

Of Mussels and Men

Des moules et des hommes



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Abstract

Some species are more equal than others. Robert T. Paine (American ecologist, 1933–2016) discovered that if you remove starfish – what he called a “keystone species” – from a tide pool, the complex ecosystem collapses. Without the predator starfish, mussels choke out other animals and plants. This phenomenon is general. Sea otters eat the sea urchins that eat the kelp that provides food and habitat for other species. On the vast Serengeti plains, wildebeest “mow” the grass, protecting habitat for many other species. Understanding the “rules” that govern the numbers and diversity of species in an ecosystem is essential to efficient and sustainable management. But those same rules apply to us. Free of predation, humans are swarming over the planet, choking out other species. We are the planetary mussels. What next? A “mussel-bound” world, or perhaps renewed microbial predation?

Résumé

Certaines espèces sont plus égales que d'autres. Robert T. Paine (écologiste américain, 1933–2016) a découvert que si l'on retire les étoiles de mer – qu'il qualifie d'espèce clé de voûte – d'une cuvette de marée, l'écosystème complexe s'y dégrade. En l'absence du prédateur qu'est l'étoile de mer, les moules prolifèrent et étouffent les autres espèces d'animaux et de plantes. Ce phénomène se répète partout. Les loutres de mer se nourrissent d'oursins qui, eux, broutent les laminaires qui fournissent habitat et alimentation à d'autres espèces. Dans les vastes plaines du Serengeti, les gnous « fauchent » l'herbe, protégeant ainsi l'habitat de plusieurs espèces. Pour une gestion efficace et durable des écosystèmes, il faut comprendre les « règles » qui gouvernent le nombre et la diversité d'espèces qui y vivent. Ces mêmes règles s'appliquent

aussi à nous. Libérés de la prédation, les humains essaient partout sur la planète et bousculent les autres espèces. Nous sommes les moules de la planète. Où cela mènera-t-il? Dans un monde dominé par les « moules », ou encore, à un nouveau type de prédation microbienne?

Small (Science) Is Also Beautiful

Big Science is way cool: Large Hadron Colliders finding the most fundamental particle of all, probes landing on comets, telescopes in space reaching to the outer edge of the knowable universe – very high “gosh!” factors. But there is also science of the most elegant simplicity, seemingly almost trivial, yet with very significant implications. A case in point: Robert Paine and the starfish.

Messing about in tide pools has a fascination all up and down the demographic spectrum. But Paine, an ecologist at the University of Washington, came up with a better-than-average excuse for incorporating such messing about into his paid employment. This description of his work is from an episode of the extraordinary CBC radio program *Quirks and Quarks*, hosted by Bob McDonald. The guest being interviewed, Dr. Sean Carroll, is a biologist and author, most recently of *The Serengeti Rules* (on which more below). Paine’s experiment, starting in 1963, consisted of nothing more radical than removing all the starfish from a number of tide pools, every month for an extended period of years, and observing how this affected the types and numbers of different flora and fauna in the pool community. Undisturbed pools in the same location served as controls.

Starfish are the top predators in this little world, being adept at opening and eating shelled creatures and having no natural enemies. But the removal of the top predator did not result in a general flourishing of other species. To the contrary, the ecosystems in the “treated” pools collapsed. The pool communities became overrun (so to speak) with mussels. Nothing else could break into their shells to eat them, and as they occupied all the available rock surfaces, other species – both plant and animal – were crowded out. Starfish, it turned out, were the “keystone species” (Paine’s term) on which the balance of the whole community depended: remove them and that community collapses (“Some Animals Are More Equal Than Others” 2016).

There are two salient aspects to this observation. First is that the web of ecological relationships – interactions among species – can be much more complex than a simple bilateral predator–prey link. But second, some species, the keystones, have powerful indirect impacts on others for which they are neither predator nor prey.

Keystone species have been identified much more widely. (Some have been discussed on *Quirks and Quarks*.) Carroll mentions the sea otter, which, by feeding on and keeping in check the population of sea urchins, prevents the “deforestation” of kelp beds that offer food and sanctuary to a number of other species, including fish and sea birds.

The Keystone Lawnmowers

But the keystone species need not be the top predator in an ecosystem. On the vast plains of the Serengeti, where a large and complex ecosystem supports an extensive array of animals,

plants, and insects, the keystone species turns out to be – the wildebeest. Huge herds grazing across the plains act as “a million lawnmowers” to keep the growth of grass in check. Cutting the grass protects habitat for butterflies and other insects; it also reduces fire danger and so protects trees that offer habitat to birds and climbing animals. The king of the beasts, the lion, may look pretty impressive, but is really a figurehead. The well-being of the Serengeti community depends on the herds of humble gardeners (who gnu?).

