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The Physics of Chicken Fat

LIFE'S DEVICES: THE PHYSICAL WORLD OF ANIMALS AND PLANTS. *By Steven Vogel. Princeton University Press. $45. Paper, $17.95.*

Reviewed by JOEL E. COHEN

Take an old dollar bill or other limp rectangle of paper, drape it over a finger, and place the finger against the edge of your lower lip. Then blow. The bill will lift up and extend horizontally away from your mouth. When you stop blowing, it will drop down again, suspended from your finger. This simple magic trick ("No hands, no strings attached!") can be advertised as a new way to raise money. For all but the very young, it demonstrates a physical law, attributed to Daniel Bernoulli (1700–1782), that keeps aloft bats, birds, and butterflies as well as airplanes, gliders, and helicopters.

Bernoulli's principle shapes biology as much as technology, sometimes in surprising ways. Prairie dogs use it to help them survive underground. Prairie dogs dig burrows that may extend three meters (ten feet) deep and fifteen meters (fifty feet) from entrance to exit. Without forced ventilation, not enough oxygen would reach prairie dogs in the bottom of the burrow to keep them alive. So prairie dogs build the entrance to the burrow in a different shape from the exit. One is often a low mound with a broad opening, the other a high cone with a narrow vent. When winds blow over the plains of North America, the air passes more rapidly over the cone than the mound. The difference in pressure pulls air through the burrow, providing the underground inhabitants with nature's air conditioning.

Bernoulli's principle asserts roughly that the faster a fluid flows over a surface, the less pressure it exerts against that surface. In an airplane wing moving forward through air, the bulge on the top surface forces the air above the wing to travel further, and therefore faster, than the air below the wing. As a result, the air pressure is lower above the wing than it is below it. The same kind of pressure difference that lifts the wing also lifts the dollar bill and pulls air through prairie dogs' burrows.

In *Life's Devices: The Physical World of Animals and Plants* Steven Vogel, a professor of zoology at Duke University, describes this and hundreds of other unexpected facts with affection, grace, and good humor. The theme of his arcane and familiar examples is that physical principles set the boundaries on what living organisms can do, and that living organisms, with impressive creativity, exploit nearly every possibility within those boundaries.

For example, have you ever wondered why chicken fat is heavily concentrated in and under the skin while cattle marble fat into their meat? (To be honest, I hadn't, but once Vogel pointed it out, the difference was obvious. How could I have overlooked it?) Physics determines that the volume of similarly shaped animals increases roughly in proportion to the cube, or third power, of their length, while their surface area and cross-sectional area increase roughly in proportion to the square, or second power, of their length. Since smaller animals (like chickens) have a higher ratio of surface area to body volume, and therefore suffer more from heat loss to the cooler surrounding air than do

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larger animals (like cattle), chickens assign their fat double duty, as energy storage and as surface insulation, while cattle have less need to line their surface with fat. The argument is valid as a first approximation even though cattle and chickens differ slightly in shape. The argument also explains why human babies are more vulnerable to winter chill than human adults, but warm up faster once they're indoors.

A similar argument explains why, when the skeletons of a cat and an elephant are drawn the same height, side by side, as they are in *Life's Devices*, the elephant has dramatically thicker leg bones, though the lengths of the legs are roughly similar. The reason is that the weight a leg bone can support is roughly proportional to its cross-sectional area, while the weight it needs to support is roughly proportional to the cube of its length. Therefore, as Galileo pointed out in 1637, the leg bones must be proportionally much thicker in big animals than in small. And so they are.

Why do hot dogs and other sausages in artificial casings usually split longitudinally when they are overcooked? *Life's Devices* gives a very intuitive explanation in terms of Laplace's law. Why do people switch from walking to jogging at a certain speed of locomotion? *Life's Devices* tells why, and tells how to calculate your very own Froude number (named after the British engineer and naval architect William Froude, 1810–1879), so that you can predict the speed at which you switch. The necessary physics is presented in the gentlest possible way, with outrageous puns and no formulas requiring more than eighth-grade algebra (which is even reviewed in an appendix, in case you've forgotten).

In *Life's Devices*, Froude's number, Laplace's law, Bernoulli's principle, and many more physical ideas illuminate facts about the entire range of organisms from bacteria to bactrians and back. "There are lessons in nature that might be applied to our [technological] designs," Vogel writes. "Looking at life's devices provides a comparison between our human technology and the only other of which we have any knowledge." This song of a man madly in love with the physical view of biology will enrich and enliven your everyday view of both living nature and human technology.