equilibria. The question of whether the absence of variation at lower taxonomic levels is due to the absence of net selection or the absence of genetic variation to respond to selection is crucial in evaluating extinction risks in a world where important elements in the environment of all species are changing at unprecedented rates. Over the past two centuries, many bird species have radically changed many aspects of their habitat use, life histories and mating systems. The absence of variation at the species level in the analysis of major life-history components tells me either that the database is wrong or that far fewer changes have occurred than would have been possible. I think that a more plausible explanation for the absence of net selection for major life-history changes is that adjacent niches were already filled by other taxonomic groups.

In summary, this book is a progress report. Almost 35 years have passed since Lack's epic work was published. Nearly all of the progress in our understanding of avian diversity has been made in the past decade. This book provides a good record of this progress but I hope and expect that it will be outdated a decade from now. Meanwhile, it provides a useful overview of the strengths and weaknesses of the comparative method, and it certainly stimulates thinking about how we can learn more about variation in avian life histories and mating systems. Part of this stimulation is achieved through annoying the reader. Whether or not this was intended doesn't really matter — it works. ■

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A monumental study

Studying monuments such as this zoomorph found at Quiriguá in Guatemala became much easier after Alfred Maudslay's visits to the ruined cities of Mesoamerica. Maudslay took many photographs but also arranged for plaster casts to be made, enabling scholars to study these artefacts of Maya culture in relative comfort away from their jungle home. Maudslay's careful documentation proved invaluable in the deciphering of Maya hieroglyphics. Ian Graham's book *Alfred Maudslay and the Maya* (University of Oklahoma Press, $39.95) is the first biography of this pioneering archaeologist, and contains many of Maudslay's own photographs.

Thinking laterally about genes

Lateral DNA Transfer: Mechanisms and Consequences
by Frederic Bushman
Cold Spring Harbor Laboratory Press: 2002. 448 pp. $59, £43 (hbk); $39, £28 (pbk)

W. Ford Doolittle

Lateral (also known as horizontal) gene transfer (LGT) is gene exchange across species boundaries, and is a hot topic in some circles. Microbial genomicists and phylogeneticists in particular become more excited about it with each new prokaryotic genome sequence that reaches completion. No one had anticipated that prokaryotic genomes would be so extensively mosaic, so obviously pieced together by the assembly of genes from so many different antecedents, in some never-ending game of molecular Lego.

The genomicists are generally happy about LGT. The acquisition of foreign genes and gene clusters can explain some of the striking differences in the properties of bacterial species (or strains within species) that by other criteria are almost identical. Large (>20%) differences in genetic make-up between pathogenic and benign strains of the same species (*Escherichia coli* O157:H7 and K12, for instance) can best be understood with models that invoke evolutionarily rapid gene acquisition (by LGT) and loss. But phylogeneticists are less pleased. They want to use gene sequences to reconstruct evolutionary trees for species on the assumption of 'vertical' gene transmission between generations, but if genes can switch species, these trees become webs — much messier. So when LGT has been inferred from comparative data only,they often somewhat petulantly ask: "What's the mechanism?"

Frederic Bushman's book, *Lateral DNA Transfer*, doesn't attempt to answer this challenge for all inferred instances of LGT. But by providing reasonably thorough and unusually readable accounts of current knowledge about the many ways in which DNA can be exchanged within and between both prokaryotes and eukaryotes, Bushman has provided LGT's proponents with a broad range of reasonable rejoinders. And he has given us even more confidence that, where there is a will (a selective advantage) for gene exchange, there is a way.

In 12 chapters Bushman summarizes the states of play in work on conjugation, transposition, transduction, antibiotic resistance (mechanisms and spread), pathogenicity islands, comparative prokaryotic genomics, retrovirology (with a special chapter on HIV), retrotransposons (LINEs and SINEs), Tc1/Mariner, P and other DNA elements, eukaryotic genomic composition and fluidity, the vertebrate immune system, and interdomain transfer (Ti plasmids in particular). These topics are not usually treated together, and are usually presented to students only after they learn about 'real' genes. So Bushman is opening the door to a more integrated general molecular evolutionary discipline that would treat all mobile elements (and in the extreme, all transferred genes) as evolutionary agents in their own right, surviving not only because of benefits that they confer on the genomes in which they currently occur, but because they are especially transferable between genomes.

The 'selfish operon' hypothesis of Jeffrey Lawrence and John Roth is the best articulated and most radical theory that this new discipline currently has. Bushman endorses it, but I wish that he had presented this theory (and several other evolutionary mechanisms) in rather more detail.

