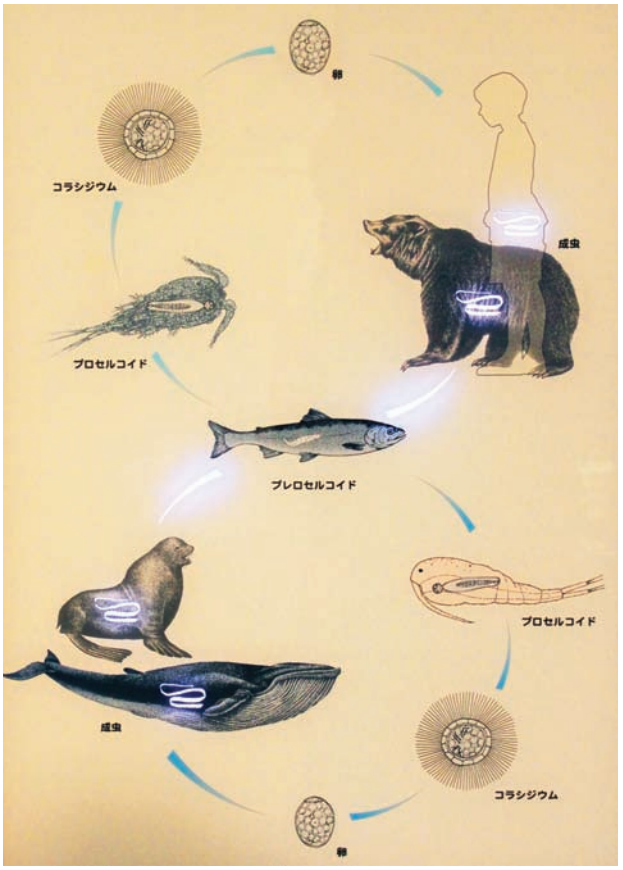
Of Predators, Parasites, and Fickle Friends



When we think of having a good meal, the image of a table set generously with our favorite foods in the company of those closest to us likely comes to mind. I myself imagine eating homestyle tofu and garlic-fried watercress while seated around my family's dining table, chopsticks in hand, or perhaps enjoying the simplicity of grilled salmon and Brussels sprouts served al fresco on my neighbor's porch. When eating with others we rightly experience a joyful sense of camaraderie. Yet we remain unaware of another, even more intimate meal that is being shared, one that occurs simultaneously inside us. Yes, I mean parasites—unwelcome guests filling their plates from the banquet tables set within our own bodies.

Above, Left: *A tapeworm's developmental journey through various members of a food chain. Meguro Parasitological Museum, Tokyo, Japan.* **Above, Right:** *A visual display showing where just a few of the "Important Parasites of Man" are located in the body. Meguro Parasitological Museum, Tokyo, Japan.*

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As a scientist, I have come to terms intellectually with this pervasive biological reality. But it wasn't until I happened to visit the Meguro Parasitological Museum in Tokyo that I understood it viscerally.[1] A colleague had suggested a side trip to the museum for some "academic recreation" while I was in Japan on a business trip. And what a visit it was! Lined up along every inch of the

