BOOK REVIEW

EVOLUTION, MEDICINE, & PUBLIC HEALTH

Evolution, Medicine, and Public Health [2021] pp. 292–294
doi:10.1093/emph/eoab024

'*Eat like animals: what nature teaches us about the science of healthy eating*'. David Raubenheimer and Stephen Simpson

Houghton Mifflin Harcourt, Boston/New York, 2020.

With all the burgeoning new methods, not to mention an ever-increasing number of conceptual frameworks, it often feels as if modern science is fulfilling the fear of Konrad Lorenz—that 'scientists are people who know more and more about less and less, until they know everything about nothing'. As a field, nutrition often seems prone to this scenario, with studies of meals disregarded in favour of foods, disregarded in favour of nutrients, disregarded in favour of cellular signalling, finally disregarded in the last few years in favour of the microbiota. Meanwhile, with all this stellar technological progress, ever more people worldwide are becoming overweight and obese, raising the risk of many diseases.

In this volume, David Raubenheimer and Stephen Simpson from the University of Sydney take a very different approach to the field of nutrition, going back to the fundamental question of 'why' we eat. Their overarching idea is that nutritionists have, for the entire 20th century, approached human appetite in the wrong way; and that this explains why public health efforts to prevent obesity have been spectacularly unsuccessful. The result is a brilliant discourse on a topic of huge importance.

The concept of appetite seems so simple. We need food to supply nutrients for the body, and the most important nutrient is energy, the fuel for all our physiological activities. We think of food as simply the petrol of the body. We therefore have regulatory mechanisms that tell us when the body's fuel stores are low; this makes us hungry and providing we are able to, we eat more food until we feel satisfied. According to clinical thresholds, people with obesity have eaten too much and must be given advice on how to balance their energy intake and output by exercising more and eating less. Of course, we need other nutrients besides energy, so we need dietary diversity and fresh foods. But if we follow that path, our appetite will work fine, and we will maintain a stable body weight, right?

This broad conceptual framework I just described has dominated nutritional science throughout the decades during which the global obesity crisis has surged, yet only a relatively small number of nutritionists have been willing to admit that their discipline's entire approach to appetite might be inadequate.

The argument at the heart of this book is that humans are not actually seeking energy to satiate their appetite, rather they have different appetites for certain nutrients, and energy might not be the primary one. This concept initially emerged from studies not of humans, but of insects. Human nutrition is often labelled a 'soft' science, as it makes less use of the experimental approach than is the case in many other disciplines, instead relying extensively on observational epidemiology, with all the limitations that this entails. Working on insects allowed Simpson and Raubenheimer to do so something completely different from conventional epidemiology: early in the 1990s, they methodically allocated 200 locusts to one of 25 different diets, each varying in the balance of protein to carbohydrate, and carefully monitored what they ate and their body composition on reaching adulthood. The results were striking: locusts with a high-carbohydrate low-protein diet overate and became fat, whereas those on the low-carbohydrate high-protein diet were so lean that their survival to adulthood was threatened. Both of these phenotypes were clearly incompatible with evolutionary fitness, whereas locusts that had consumed an intermediate balance of carbohydrate and protein exhibited neither penalty, and were well set to survive and reproduce.

By developing a framework termed 'nutritional geometry', the authors had a conceptual model that could not only identify the optimal diet for locusts, but could also explain what happened when the diet was unbalanced: given too little protein, locusts overate carbohydrate to satisfy their protein requirements, whereas given inadequate carbohydrate, they overate protein. Given a range of different foods, insects selected from them so as to rebalance the diet towards the optimum. Some species do this in extraordinary ways, such as spiders that selectively inject different cocktails of digestive enzymes into their unfortunate victims, to extract the optimal balance of nutrients. This idea of 'balancing' competing appetites is thus the kernel of the book, and the authors go on to show how it can be applied to other species, including humans, and to test new ideas about appetite, health and evolutionary fitness.

One key message is that for many animals, the appetite for protein is the strongest and can override other appetites. Beyond understanding animal foraging in general, this has major implications for understanding human obesity. First, the authors show that, as in many other species, human given low-protein diets will overeat calories to satisfy their protein needs. The authors have termed this the 'protein-leverage' hypothesis. Second, the ultra-processed foods (UPFs) that increasingly dominate human diets are generically low in protein, as this reduces their production costs and maximizes profit. Unsurprisingly, therefore, UPFs are increasingly linked directly with weight gain and obesity as well as the associated comorbidities [1–3]. Third, UPFs that are almost entirely carbohydrate, and so will be substantially overeaten if part of a low-protein diet, are often crafted to have a savoury taste—'umami'—thus 'mimicking' protein. This makes it even harder to match energy intake and expenditure, if the regulatory responsibility is delegated to appetite.

