yielded to analysis. Our task of reconstructing organismal phylogeny down to species level is still daunting but is beginning to look achievable. Biologists of all stripes are using phylogenies and classifications as frameworks for combining and comparing information in novel ways that few systematists anticipated. The *Systematics without Borders* conference will provide a forum for systematists and other biologists to present the results of their research and to explore the possibilities for collaborating further in the age of integrative biology.

Program

The conference will run from Sunday 1 to Friday 6 December 2013 and will include plenaries, themed concurrent sessions and posters. Post-conference field trips and collection visits to local museums and herbaria are also planned.

Symposia, contributed papers and posters

Expressions of interest from potential participants are now invited as are ideas for symposia of 3–4 talks each (see http://www.systematics2013.org/expression-of-interest/). In line with the conference theme, the organizers wish to encourage contributions that reflect the integration of systematics with other biological disciplines.

For more information and to register your interest, please visit the conference website: http://www.systematics2013.org/

Shane Ahyong

Pictorial History: A review of *Trees of Life* by Theodore Pietsch

Trees of Life: A Visual History of Evolution. Theodore W. Pietsch. The Johns Hopkins University Press, Baltimore. ISBN 978-1-4214-0479-0 (hardcover) xiii + 359 pp. $AU92.

This is a fascinating book. Almost the whole history of systematics is laid out in pictures. It is a treasure trove for anyone who is interested in the history of human thoughts about how to pictorially represent biological relationships; and let's face it, all systematists are historians at heart. So, do your favourite systematist a real favour and buy them a copy of this book sooner rather than later (they cannot afford the price for themselves).

There have been a number of publications discussing the iconography used by evolutionary biologists and its effect on their work (Brace 1981; Stevens 1984; O'Hara 1992; Stevens 1994; Clark 2001; Ragan 2009; Gontier 2011; Tassy 2011). These papers outweigh Ted Pietsch's book in words, but they pale into insignificance when it comes to pictures. There are 230 of them in this book, of all shapes and sizes, representing relationships based on similarity, genealogy or some unspecified form of affinity. Most of them are trees of some sort, but there are also scales, keys, maps and sets. Biologists are ingenious folk, and this book shows you just how ingenious they have been, and in many cases how artistic as well.

The book's blurb claims that "Pietsch has spent decades collecting and researching" for his book, and I can well believe it. The book is arranged roughly in chronological order (1305–2005), and the book tries to illustrate some of the key trends in the history of systematics. It does not always succeed at the latter, as I will elaborate below, but this is a relatively minor quibble. Pietsch provides a brief contextual introduction to each chapter, providing the relevant historical and intellectual background. However, he wisely lets the pictures speak for themselves whenever they can.

Most of the diagrams are very well presented and remarkably clear. I have seen scanned copies of many of the originals (they are available in various repositories on the web, notably Gallica, Google Books, and the Biodiversity Heritage Library), and these are often very poor, as are many of the copies included in other published collections. Therefore, considerable work has been put into cleaning these scans for this book, or making new ones, for which we should be very grateful.

All of the figures are in black and white, although there are colourized versions known of some of the originals (and colour often helps with their comprehension). In most cases the original illustration is presented, but for two of Darwin's unpublished figures later typeset versions are used (Figures 61 & 63), and Figure 63 does not match Darwin's hand-drawn original (see Morrison 2012g). (Pietsch is simply following precedent here, as both published editions of Darwin's correspondence use typeset versions of his figures rather than the manuscript originals.)

Abstract trees were applied first as tools to arrange knowledge and ideas, and from there they were adopted to illustrate relationships among taxa (cf. individuals), notably by Bonnet (in 1764) and Pallas (in 1766). They are complex icons, at least as compared to a chain (eg. the Scala Naturae). As Baum & Smith (2012) have recently noted: "we have learned from working with thousands of students that, without contrary training, people tend to have a one-dimensional and progressive view of evolution. We tend to tell evolution as a story with a beginning, a middle, and an end. Against that backdrop, phylogenetic trees are challenging; they are not linear but branching and fractal, with one beginning and many equally valid ends. Tree thinking is, in short, counterintuitive."

In this context, Pietsch's book is an important one. It shows, on the one hand, just how complex trees can be, and on the other hand it shows just how comprehensible biodiversity can become once we try to organize our thoughts in some rational way. A phylogenetic tree is a metaphor, and we use this metaphor to provide a pictorial representation of our ideas regarding biological relationships. The history of tree iconography is thus the history of systematic thought. More to the point, the future of these trees is the future of systematic thought—we will change our iconography as we change our ideas.

