

The Best Medicine

By Colin Tudge

SURELY the whole thing should have been sewn up long ago. It's been 300 years since British sailors discovered the value of limes for staving off scurvy, and the science of nutrition was born. Now there are charts and textbooks galore to tell us exactly what each of us needs each day, and why: energy, protein in all its forms, the many kinds of fats, the peculiar miscellany of essentials known collectively as vitamins, plus a catalogue of minerals that seems to include half the periodic table; all that plus dietary fibre. There is nothing to do now, it seems, but dot a few i's and cross a few t's.

Wrong. On supermarket shelves and in the labs of multinational companies a quiet revolution is taking place. Bemused consumers are being bombarded with an ever-swelling range of products loaded with ingredients quite alien to standard nutrition texts. There are yoghurts containing the Shirota strain of the bacterium *Lactobacillus casei*, margarines containing plant sterols. Even everyday fruits and vegetables are being presented in a new light; for centuries regarded as "just food", they are now being rebranded as handy devices for delivering antioxidants or natural repositories of agents that have pharmacological effects over and above their role as conventional nutrients.

It is easy to be cynical, and regard these so-called functional foods and nutraceuticals as commercial gimmicks. Or worse, to view them suspiciously as medicines thinly disguised as food supplements, evading regulation and rigorous clinical testing—the modern equivalent of past centuries' snake oil. And in truth, the benefits are in many cases still contentious. Does lycopene in tomatoes really reduce the risk of prostate cancer? The evidence is incomplete. Do plant sterols lower blood cholesterol? Some studies say yes, others no. Should we all be consuming "probiotics" so encouraging "friendly" bacteria to grow in our guts to protect us against disease? Again, the evidence is mixed.

Yet there are sound scientific reasons for taking this revolution very seriously. These nutraceuticals may represent just the first foray into a whole new category of nutrients that lie somewhere between vitamins that we can't do without and toxins that we must avoid. Plants have evolved a host of chemicals to protect them from being eaten, and we, in turn, have evolved a tolerance to many of them. But evolution didn't stop there.

I believe that we may have turned many of these chemicals to our benefit, and that our diets are impoverished without them. Nutritional science so far is actually nothing more than a first draft. I suggest that we need to rethink the way we farm, cook and eat. Not only that, but viewed in the light of evolution, I think that many of the chemicals we think of as damaging drugs may well have hidden benefits.

I arrived at these ideas by asking why we need even such well-accepted entities as vitamins. The answer is far from obvious. Vitamins are an extraordinarily mixed bag of chemicals, which complicate our nutrition no end. Our dependence on them seems bizarre: no engineer would design a motor with such an arbitrary list of extra requirements. Yet in a state of nature, vitamin deficiency does not seem to be a problem. How do we make sense of all this?

Part of the answer, of course, is that human beings are not "designed" at all. We are not simple machines. We are innately messy because we have evolved. And because all creatures are constantly exposed to the presence and the importunities of others, we are permanently locked in what modern biologists call an arms race.

Some of the fiercest battles are fought at the level of chemistry. Below ground, bacteria and fungi have been slugging it out for billions of years. We take advantage of this by creaming off an ever-increasing range of antibiotics, those organisms' principal armaments. Above ground, animals slug it out with plants. All terrestrial animal life depends in the end on the consumption of plants; the plants, for their part, have to have ways of dealing with the onslaught of animals. To some extent they seek simply to outgrow the animals that prey on them. But plants also produce an array of spikes, fibres and hairs to make themselves unpalatable. In addition, most wild plants are toxic to some degree.

Chemical warfare is expensive, metabolically speaking. If it were not necessary, plants would be able to spend their hard-won energy on making seeds, to spread their own genes. But like a beleaguered nation, they must invest heavily in defence. When animals eat the plants, as they must (or, if they eat meat, they rely on those that do eat plants), they in turn evolve detoxifying mechanisms. Koalas are the supreme

detoxifiers. The leaves of eucalyptus, their only food, are steeped in toxins and noxious oils, all bound up in the toughest fibre. But the koala appendix takes the poisons in its stride.

Here's the twist. Evolution is supremely opportunistic. Any organ or metabolic system that has evolved in response to any one problem is liable subsequently to be pressed into some different service. Natural selection would favour any individuals who could turn the costly detox mechanisms, or the residues that they produce, to some further purpose. For such organisms, detox would not just be a matter of cleaning up. It would become a positive bonus.

Are there examples of such a progression, from negative to positive, that would make such musings more convincing? Indeed there are. Earth's earliest life flourished in an atmosphere that was almost totally devoid of free oxygen. Then, probably around 3 billion years ago, bacteria comparable to the modern cyanobacteria evolved a primitive form of photosynthesis, harnessing energy from sunlight and releasing oxygen gas as a by-product. Photosynthesis works, and the organisms that could do it flourished.

Suddenly, geologically speaking, the Earth acquired air rich in oxygen.

Oxygen is extremely reactive. It rusts iron, it turns fats rancid, it makes fire. For creatures that did not evolve in its presence, oxygen is lethal. Natural selection would have favoured creatures that could detoxify this awful gas. All creatures that choose to live in the modern atmosphere contain a host of oxygen detoxifiers.