Another key message, demonstrated by further mass studies of diet in insects and rodents, is that animals given different diets show contrasting outcomes for key life history traits, such as longevity or reproductive success. Put simply, a diet that maximizes longevity reduces reproductive fitness and vice versa. This links with a fundamental tenet of evolutionary medicine, that natural selection inherently favours traits that maximize fitness, not health [4]. These findings therefore have major implications for understanding how human diets shape not only our body composition through the life-course, but also our longevity.

The nutritional geometry framework presented by these authors is compelling, and demands in particular that we reconsider our conventional models of energy balance and obesity. But is it the case that the 'calories-in calories-out' concept of weight gain is completely wrong? It is important to emphasize that the energy balance equation itself is not actually wrong (it is based on fundamental physics), the problem is rather that for decades it has been *used* in the wrong way. The conventional energy balance approach has always failed to give a clear answer to the 'why' question—*why* are 'calories in' greater than 'calories out' in some people? That weight gain is associated with positive energy balance is a mathematical truism, meaning that in itself, the energy balance equation has zero explanatory power [5]. That *manipulation* of energy balance can successfully treat obesity is elegantly demonstrated by the management of overweight pets by veterinarians. Pet owners can exert substantial control over both the diet and activity of their animals: unsurprisingly, a dog given half its former food intake, and walked twice as often each day in the park, rapidly loses weight. These behaviours could also easily be maintained, preventing any regain of weight. But knowing how to treat obesity, given control of diet and exercise, does not actually tell us why animals slowly and cumulatively gained weight in the first place.

Humans, moreover, like to express agency over their diet, and tend not to make such extreme changes to their lifestyle as pet owners can inflict on their animals. In other words, it all seems to come back to appetite: if weight gain occurs, according to the conventional approach, appetite or willpower are considered to have failed in their role of balancing calories in and out.

But dietary agency in a food landscape of UPFs is substantially illusory [6]. One of the messages in 'Eat like the Animals' is that food companies are extensively prioritizing the production of foods that overall construct a low-protein low-fibre diet. The argument of food companies that they are not responsible for obesity has always been that there is no such thing as a bad food, only a bad diet, and that everyone is free (meaning responsible) to construct their own healthy diet. How can eating one bag of crisps a day make you fat if the rest of your diet is apples and broccoli? Recent research on UK primary and secondary schoolchildren found, however, that an astounding 65% of their dietary intake came from UPFs, and this finding was widely replicated in other high-income countries [7]. Essentially, children's appetites are running up against a food environment in which over-eating calories to satisfy protein appetite is inevitable, and indeed fundamentally structured into the corporate strategy: this is how to maximize profit, while still producing foods that appear relatively cheap to their consumers.

The ideas presented in 'Eat like the animals' are compelling, and genuinely shed a fresh light on human diets, eating patterns and the global epidemic of obesity. Like any overarching overview, the book also deserves a critical appraisal. The authors argue that their model can entirely explain the current obesity epidemic, but I would have liked to see more plots of the data, especially for humans, to see the

variation among individuals in their dietary patterns, and the noise. This would have helped understand how well these ideas actually work at the level of individuals. It is very unlikely that any single thing explains the global obesity epidemic, and there are other avenues that still merit exploration. The role of other aspects of human biology and behaviour were sometimes downplayed, to focus on the main argument. At the end of the book, tables are given to help individuals calculate their daily protein needs as a function of age, and then identify foods that will match their diet composition to their requirements. On the one hand this might be helpful, but on the other it fits poorly with another message given early in the book—that we should not all need to have PhDs in nutrition, and refer to huge tables of numbers, to eat well and remain healthy. Is there another less prescriptive approach that would allow our appetite to function more successfully?

Overall, this book does a fantastic job at presenting a coherent set of fresh ideas about appetite with great clarity, and the ease with which one can read the chapters should not conceal the fact that underlying them is some very elegant and important science. The real test of this approach will be whether, if these insights lead to societal action and public health interventions, efforts to prevent and treat obesity will become more successful. I think they will, but only if nutritionists are given more agency, and food corporations less. In other words, rebalancing agency across the different actors and stakeholders in food systems is essential if we are to reap the rewards of this theoretical approach [8].

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