thors emphasize the huge advance achieved by Sanger's decade of work on the amino acid sequence of insulin, which showed that proteins have a definite, iron-clad chemical structure. From this, the idea of a genetic code easily followed. Almost as important was Sanger's additional feat of finding that although the β chains are identical in beef, pig, and sheep insulin, the α chains differ by substitutions in positions 8 to 10: essentially the discovery of orthologs. Could this be considered the first step in bioinformatics?

Every history book has to stop somewhere; this one finishes with interesting historical sections on the links of proteins to physiological functions and to genetics. Readers may feel deprived of hearing about the achievements of genome sequencing and our ability to enumerate nearly every protein produced by an organism. But there is so much of interest here, described with scholarship and punch, that they will enjoy *Nature's Robots* even without the genomic catharsis.

NOTA BENE: ANIMAL BEHAVIOR

Creature, Heal Thyself

"Leave your drugs in the chemist's pot, if you can heal your patient with food," advised Hippocrates in the 5th century B.C. Living in the industrialized world, we seem to forget this advice each time we reach for the latest pharmaceutical wonder. In contrast, wild animals are experts in the art of staying well: not only do they carefully select a nutritious diet, but they also treat ailments by eating plants with medicinal properties. Indeed, watching what animals ate when they became ill helped our ancestors to concoct their herbal remedies.

Wild Health
How Animals Keep Themselves Well and What We Can Learn from Them
by Cindy Engel

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Cindy Engel, a lecturer in environmental sciences at the Open University in the United Kingdom, has written a fascinating account of the numerous behaviors that help animals to maintain their health and stay well in the wild. Determined not to anthropomorphize, Engel argues that the survival strategies of wild animals—seeking plants from "Nature's pharmacy" to treat illness, and altering their diets to prepare for migration, hibernation or reproduction—do not reflect innate animal wisdom, but rather are the result of millions of years of natural selection.

Plants synthesize an astonishing array of secondary compounds that fend off attack by herbivores, protect against pathogens, prevent growth of competing plant species, and attract animal pollinators. Although toxic at high doses, many of these compounds are medicinal if taken in small quantities. How do animals "know" which plants to eat to alleviate their unpleasant symptoms? Engel details the evidence for self-medication by animals, much of which comes from long-term studies of wild chimpanzee colonies in Tanzania, such as Jane Goodall's work at Gombe over the last 40 years and research in neighboring Mahale by Toshisada Nishida and Michael Huffman.

More than ten years ago, Huffman reported on a sick female chimp that recovered her health after she sucked out the bitter pith of *Vernonia amygdalina* (a plant not normally eaten by healthy chimps), but his observation was met with skepticism. However, this self-medicating behavior was subsequently witnessed in other chimps, and *Vernonia* is used by the local Tongwe tribe as a herbal remedy. Chemical analysis revealed that the pith contains several sesquiterpene lactones that have activity against internal parasites. Goodall's group and Huffman have also observed chimps scouring their guts of parasitic worms by carefully folding and swallowing whole leaves selected from plants that they would normally ignore (see photo above). The leaves—with their rough texture, tiny hooks, and folded concertina shape—act like velcro, scraping off loose worms from the gut interior. Bears, wolves, tigers, and snow geese are also known to swallow rough leaves or grass to get rid of intestinal worms.

Many mammals (including gorillas, chimps, and elephants), some birds, as well as certain indigenous tribes eat soil with a high clay content. Such clay-rich soils not only contain essential minerals but also bind to plant toxins and stop diarrhea. We still follow this ancient practice when we take anti-diarrheal preparations containing kaolinite clay. Engel describes many other striking behaviors of wild animals that seem to be ways to maintain health: Muriquis monkeys in Brazil alter the plants they eat to regulate their fertility, so that they will reproduce when food is plentiful. Elephants and gorillas cover their dead with earth and vegetation, which hastens decomposition and reduces infection. Capuchin monkeys rub the toxic secretions of millipedes into their fur to repel biting insects.

In a delightful digression, the author reveals that humans are not the only creatures to enjoy certain vices. Apparently, many animals and birds have a strong predilection for alcohol, which they obtain by eating fermented fruit; they often overindulge and become inebriated. Engel proposes that a taste for alcohol may have been maintained by natural selection—despite the dangers associated with inebriation (accidents and predation, for example)—because alcohol is both rich in calories and a stress reducer. This attraction to alcohol can have disastrous consequences: In 1985, a herd of 150 thirsty elephants stormed an illicit still in a West Bengal village, gorged themselves on moonshine, and then pulverized seven concrete buildings in a drunken stampede. Animals also partake in certain stimulating refreshments. Coffee is reputed to have been discovered 1500 years ago when a goatherd noticed that his goats became excessively energetic after feeding on the red berries of a small shrub. Ancient Peruvian Indians, observing that their llamas chewed coca leaves when carrying heavy loads on long journeys, took up the habit themselves.

Combining scientific observations and anecdotes of wild animal behavior together with our own traditions of folklore and herbal medicine, Engel has produced an enticing, well-referenced (although poorly illustrated) narrative that should be easy for any reader to digest. She concludes this entertaining book by sensibly proposing that long-term research into animal behavior in the wild could provide valuable insights into ways to keep ourselves and the captive creatures that depend on us—pets, livestock, and zoo animals—in good health. —ORLA SMITH

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