer journals are available to taxonomists for publishing their work. Compounding the problem, the SCI draws its statistics from the number of authors citing a paper during a short period of time (ten years), whereas a taxonomic work usually has few citations in the first ten years but lasts longer in the “citation world” (i.e., has a longer “citation half-life”) than any molecular paper.

A Narrow Research Program. Systematics is faced with several superimposed levels of integration of structures and functions, including molecules, organisms, populations, and species.

The dominant discourse in the discipline has a strong emphasis on the molecular level at the expense of the organismal level. Evidence of this narrow research program includes recent attempts toward the molecularization of taxonomy (DNA barcoding) using a few chosen (“standard gene”) sequences across all organisms to discover, characterize, and distinguish species, and to assign unidentified individuals to species (Tautz et al. 2003). On the other hand, this molecularization of taxonomy appears inadvisable for both practical and theoretical reasons (Dunn 2003; Lipscomb et al. 2003; Seberg et al. 2003; Lee 2004; Will and Rubinoff 2004).

Most of the information about organisms (morphological, anatomical, physiological, cytological, ecological, etc.), which is of interest and of use for understanding their nature and evolution, is of course, in some way determined from information at the molecular level; however, it is unrecoverable from data at this level. Such emergent properties must be studied directly, and an extreme emphasis on the molecular level leaves little or no time and effort for the search for new properties at the organismal level.

Importantly, although in microbial organisms it is possible to get information about organismal diversity and phylogeny using only molecular data (e.g., De-Long and Pace 2001), in general, molecular systematics requires a taxonomic framework with information at the organismal level in order to be more generally useful.

Lastly, a consequence of a narrow research program is a fragmentary approach to nature. Fragmentation in science arises when an attempt is made to impose divisions in an area of knowledge in an arbitrary fashion, without regard to a wider context (Bohm and Peat 2000). An analogy from human vision will help us to see the perils of a fragmentary approach in science. The details of what we see are picked up in a small central part of the retina called the fovea. If this is destroyed, then detailed vision is lost, but general vision, which comes from the periphery of the retina, remains. But if the periphery is damaged, while the fovea remains intact, even the details lose all their meaning. By analogy, systematics is in danger of suffering a similar “damage” to its vision. By giving so much emphasis to molecular data, systematics is losing sight of the indispensable wider context of its field of study.

An Unbalanced Education. In 1970, two systematist-statisticians, Robert R. Sokal and F. James Rohlf, published a paper entitled, “The intelligent ignoramus” (Sokal and Rohlf 1970). They discussed the establishment of relationships among organisms (= “phylogenetic reconstruction” in modern terms). They asked: Are the differences between different hypotheses of relationships due more to the difficulty of choosing appropriate characters, or to processing extensive and complex information? If the former is true, there is a good reason to value deep experience in a particular group of organisms. If the difficulties are mainly those of processing complex information, an inexperienced worker should be able to choose characters that give a satisfactory hypothesis. They described a worker ignorant of the particular taxon to be studied but trained in the techniques of collecting characters and analyzing them with numerical computational methods. After a series of experiments Sokal and Rohlf predicted a future where technicians, untrained in taxonomy, could generate acceptable hypotheses of relationships through automation of the data-gathering process and a numerical computational analysis of the data. It seems that Sokal and Rohlf’s “future” is the current curriculum of most universities, since the new generation of systematists is strongly specialized on gathering molecular data and analyzing them with the use of computer algorithms, with little instruction in taxonomic work, such as collections, identification, description of species, construction of keys, delimitation of gross and ultrastructural morphological characters,
chromosomal work, nomenclature, etc. (Sytsma and Pires 2001).

From time to time, systematics (as with any other scientific discipline) needs a labor of reconstitution as a necessary contribution to its own advance. This demands an effort towards unification involving broad areas of biological knowledge, areas that lie outside the extreme specialization of an intelligent ignoramus. The late Lawrie Johnson, an outstanding Australian systematist, wrote in 1968 (Johnson 1968) “If systematics is made into a sterile exercise, a purely pragmatic service, or a playground for technicians, I would advise intelligent young biologists to steer well clear of it.”

A Depreciation of Natural Science Collections. Specimens in natural science collections are preserved to document the presence of organisms in given localities at a given time, to validate past research, and to be available for future research. Specimens also represent a sample of a region’s natural and cultural environment; preserving them is to preserve humanity’s environmental heritage. The plight of a growing number of natural science collections has received some attention in scientific journals (e.g., Dalton 2003). Cutbacks are attributed largely to poor state budgets, but some biologists (Gropp 2004) believe the problem is due to a bias of some university and museum administrators towards molecular biology.

