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The New York Times
Thursday, April 10, 2008

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[Back to front page »](#)

April 8, 2008, 9:12 pm

A Mutual Affair

I'd like to introduce you to one of my favorite animals: the shrimp goby. These pretty little fish lead lives of enviable indolence. As their name suggests, they live with shrimp (often, a pair). The shrimp build and maintain a burrow, which the goby and shrimp live in together. Each shrimp works hard, shoveling sand out of the front entrance like a miniature bulldozer. As soon as it's delivered the rubble to a suitable distance, it shoots back into the burrow.



Shrimp with its goby, Gulf of Oman. (Courtesy: Operation Pufferfish)

The front entrance of the burrow is often reinforced with bits of shell and coral — all of which is done by the shrimp. The goby just sits in the entrance of the burrow, keeping guard and warning the shrimp, which is nearly blind, of danger. At any sign of danger — a diver coming too close, a passing predator — the goby darts into the burrow. If the goby zooms in, the shrimp hastily retreats deep inside. And before the shrimp emerges from the burrow, it touches the goby's tail with its long antennae. To show it's safe to come out, the goby gently wiggles its tail. When the shrimp is out of the burrow, it keeps one antenna touching the goby. If the goby suddenly retreats, so does the shrimp.

These animals are dependent on each other. Remove the fish, and the shrimp stops burrowing; the shrimp forage while burrowing, so without a fish, they grow more slowly, too. The shrimp need their guard goby. And the guard goby needs its shrimp: deny the goby shelter in a burrow, and it will promptly be killed by predators (yes, someone did the experiment). The shrimp keep the goby clean, too: they groom it.



A shrimp goby keeping guard, Gulf of Oman. (Courtesy: Operation Pufferfish)

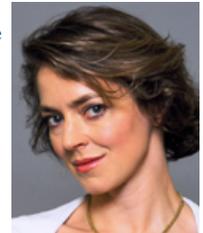
Close, beneficial associations between creatures of different species are nothing unusual. On the contrary, they are the very fabric of nature. The lichen you see on that old gravestone is a liaison between a fungus

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About Olivia Judson

Olivia Judson, an evolutionary biologist, is the author of "[Dr. Tatiana's Sex Advice to All Creation: The Definitive Guide to the Evolutionary Biology of Sex](#)," which was made into a three-part television program. Ms. Judson has been a reporter for The Economist and has written for a number of other publications, including Nature, The Financial Times, The Atlantic and Natural History. She is a research fellow in biology at Imperial College London.



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and an alga. The fungus provides shelter and a good growing environment — a kind of greenhouse — and the alga provides the fungus with food. The corals you're snorkeling over are colonies of animal-algal partnerships; again, the animals provide the shelter, the algae provide the food, and also help the coral animal to secrete its hard outer skeleton. In some associations, the algae generate as much as 98 percent of the colony's nutrients. And look in the mirror: your digestion is aided by the bacteria you are housing in your gut.

Peer at the undersides of the leaves of the riverbank grape, *Vitis riparia*, and you'll find tufts of hair at points along the veins; the tufts are shelters for mites (*Orthotydeus lambi*). The mites feed on grape powdery mildew (*Uncinula necator*), a parasitic fungus that otherwise grows into the grape plant and steals its nutrients, at great detriment to the plant. The mites keep the leaves clear of the fungus. (Interestingly, most commercial grape varieties don't have shelters for mites on their leaves, and they are home to few mites. Unsprayed, they also have a big problem with powdery mildew.)

Or take bobtail squid. These house luminous bacteria — around a trillion — in a special chamber, the light organ. The bacteria make light, thus providing the squid with counter-illumination — a way of disguising their silhouette and blending in with moonlight filtering through the water. As a result of the counterillumination, when a predator looks up, it doesn't see a dark blotch, but a faint silvery shadow, or perhaps nothing at all. The bacteria benefit, too: they grow faster inside the squid than they do in the open sea.

Or, or, or — I could sit here describing beneficial associations for days.

Yet despite their ubiquity, much about the evolution of beneficial associations — or mutualisms, as they are usually called — remains mysterious. There are several difficulties. The first is that the term covers a huge spectrum of phenomena. For instance, some mutualisms are extremely specific, involving the same sets of species. Bobtail squid, for example, are fussy about their bacteria; they have a strong preference for a particular strain.