Just as importantly, the tree metaphor provides a quantitative connection between biology and mathematics. Graph theory is a well-developed branch of mathematics, and the tree metaphor connects very well with acyclic line graphs (see Morrison 2012a). This has allowed us to develop objective and repeatable methods for producing trees from phenotypic and genotypic data, thus linking systematics to mainstream scientific activity. Literally, without trees systematics is natural history rather than science. The development of the tree metaphor thus plays a double role in systematics: both as a representation and as an analytical tool. Pietsch's historical compendium neatly summarizes and illustrates this duality.

I have recently spent some time investigating the history of phylogenetic networks (as opposed to phylogenetic trees), and so I feel currently (perhaps temporarily!) competent to comment on some of what I see as the important points that Pietsch makes about changing systematic iconography.

The relationship between dichotomous keys and classifications is mentioned at the beginning of the book. Any key can be treated as a classification system, although not all classifications are easy to represent as keys. However, a key presupposes a classification rather than being one itself—we create a classification of the specimens first, and then afterwards create a key to allow identification of new specimens. There needs be no simple relationship between the classification and the key, as the former is theoretical and the latter practical.

To me, one of the better illustrations of the potential confusion is the continued treatment of Carl von Linné's plant "sexual system" as a classification, in spite of the fact that he clearly labelled its presentation (Linnaeus 1735) as "Clavis Systematis Sexualis" [Key to the Sexual System]. Linné used this system to file away his specimens, both literally in his specimen cabinet and metaphorically in his mind. He knew exactly where to put any new specimen and exactly where to find his old ones. This is an index rather than a classification. He saw his own ability to create an efficient information storage and retrieval system (in modern parlance) as his greatest strength; he was an organizer of knowledge rather than an innovator of ideas.

Moreover, he was perfectly well aware that biological relationships are much more complex than his simple index indicated. Pietsch illustrates this (his Figure 16, Figure 1 here) with the Mappam Affinitatum Genealogico-Geographicam that Paul Giseke appended to Linné (1792). Linné's Aphorism 77 (Linnaeus 1751) had previously specified that: "Plantae omnes utrinque affinitatem monstrant, uti Territorium in Mappa geographica" [All plants show affinities on either side, like territories in a geographical map]; and the published map illustrates the natural orders described in Linnaeus (1751).

The important diagrams of both Buffon (Figure 17) and Duchesne (Figure 20) are represented in Pietsch's book, as these appear to be the first known illustrations of explicitly genealogical relationships among groups of organisms, albeit these are intra-species relationships (see Morrison 2012b, 2012c). Interestingly, both diagrams illustrate hybridization (in dogs and strawberries, respectively), thus making them also the first reticulating networks rather than simple trees.

Charles Darwin actually used a combined metaphor in his most famous publication (Morrison 2012i). The idea of using a tree as an icon to represent time is usually credited to the mystic Joachim of Fiore, in his Liber Figurarum of 1202. Darwin combined this idea with the Tree of Life (ie. immortality), which was originally a biblical image, being contrasted with the Tree of Knowledge (of good and evil) from which Eve and Adam ate the forbidden fruit. According to some scholars, these are in fact two names for the same tree, both being forms of the World Tree that has existed in many cultures (Cook 1974).

Six of the ten tree-like sketches known among Darwin's manuscripts and letters are illustrated by Pietsch (the complete set is shown in Morrison 2012f, 2012g), as is his one and only published tree (a theoretical one). Darwin is usually considered to be the first to explicitly use a tree as a simile for genealogical history in the modern sense (ie. contemporary taxa at the leaves, inferred ancestors at the nodes). Lamarck's earlier