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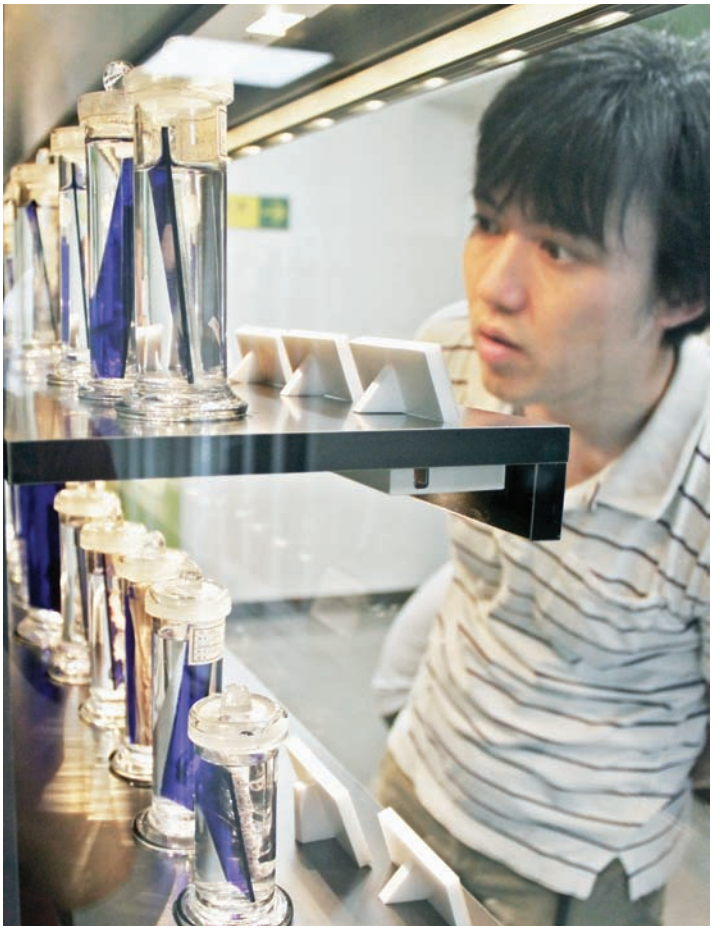

Above: *A visitor marvels at rows of preserved parasites. Meguro Parasitological Museum, Tokyo, Japan.*

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museum's wall space were specimens of large and shapely parasites floating in jars or, more impressively, preserved *in situ* along with the animal in which they were originally discovered. My memory cannot dislodge, for instance, the image of the distended dolphin stomach. The tendril-like organisms bursting like sunrays from that belly were in fact hundreds of worms that had grown out from the gut in all directions. Equally horrifying was a far simpler display—a piece of white rope so long that I could wind it around my waist over thirteen times. The signage explained that this rope represented the length of the longest tapeworm ever removed from the innards of a human being. Even though most texts were written in technical Japanese, the exhibits needed no elaborate translations to make their very direct, compelling point. With that visit the physicality of parasites impressed itself upon my mind (and, perhaps, into my brain, I worried hypochondriacally).

The museum also made one unavoidable truth about parasites especially clear: food is the medium through which we usually acquire them. Go without things like sushi, as I did on the evening after my museum visit, and you'll sidestep some parasite forms. But you can't very well stop eating. Given the *Trichinella* roundworms in pork chops, *Salmonella* bacteria on spinach greens, and *Anisakis* nematodes lurking within that perfectly pink piece of salmon, there is nothing to do but freeze, cook, wash, and cross your fingers. As with vampires keen to enter your house and suck your blood, it is mostly a matter of not inviting them in.

When pondering the food habits of parasites, unappealing as these thoughts may be, it is important to remember that taste is a matter of, well, taste. Most of us are fully aware of the role that acculturation plays in our food preferences. Less familiar may be the fact that we also have adaptive biological evolution to thank for crafting our gastronomic preferences and pleasures along the lines of certain flavors that promote survival and reproduction. And yet, where once nature provided very limited access to the tastes we most desired, human technologies now offer the strange privilege of unending gluts. We will grow fat and eat sweets until we are sick. Old habits, especially evolutionary ones, die hard.

Charles Darwin was among the first to recognize the foundational role of food in almost every ecological dynamic, although for him it was not always a pleasant

acknowledgment. Unlike one of his intellectual predecessors, the Right Reverend William Paley, who maintained that "It is a happy world after all. The air, the earth, the water, teem with delighted existence,"[2] Darwin understood things quite differently. As he wrote in *On the Origin of Species*:

> We behold the face of nature bright with gladness, we often see a superabundance of food; we do not see, or we forget, that the birds which are idly singing round us mostly live on insects and seeds, and thus are constantly destroying life; or we forget how largely these songsters, or their eggs, or their nestlings, are destroyed by birds or beasts of prey; we do not always bear in mind, that though food may be superabundant, it is not so in all seasons or each recurring year.[3]

