some rare species and some of the exotic (introduced species) have not been included by the author. But the author has taken care to incorporate the very latest works done in most of the taxa – e.g. some new descriptions of species, some extended distributions and misinformation which have been noted later – have been added.

The systematic accounts of genera have been arranged according to their known phylogenetic affinities. The orders Osteoglossiformes and Clupeiformes have been dealt with first, followed by the other orders like the Cypriniformes, Siluriformes and the orders belonging to the superorder Protacanthopterigii, Cyclosquamata and Acanthopterygii. Each account begins with the salient features of the superclass given in brief along with the distribution of the group and the number of the orders described. A key for identifying each order follows this. Once that is done, a more elaborate description of each order has been provided along with the families covered within each order. Again within each family, a set of diagnostic features for that family is given along with the range of distribution and the number of genera belonging to that family. Elaborate descriptions of each genus are given, including information on the naming of the genus, its diagnosis, distribution and the number of species of the given genus. At places the author has also given additional information on the importance of a genus in terms of commercial value and life-history patterns like migration and spawning habits and also peculiar feeding habits which give interesting additional information about the genus. For groups where there have been ambiguities in the placement or their naming, the author has carefully added them as remarks or as footnotes. A description of each genus is concluded with a list of species belonging to that genus along with its range of distribution. At least one figure of a representative species of the genus is given and this is followed by a key to the species. The most impressive feature of the book is the excellent quality of these diagrams and figures, which makes identification so much easier. The diagrams are very clear and have legends wherever new or peculiar features have been depicted. It would be too much to ask for to have further descriptions of each species and still want it to remain an easy reference single volume handbook! But an elaborate description of each species is hardly a requirement for most researchers and fieldworkers who want an identification of their fresh specimens in the field itself. One feature, which is lacking in this book though, is the absence of fin formulae for species. A useful feature, which could have been added in this volume, would have been a description of the fin formula and how it is prepared, which is important for every fish biologist.

A very comprehensive bibliography wraps up the volume (more than 650!) covering almost all work done so far on Indian fish species as well as relevant works done in other regions. It would be very useful for further reading if any researcher needs additional information on specific taxa or topics. This book is a must for every student of ichthyology to possess as a ready reference to fish identification.

ANURADHA BHAT

Centre for Ecological Sciences,
Indian Institute of Science,
Bangalore 560 012, India
e-mail: anuradha@ces.iisc.ernet.in

Levels of Selection in Evolution. L. Keller (ed.). Monographs in Behavior and Ecology. Princeton University Press, 41 William Street, Princeton, NJ 08540, USA. 1999. 272 pp. Price: US $ 59.50.

The quest for immortality was what drove Medea to kill her sons. 'I will make your children immortal', said Hera, 'if you lay them on the sacrificial altar in my temple[1].' Medea, the daughter of King Ætes, had magical powers, which she used to help Jason bring back the Golden Fleece to Corinth. Medea bore Jason two sons, but he later rejected her in favour of Glauce, daughter of King Creon. Medea murdered Glauce by gifting her poisoned garments which burst into flames when she wore them. The conflagration also killed King Creon and many others in the palace. Zeus fell in love with Medea for her angry, retaliatory spirit and attempted to seduce her but she repulsed all his advances. Grateful Hera, wife of Zeus, promised immortality to Medea's sons, and Medea herself sped away in a chariot drawn by winged serpents.

The quest for immortality is at the centre of all theory and investigation of evolution by natural selection. It is the basis of Orgel and Crick's selfish DNA and Dawkins' selfish genes. Although evolution also occurs by random genetic drift and by fixation of neutral alleles, it is the driving force of natural selection which largely confers immortality or death. Although the 'survival of the fittest' is a tautology, it is only the fittest who are on the road to immortality.

For decades, the long-standing debate in evolutionary biology has concerned the units of selection. What is the level at which selection acts? Does it act at the level of codon, gene, individual, kin, group, species, clade, lineage and so on? Which level is really 'visible' to the force of natural selection? This has led to the distinction between replicators and vehicles[2,3] and replicators versus interactors[4]. A replicator (which may include both genetic and non-genetic cultural elements such as memes) must possess the general criteria of longevity, fecundity and fidelity and must pass on its structure directly in replication, while an interactor is an entity that directly interacts as a cohesive whole with its environment in such a way that replication is differential[4]. In this sense, sections of DNA or genes are replicators while the individual organism is an interactor. For Dawkins, 'the unit of selection [in the sense of a replicator] must be a unit that is potentially immortal'[5,6], i.e. for a replicator to be a unit of selection it should have low levels of change due to mutation or recombination. In this sense, a non-clonally, sexually reproducing organism can never be a unit of selection because it can never exactly reproduce itself (sexually reproducing eukaryotic organisms pay the cost of sex, whereby only 50% of the genome is transmitted to each offspring), and can therefore never achieve immortality. This then is the paradox of the individual. Can this paradox be resolved only if the individual is considered as a vehicle for the self-promoting, immortality-seeking replicators that it contains?