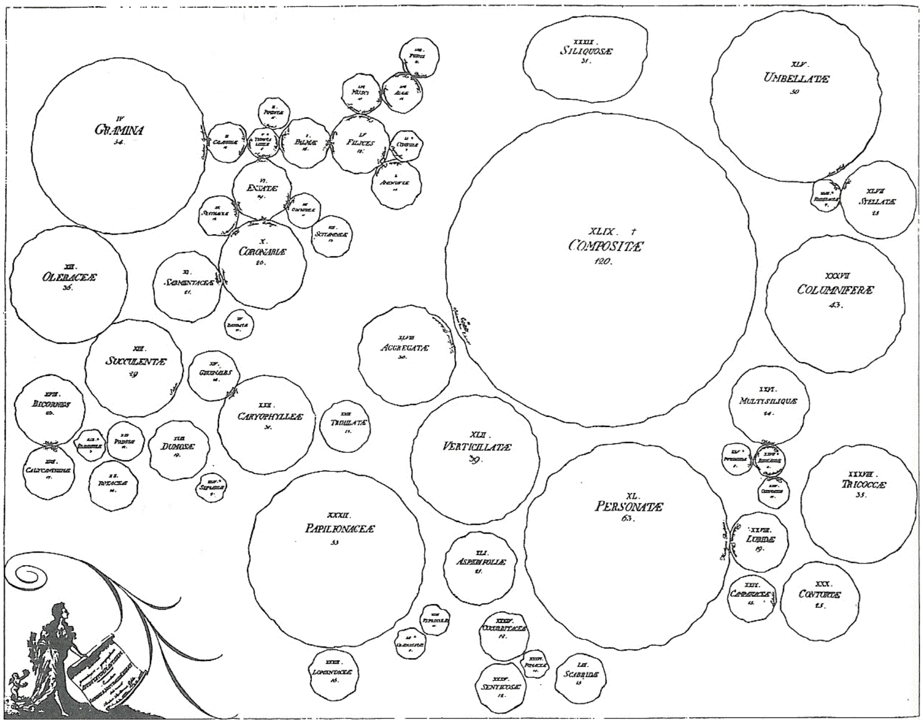

Figure 1. Mappam Affinitatum Genealogico-Geographicam by Paul Giseke.

tree-like diagrams (Pietsch's Figures 24 & 25) were intended to represent transformation series among species groups (based on morphoclines), and thus showed historical descent with modification, but they were not concerned with diversifying evolution in the manner envisioned by Darwin. (Basically, Lamarck did not believe in extinction, and thought that the disappearance of species was due to their transformation into new species.)

Darwin challenged these ideas, insisting on both the origin of new biological forms and the extinction of some of the old forms. He used a multi-stemmed bush as his published icon, but we have always referred to it as a tree. Indeed, it is worth noting that Darwin never explicitly referred to any of his diagrams as a "tree" (although he did refer to phylogeny as "genealogy" and "pedigree"). In *The Origin of Species* he referred to the Tree of Life at the end of the chapter containing his bush-like figure, and later in the book he referred to relationships as being "somewhat like the branches of a tree", but neither of these was a direct reference to any diagram. His well-known Tree of Life metaphor was thus quite independent of his diagrams (see Penny 2011).

Interestingly, Darwin's first tree-like diagrams were actually drawings of corals, accompanied by the text: "The tree of life should perhaps be called the coral of life, [with the] base of [the] branches dead; so that [the] passages cannot be seen". Darwin had, of course, studied corals extensively on the Beagle voyage, and subsequently published his monograph on the development of reefs in 1842. Pietsch does not include either of these two small pictures.

Pietsch then moves on to Ernst Haeckel, who is usually credited with providing the first empirical phylogenetic trees in the modern sense, in 1866 (all eight trees from *Generelle Morphologie der Organismen* are included by Pietsch). However, Haeckel's tree-construction method seems to have owed more to Lamarck than to Darwin, as his diagrams basically illustrated morphoclines (see Dayrat 2003). This is most obvious in his famous Tree of Man (Pietsch's Figure 82, Figure 2 here), which looks very much like the Scala Naturae but with some of the species moved from the main trunk to short side-branches.

Moreover, it was apparently St George Mivart who published the first known empirical tree in 1865, followed by Franz Hilgendorf in 1866, and Albert Gaudry in 1866 (Bigoni & Barsanti 2011; Tassy 2011). Unfortunately, none of these trees are included by Pietsch. However, they are discussed and illustrated by Morrison (2012h).

St George Mivart's (1865, 1867) trees are doubly important because they are the first to depict humans as not being the pinnacle of creation but simply as part of the primate family tree, as well as being trees based on carefully homologized phenotypic data (osteology of the vertebral column, and measures and proportions of all appendicular bones, respectively). Pietsch incorrectly attributes this insight to both Darwin (p. 88) in 1868, who must surely have known of Mivart's works, and also to Haeckel (p. 98) in 1866, who probably did not know; and, besides, Huxley (1863) had already considered the question even though he did not draw a tree. (Note: Darwin signed Mivart's 1867 request for admission to the Royal Society, and the 1867 paper was used in support of that application; Bigoni & Barsanti 2011.)