On the other hand, it is clear that a broader trend away from organismal biology will include, inevitably, a depreciation of natural science collections. For instance, the recent characterization by some editors of voucher information (the specimens examined in a study) as “supplementary material” and the fact that many phylogenies based on molecular data have been published without any information on specimens examined, are probably a side effect of the molecular age. This indifference to vouchers by some editors and some researchers is a step back in systematics, since repeatability is the cornerstone of the scientific method and vouchers are the basis of the reproducibility of results (Ruedas et al. 2000; Funk et al. 2005; Kristiansen et al. 2005).

A Slowdown of Taxonomic Work. Through the Convention on Biological Diversity, governments have acknowledged the existence of a “taxonomic impediment” to the sound management of biodiversity. This “taxonomic impediment” results from the knowledge gaps in our taxonomic system, the shortage of trained taxonomists and curators, and the impact these deficiencies have on our ability to conserve, use, and share the benefits of our biological diversity. The Global Taxonomy Initiative (GTI) is a program that has been established by the Conference of the Parties of the Convention on Biological Diversity to reduce the taxonomic impediment, and thereby to improve decision-making in conservation, sustainable use, and equitable sharing of the benefits derived from biodiversity.

A recent report by the House of Lords of the United Kingdom (2002) pointed out that the science of systematic biology is a vital discipline that underpins the conservation of the Earth’s biodiversity and recommended to its government strong support of taxonomic work and major fundings to natural history collections. Working in the same direction are programs such as the United States National Science Foundation’s PEET: Partnerships for Enhancing Expertise in Taxonomy (Rodman and Cody 2003). The GTI, the House of Lords’ report, and the PEET program explicitly recognize the societal value of taxonomy and the need of good taxonomy for the conservation of biodiversity.

An Intellectual Climate. Systematics, as with any other human activity, has a social context. Peer pressure plays a significant role in shaping the spirit of the age. Social scientists have studied how the climate of opinion depends on who speaks and who keeps quiet, and describe the process as a “spiral of silence” (Noelle-Neumann 1993). Observations made in one context spread to another and encourage people either to proclaim their views or to suppress them and keep quiet until, in a spiraling process, one view dominates the public scene and the others disappears from public awareness and their adherents become mute.

This social phenomenon is what Alexis de Tocqueville (1856) described when he wrote in his history of the French revolution: “…dreading isolation more than error, they professed to share the sentiments of the majority… So what was in reality the opinion of only a part… of a nation came to be regarded as the will of all and for this reason seemed irresistible, even to those who had given it this false appearance.”

In this sense, a peculiar dynamic has developed in the molecular age of systematics. Those who are convinced that molecular data are going to be adopted by everyone express themselves openly, and self-confidently defend their views. Those who are against the unbalanced emphasis on molecular data (though most definitely not against its use for phylogenetic reconstruction and other appropriate areas) feel themselves left out; they withdraw and fall silent. That most of those who are unhappy with the current narrowness of focus of the field have been cowed into silence, reinforces the false impression that the current view has stronger intellectual and political support than it indeed has.

Editors, peers, administrators, and policy-makers (though fortunately not all of them) become enforcers of a vox populi-vox dei in systematics. This trend is leading the systematics community to historical amnesia (Nelson 2004) and to a new kind of superficiality (in the most literal sense) where technological advance is equated with conceptual progress (Heads 2005).
Conclusion. The value of molecular data in systematics is undeniable. However, there are profound perils in a strict dominance of its view over the rest of the tasks of systematics. The current atmosphere within the discipline is fostering a trend to what political scientists call “incestuous amplifications” (Krugman 2003), a condition where the decision-makers listen only to those who are already in lock-step agreement with them, reinforcing a set of beliefs and creating a situation ripe for misjudgments. An unbalanced systematics and its aftermath (a narrow research program, one-dimensional education, and deprecation of natural sciences collections) are serious misjudgments in a time of biological extinctions. Systematics is a basic tool in the conservation of biodiversity, and it is only by moving beyond the present fragmentation that the discipline can hope to make a realistic contribution to ameliorate one of the most serious problems facing humanity. On the other hand, it would be dreadful if molecular systematics ended up by swallowing its parent. To prevent this catastrophe from occurring, it will be necessary to realign priorities following a systematics agenda that will ensure a harmonious progress of the discipline.

We are in a time when systematists, particularly taxonomists, are increasingly and distressingly accustomed to hearing themselves defined pejoratively. I write, therefore, as someone who notes his own convictions regarding what systematics is as a whole: a rigorous multidimensional scientific discipline.

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Literature Cited


