Designs on evolutionary invention

Cats' Paws and Catapults: Mechanical Worlds of Nature and People
by Steven Vogel
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The earliest patent for barbed wire, of 1868, says the invention was designed to give wire the character of a thorn hedge. The same message is given by the name of the manufacturer, the Thorn Wire Hedge Company. The inventor of modern chain-saw teeth had studied the jaws of a wood-boring beetle, and the inventor of Velcro was inspired by burrs. These inventions are well documented as having imitated nature, but it would be hard to find many more to add to the list. We often want to do things that nature does well, but we seldom copy nature's methods.

Engineers have looked to nature for ideas more often than they have imitated it directly. Otto Lilienthal wrote a book entitled *Bird Flight as the Basis for Aviation*, and his pioneering gliders of the 1890s had wings of cloth stretched between radiating spars, very much like the wings of bats which are stiffened by long radiating fingers. But the Wright brothers and their successors built wings with a rectangular grid of spars, unlike any animal wing, and no successful aircraft has been powered by flapping wings. In his new book comparing human and natural engineering, Steven Vogel argues that flapping wings are fine for birds that fly relatively slowly, but could not work well for large, fast aircraft.

Our preference for rectangular grids, straight lines and square corners contrasts with nature's preference for curves, especially spirals. Our rectangular products stack neatly (imagine what supermarket shelves would be like if cereal packets were shaped like snail shells), and they lend themselves to constructions built from many identical modules. Spiral structures such as snail shells give a different advantage: they can be extended without changing their shape. If you extend your garage without demolishing any of the existing walls you will get a longer garage that is relatively narrower, but a snail adds to the edge of its shell and enlarges it while keeping the same proportions. Cylinders, however, are found frequently both in nature and in engineering, often (in both cases) reinforced by helically wound fibres. Examples include pressure hoses and parasitic worms.

Different priorities, in natural and human engineering, explain why we make rectangular boxes while nature makes spiral shells. There are also major differences in materials and power sources. Nature cannot extract metals from their ores, which generally requires high temperatures and large quantities of energy. It cannot use internal combustion engines (again, high temperatures are involved), and its lack of good electrical conductors makes electric power impractical. In some respects, however, nature performs much better than human engineering. Bone is a composite material that exploits the same principles as glass fibre, but its fibres are orientated to match the loads it has to bear far more subtly than we can manage with manufactured materials, and it adapts automatically when loading patterns change.

Our workshops and kitchens are full of lever systems designed to amplify forces — pliers, wire-cutters, nutcrackers and can-openers. In contrast, as Vogel points out, animal lever systems usually amplify movement at the expense of force — muscles shorten by small amounts to move our hands and feet through much larger distances. That is a consequence of the properties of our muscles, which can lengthen and shorten only by small fractions of their length, but it seems paradoxical that, to exert the large forces needed to crack a nut, we have to use force-amplifying nutcrackers to counteract the force-reducing lever system of our own skeleton.

Vogel's book has been written to be enjoyed, with the same clarity as his previous books. It is full of ideas and well-explained principles that will bring new understanding of everyday things both to non-scientists and scientists alike. It covers some of the same ground as Michael French's *Invention and Evolution* (Cambridge, 1988) and James Gordon's *The Science of Structure and Materials* (Scientific American Books, 1988), but having read those fine books is no reason for avoiding this one, which offers plenty of new insights. □

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Listen out for the death rattle

This is as close as most people would want to get to a San Lucas rattlesnake (*Crotalus ruber lucasensis*). But for those who want to know more, Chris Mattison's easy-to-read *Rattler! A Natural History of Rattlesnakes* is now out in paperback (Blandford, $19.95, £10.99).

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