Number-crunching

The hidden maths of organisms, cities and companies

Non-linear scaling explains everything from the productivity of cities to the safe dosage for LSD

Print edition | Books and arts › May 11th 2017

Scale: The Universal Laws of Growth, Innovation, Sustainability, and the Pace of Life, in Organisms, Cities, Economies, and Companies. By Geoffrey West. *Penguin Press; 479 pages; $30. Weidenfeld & Nicholson; £25.*

GEOFFREY WEST is the restless sort. He has spent much of his career as a theoretical physicist, working at the Los Alamos National Laboratory in New Mexico. After a while he became fascinated by biology, then cities and companies. He is interested in all sorts of things, from Isambard Kingdom Brunel's ship designs to Ingmar Bergman's films. When he says that he drives his wife nuts, you believe him.

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On one level, "Scale" is a book about Mr West's peculiar career path. But on another, it is about the hidden mathematical patterns underlying life, cities and commerce. Many things that appear unrelated are actually linked, he says. The size of an animal is related to the speed of its metabolism and its lifespan. If you know the population of a city and what

country it is in, you can predict fairly accurately how many petrol stations it has and how many patents its citizens produce. Mr West even suggests that the mice and the metropolises are linked.

To take an odd example: how much LSD should you give to an elephant, should you feel minded to do such an irresponsible thing? The answer is not the 297 milligrams that was injected into a poor pachyderm called Tusko in 1962, leading shortly to his death. The researchers came up with that amount by extrapolating from research on cats. They had simply scaled up a feline acid dose to account for the greater mass, without accounting for the fact that safe dosages for drugs do not quite double with a doubling in mass, and other factors also play a role. Extrapolate this over the many multiples of mass an elephant has over a cat, and Tusko should have had a few milligrams, not several hundred.

Non-linear scaling relationships such as these fascinate Mr West. "Underlying the daunting complexity of the natural world lies a surprising simplicity, regularity and unity when viewed through the coarse-grained lens of scale," he writes. In other words: do not get too distracted by what animals and plants look like, or how they have evolved. Just look at fundamental properties like their size and weight. These tend to obey mathematical laws.

Cities, he suggests, are a little like giant organisms. They often grow in the same exponential way. A map of lorry journeys looks a bit like a network of blood vessels. Cities also scale non-linearly. A city that is twice as populous as another does not have twice as much infrastructure and twice as much productivity. It has a bit less infrastructure than you would expect, and a bit more productivity per head (as well as more crime). Just as an elephant is a more efficient animal than a cat, big cities are more efficient than small ones. That is why people are drawn to them.

Having charted these patterns, Mr West is not quite sure what to make of them. He suggests that urban planners should think of themselves as facilitators of fundamental natural processes. But how, exactly, should they do that? Like many urbanists, Mr West admires Jane Jacobs, who believed that cities such as her beloved New York should be left to evolve naturally rather than being tweaked by meddlesome planners. In fact New York is one of the world's most rigorously planned cities. Its grid pattern was laid down when the city was just a small

settlement on Manhattan's southern tip.

Mr West is an entertaining, chatty guide to the things that interest him. That is mostly to the good, although the chattiness does mean that "Scale" suffers from a problem of scale. A ruthless editor could have excised at least a quarter of the words and created a tighter, more compelling book. Size is not always everything.

This article appeared in the Books and arts section of the print edition under the headline "Mr Big"