The discovery of a variety of selfish elements in the nuclear and cytoplasmic genome that engage in intragenomic conflict, gives credence to this approach.

Some of these selfish units are transposable elements, meiotic drive genes on X or Y chromosomes which result in an excess of male or female gametes by over-replication or by inhibiting gametes that do not possess the gene, post-zygotic maternal-effect lethal distorter genes which kill progeny not receiving the gene from their mothers, and mitochondrial genes that cause cytoplasmic male sterility in hermaphrodite plants. Not surprisingly, the maternal-effect lethal distorter-gene discovered in the *Tribolium* beetle has been christened *Medea*[7]. Besides these self-promoting entities which inhabit the genome, recently discovered maternally-inherited bacterial agents (especially the rickettsia *Wolbachia*) have been found to cause cytoplasmic feminization of genetic males, male killing and cytoplasmic incompatibility wherein all or nearly all the progeny of the union between an infected sperm and an uninfected egg die (reviewed in Hurst *et al.*[8]). For cytoplasmic genetic elements which are typically uniparentally inherited through maternal transmission, males are an evolutionary *cul-de-sac*; hence male killing or feminization of males is the strategy of choice.

Obviously, self-promoting genetic elements if uncontrolled would hijack the genome, to the disadvantage of other genes and other alleles. This has led to the establishment of suppressor or repressor genes which control these rogue elements. Leigh's 'parliament of genes' actually works. Has meiosis therefore evolved largely to ensure a fair chance to any of a pair of chromosomes to be transmitted, thus breaking the monopoly of any particular homologue? Has recombination arisen largely as a means to restrict sizes of linkage groups and to prevent establishment of meiotic drive allegiances[9]? Have chromosomes evolved to facilitate this random assortment and segregation of genes[8], which is the hallmark of classical Mendelian genetics? Why is organelle-DNA paternally or biparentally inherited in gymnosperms and several angiosperms while it is maternally inherited in animal taxa? Mendel's view of the gene-world was an equitable one, but now there is so much evidence of non-Mendelian transmission, of genes that are just not playing fair.

If the paradox of the individual has been resolved by the discovery of these self-promoting genetic elements, and if it is therefore generally accepted that genes are units of selection, this raises the issue of how the individual can be defined and whether it really matters. For example, in plants which do not have strict germ-line sequestration, and where many individuals are somatic mosaics, what is *the* individual? Other complications arise in haplodiploid species such as honey bees. A honey bee colony in which there is high relatedness between workers (assuming that the queen is not multiply-mated) has often been considered as a super-organism (one colony with one queen = one organism), and colony-level selection is often invoked. But here too, there are genetic conflicts of interest between queens and workers and between workers themselves. Workers sometimes lay unfertilized eggs which develop into sons and thus escape the hegemony of the queen. However, when the queen has mated with more than one male, the workers are less related to other workers than they are to the queen and therefore the workers are on average more related to queen-produced sons than to worker-produced sons. This can result in workers actively preventing each other's reproduction by destroying worker-laid eggs via a 'disciplinary' behaviour called worker-policing. The super-organism can break down in anarchy in the absence of control.

Still other complications arise from the important issue of the short-term versus the long-term. Is evolution always controlled by the shortest time scale operating[10]? Short-term fitness benefits to feminizing cytoplasmic agents may result in severely skewed sex-ratios resulting in the extinction of the species in the long-term. Or uncontrolled growth of cells causing tumours can result in the death of the individual. Since natural selection is blind to the future, is it bottom-up forces (selection acting on genes, linkage groups, chromosomes, cells, individuals, groups, species and so on up the hierarchy) that will control evolutionary patterns viewed at higher levels or is it top-down forces that really matter (e.g. selection between trait groups that can cause the increased survival of individuals with a certain trait, and thereby influence gene frequencies at the lowest level)? Selection may act on any or all of these levels simultaneously based on differential survivability and reproductive success of replicators and their vehicles.

In the Darwinian universe of selfish interests, rational decisions at the individual level dictate that defection and not cooperation is the stable strategy in the prisoner's dilemma game despite the fact that the payoffs to mutual defectors are less than if the two players cooperated. How then can cooperation be ensured and protected against defection? In the absence of kin selection and high levels of inclusive fitness, the maintenance of cooperation in complex societies like human society can only be ensured by a form of social contract (sensu Rousseau[11]) which in turn will require policing to ensure that the contract is upheld. War crime tribunals, justice departments, and the recent recommendation by a government to split up a huge corporation into smaller companies to 'punish' the giant for using monopolizing tactics by sneakily transmitting certain components into a software package in order to flood the market, are all examples of the need to maintain a balance of power, and a regulation of the quest for immortality. This is why Leigh[12] states, 'Finally, evolutionary studies of social animals suggest that truth, beauty and goodness are not totally beyond the reach of evolutionary biology.'

