Intellectual tools can have profound impacts. Feynman diagrams have greatly improved how theoretical physicists think and, consequently, our understanding of nature. *Drawing Theories Apart* provides an informative description of how their influence came about.

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ECOLOGY

Mothers Driving Cycles

Günter Wagner

It is widely known that one needs at least some mathematical knowledge to understand physics at any degree of sophistication above the most elementary. The laws of nature are seemingly written in the language of mathematics. It is less well appreciated that there was a time when this seemed very unlikely. In the 16th century, mathematics was the tool astronomers used to describe and predict the regular motions of heavenly bodies, whereas the realm of terrestrial physics was considered too messy to be amenable to mathematical modeling. But eventually, a mathematical theory covering both celestial and terrestrial physics was developed, and the argument that terrestrial processes are too complex for mathematics was refuted. Ever since I learned about this episode, in Erhard Oeser's history and philosophy of science course at the University of Vienna, I have been skeptical about claims of impossibility, including the claim that life is too messy to yield to mathematical abstraction. We simply cannot tell whether some scientific goal is in fact impossible or we are just admitting our lack of imagination when we declare it to be. *Ecological Orbits* may well turn out to mark such a transition from what was considered unthinkable—namely a rigorous and nontrivial theory of population dynamics akin to a law of nature—to a real scientific achievement.

Ecological Orbits
How Planets Move and Populations Grow
by Lev Ginzburg and Mark Colyvan

Oxford University Press, New York, 2004. 182 pp. $29.95, £17.99. ISBN 0-19-516816-X.

The book is written by Lev Ginzburg, a theoretical ecologist at Stony Brook University, New York, and Mark Colyvan, a philosopher of science at the University of Queensland, Brisbane, Australia. Its title plays on the mathematical analogy between the authors' theory of population dynamics and the Newtonian laws of mechanics that explain the periodic motions of planets around the Sun. Over recent years, Ginzburg and his students have developed a theory of population dynamics that has close mathematical similarities to the Newtonian laws of motion, and in the book the authors use these analogies to explain the existence of population cycles. If the book's substance was merely that—a play on a formal mathematical analogy—the work would not be worth a review here. What makes the book so convincing is that the mathematical analogy derives from an elementary and possibly fundamental change in perspective.

It is fair to say that classical population dynamical theory treats organisms as tokens for bookkeeping, tokens that are endowed with arbitrary probabilistic rules of transformation (death rates, birthrates, etc.). These rules define models that describe population dynamics, models such as the logistic equation or the Lotka-Volterra equation. In contrast, Ginzburg and Colyvan start with the (elementary) observation that the chance of an individual to reproduce or die depends on its ability to acquire its share of the energy available to a population. That is, they treat organisms as the real physical nonequilibrium systems that they actually are. This in itself is not news to biologists, but to make it to the core of a theory of population dynamics is novel.

Somewhat surprisingly, this change in perspective leads to a radically different mathematical shape of the population dynamical equations. As Ginzburg and Colyvan point out, the mathematical difference between their theory and the classical equations is the same as that which separates Newtonian mechanics from Aristotelian physics. The core of this difference is that like Newtonian equations (and, one may add, real bodies), the Ginzburg equations respect a law of inertia. For physical bodies, this means that they continue in motion unless acted upon by a force. But why should something similar hold for populations? What would be the connection between generations that makes what happens to generation N depend on what happened to generation $N-1$? The answer lies in what are called maternal effects: (energetically) well-endowed and healthy mothers give rise to offspring that are themselves better off than the offspring from less well-endowed mothers. Accordingly, their chances in life will differ from those of their less lucky contemporaries. For this reason, the dynamics of populations depend not only on the amount of food available to a generation but also on the conditions under which the parental generation lived.

Why should all this matter? There are both basic scientific and eminently practical reasons. Among the former is that the new form of population dynamics models leads to different explanations of well-known phenomena that do not yet have a good explanation (such as population cycles of lemmings). The new theory also leads to nontrivial predictions—for example, that intrinsic population cycles cannot have a period of less than six generations. In addition, Ginzburg and Colyvan challenge the widely held opinion that there cannot be laws of nature in biology that have a standing comparable to those in physics. Their explanations of these and other points make the short book an exciting read on many levels.

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As the authors emphasize, their theory has important implications for the management of endangered populations or, for that matter, any populations we wish to control (such as those of parasites and pathogens). Clearly, controlling a vehicle with strong inertial tendencies (like a boat) requires a different strategy than controlling something that has no inertia (like the cursor on a computer screen). Ginzburg and Colyvan suggest that some difficulties of environmental management stem from the fact that our current tools ignore the inertial aspects of population dynamics. If they are correct, *Ecological Orbits* ought to become an instant classic, one to be read by every professional and aspiring ecologist and environmental biologist. The danger, though, is that not only physical bodies and possibly populations have inertial tendencies—so do habits of mind.

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A driving cycle commonly represents a set of vehicle speed points versus time. It is used to assess fuel consumption and pollutants emissions of a vehicle in a normalized way, so that different vehicles can be compared. The driving cycle is performed on a chassis dynamometer, where tailpipes emissions of the vehicle are collected and analyzed to assess the emissions rates. In commercial 3 116 man driving cycle royalty-free stock videos. See man driving cycle stock images. of 32. cycling way happy senior sky couple young sun bike seniors bike tour couple old man with cycle men driving bicycle healthy living men senior citizen sports old couple motorcycle. 4k00.12Backside view of bicycle male courier with food backpack riding at street. Man in protective cycling helmet delivering order. A driving cycle is a series of data points representing the speed of a vehicle versus time. Driving cycles are produced by different countries and organizations to assess the performance of vehicles in various ways, as for instance fuel consumption, electric vehicle autonomy and polluting emissions. Fuel consumption and emission tests are performed on chassis dynamometers. Tailpipe emissions are collected and measured to indicate the performance of the vehicle.