

tension within science. He contends that Newton's success and reputation allowed "the conflation of natural philosophy with instrumentality". Antoine-Laurent Lavoisier reinforced this by insisting that precise measurement of chemical reactions could be a model of scientific method without any commitment to a view about the underlying elementary structure of matter. In contrast, John Dalton's atomic theory was an attempt at traditional natural philosophy. In so far as Lavoisier was triumphant, the criterion of instrumentality began to rival that of intelligibility, the hallmark of natural philosophy. By the nineteenth

century, modern science "was born a hybrid of two formerly distinct endeavours".

In 1833, William Whewell, surprisingly absent from the book, coined the term 'scientist' in opposition to 'artist'. Both the date and the terms of this contrast resonate with Dear's theme. If the dynamic between the two rationales for science was already in play by Newton's day, what was added in the nineteenth century? The dust-jacket suggests one answer, declaring that the investigation of nature "would be carried out by a new kind of person, the scientist". Although the features of this new persona are not made explicit, there are indications that it

was, and remains, a problematic one. For a cosmologist, being a scientist might be a natural-philosophic quest for laws of nature that cannot become intellectual property; for a microbiologist, it is likely to involve a search for techniques that will be patented. Scientists who wish to reflect on their vocation will gain valuable insights from this beautifully contrived book, and all readers will be prompted to think more carefully about the nature and ethos of science. ■

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## Ordering according to size

### Why Size Matters: From Bacteria to Blue Whales

by John Tyler Bonner

Princeton University Press: 2006. 176 pp.  
\$16.95, £9.95

#### Victor Smetacek

I used to think that the story of the mother who starts a letter to her grown-up son with: "Dear son, I am writing this letter slowly because I know you cannot read fast," was just funny. But after reading the tiny book *Why Size Matters* by John Tyler Bonner twice, I now realize that the story had a deeper meaning than had first met my eye. Bonner says in the preface that the big picture he has painted on a small canvas took a lifetime to mature and that writing this book was a slow process. Indeed, I found myself reading it slowly as well, making sure that I did not miss anything. The territory covered is so vast, as indicated in the subtitle, that I often stopped to get my bearings and ponder the view.

The message of this book is that size rules biology to a greater extent than most of us are aware, because our untrained mind's eye expects its sense of proportion to be universal, whereas in reality, it is relative. When things get bigger, their length increases linearly but their surface area increases by the square and their volume by the cube. So when the proportions, properties and performances of organisms, such as body shape, life span or speed of movement, are plotted against size or weight in log-log graphs, they fall on straight lines with interesting exponents.

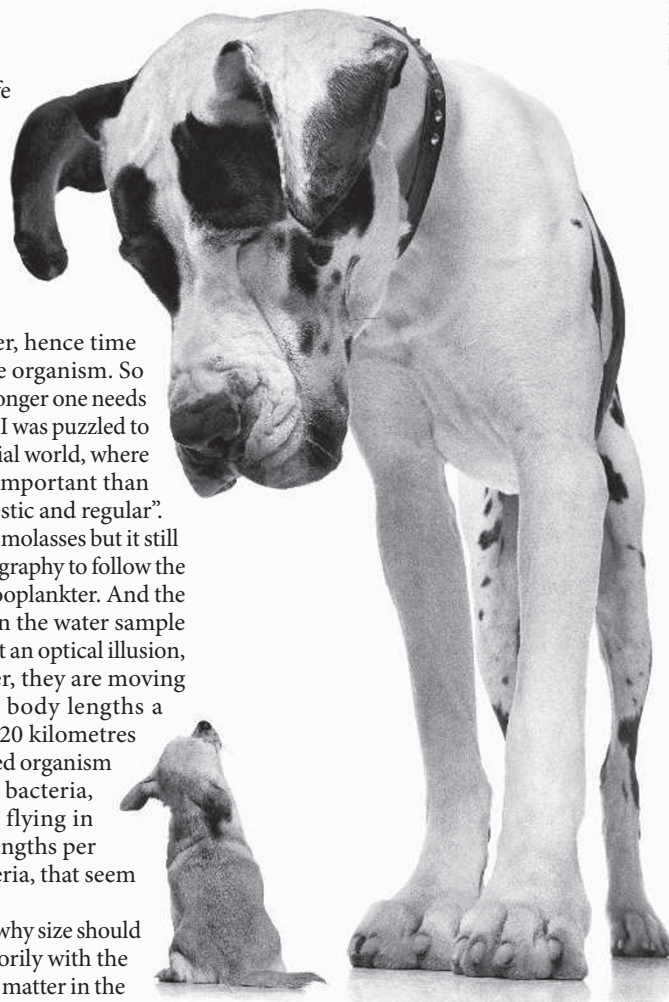
The relationship between weight and strength dates back to Galileo, who calculated the effect of increases in animal size on body proportion. I find his sketch comparing the bones of a 'normal' and an oversized animal greatly exaggerated. I cannot train my mind's eye to conjure up images of small and large animals commensurate with Galileo's bones. To me, a tiger viewed from a distance looks as graceful as a house cat. On the other hand, the branch-breaking, heavy-duty elephant and the

leaf-nibbling, slender giraffe look so different because they do different things, which need varying levels of strength. Yet both animals need to spend most of the day feeding. But these are minor details on log-log graphs.

In general, life is shorter, hence time flies faster, the smaller the organism. So the bigger the picture, the longer one needs to get it. Perhaps that's why I was puzzled to read that life in the microbial world, where viscosity becomes more important than gravity, is "very slow, majestic and regular". The medium might be like molasses but it still takes high-speed cinematography to follow the movements of a feeding zooplankton. And the bacteria zipping around in the water sample under a microscope are not an optical illusion, as Bonner suggests; rather, they are moving at more than a hundred body lengths a second — equivalent to 720 kilometres per hour for a 2-metre-sized organism like humans. It is not the bacteria, but the planes overhead, flying in the same range of body lengths per second as the fastest bacteria, that seem to move majestically.

Bonner argues at length why size should matter, but deals perfunctorily with the question: "What made size matter in the first place?" Selection by predators is the most obvious reason, with increasing size a type of escape. A 'food-for-thought' insight I had was the statement 'there is always room at the top', implying that organisms can always get bigger. But the bigger they are, they harder they fall, so it is the small ones that are less vulnerable in the long run. There is another intriguing insight on size and speed waiting for the reader in the penultimate chapter, but I will not divulge it here.

Bonner's style is to open windows and then step aside so that his readers can see for themselves. If you are up to date with the recent



Size differences among animals can result in great differences in the way they move and live.

literature on size rules then you have already looked through many of these windows, but if you have not done so consciously, or if you are studying the topic, this pithy little book is worth the time spent reading it, whether slowly or not. ■

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