All these fascinating and fundamental issues are the subject of this book which is vast in scope and is a collection of elegantly written chapters by various authors. Here is Eors Szathmáry on the first replicators, Egbert Leigh on the 'common good', Charles Godfray on parent–offspring conflict, Keller and Reeve on conflicts in insect societies, John Maynard Smith on human conflict and cooperation, Edward Herre on species-interactions using the fig and fig-wasp mutualism as a model system, Leonard Nunney on lineage selection, Kitchen and Packer on complexity in vertebrate societies and several others. This is a very high-quality book which has brought together theoreticians and empiricists and has explored all levels of selection from the first autocatalytic molecular hypercycles to the rise of highly complex co-operatives. There is much here to debate, to ponder and to learn. I recommend this book very strongly to any scientist who has contemplated the virtues and meaning of immortality.

1. Graves, R., *The Greek Myths*, Penguin, England, 1992.

2. Dawkins, R., *Z. Tierpsycholo.*, 1978, **47**, 61–76.
3. Dawkins, R., in *Current Problems in Sociobiology* (eds King's College Sociobiology Group), Cambridge Univ. Press, 1978, pp. 45–64.
4. Hull, D. L., *Annu. Rev. Ecol. Syst.*, 1980, **11**, 311–332.
5. Williams, G. C., *Adaptation and Natural Selection*, Princeton University Press, New Jersey, 1966.
6. Dawkins, R., *The Selfish Gene*, Oxford University Press, Oxford, 1976.
7. Beeman, R. W., Friesen, K. S. and Dennell, R. E., *Science*, 1992, **256**, 89–92.
8. Hurst, L. D., Atlan, A. and Bengtsson, B. O., *Q. Rev. Biol.*, 1996, **71**, 317–364.
9. Haig, D. and Grafen, A., *J. Theor. Biol.*, 1991, **153**, 531–558.
10. Nunney, L., in *Levels of Selection* (ed Keller, L.), Princeton Univ. Press, 1999, pp. 238–252.
11. Rousseau, J-J., *The Social Contract*, 1762, Translated by Maurice Cranston, Penguin, England, 1968.
12. Leigh, E. G. Jr., in *Levels of Selection* (ed Keller, L.), Princeton Univ. Press, 1999, pp. 14–30.

RENEE M. BORGES

Centre for Ecological Sciences,
Indian Institute of Science,
Bangalore 560 012, India
e-mail: renee@ces.iisc.ernet.in

Edited and published by P. Balaram and S. Ramaseshan, Current Science Association, Bangalore 560 080.
Typeset by R D Typesetters, Bangalore (Ph: 3405672). Printed by Lotus Printers, Bangalore (Ph: 3209909).

PERSONAL NEWS

S. P. Nautiyal – An obituary

On the afternoon of 5 April 2000, India lost a great institution-builder, a visionary technocrat, an innovative earth scientist. Establishing the Mineral Exploration Corporation of India as its Chairman and Managing Director (1972–1975), Nautiyal launched a massive programme of prospecting for commercial utilization of economic mineral deposits of India. As Chairman of the Uttar Pradesh (UP) State Hill Development Corporation (1975–1977) and the UP State Mineral Development Corporation (1975–1977), he set out the agenda for economic development of Uttaranchal. Under his vibrant stewardship (1977–1980) Wadia Institute of Himalayan Geology graduated from a small centre with tenured life to a national institution of excellence. When he was at the helm of affairs (1988–1991), the Garhwal University found a new campus and a new thrust in development initiatives.

Nautiyal changed the tenor and tempo of whichever organization he headed. As the representative of the Geological Survey of India (GSI) – and building strong teams of devoted and earnest earth scientists – he laid the foundation of systematic mapping and mineral exploration in Nepal and Bhutan. He is among the pioneers – the founding members of the team – which launched the Oil and Natural Gas Commission (now a giant oil corporation). He carried out exploration for potash in Ethiopia; in Iran he investigated the salt deposits; and in Iraq he looked for rock phosphate. In the GSI

under the leadership of J. B. Auden, he was instrumental in laying the firm foundation of the division of engineering geology for geotechnical investigations of water-resource development projects, in the Himalaya and elsewhere. In the earlier years of his service in the GSI – which he joined in 1941 – he carried out brilliant petrogenetic studies, and embarked on a regional survey for economic mineral deposits in Uttaranchal.

Satyeshwar Prasad Nautiyal was born on 16 June 1914 in a remote hamlet in the Alaknanda Valley in the Garhwal Himalaya. He had early schooling in his village and at Roorkee where his father was in service in the army. Passing his intermediate examination from Ewing Christian College at Allahabad, he did his graduate and post-graduate studies in the Banaras Hindu University at Varanasi. Before he joined the GSI, Nautiyal held a teaching position for a short while (1939–1941) at his alma mater. His business has always been to go forward.

A very warm-hearted and compassionate person whose generosity was boundless, whose candidness unsettling, and whose attitude towards life very buoyant, Nautiyal has left behind several generations of intensely loving admirers.

K. S. VALDIYA

Wadia Institute of Himalayan Geology, Dehradun 248 001, India

Edited and published by P. Balaram and S. Ramaseshan, Current Science Association, Bangalore 560 080.
Typeset by R D Typesetters, Bangalore (Ph: 3405672). Printed by Lotus Printers, Bangalore (Ph: 3209909).