The most visually strong phylogenetic trees of the 20th century were drawn by William King Gregory, and Pietsch justifiably devotes more space in the book to him than to anyone else (Figures 157–173). Gregory was an artist by disposition as well as a comparative zoologist, and most of his trees included drawings of the organisms concerned (an innovation attributed by Pietsch to Benjamin Gruenberg in 1919). More importantly, Gregory was usually concerned about the time dimension of his trees, which was then included in the diagrams in some way. He was also the most prolific popularizer of trees known, although it must be admitted that some of his trees seem to contain almost no actual phylogenetic information (eg. Figure 166).

As an aside, I've sometimes wondered why Ernst Haeckel himself never drew organisms on his trees. He had two passions in life: art and science (he saw the universe as an infinite unfolding work of art, and a scientist's job was to portray it with both accuracy and passion). He could have satisfied both of these desires with his trees. It thus seems contradictory that his trees became more stick-like through time (as illustrated by Pietsch) rather than becoming more artistic. Thus, we are left to marvel at his immaculate sketches and paintings (Haeckel 1904) independently of his trees.

Willi Hennig has several of his theoretical diagrams illustrated in the book (Pietsch's Figures 190-192), which is mandatory, but there is nothing from Herb Wagner, whose groundplan-divergence method for reconstructing phylogeny anticipated Hennig's approach (Wagner 1961). Zuckerandl & Pauling's pioneering molecular tree from 1965 is included (Figure 198), along with those of other originators of molecular phylogeny (eg. Fitch, Goodman, Sarich, Sibley, Woese), although the initial sequence-based work of Morris Kreitman (1983) is sadly absent. Clearly, Pietsch's book could easily have been much bigger than it is.

