Peril: The Delacour's langur, from Vietnam, is one of the primate species declining alarmingly as a result of increased human encroachment. (Photo: © Terry Whittaker/Alamy.)

Washington-based environmental group, Conservation International.

Primates are in peril from a range of human activities, of which the bushmeat trade in central Africa is particularly threatening, along with the logging of rainforests in Indonesia and South America, says the IUCN.

A separate major report by the UN Environment Programme on the state of the world's environment warns of the continuing and growing problem of an expanding human population, climate change and the mass extinction of animals and plants. On primates, it highlighted the bushmeat trade as a particular danger which it said is running at six times the level that can be considered sustainable.

Mittermeier said that protecting forests from logging would preserve the habitats of many endangered primates while at the same time would help to protect the planet against climate change. "By protecting the world's remaining tropical forests, we save primates and other endangered species," he said.

The list of the most endangered species includes eleven from Asia, seven from Africa, four from Madagascar and three from South America. The loss of primates is also affecting the health of trees because of the role primates play in seed dispersal and forest regeneration, the report said.

The UNEP warns: "Without an accelerated effort to reform the way we collectively do business on planet Earth we will shortly be in trouble if indeed we are not already."

Q & A

David A. Weisblat

David Weisblat is a professor of Cell and Developmental Biology at the University of California, Berkeley, USA. Born in Kalamazoo, Michigan, USA (1949), he studied biochemistry, among other things, as an undergraduate at Harvard College and received a PhD (1976) for studies of Ascaris *muscle physiology with the late Richard Russell at CalTech. As a postdoc at Berkeley with G.S. Stent, he resumed studies of leech development pioneered by C.O. Whitman in the 19th century. This work has occupied him ever since, and he has remained at Berkeley, moving first to the Department of Zoology (1983) and thence to the Department of Molecular & Cell Biology (1988). In Stent's lab, he showed that intracellular microinjections of marker substances can be used to follow embryonic cell lineages precisely in fixed and living embryos (1978, 1980). In addition to teaching and research at Berkeley, he has taught at the MBL, Woods Hole, Massachusetts and as a member of various IBRO Visiting Lecture Teams led by John Nicholls and Jack McMahan, and is an Associate Editor for the journal* Development, Genes and Evolution*.*

Why the leech? Funny you should put it that way. That is the title of the memoir I will never get around to writing. In fact, there are at least two answers to that question, one scientific and one personal.

Let's take them one at a time, OK? The most compelling scientific justification for studying leech development is its relevance to understanding the evolution of animal body plans. A priori, changes in animal body plans — morphology — must come about by changes, over the course of many millions of years, in the developmental processes by which they arise. We now have a decent understanding of how a very few species, chiefly

Drosophila, develop, but the ancestral species from which they evolved are by definition extinct, so we cannot make any retrospective comparisons. Thinking prospectively, waiting to see significant morphological and underlying genomic/developmental changes is an exciting long-term possibility. Unfortunately, that will require maintaining both human society and natural populations of the species of interest for the millions of years required for significant evolutionary changes to occur, a dicey proposition at best.

The only alternative is to work with extant species, comparing their developmental processes and then interpreting the similarities and differences with respect to the phylogenetic tree by which they evolved, so as to draw inferences about the nature of the ancestors represented by the various branch points of the tree, and the changes in development that might have accompanied species divergence along its branches. Here, however, we run into another problem arising from the fleetingly brief span of human culture — how can we know the branches of the phylogenetic tree as we weren't there to observe it grow? The traditional approach, constructing phylogenetic trees according to progressively more fine-grained similarities and differences in adult and/or embryonic morphology, suffers from an inherent circularity; whatever criteria are used to assign animals to particular clades automatically build in assumptions about the nature of the evolutionary process that we are trying to elucidate. Molecular phylogenies are fraught with their own problems, but provide the only hope of breaking out of this circular logic. The assumption that sequence divergence accompanies phylogenetic divergence is well accepted, and sequence comparisons take place independently of subjective judgments about the phylogenetic significance of morphological traits.