Bushman does attempt a broader integration in his final two chapters, the first of which deals with regulation (usually negative) exerted on LGT by the recipients and agents of transfer. Mostly this has to do with limiting the copy number of mobile elements within genomes or the virulence of viruses, rather than with modulating interspecies exchange, and what Bushman has to say about the latter seems less sophis-

ticated. He cites but then slights Ichizo Kobayashi's elegant selfish-element theory to explain restriction modification systems, and misses out completely on Rosemary Redfield's data on transformation that show that bacteria care most about the food value of foreign DNA.

Similarly, the final chapter summarizes Bushman's earlier generalities about the differences between prokaryotes and eukaryotes with regard to the mechanism, frequency and impact of LGT, and other people's ideas about the role of LGT in the evolution of introns, sex and life. The bold new unifying theory I had hoped to see simply isn't here, and in particular there is no attempt to bridge the gap to population genetics: this is a molecular biologist's book. But then I could do no better myself, and Bushman's book does provide, in one place, the best review of the many pathways and processes of LGT now available. I'm glad it's on my shelf. ■

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More on gene transfer

Mobile DNA II
edited by Nancy L. Craig, Robert Craigie, Martin Gellert & Alan M. Lambowitz
ASM Press, $169.95

Horizontal Gene Transfer, 2nd Edition
edited by Michael Syvanen & Clarence I. Kado
Academic Press, $99.95

Science in culture

Algorithmic architecture

The Serpentine Gallery Pavilion by Toyo Ito and Cecil Balmond.

Martin Kemp

The most spatially ambitious buildings have invariably extended the potential of engineered structures into new realms. We need only think of the soaring Gothic cathedrals, the ultimate high-tech of their day. Mathematical principles are integral to this quest, even when the methods have been more empirical than theoretical.

At key moments — as with Antoni Gaudí, architect of the church of the Sagra Familia in Barcelona, and Richard Buckminster Fuller, who invented the geodesic dome — the mathematics of structure has been consciously embedded in the broader context of the generation of form within nature. Rather than the literal imitation of natural structures, this ambition exploits design processes that are analogous to nature's organizational principles.

For like-minded contemporary architects, designers and engineers, the advent of the computer has released radical new potentiality, as witnessed in the joyous pavilion erected outside the Serpentine Gallery in London's Hyde Park by the Japanese architect Toyo Ito and the London-based engineer Cecil Balmond of Ove Arup. To describe them respectively as architect and engineer is inadequate. Both are visionaries who blend structural insight, innovative processes of form generation, aesthetic adventure and wide cultural reference. They are forging new modes of building that subvert the dominant box of modernist architecture.

D. GRANDORGE

D. GRANDORGE

Ito's personal vision is to transmute traditional buildings, viewed as 'bodies', into entities adapted to the electronic age. He argues that the "virtual body of electron flow is drastically changing the mode of communication in family and community, while the primitive body in which water and air flow still craves for beautiful light and wind. The biggest challenge for us is how we can integrate these two types of body."

Balmond, for his part, is fascinated by proportion and number theory, and has published a tale of numerology, *Number 9: The Search for the Sigma Code* (Prestel, 1998). He delves into pythagorean harmonics, sacred geometry, Islamic tiling, tantric numbers, the mathematics of symmetry and asymmetry, chaos theory and fractals for interlocking insights into the magic of form and number.

It is perhaps surprising to find that the underlying form of the pavilion is so simple. It is a cubic structure, 17 metres square and 4.5 metres high. But this is where the simplicity ends. The floor and walls dissolve into an intricate web of interpenetrating squares, triangles and irregular polygons generated by an algorithm. From the mid-point of one side of a square, a line is drawn to a point two-thirds along an adjacent side. The procedure is then repeated to produce an internally 'suspended' square which is rotated on the diagonal axis. Through iteration and extension of this linear construct, a flat sheet is generated, which folds perpendicularly to produce the walls.

The not inconsiderable load of the roof glides above our heads, like a flight of tethered kites. The angular music of the design, with its alternating sets of opaque and open panels, generates a visual dynamism that subverts architectural convention. The net impetus is up and across rather than static, as in the classic post-and-lintel system.

Building a temporary structure of this kind, as part of the Serpentine Galley's annual programme, has proved liberating for Ito: "One need not be so strict about function nor worry about how it will age. And, it seems to me, it just might offer the clearest expression of the concepts I habitually imagine." The pavilion serves, in effect, as a laboratory for a structural aesthetic which would have been inconceivable in an earlier era.

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Visualizations: The *Nature* Book of Art and Science *is a collection of essays edited by Martin Kemp (published by Oxford University Press and the University of California Press; £20, £35).*