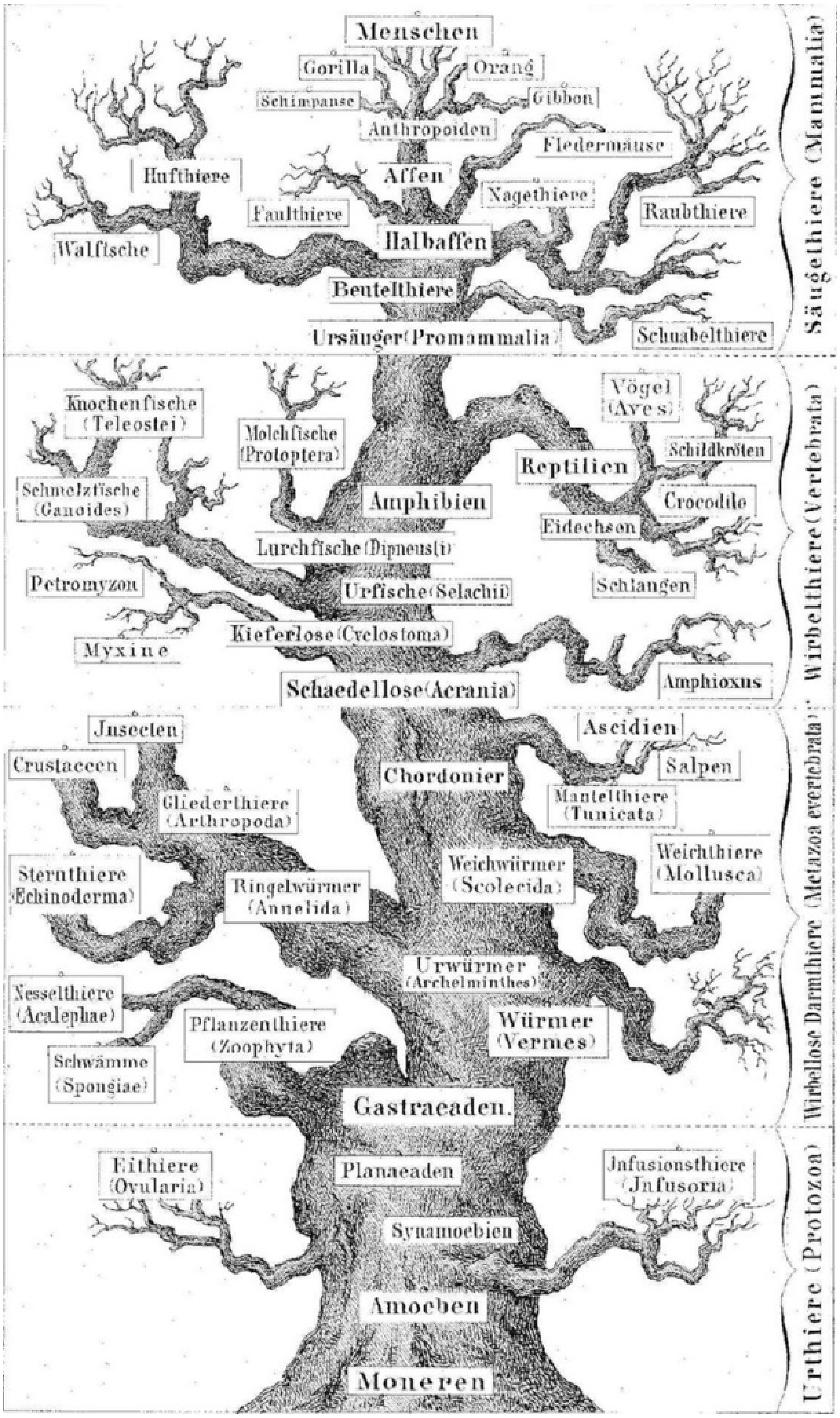

Figure 2. Haeckel's 1874 Tree of Man.

If I was to make one general complaint about the book it would be the relative lack of network illustrations. Historically, there were quite a number of these between 1760 and 1960, as discussed (and illustrated) by Morrison (2012d, 2012e); and it looks very much like there will be many additional ones in the future, especially in botany (where reticulation is caused by hybridization) and bacteriology (where it is caused by horizontal gene transfer). So, Pietsch may have missed a good bet by not including more networks, along with some pertinent comments about the future. Nevertheless, the book does include a selection of the numerous "webs, nets, maps, or other basically horizontal, planar, reticulating structures" (Stevens 1984) produced by biologists over the years.

Every time I dip into this book I find something new: every time I look at one of the pictures I find an interesting new feature, or gain a new insight into what the originator was trying to communicate. I may well have learned more about systematics from this one book than from anything else I have ever read. What good this will do me I don't know, but it has been a hell of a lot of fun. I hope that you get to enjoy the book for yourselves.

David Morrison
Section for Parasitology (SWEPAR)
Swedish University of Agricultural Sciences
751 89 Uppsala
Sweden

References

Baum, D.A., Smith, S.D. (2012) *Tree Thinking: An Introduction to Phylogenetic Biology*. Roberts & Company Publishers, Greenwood Village, CO.

Bigoni, F., Barsanti, G. (2011) Evolutionary trees and the rise of modern primatology: the forgotten contribution of St. George Mivart. *Journal of Anthropological Sciences* 89: 93-107.

Brace, C.L. (1981) Tales of the phylogenetic woods: the evolution and significance of evolutionary trees. *American Journal of Physical Anthropology* 56: 411-429.

Cook, R. (1974) *The Tree of Life: Image for the Cosmos*. Thames & Hudson, London.

Dayrat, B. (2003) The roots of phylogeny: how did Haeckel build his trees? *Systematic Biology* 52: 515-527.

Gontier, N. (2011) Depicting the Tree of Life: the philosophical and historical roots of evolutionary tree diagrams. *Evolution: Education and Outreach* 4: 515-538.

Haeckel, E. (1904) *Kunstformen der Natur*. Verlag des Bibliographisches Instituts, Leipzig & Wien.

Huxley, T.H. (1863) *Evidence as to Man's Place in Nature*. Williams & Norgate, London.

Kreitman, M. (1983) Nucleotide polymorphism at the alcohol dehydrogenase locus of *Drosophila melanogaster*. *Nature* 304:412-417.

Linnaeus, C. (1735) *Systema Naturae*. Theodorum Haak, Leiden.

Linnaeus, C. (1751) *Philosophia Botanica*. G. Kiesewetter, Stockholm, & Z. Chatelain, Amsterdam.

Linné, C. von (1792) *Praelectiones in Ordines Naturales Plantarum*. B.G. Hoffmann, Hamburg. [Transcriptions by Johann Christian Fabricius and Paul Dietrich Giseke of Linn's posthumous collection of lectures about plant families.]

Mivart, St G. (1865) Contributions towards a more complete knowledge of the axial skeleton in the Primates. *Proceedings of the Zoological Society of London* 33: 545-592.

Mivart, St G. (1867) On the appendicular skeleton of the Primates. *Philosophical Transactions of the Royal Society of London* 157: 299-429.