So what does this all have to do with leeches? Molecular phylogenies indicate that most bilaterally symmetric animals fall into three super-phyla, Deuterostomia, Ecdysozoa and Lophotrochozoa. If we want to understand how changes in developmental processes permit the evolution of body plans, and to draw inferences about what ancestral animals were like, we obviously need to include representatives of all the main groups of animals. Our standard models for developmental studies fall into the first two of these super-phyla, yet most of the currently recognized phyla, including leeches and other annelid worms, fall into the third. Lophotrochozoa thus constitutes a vast frontier for comparative development and evolution. The species we study, *Helobdella robusta* and its relatives, are among the most experimentally tractable lophotrochozoans currently under investigation, and thus are a good place to start in examining that clade.

But aren't leeches a highly derived group of animals, hardly a representative lophotrochozoan species? You're missing the point! There's no such *thing* as a 'representative lophotrochozoan'. The group is far too diverse. I'm saying that leeches are tractable representatives — members— of the Lophotrochozoa. It's an important distinction. Remember that, whatever their morphology and however distantly related they may be to each other, any two extant species are equally far removed from their last common ancestor. This is why Darwin enjoined us to "Never say higher or lower in referring to organisms".

At present, we have no good understanding about the extent to which genomic, developmental and morphological changes are correlated in evolution. This is the challenge facing the field called evo-devo, and it's going to take a long time to make real progress. Of course there must be *some* changes in developmental mechanisms as morphology changes. But there are cases in which a minor tweaking of development results in a dramatic morphological change, and conversely there are cases in which highly conserved and undeniably homologous developmental events or structures arise by dramatically different processes in terms of molecular mechanism. Thus, I see no justification in assuming that the development of any extant species approximates that of the ancestor, even if it resembles some fossil species morphologically. There's no avoiding comparative work if we seek to understand the links between evolution and development. So it's both exciting and appropriate that studies of lophotrochozoan development are being carried out on a range of species. Of course it's also frustrating because it's still early days and the comparisons don't always make sense, and the necessarily small research communities make progress slower.

And the personal reasons for studying leech? The work is tremendously exciting and esthetically pleasing; and I guess I'm somewhat of a contrarian. Given that one is going to engage in basic research, I find it more satisfying to be in a situation where, if we weren't doing the work, it probably wouldn't get done. Isn't it a waste of resources to have many different labs all chasing the same question, frequently even publishing back to back papers with essentially the same results? There's a balance of course. It's nice to have a community of people who can critique and maybe even appreciate your work.

But how did you end up working on leech in the first place? It's an example of contingency, how even minor events have unforeseeable consequences. As an undergraduate, I was happily looking for secondary isotope effects in a bacterial enzyme reaction, when my tutor suggested that I broaden my horizons by taking a course in development or neurobiology. I chose the latter, Bio166, thinking maybe I could eventually work out the biochemical basis of consciousness. Embryos at that point appeared to be hopelessly complex masses of non-descript, yet heterogeneous cells.

It was a life-changing decision, despite the ill-informed rationale. Along with organic chemistry, Bio166 was among the best classes

I had at Harvard, with lectures by Zac Hall, David Hubel, Jan Jansen, Jack McMahan, John Nicholls and Torsten Wiesel. Nicholls' lectures and demonstrations on the mechanosensory neurons and simple reflexes of the medicinal leech were most exciting for me. From that point on, I knew that I wanted to study the leech nervous system. The decision to do a postdoc with Gunther Stent on leech swim circuits was one of the few well-informed and rational career choices I've made, so (more contingency) it's ironic that, by the time I got to Stent's lab, he had decided he knew enough about leech swimming, and that the next big frontier was neurodevelopment. So I ended up studying CNS cell lineages in leech, and from there it was down a slippery slope to basic development. The leech embryo was, and remains, completely engrossing for me. The emergence of evo-devo just provided a new context for work to which I was already committed through accidents of history and personality.