The importance of the wildebeest was worked out by ecologists studying the Serengeti in the 1960s; Carroll refers particularly to the work of Tony Sinclair at the University of British Columbia. These researchers came to the Serengeti at a fortuitous time in its history. As Carroll notes, to understand how a complex ecosystem works, biologists need an opportunity to observe its response to a perturbation. Bob Paine’s crowbar prying off the starfish was such a perturbation in the tide pools.

The perturbation in the Serengeti was disease and recovery. Starting in the 1800s, wildebeest and buffalo had been dying from diseases spread from domestic cattle. These diseases had drastically reduced the populations from historic levels. But starting in the 1960s, vaccines developed to protect domestic herds had largely removed the pressure of mortality on the wild populations. Carroll says that the fleets of wildebeest “lawnmowers” increased from 200,000 to 1.4 million in only 15 years. There was the ecologists’ natural experiment, a perturbation on a massive scale.

Learning the Rules – and Following Them

The Serengeti is an amazing place. But Carroll’s book is titled *The Serengeti Rules* because he focuses on the rules that regulate interactions among the region’s myriad inhabitants, and indeed among all living things. More generally, all of nature is regulated, and science is about discovering the rules that govern the natural world. In the physical world, these are sometimes amazingly simple, as with Newton’s Universal Law of Gravitation (well, at least until Max Planck came along and turned the quantum theorists loose). But in the biological world, the rules governing the interactions among living species are much more messy and complex. The basic theme of Carroll’s book is that there are such rules.

These rules are illustrated on a grand scale in the Serengeti. The numbers and types of living things are regulated by a complex web of feedback mechanisms arising from the numbers and behaviours of all the other species in the ecosystem. The last 50 years of ecological research, whether in the Serengeti or in Pacific tide pools, or anywhere else on Earth, has provided ever more examples not only of the negative feedback processes that regulate the biological world but also of the critical importance in each ecosystem of certain keystone species on which the whole regulatory framework depends.

All very fascinating, but what does this have to do with healthcare policy? The answer is two-fold. The first came out in the conversation between Sean Carroll and Bob McDonald, but the second was conspicuously absent. And as is often the case, what was said was interesting but what was *not* said was crucial.

On the first level, understanding the rules that govern the natural world, both physical and biological, is extremely important for human activity, as we pursue our individual and, particularly, our collective objectives. The feedback mechanisms illustrated in the Serengeti on a macro scale also operate on a micro scale, inside our bodies. Homeostasis, maintaining the organism in a healthy state, depends upon the interaction of a huge number of feedback processes. If these go haywire, the results can vary from uncomfortable to deadly. The many varieties of cancer all have in common the failure of the feedback processes that govern the proliferation of cells.

Carroll puts more emphasis on the importance of “knowing the rules” at the macro scale. For better or for worse, human activity now has major direct and indirect impacts throughout the biosphere. And since there are now 7.4 billion of us on the planet, and counting, we had better know the rules if only to be able to keep feeding ourselves. If you do not know what you are doing, the ecosystem can be an expensive place to find out.

Carroll, as a scientist, seems relatively optimistic about the progress that has been and is being made in the ecological sciences. We, or at least the scientific community, are learning more and more about the rules. With that knowledge, humans could, in principle, increasingly manage the biosphere in a sustainable way, to our collective and long-term advantage.

De Nobis Fabula Narratur

But here, I think, both Carroll and McDonald failed to bring out a truly fundamental point: *the Serengeti rules apply to us.*

The human population is still increasing steadily. It is variously forecast to top out at somewhere near 11 billion around mid-century, but those forecasts are based on economic models in which fertility rates decline with increasing prosperity. Those models depend upon an underlying assumption of cultural homogeneity. Simple mathematics shows that the rate of growth of an aggregate of diverse components will eventually converge to that of its most rapidly growing component. The populations of Germany, Russia and China may be stable or declining, but the average rate of growth will increasingly be dominated by Ethiopia, Somalia and Pakistan. (Those larger populations may, however, increasingly be located elsewhere, for example, in Europe.)

And maybe not. Forecasting is notoriously hazardous. What we know for sure is that the total human population has risen a lot and is still rising, and any projections of top-out are a long way away and (in at least one opinion) based on quite shaky assumptions.