But that, of course, was not the end of the story. We may speculate that some organisms detoxified oxygen by exposing sugars to it. The energy thus released was presumably wasted at first, as heat. Later, though, it was harnessed: used to create ATP, the universal currency of energy exchange. Thus was born aerobic respiration. Oxygen, so lethal because it is so fiery, was put to good use.

A similar process, I suggest, explains our reliance on vitamins. Some, at least, arose as toxins. Plants evolved the means to produce them because at first this kept animals at bay. Then those animals evolved detoxifying mechanisms in response. Later, the descendants of those first detoxifiers began to exploit the toxins themselves, or their breakdown products. These attempts to cope with plant toxins, I suggest, have left us with the need for vitamins.

Now apply this notion more broadly. We know that plants between them produce an astonishing pharmacopoeia of recondite chemicals, often in the spirit of self-defence. What they do to us, or for us, depends on where we've got to in the arms race. A great many materials that plants produced as toxins still poison us: here, the arms race favours the plants. At the other end of the spectrum are the vitamins that have become as vital to us as oxygen.

Somewhere between the two extremes lie a host of pharmacologically active agents that affect us to some extent, but are not generally lethal except when taken in very high and unlikely doses, and yet are not absolutely vital either. These materials include all those that have long been recognised as "tonics": everything from camomile tea to ginseng—indeed embracing a great deal of traditional, herbal medicine. But also, near the vitamin end of the spectrum, is the growing list of beneficial but not absolutely vital materials that are now being classed as nutraceuticals or functional foods. Our bodies have come to terms with them, evolved ways of using them, but are not absolutely dependent.

If nutraceuticals are so important, why has it taken so long to discover them? Many reasons. In part, there's simply a lot to find out. Knowledge even of the recognised vitamins has been hard won. The notion that lack of folic acid in pregnant women might predispose to spina bifida has been verified only in the past few decades. (I attended a meeting in the 1970s at which doctors discussed the ethics of conducting a controlled study of the role of folic acid, given that its role in protecting fetuses was already strongly suspected). Nutraceuticals might be seen as "quasi-vitamins", with many obscure effects. It is good to lower the blood cholesterol, as plant sterols seem to do. But most of us live to reproductive age and beyond even if our cholesterol is higher than is ideal. It is a tribute to modern pharmacology that the effects of these plant chemicals have been noticed at all. A few extra years of life or a slight but significant improvement of mood, for example, would be even more difficult to detect. How much more is there to be found out?

Although specific tests have yet to be done, if the thesis is true then the implications are immense. To begin with, the host of companies now involved in nutraceuticals stand to make billions, and perhaps deserve to. They may be onto something big. Yet there are far broader implications. For the thesis suggests that human beings need a huge variety of chemicals that are made by plants and fungi and microbes that are as yet unquantified or even unsuspected. People gathering plants from nature achieved this in passing: a hunter-gatherer's diet typically included scores of species, most of them shot through with tannins, terpenes, alkaloids, oils, and all the rest.

Modern diets are based on just a few domesticated plants which in general have been bred not for their biochemical variety but for yield and succulence. Biochemically speaking, modern crops tend to be far blander than their wild counterparts. In general, then, I suggest that modern, agricultural human beings, are "pharmacologically impoverished": deprived of that host of quasi-vitamins that our physiology has evolved to make use of. The real message, perhaps, is that we should revert to a more "primitive", botanically far more varied, diet much closer to the diets not simply of our hunting-gathering ancestors, but of our pre-human ancestors. All the world's agriculturalists, both breeders and farmers, and indeed the world's chefs, should go back to the drawing board. Indeed, the whole of herbal medicine needs looking at again in the light of this idea.

We might also apply a little evolutionary thinking to the great *bête noire* of our age: "drugs". Behind the official condemnation of opiates and cocaine, alcohol and nicotine, marijuana and caffeine—and the undoubted dangers that their misuse can pose—lies the largely unexplored conceit that "drugs" in general must be bad. Yet our brains, like our bodies, evolved in the presence of weird, extraneous materials made by plants and mushrooms. We know from experience that if we expose ourselves to some of them, we perceive the world differently.

Puritans, along with most modern lawmakers and medical scientists, feel that any deviation from the most unadulterated baseline in what we ingest is by definition abnormal. But our ancestors, gathering wild plants, must have been steeped in these recondite materials. Perhaps our brains work best in their occasional presence, just as our bodies work best in the constant presence of oxygen. Perhaps our brains, like the rest of us, are "pharmacologically impoverished". Maybe there is survival value in looking at the world from different points of view at different times; perhaps the agents that we recognise and have often condemned as "drugs" help us to do this.

Many people with no criminal or otherwise pathological tendencies adjust the tenor of their lives by judicious intake of alcohol, caffeine and nicotine. Is it because they are "weak", as puritans have maintained, or because that's the way the human brain works best? Perhaps we should ask whether the current often hysterical war against "hard" drugs is really appropriate—and I write as one with almost no exposure to any drug less respectable than Glenmorangie.

Only in recent years, 140 years after Charles Darwin laid out the idea of natural selection in *On the Origin of Species*, has it become fashionable to apply elementary evolutionary thinking directly to day-to-day human affairs. When applied to nutraceuticals, such thinking suggests that they are not mere hype. They could be the start of an even more exciting era in biology than we have yet realised.

Colin Tudge writes about science. His latest books are *In Mendel's Footnotes* (from Jonathan Cape) and *The Variety of Life* (Oxford University Press)