Other mutualisms are less tightly linked. For instance, around 120 species of goby interact with just 30 species of shrimp. Although both fish and shrimp are attracted to each other — the fish by sight and the shrimp by smell — the attraction doesn't seem to be limited to a particular species. The same goes for corals and lichens: the animal that makes the coral can host a variety of algae; ditto, the fungi that form lichens.

Different mutualisms are also perpetuated in different ways. The leaf-cutting ants of central and south America farm a fungus; the ants depend on the fungus for food. If the fungus sickens and dies, the ant colony collapses. The ant-fungus is transmitted from colony to colony by successive generations of queens. It is, in other words, transmitted from mother to daughter, like a family heirloom. (Heirloom fungus, anyone?) The clam *Calypotgena magnifica*, which lives on deep-sea vents, depends on a bacterium to supply



The leaf-cutter queen ant in her

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Feeds

it with nutrients; the bacterium is transmitted through the clam's eggs. The same goes for our mitochondria — the remnants of bacteria that live in our cells and provide us with energy.

In contrast, baby bobtail squid get their bacteria from the environment; the association begins anew every generation. So, too, with shrimps and gobies: both spend their larval life floating about as plankton, so you don't have successive generations of animals living in the same burrows. Indeed, shrimps don't necessarily live with the same goby throughout their lives. A small goby may be evicted from a burrow by a bigger one, and in any case, some gobies leave their burrows during the mating season, and shack up temporarily with another for spawning.

On top of that, according to current evolutionary thought, mutualisms should be prone to evolutionary instability. The reason is that mutualisms depend on the continued cooperation of both parties. But cooperation is often fragile: an association that starts out being of mutual benefit can quickly evolve into one that is parasitic. This is especially true in situations where the evolutionary interests of the two parties are not tightly linked — such as when the mutualism is established anew in each generation. When the transmission of one party is dependent on the other — as in the clam — the association is expected to be more stable, because harm to one partner is harm to both.

But some of these associations may have evolved to be more stable than they appear. Consider soybeans. These — like other legumes — have bacteria living in nodules on their roots. The bacteria supply the plant with nitrogen, and receive nutrients from the plant in return. Why don't the bacteria cheat, and collect nutrients without doing any "work"? Because soybeans punish non-cooperators: apparently, they deny oxygen to nodules that fail to produce nitrogen. In a similar fashion, some species of sea anemone evict algae that divide too fast and thus threaten to overrun their anemone host.

Given the difficulties of sustaining mutualisms, why do they evolve? Why don't grapes evolve a fungicide, or bobtail squid evolve to make their own light? I think the answer is that mutualisms, for all their imperfections, are easier. Evolving an association with another organism gives access to a whole other genome, a whole new set of capacities and capabilities that have already been tested by evolution. It's faster and more powerful than going it alone.

NOTES:

*Details of the shrimp-goby mutualism differ a little bit depending on which species are involved: in the Atlantic Ocean, the relationships between shrimp and goby can be more flexible. I have based my account on Karplus, I. 1972. "Associative behavior of the fish *Cryptocentrus cryptocentrus* (Gobiidae) and the pistol shrimp *Alpheus djiboutensis* (Alpheidae) in artificial burrows." *Marine Biology* 15: 95-104; this paper describes the shrimp maintaining antennal contact, the fish wagging its tail to give the "all-clear," and the shrimp cleaning the fish. For shrimp growing more slowly in the absence of gobies, and for gobies evicting each other, see Thompson, A. R. 2005. "Dynamics of demographically*

open mutualists: immigration, intraspecific competition, and predation impact goby populations. *Oecologia* 143: 61-69. For the mating behavior of gobies, as well as most other details of the association, see the definitive paper by Karplus, I. 1987. “The association between gobiid fishes and burrowing alpheid shrimps.” *Oceanography and Marine Biology* 25: 507-562.

For riverbank grapes, mites, and powdery mildews, see Norton, A. P., English-Loeb, G., Gadoury, D. and Seem, R. C. 2000. “Mycophagous mites and foliar pathogens: leaf domatia mediate tritrophic interactions in grapes.” *Ecology* 81: 490-499.

For counter-illumination in bobtail squid, see Jones, B. W. and Nishiguchi, M. K. 2004. “Counterillumination in the Hawaiian bobtail squid, *Euprymna scolopes* Berry (Mollusca: Cephalopoda).” *Marine Biology* 144: 1151-1155. For the specificity of squid and bacteria, see Nishiguchi, M. K. 2002. “Host-symbiont recognition in the environmentally transmitted sepiolid squid-vibrio mutualism.” *Microbial Ecology* 44: 10-18.