Morrison, D. (2012a) Primer of phylogenetic networks. http://acacia.atspace.eu/Tutorial/Tutorial.html

Morrison, D. (2012b) The first phylogenetic network (1755). http://phylonetworks.blogspot.com/2012/02/first-phylogenetic-network-1755.html

Morrison, D. (2012c) The second phylogenetic network (1766). http://phylonetworks.blogspot.com/2012/04/second-phylogenetic-network-1766.html

Morrison, D. (2012d) Networks of affinity rather than genealogy. http://phylonetworks.blogspot.com/2012/05/networks-of-affinity-rather-than.html

Morrison, D. (2012e) Networks of genealogy. http://phylonetworks.blogspot.com/2012/05/networks-of-genealogy.html

Morrison, D. (2012f) Charles Darwin's unpublished tree sketches. http://phylonetworks.blogspot.com/2012/06/charles-darwins-unpublished-tree.html

Morrison, D. (2012g) Charles Darwin's unpublished tree sketches, Part 2. http://phylonetworks.blogspot.com/2012/06/charles-darwins-unpublished-tree_27.html

Morrison, D. (2012h) Who published the first phylogenetic tree? http://phylonetworks.blogspot.com/2012/08/who-published-first-phylogenetic-tree.html

Morrison, D. (2012i) Relationship trees drawn like real trees. http://phylonetworks.blogspot.com/2012/11/relationship-trees-drawn-like-real-trees.html
O'Hara, R.J. (1992) Telling the tree: narrative representation and the study of evolutionary history. *Biology and Philosophy* 7: 135-160.
Penny, D. (2011) Darwin's theory of descent with modification, versus the biblical Tree of Life. *PLoS Biology* 9: e1001096.
Ragan, M. (2009) Trees and networks before and after Darwin. *Biology Direct* 4: 43.
Stevens, P.F. (1984) Metaphors and typology in the development of botanical systematics 1690–1960, or the art of putting new wine in old bottles. *Taxon* 33: 169-211.
Stevens, P.F. (1994) *The Development of Biological Systematics: Antoine-Laurent de Jussieu, Nature, and the Natural System*. Columbia Uni. Press, New York.
Tassy, P. (2011) Trees before and after Darwin. *Journal of Zoological Systematics and Evolutionary Research* 49: 89-101.
Wagner, W.H. (1961) Problems in the classification of ferns. In: *Recent Advances in Botany*, pp. 841-844. Univ. Toronto Press, Toronto.

Polychaete conference and general taxonomic workshops

Australian Museum, Sydney, July–August 2013

In July and August 2013 the Australian Museum Sydney, will be hosting the 11th International Polychaete Conference and several associated taxonomic workshops which are likely to be of interest to members of the Society of Australian Systematic Biologists. Please note that the workshops have a lower class limit and will not be held if numbers do not exceed this.

The **11th International Polychaete Conference** will take place on 4–9 August 2013 with program themes including ecology, evolutionarly biology, phylogeny and reproduction of polychaete worms. Keynote speakers and their topics include Dr Jim Gehling (evidence for ancestors of modern protostomes among the Ediacara faua), Prof. Damhnait McHugh (current understanding of annelid evolutionary relationships), Dr Günther Purschke (a morphological perspective on annelid systematic and evolution) and Prof. Pei-Yuan Qian (molecular mechanisms of larval attachment and metamorphosis). The conference website (http://www.ipc2013.com.au/) is now open for registrations and submission of poster and oral presentations. Early registrations close 31 March 2013. Three pre-conference workshops will take place in the week preceding the conference and are not restricted to those attending the Polychaete Conference:

On Monday 29 July to Friday 2 August 2013 Dr Kirk Fitzhugh (Natural History Museum of Los Angeles County) will present a course on the **Philosophy of Biological Systematics**. This one week course offers a unique opportunity for participants to acquire an understanding of the philosophical and scientific foundations necessary for systematics practice, and will provide clear-cut guidelines for how to critically assess the worthiness of methods. Details of the topics to be covered are provided under the link "Pre-Conf Workshops" at http://www.ipc2013.com.au/. Course notes will be made available as pdf files with associated notes.

On 1–2 August 2013 Dr Pat Hutchings, Dr Elena Kupriyanova, Dr Robin Wilson and visiting international and Australian specialists to the Polychaete Conference will present a workshop on **Identification of Invasive Polychaetes**. This course is designed for environmental consultants, fisheries staff, quarantine officers and port authority officers and will have a particular focus on those polychaetes families which have been most often introduced to Australia: Sabellidae, Serpulidae and Spionidae. Each participant will receive a book with detailed pictorial keys to introduced species and closely related native species, as well as illustrated descriptions of each of the listed introduced species and those listed as potential invasives. Participants will be shown the