Are Stent and Nicholls your scientific heroes then? Do contrarians have heroes? Both these men influenced my career tremendously, by their support and encouragement, and by their two very different examples of how to be passionately and productively involved in science. John Nicholls' dedication to remaining actively engaged with experiments and teaching, especially in developing nations, is one great example of a fulfilling career. And Gunther Stent's tireless pursuit of the philosophical implications and underpinnings of his work, his emphasis on finding a model, however short-lived, to explain current results and frame future experiments, is another.

If I do have a scientific hero, however, it would be the aforementioned tutor, the late Bernard M. Babior, a brilliant scientist and physician with a wide-ranging intellect and a wonderfully acerbic sense of humor. There's no way to convey all that I learned from him, so I'll mention only two trivial items: pipetting phenol by mouth in the dark (don't try this at home), and the correct lyrics to the Glenn Miller song, "I've Got a Gal in Kalamazoo".

If you could start all over again, is there anything you would do differently? Don't get me started! Not that I'm not satisfied with the life I have, but it's so frustrating to have only one. I wish I could have seen the forests and prairies of pre-Columbian America, sailed around Cape Horn in the days of "wooden ships and iron men", met Abraham Lincoln, seen the dinosaurs, made a time-lapse movie of the formation of the solar system, and worked with my maternal and paternal grandfathers in their respective trades of carpentry and scrap dealing. Within the confines of my own life, I think I would have enjoyed forestry, linguistics or materials science as careers. Yet more narrowly, I wish I had mastered at least one foreign language to the point of fluency and had taken a year to live and study or work abroad. Looking back at my 20 year old self, I'm puzzled. Why exactly was I in such a hurry to 'get done' as an undergraduate, and who I was worried about 'getting behind' if I took time off?

Are you optimistic about the future? By nature I'm reasonably cheerful, at least as defined by functioning without exogenous serotonin re-uptake inhibitors. But even after the age-appropriate correction for codgeritis, and ignoring the sorry state of political affairs in the US and elsewhere, the magnitude and speed of the anthropogenic destruction of the global ecosystem are so frightening, and our societal responses so pathetically slow and ineffective, I just don't know whether to laugh or cry.

Take me for example. San Francisco Bay is apt to rise well over my home during my daughter's lifetime from the melting ice caps. Yet I spend an inordinate amount of time trying to figure out how leech embryos develop, and much of what's left trying to tile a bathroom in that soon-to-be inundated home.

When I first realized that I must die, and that all known life and earth itself will end (when the sun expands into a red giant in about 6 billion years), I spent a lot of time trying to understand the meaning of it all. Religion had no explanatory power for me, but I eventually came up with the idea of a giant pin ball game of sorts, in which one goal of human existence could be to maintain life on earth, including our own species, as long as possible, working to the best of our ability to simultaneously avoid mass extinctions and increase human knowledge and understanding, as an arbitrary end in itself, and also on the chance that with 6 billion years of effort, we might even figure out a way to survive the next stage of solar evolution. It's early in the Game, so to speak, and I had a flash of hope when the Cold War ended, that maybe humans could learn to act for the common good, continuing to explore space and channeling our need to destroy into mapping and deflecting the threatening asteroids. But that hope has mainly gone a glimmering, and even with most of the human population living in abject poverty, we are now so far beyond the carrying capacity of the planet that the chances of getting much further at all in the Game are slim at best. The situation is paradoxical. On the one hand, there's this terrible urgency to act and such terrible consequences for failing to do so. On the other hand, even if we and so many other species are no longer here to appreciate it, this pretty blue, green and swirly white planet will go on — until it doesn't. Perhaps Kurt Vonnegut said it best, "Heidi ho ...".

Still I take cheer from the Framingham Heart Study findings that obesity (and thinness) can spread within social networks.

Huh? Well, if we influence others, even without consciously trying, maybe I can stop nagging about recycling and power consumption. and just try to set a good example, in hopes that the mind-melded mass of humanity will do likewise.

You're weird, you know it? Yup, my daughter tells me every day.

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