For the flexibility of lichen associations, see Piercey-Normore, M. D. and DePriest, P. T. 2001. “Algal switching among lichen symbioses.” *American Journal of Botany* 88: 1490-1498. For corals, see Baker, A. C. 2003. “Flexibility and specificity in coral-algal symbiosis: diversity, ecology, and biogeography of *Symbiodinium*.” *Annual Review of Ecology and Systematics* 34: 661-689.

For transmission of the ant-fungus, as well as a discussion of fascinating aspects of the mutualism I didn't have space to mention here, see Currie, C. R. 2001. “A community of ants, fungi, and bacteria: a multilateral approach to studying symbiosis.” *Annual Review of Microbiology* 55: 357-380. For vertical transmission of clam bacteria, see Hurtado, L. A., Mateos, M., Lutz, R. A. and Vrijenhoek, R. C. 2003. “Coupling of bacterial endosymbiont and host mitochondrial genomes in the hydrothermal vent clam *Calyptogena magnifica*.” *Applied and Environmental Microbiology* 69: 2058-2064.

Mutualisms and their stability (or lack of) have been written about extensively; see, for example, Herre, E. A., Knowlton, N., Mueller, U. G. and Rehner, S. A. 1999. “The evolution of mutualisms: exploring the paths between conflict and cooperation.” *Trends in Ecology and Evolution* 14: 49-53; and Sachs, J. L. and Simms, E. L. 2006. “Pathways to mutualism breakdown.” *Trends in Ecology and Evolution* 21: 585-592.

For punitive soybeans, see Kiers, E. T., Rousseau, R. A., West, S. A. and Denison, R. F. 2003. “Host sanctions and the legume-rhizobium mutualism.” *Nature* 425: 78-81. For sea anemones expelling algae, see Baghdasarian, G. and Muscatine, L. 2000. “Preferential expulsion of dividing algal cells as a mechanism for regulating algal-cnidarian symbiosis.” *Biological Bulletin* 199: 278-286. For a whacky discussion of the advantages of acquiring genomes, see Margulis, L. and Sagan, D. 2002. “Acquiring Genomes: A Theory of the Origins of Species.” Basic Books.

Many thanks to Dan Haydon, Gideon Lichfield and Jonathan Swire for insights, comments and suggestions.

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51 comments so far...

1. April 8th, 2008 10:23 pm

Dear Olivia,

As is your habit in these lovely essays, you stick scrupulously to the fine points of your scientific analysis and leave it to your readers to apply your lessons to the deep dilemmas of modern mankind.

Let us begin by acknowledging that homo sapiens is fully capable of entering into long term mutualistic arrangements with other species. Man and dog is the most conspicuous of these alliances, a form of mutualism with roots that may be as ancient as two hundred thousand years.

The deeper question your essay implicitly raises is why humanity has so profoundly forsaken the obvious benefits of mutualism in favor of an extreme form of dominance over all other species. The short term benefits of this dominance are clearly at odds with the evolutionary catastrophe we are in the process of precipitating.

Let us hope that one day you will focus your theoretical prowess on that tragic paradox, and maybe even point the way toward a solution to it.

— Posted by David Moody

2. April 8th, 2008 10:39 pm

I still remember my college biology teacher saying that the relationship is rare and unstable. At the same time I had the pleasure of seeing a series called Life on Earth that made a case for mutualism similar but not as detailed and compelling as yours.

I am glad he was wrong even as I learned much else and did well in his class.

The story of the shrimp and the goby could be a Disney movie. In a few sentences you told us how it starts what challenges they have and what could go wrong.

Keep teaching and giving your fine writing to us and I look forward to learning an growing with every new essay.

— Posted by Mark

3. April 8th, 2008 11:05 pm

I see there is some evidence of mutualism between certain cyanobacteria and viruses, to the degree that the latter are incorporated into the former's genome. But I wonder if the cyanobacteria didn't actually invent the phages, for use as messengers, and which only later developed independence.

— Posted by Nathan Myers

4. April 9th, 2008 1:11 am

Symbiosis, or mutualism, is one of my favorite scientific subjects. Recently I have become aware of the extent to which humans depend on the beneficial gut bacteria for both digestion and immune function—and these same bacteria may explain why some people like chocolate and others do not. Intestinal worms, previously thought to be parasitic only, seem to have a modulatory effect on the immune system, staving off allergies, asthma, and some autoimmune disorders. Makes one wonder what other “disorders” have hidden medical benefits.