In any case, we are probably far beyond the point at which the Earth’s resources – including its atmosphere – would permit the whole population to live in the current North American lifestyle, even if we were not expecting another four to five billion people over the next few decades. It is true that the prophets of population doom of 50 years ago have been proven wrong – so far. But it is worth noting that Norman Borlaug, the biologist generally credited as the “father of the Green Revolution” that averted the threat of mass starvation, said in his Nobel Prize acceptance speech that he had bought us 40 years. The 40 years were up in 2011.

So, we are the mussels in the planetary tide pool. We have already crowded out many other species. We reserve and protect little stretches of rock for some to live on, while other species have simply gone extinct or soon will. We have escaped from the feedback processes that once kept our numbers in check and maintained a balance with the other species in our global ecosystems. To borrow one of Carroll's nastier examples of biological systems out of control, *Homo sapiens* is a cancer on the planet. We are not regulating our own numbers, and nothing else is helping us to do so.

So, Who's in Charge Here?

This is not exactly a new insight, and certainly not to Carroll or to McDonald. But their discussion of the importance of elucidating "the rules" presumes that, knowing the rules, we as a species can better manage our planetary environment. We are in charge, the steersmen, and need only better knowledge to make the right decisions.

This conception of our position in the ecosystem has a very long history – all the way back to Adam. Carl Becker (1932) traces the way in which mediaeval patterns of thought were carried over into the preconceptions of the eighteenth-century rationalists. The Great Chain of Being, for example, placed God at the top, angels and humans next, then the various other animals that have no souls. When God and the angels were removed, the Great Chain became the Tree of Life, with us at the top and uniquely endowed with culture and the capacity for thought. Only in the last few decades have biologists recognized that the "Tree" is actually a very dense bush with many vertical branches that sometimes intersect, and that "survival of the fittest" is actually a circular concept. Fitness has no other definition than survival. (The oysters are far ahead of us in that department.) Moreover, many other animals can think and have unambiguously identifiable cultures.

And maybe we are not quite at the top of the food chain. It has been so long since humans last had to take seriously the threat from large predators. But perhaps we have been looking through the wrong end of the telescope. It may be the micro-organisms that will enforce the Serengeti rules. Historically, micro-organisms have killed off millions of humans, particularly among large populations living under crowded conditions. Mass epidemics, but also a steady toll on infants, enforced the rules.

Catching a Break – and Dropping the Ball

Public health, sanitation, and the antibiotic revolution changed all that. But the bugs are back. They have proven much more resilient, much more dangerous, than lions and tigers and bears. A recent cover of *The Economist* is graced by a gruesome-looking skull composed from various shapes of pills and tablets. The cover story is "When the Drugs Don't Work: How to Combat the Dangerous Rise of Antibiotic Resistance" (2016). To this must be added the rise of new diseases – most recently, the Zika virus.

This resilience is not unexpected. It has been understood for at least a generation that the profligate use of antibiotics in medicine and agriculture would bring us to this point. Responsible physicians and epidemiologists have been sounding warnings for at least 50 years. But no effective response has been forthcoming, and now we are told that the newest superbugs are beyond the reach of our most powerful antibiotics. Now what?

Well, now, presumably, vulnerable patients begin to die of untreatable infections. Hospitals and healthcare professionals will have to rediscover the routine infection control measures of the pre-antibiotic era. The larger point is that “knowing the rules” does not mean that humans, collectively, can figure out how to obey them. Like Paine’s mussels, or cancers, our population just keeps on growing. Sometimes we get a break that temporarily relaxes the rules, as with the antibiotic revolution or Borlaug’s Green Revolution, which staved off the consequences of overpopulation for 40 years. But both revolutions may now have run their course.

Stewing in Our Own Juice?

As for the fact that we are heating up the planet, again, science has been telling us this for decades. But the liars and deniers, with strong economic and even religious interests, succeeded in obscuring the obvious and necessary responses. Now the facts are out in the open, and the need for concerted international action is universally understood. But to date, international commitments have been too limited and actions too slow. We have plenty of science; we need better politics.

A planet ever more crowded with people, like a tide pool full of mussels, may turn out to be biologically sustainable, albeit rather dull. But if the temperature keeps rising, there will be *moules à la marinière*.

Note

This will be the last *Undisciplined Economist* column to benefit from conversations with Managing Editor Ania Bogacka. Many thanks for your counsel over the years, Ania, and good luck in your future endeavours! – Robert G. Evans

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