From such insights Darwin was able to make a compelling case for his principle of natural selection as the central mechanism by which life was continually diversifying into all its multitude of forms.[4] He noted, for example, how various species of finches on the Galapagos Islands differed in their beak shapes and sizes in a manner that corresponded to the types of seeds they ate. More recently, researchers have discovered that all seven species of (the now eponymous) Darwin finches are plagued by a parasitic fly whose larvae infest their nests and feed on their nestlings. The relevant "beasts of prey" for these birds are in fact insect grubs the size of a comma, the young of one species living off the young of another. Where did these flies come from? It is reported that they may have been accidentally introduced in the 1990s in foodstuffs imported from Ecuador to feed the islands' human inhabitants.[5] The neverending food chain links space, time, and the ecology of creatures in ways that are both complex and unexpected.

When Darwin discussed the predatory behavior of creatures in *Origin*, he attempted for the sake of Victorian sensibilities to downplay the gruesomeness of his view of nature. "When we reflect on this struggle," he wrote, "we may console ourselves with the full belief, that the war of nature is not incessant, that no fear is felt, that death is generally prompt, and the vigorous, healthy, and the happy survive and multiply."[6] But this is exactly how we *don't* feel about parasites. For those of us unfortunate to find out we are harboring, say, a botfly larva under our skin, fear is precisely what we do feel. It may not be quite like the fear inspired by other sorts of "predators," a word evoking the tiger's teeth or eagle's talon—a hunt, a kill, a final and decisive moment. A parasite's well-being depends not on the death of its victim, but rather on its continual life. If there is to be death, it is unlikely to be swift. Parasites definitely take a slow food approach.

I won't claim that a parasite living inside you or me right now is a "good" thing in any objective sense. It is just the way things are, trophically speaking. The parasite is just making a living, although we obviously take issue with the fact that we suffer from the arrangement. When roundworms, tapeworms, flatworms, and various protozoan parasites feed in and off us, we are in effect being burglarized.

Some of these creatures have sophisticated, if not somewhat eccentric, tastes that make them partake of multicourse meals. Consider the liver fluke, *Clonorchis sinensis*, which is estimated to infect over thirty million people worldwide. As its name implies, this fluke is found in the liver, the bile duct in particular. The bile would seem to represent some kind of *digestif* for the adult form, which by that point will have experienced a multicourse meal—the parasite's lifecycle obliges it first to infect snails (the appetizer), then fish (the entrée), and finally mammals like us to close out the menu of their life. Others, like the roundworm *Acaris*, are more parochial and prefer to enjoy a second serving of the same. In infecting a human through contaminated food, the young worm pushes through the intestinal wall and into the bloodstream, where it is carried on a tour of the liver and heart, ending up in the lungs. Once there, it is coughed up only to be reflexively swallowed again so that it can return to our intestines, where it will finally attach, mature, and produce eggs by the hundreds of thousand per day.

We know, of course, that nature is not solely red in tooth and claw. We witness, for example, the copacetic relationship of bee to clover flower, in which there is an amicable exchange of sweet nectar for free transport of the plant's pollen: food for sex. Similarly, in the aquatic realm, stony-colored fish called groupers settle on coral reefs where "cleaner shrimp" come and eat buffet style, picking off algae, parasites, and other small items that round out their diet. Such symbiotic relations between creatures abound in nature, and when the barter involves food, it is the very opposite of parasitism in the sense that the food, though sometimes still originating from one partner's body, is willingly exchanged for something mutually beneficial.

One notable mutual relationship in the animal world is that between ants and lycaenid butterflies, commonly known as blues, coppers, and hairstreaks. With six thousand species comprising the group, one of every three butterflies in the world is some kind of lycaenid. (Known for their striking colors and diminutive grace, these were the butterflies to which Vladimir Nabokov was devoted.[7]) The mutualisms between ants and lycaenids are as complex as they are varied, but it is clear that as caterpillars, lycaenids

are equipped for the job. For instance, they all have something called a pore cupola organ that excretes a substance to pacify otherwise potentially aggressive ants. This process allows a mutualism to blossom: the caterpillar then feeds the pacified ants through a second gland, the dorsal nectary organ, excreting a nutritious fluid for the ants to imbibe. In exchange, the ants guard the caterpillars from other potential insect threats. Yet another organ, called the tentacle organ, allows the lycaenid to call in the favor at any time by releasing a compound that alerts the ants when the caterpillar feels threatened. The protective ants rush to its side.