As you mentioned, you could go on forever talking about mutualisms, but you did omit one of my favorites. It's another one involving ants and fungi, but parasitic rather than symbiotic. In this case, the fungus infects the ant's brain, causing it to climb to the highest treetop where it is essentially petrified and dies. Then the fungus consumes the ant's body, and the spores are dispersed from an optimal location, high above the ground.

I don't have complete citations, but in the spirit of your detailed references I feel obliged to provide some supporting info. The parasitic fungus is cordyceps. The paper about the correlation between liking/disliking chocolate and metabolism is “Human Metabolic Phenotypes Link Directly to Specific Dietary Preferences in Healthy Individuals” by Rezzi et al. Dr. Joel Weinstock, at the

University of Iowa, has done research on using pig whipworm eggs as treatment for inflammatory bowel disease, irritable bowel syndrome, and Crohn's disease.

– Posted by Aurelio Ramirez

-
5. April 9th, 2008 1:23 am This is a wonderful and unusual column. I am very grateful for it.
– Posted by Chicago Steve
-
6. April 9th, 2008 3:20 am Just thought I would point out that there are some symbioses very similar to the one involving the Calyptogena clam in which the symbionts are transmitted environmentally not vertically. We are in the process of sequencing the genomes of these symbionts in order to compare them to the genome of the Calyptogena symbiont (which we sequenced previously). We are interested in whether the vertically transmitted symbionts evolve in different ways than the environmentally transmitted ones.
– Posted by Jonathan A. Eisen
-
7. April 9th, 2008 4:20 am Every week, I wait for the next journey she narates. LOVE IT!
– Posted by v ogle
-
8. April 9th, 2008 6:06 am Aren't mutualisms just like some human relationships?
– Posted by Roberto Garcia
-
9. April 9th, 2008 6:10 am Fascinating!
– Posted by addicted
-
10. April 9th, 2008 7:18 am One way to look at all mutualisms is that they actually are situations of mutual exploitations. This is what Julia is actually saying in the last few paragraphs of this fascinating (as ever) essay.
– Posted by Alain
-
11. April 9th, 2008 7:28 am wouldn't the term symbiosis apply here?
– Posted by Marilyn
-
12. April 9th, 2008 8:13 am In response to David Moody, post #1:
Isn't farming a human / plant mutually beneficial relationship?
– Posted by Sinead Miriam Mason
-
13. April 9th, 2008 8:22 am Ms. Judson,
Thank you for this wonderful essay. It is an example of the deep reservoir of fascinating stories from science that are relevant to the humanities. I agree with David Moody's point about the need for a greater awareness of man's dependence on the rest of life on the planet. Unfortunately, what man's limited intelligence won't produce wisely, evolution will produce brutally.
– Posted by Paul Cote
-
14. April 9th, 2008 8:26 am I love your column, look forward to reading it, and wish I could write half as well as you.
– Posted by R.
-
15. April 9th, 2008 8:33 am Ms. Judson:
Any possibility you might live-link your references? I am reasonably certain that you and your editors have already discussed doing so.
Even with the likelihood of many links to for-fee professional journals, this would increase the intellectual utility of your well-written discussions.

Some of the journals might even accept opening their mentioned articles to public access, if linked from the august New York Times.

Many thanks.

– Posted by Robert Hanke

-
16. April 9th, 2008
9:06 am
- One of the more interesting mutualisms is the relationship between *Toxoplasma gondii* and cats. Toxo reproduces in a cat's intestines and its spores are distributed through cat feces. It can then infect many other species including birds rodents and humans (see "Cat-Lady Conundrum" NY Times 12/9/07). In the non-feline species, Toxo grows outside the gut, often infecting the brain. It can produce bizarre behavioral changes such as making a rat attracted to rather than repelled by cat urine. The cat eats the rat and Toxo is back in the environment where it reproduces.

It can be argued that wheat or corn is the most successful organism on earth through the mutualism it has formed with humans. By offering up carbohydrate and a bit of protein in the seed, wheat and corn have induced humans to clear and cultivate millions of acres of land to provide them with ideal growing conditions. Furthermore, those indentured humans toil to keep the diseases and predators of wheat and corn at bay.

As for "heirloom fungus", consider the yeasts that produce sourdough, kombucha, beer, wine and even pharmaceuticals.

As usual, you have written a very thought provoking column.

– Posted by Todd Patton

-
17. April 9th, 2008
9:27 am
- This is a fascinating subject. However, in the last paragraph the author asks why mutualisms evolve and answers that they do because it is "easier." I do not understand. I assume she means that it is easier for both the shrimp and the goby. But the answer seems to presuppose that the shrimp and the goby are making a choice of some kind. This makes their relationship even more amazing because, not only do they have an ongoing symbiotic relationship, but, in some sense, they evolve together. But Since mutation does not appear to be something that is chosen, then I assume that the choice is related to natural selection. Can anyone out there explain how they believe this actually worked? Thanks.

– Posted by ehillesum

-
18. April 9th, 2008
9:46 am
- Don't stop! Your work has become the most awaited set of articles in the NYT.

– Posted by TED

-
19. April 9th, 2008
10:19 am
- As much as I sympathize with the concerns of David Moody, author of the first comment, and am likewise concerned with humanity's assumption of dominance over other species, the idea that humans have somehow eschewed mutualistic relationships with other species reflects a very narrow and idealized conception of mutualism. In fact, humans have many such relationships, not least in the realm of agriculture. We exploit the riches of plants' genomes while they gain guaranteed reproductive success and protection (if imperfect) from herbivores. Moody mentions dogs, but neglects all of the other nonhuman animals with whom we have close mutualistic relationships. I think that the reason human-dog relationships seem more apparently mutualistic than human-cow or human-chicken relationships is a misconception of mutualism as somehow benevolent, driven by caring rather than mutual gain. Mutualism, in a biological sense, does not reflect the inherent benevolence of nature, but rather reflects, as Judson describes in her final paragraph, the efficiency of making an alliance with another entire genome—the exploitation of another species' evolutionary history.

That said, it's up to us, as humans, to define the "nature" of those relationships from a cultural standpoint. Caring is not a biological imperative of our myriad relationships with other species, but it is a quality with which we can (and should, from my perspective) choose to imbue those relationships. Cows achieve reproductive success in a

strict sense through factory farming, but this does not mean that we should endorse the practices of factory farming. Likewise, forethought about the long-term consequences of our actions should have the power to change our cultural practices. In the short term, heavy insecticide use protects our crops from herbivores, to mutual (plant and human) biological gain, but the long-term impact on the health of human populations and ecosystems, not to mention the evolutionary effects on populations of crop-eating insects, should lead thoughtful humans to reconsider this practice.

It's misguided to think that we can learn how humans should act from the wise lessons imparted by a benevolent nature. Mutualism is not built on benevolence. If humans are to act benevolently toward our mutualists, it will be a worthy cultural decision, rather than a biological imperative.

— Posted by Rachel Mason Dentinger

-
20. April 9th, 2008
10:21 am
- A truly wonderfully crafted gem of an account indeed from Olivia Judson's pen, on a sample of the many mysteries nature offers. Reading the article I could not help but think about that this symbiotic parasitic relationship probably applies to association between nation states as well. The once mutually beneficial harmonious friendship - as time's arrow flies - can evolve into an ugly parasitic relation before our own eyes.
- Posted by andre
-
21. April 9th, 2008
10:34 am
- As always, a fabulous column, Ms. Judson. In fact, perhaps my favorite thus far. 😊 I look forward to every Wednesday where I learn something new (and fascinating) about nature and the beautiful, mysterious and powerful world in which we live. (Plus, I get to "impress" people with the ample knowledge you provide.) Thank you for opening my eyes wider each Wednesday.
- Posted by Virginia Duan
-
22. April 9th, 2008
11:13 am
- As the proverb goes, "If you want to go quickly, go alone. If you want to go far, go together."
- Thanks for the column.
- Posted by Aron Rosenthal
-
23. April 9th, 2008
11:13 am
- Are you sure about the Rhizobium-soybean story? Nitrogen fixation is an obligately anaerobic process and the bacterial nodule produces a specialized pigment (leg-hemoglobin) to "mop up" excess oxygen. Oxygen must be denied if nitrogen is to be fixed.
- Posted by Frank
-
24. April 9th, 2008
11:24 am
- Excellent column. Thanks for the great read.
- Posted by Angela
-
25. April 9th, 2008
12:12 pm
- Isn't the biosphere of our planet a product of mutualism rather than the presumed evolutionary process of competitive adaptation? Survival of a species depends on the symbiotic relationship with even the most elemental particles before more complex forms can evolve. Organisms that do not survive may be viewed as not being mutually compatible with their environment. We are too caught up in the survival of our species to take the wider view of the amoral equality of natural law.
- Mutations are tested by their compatibility to their immediate environment before the organism is tested for survival.
- Evolution has been explained as survival of the mitochondria, survival of the DNA, and survival of the fittest when observed from the point of view of these components. It is as true that the biosphere is the organism in which all components contribute to a mutualism of life. In that event, without this possibility the parts would not have the proper perspective from which to understand their place in the whole organism, let alone theorize on the origin or purpose of the