But familiarity can breed a variety of things. Contempt, certainly, is one; false confidence is another. Once the lycaenids had won the symbiotic trust of ants over millions of years, the dastardly logic of natural selection made conniving use of the cooperative traits the caterpillars had evolved, repurposing them for a con. This means that the pacifying perfume of the lycaenids has not only allowed certain species of the butterfly to move into the ants' nests for further protection, but some species have evolved scents that mimic those of juvenile ants. Hapless ants then feed the caterpillars from their own mouths in the belief that they are feeding their own young, oblivious to the fact that the lycaenid larvae take further, grisly advantage by eating the ant eggs among which they are cozily ensconced. These species have taken an evolutionary journey from what was initially a cooperative mutualism to become elaborately parasitic of their former friends—all for the purposes of an easier meal.[8]

Good relationships don't always break down, however. The extravagant contingencies of nature also mean that initial antagonisms can give rise to remarkable reciprocity, and indeed to one of the most important innovations life has ever known. Structures inside the cells, known as mitochondria, are credited with nothing less than conferring an essential functionality that set the stage for complex multicellular creatures like animals and plants to evolve from their single-celled ancestors. It is now hypothesized that mitochondria likely originated as one of two things: a pernicious parasite of larger cells that was finally domesticated by its hosts, or as a food item engulfed by a larger cell only to be found indigestible. In either case, this crucial mutualism arose in a moment of feeding gone sideways, and happily so. It is now impossible to distinguish the mitochondria and the cell as individual entities. We might similarly ponder the trillions of bacteria that live within our guts and on our skin: recent studies reveal the wondrous but unsettling fact that mutualistic bacteria are estimated to outnumber our own cells by ten to one. This leaves "us" being more "them" than anything else.

Granting the sometimes creepy and other times disease-inducing tendencies of the parasites among or within us, our complaints could be considered somewhat hypocritical in view of the broader ecological picture. After all, we too are animals, which by definition means that we are organisms surviving off the largesse of others. Unlike plants, the so-called autotrophs, we cannot make our own food through the process of photosynthesis. That leaves all of us heterotrophs no option. We must eat others and be quintessential grifters in the consumptive game. We are most certainly predators. But in a way, we are parasites too.

NOTES

1. Meguro Parasitological Museum. See http://kiseichu.org/english.aspx.

2. William Paley, *Natural Theology: or, Evidences of the Existence and Attributes of the Deity*, 12th ed. (London: Printed for J. Faulder, 1809), 485, at http://darwin-online.org.uk/. Accessed 25 September 2009.

3. Charles Darwin, *On the Origin of Species: A Facsimile of the First Edition* (Cambridge: Harvard University Press, 2001), 62.

4. Darwin found much of his theoretical inspiration in Thomas Malthus's essay "On Population" (1798), which posed the problem of food production for an ever-increasing European population.

5. "Deadly Parasites Infect Darwin's Famous Finches," Environmental News Service, at www.ens-newswire.com/ens/nov2002/2002-11-11-04.asp. Accessed 25 September 2009.

6. Darwin, *On the Origin of Species*, 78–79. Parasitism is likely to be far more significant in trophic webs than ecologists have assumed. In some ecosystems it appears that the total biomass of parasites may, in fact, outweigh top predators by an order of magnitude. "Study Shows Parasites Outweigh Predators," University of California, Santa Barbara, Public Affairs Office, www.ia.ucsb.edu/pa/index.shtml. Accessed 25 September 2009.

7. Vladimir Nabokov, *Strong Opinions* (New York: Vintage Books, 1990). He writes: "My loathings are simple: stupidity, oppression, crime, cruelty, soft music. My pleasures are the most intense known to man: writing and butterfly hunting" (p.iii).

8. Naomi E. Pierce et al., "The Ecology and Evolution of Ant Association in the Lycaenidae (Lepidoptera)," *Annual Review of Entomology* 47 (2002): 733–771.