process.

— Posted by Morton Kurzweil

-
26. April 9th, 2008
12:19 pm
- In many cases of obligate mutualisms (a life form can only exist in a relation with a specific host) the form “degenerates” - body structures or genes are lost because their function is provided by the host.
- What is the genome of such a form? Is it just the DNA of the form itself or does it include the DNA of the host. From the first perspective the genome has decreased while for the second it has increased.
- Somewhere I read that 3/4 of all life forms were obligate parasites.
- Posted by mcguire
-
27. April 9th, 2008
12:22 pm
- Several people have commented upon the mutualism of E. coli and human beings — without those bacteria in our gut, we would not be able to digest the food we eat. As James Lovelock emphasizes, the E. coli are the remnant survivors of the happy anaerobic world of a billion years ago before it was destroyed by the poisonous oxygen generated by the photosynthetic organisms that evolved — these old life forms survive only in our bowels and in swamps where they are protected from oxygen. Perhaps in the future, as digital systems further evolve and carbon-based life forms give way to silicon-based entities, a few of us will be protected from the exigencies of hyper-cyberspace and be maintained for special analog processing in the bowels of the big silicon information eaters where we will happily spend our days churning out digital feces.
- Posted by Edward Cranswick
-
28. April 9th, 2008
12:27 pm
- I have been reading the nytimes internet edition for a few years now, and the first time i noticed this excellent write up, i'm hooked, Ms Judson. It has been my regular “must read items” in the week. I usually look up the science and technology sections first, but that will change; and your column will be my priority every Wednesday. Such fascinating subjects.
- Posted by joe
-
29. April 9th, 2008
12:28 pm
- Beautifully written. Thank you.
- Posted by Lucy
-
30. April 9th, 2008
12:30 pm
- I was, like ehilsum, intrigued by the observation that mutualism occurs because it may be ‘easier’ than the alternative.
- I suggest a parallel - outsourcing as a business form of evolving and solving environmental problems, or taking advantage of environmental opportunities, without having to develop all systems internally. The same benefits, as well as risks, seem to apply to the outsource relationship as described for mutualism by Ms. Judson.
- Posted by Jesse
-
31. April 9th, 2008
12:41 pm
- I don't always read these columns, but I do enjoy the ones I happen to catch. But even more importantly, I LOVE the fact that the NYT recognizes and promotes such an important topic — science — with such glorious writing. Thanks to all.
- Posted by Elizabeth Connor
-
32. April 9th, 2008
12:48 pm
- Great science writing—authoritative, engaging, informative!!
- Posted by R. L. Pardy
-
33. April 9th, 2008
1:03 pm
- To David Moody: “The deeper question your essay implicitly raises is why humanity has so profoundly forsaken the obvious benefits of mutualism in favor of an extreme form of dominance over all other species.”
- Humanity has done no such thing. Civilization certainly has, but

civilization is hardly the sum of humanity.

– Posted by Josh Saulter

-
34. April 9th, 2008
1:08 pm
- #23, the soybean work was done in my lab and is correctly described here. It is true that too much oxygen will destroy the nitrogen-fixing enzyme, but too little limits bacterial respiration. I will post more details on my blog, This Week in Evolution, later today.
- Posted by Ford Denison
-
35. April 9th, 2008
1:33 pm
- Dear Olivia, Wednesday, April 9, 2008
May I endorse the remarks of David Moody, above, particularly his praise about the scientific analysis of your lovely essays. David Moody asks why the paradox?
What, indeed, has brought about nature's "forsaking the obvious benefits of mutualism in favor of (humanity's) extreme form of dominance over all other species."
Would you, if the evidence is available, particularly address his question of the cause of that tragic paradox?
From that might come a solution.
- Posted by Robert C. Behan
– Posted by Robert C. Behan
-
36. April 9th, 2008
1:35 pm
- Brilliant! I wish NYT would feature more articles like this one.
- Posted by Alan
-
37. April 9th, 2008
1:58 pm
- I teach high school biology and was thrilled when I discovered this column only a couple of months ago. My students are benefiting not only from the fascinating information but also from the fabulous writing. We all now look forward to Wednesdays! Thanks!
- Posted by Kathy
-
38. April 9th, 2008
2:21 pm
- This charming essay reminds me of a favorite book of mine, Peter Kropotkin's anarchist classic, *Mutual Aid: A Factor of Evolution* (1902). The idea that nature is all bloody competition is an ideological construct that came from nineteenth century predatory capitalism—not like the gentle, friendly capitalism of today! (Well, not predatory, since there is mutualism as well among species of predators and prey. Predatory shouldn't be a bad word.) This idea of bloody, competitive nature was a notable fixture (*idee fixe*?) in the recent, disappointing Discovery series, "Planet Earth"—nature as all sex and gladiatorial combat. It is unfortunate that hardly anyone reads Kropotkin's book any more. It's worth noting that the idea of mutualism is an old one (it was common among tribal land-based peoples as well), and one that, besides being more humane (another funny word in this context), is also good science.
- Posted by David Watson
-
39. April 9th, 2008
2:26 pm
- I seem to recall reading that the grapes which grow in colder, damper climates do in fact develop their own fungicide—resveratrol—and that is why grapes grown in the Finger Lakes of New York State, or the ones from just south of Portland, Oregon, or even the ones from Tasmania, south of Australia are particularly rich in this valuable antioxidant. Or is resveratrol a separate, cooperative beastie or the product of such a hanger-on?
- Posted by Eric Berman
-
40. April 9th, 2008
2:35 pm
- Again, I want to thank you for expanding my inventory of science and especially information on genomes and evolution. Charles Rogers
- Posted by Charles Rogers
-
41. April 9th, 2008
3:37 pm
- I read this article aloud to my German Shepherd Dog named Cassius. He's a Search And Rescue Dog, who served alongside me in New Orleans after Hurricane Katrina struck. I laughed at the idea that two

animals could have a mutually beneficial relationship. “Impossible” I exclaimed as Cassius snuggled closer attracted by my voice. He curled up against my feet and kept them warm as I read to us. After I finished reading the article, Cassius’ ears perked up and his tail began to thump. He noticed that I was spying his leash and that it might be time to play the game where we practice saving human lives. Yup, these mutually beneficial interspecies relationships are crazy talk. My dog and I know better than to buy into such nonsense.

— Posted by Peter JL Taft and K9 Cassius

42. April 9th, 2008 3:38 pm
You don’t mention what might be the most amazing symbiosis, given the high level of development of the two animals: the hunting teams formed by coyotes and badgers. See the section titled “Hunting Behaviors” at www.bio.davidson.edu/people/vecase/Behavior/Spring2004/holmberg/Holmberg4.html.

— Posted by Alex

43. April 9th, 2008 3:39 pm
fascinating story about the goby and the shrimp

— Posted by nmitra001@gmail.com

44. April 9th, 2008 3:49 pm
Great column as usual. Reading about the shrimp/goby pair is just too interesting. I would like to get a fish tank and raise a few of these to watch the pair in work. I wonder if they would still interact in a tank without any predators around.

In response to Eric Berman:

Your question is interesting. Here’s what I know. Plants produce a wide variety of polyphenols and phenolic compounds that are used to defend them against invaders (bacteria, insects, etc.). Many of these compounds are antioxidants in certain conditions and prooxidants in other conditions. So when you note that the red-wine polyphenol resveratrol is an antioxidant, it might be a feeding deterrent or stimulant. It often depends on the “reaction conditions” inside the insect’s gut (pH). So resveratrol could easily be a prooxidant, and thus damaging, for one type of bug, and at the same time an antioxidant to us. I am guessing that the same would hold true for other invaders like fungi. I’m less likely to believe that the compound is for a cooperative beastie though.

— Posted by Chris Jones

45. April 9th, 2008 4:41 pm
Responding to #1 Mr. Moody, #16, Mr. Patton, and #19, Ms. Dentinger: A wonderful book, accessible to lay readers like myself, is *The Botany of Desire*, by Michael Pollan, also author of *The Omnivore’s Dilemma* and *In Defense of Food*. He writes about four plant species with mutually dependent relationships with humans: Potatoes, Apples, Tomatoes, and (!) marijuana. A wonderful book, recommended.

— Posted by Kerry Curtis

46. April 9th, 2008 5:07 pm
This series of science is one of the best discoveries I’ve ever made by surfing the NYT. Olivia Judson has a true gift knowledge and a way with words. I hope there are plans to put her columns in a book with lots of photographs.

Thanks for enriching my science horizons.

— Posted by Ruth Mutchnik

47. April 9th, 2008 5:25 pm
This was a great read. I study mutualisms and love to see people getting excited about them. One thing I noted was many people were confusing mutualism with symbiosis. A mutualism is a relationship between two species where both species benefit one another. A symbiosis is a relationship between two species where they are closely associated. Some of the relationships readers have discussed, while they are symbioses, the fungus in the ant’s brain, they are parasitic (one species benefits and one does not), and not mutualistic.

Also, no mention of mycorrhizal fungi was made. Mycorrhizae is a mutualism between plants and fungi and the majority of land plants engage in the mutualism. The plants supply the fungus with carbon and the fungus supply the plant with nutrients and water. Since this mutualism takes place below-ground in plant's roots, it is sadly, often overlooked.

— Posted by Meghan

-
48. April 9th, 2008 5:26 pm
- Would it be wrong to extrapolate a lesson about intra-species relationships as well?
- The question Ms. Judson poses at the end of the piece is answered best, I think, in Annie Hall:
- This guy goes to a psychiatrist and says doc, "My brother's crazy, he thinks he's a chicken." And the doctor says, "Well why don't you turn him in?" And the guy says "I would, but I need the eggs." Well, I guess that's pretty much how I feel about relationships. They're totally irrational, and crazy and absurd, but I guess we keep going through it because most of us need the eggs.
- "Given the difficulties of sustaining mutualisms, why do they evolve?" Most of us need the eggs.
- Posted by Dave R

-
49. April 9th, 2008 5:28 pm
- This is a fascinating article, but what about farmed shrimp? I'll bet they are very lonely without their goby companions.
- Posted by Dot K

-
50. April 9th, 2008 5:43 pm
- "This is a fascinating subject. However, in the last paragraph the author asks why mutualisms evolve and answers that they do because it is "easier." I do not understand. I assume she means that it is easier for both the shrimp and the goby. But the answer seems to presuppose that the shrimp and the goby are making a choice of some kind. This makes their relationship even more amazing because, not only do they have an ongoing symbiotic relationship, but, in some sense, they evolve together. But since mutation does not appear to be something that is chosen, then I assume that the choice is related to natural selection. Can anyone out there explain how they believe this actually worked? Thanks."
- Posted by ehillesum
- What is meant by 'easier' is that it is easier to evolve this relationship than to evolve all the functions of the partner species in the mutualism. Or that it's more efficient to maintain two different bodies with two specialized functions than to have all the functions in one body. Usually in articles like this, the writer has to strike a balance between hard-to-understand, clunky wording, and anthropomorphizing the organisms in the article—making it sound like they're 'choosing' things when they're not, in order to communicate the basic idea to casual readers.
- In the case of legumes, the legumes would have to accumulate all the genes that allow nitrogen fixation in order to replace their mutualism-partner bacteria and do the job themselves. And there is no guarantee that this would ever happen, since evolution occurs through chance mutations. If you start a plant species out with neither a mutualism nor any nitrogen-fixing genes, the probability is greater of them getting the necessary genes to start a mutualistic relationship with bacteria than the probability of them acquiring all the necessary genes to fix nitrogen.
- In the case of the shrimp and the goby, though, I think it might just be more efficient to keep the different functions in different bodies—the shrimp doesn't have to maintain good eyes and alertness, and the goby doesn't have to burrow, which a fish can do, but would probably never be able to do as efficiently as a shrimp.
- Posted by L. Isham

-
51. April 9th, 2008
- First Ms. Judson column for me, and indeed a beautiful one it is. I hope that her symbiotic relationship with the NYT will evolve — in

5:48 pm

the meantime, I hope that she and others will consider the possibility that the relationship between the shrimp and the goby was created before we were and didn't evolve from some non-symbiotic state. Keep up the fine work, Ms. Judson!

– Posted by MP

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