complex genetic pathways involving repression of repressors. Students who find modern developmental biology difficult would find it a lot easier if they had mastered this material first. So logically they should be required to take a course in descriptive animal embryology using Gilbert's book, and then progress to developmental biology I and II using Wolpert's.

However, the appetite for animal structure in most places is so small that I suspect this could happen only in universities with a very strong zoology programme. In most places Gilbert's book is likely to be relegated to small but eager graduate classes studying Evo–Devo. Still, as the authors claim in the preface, this is a "timeless" book and it will still be useful when fashions change. □

Jonathan Slack is in the Department of Biology and Biochemistry, University of Bath, Bath BA2 7AY, UK.

The great elusionist

The Elusive Neutrino: A Subatomic Detective Story
by Nickolas Solomey
W. H. Freeman/Scientific American Library: 1997. Pp. 206. $34.95, £19.95

Stephen Battersby

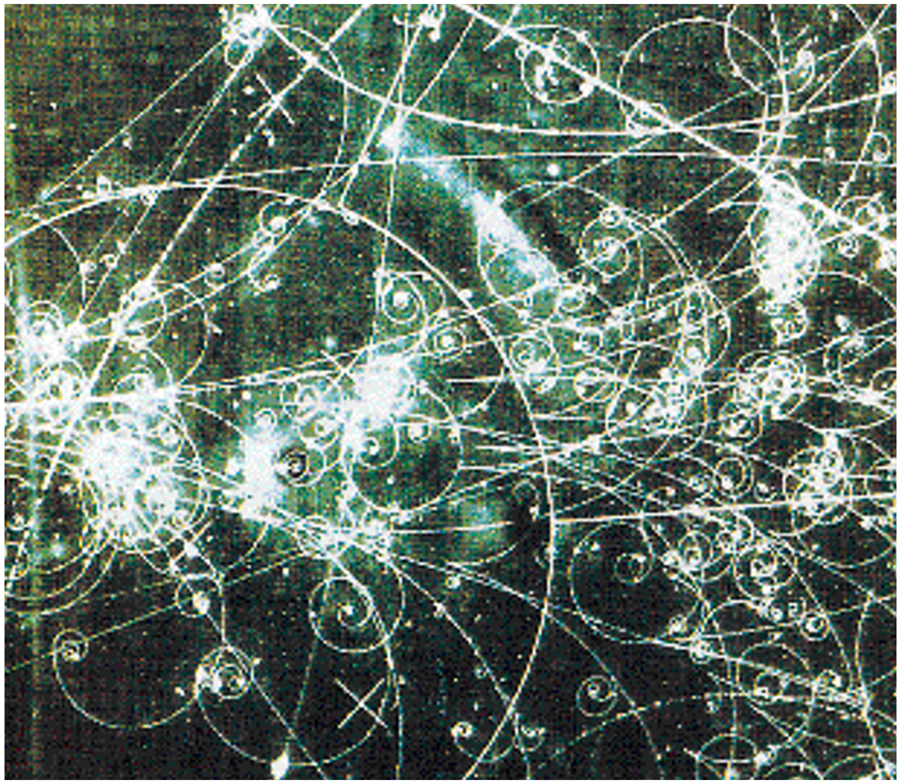

Image-makers: tracks left by the many different particles produced in a neutrino reaction.

The manner in which a nothing-particle was first reluctantly proposed and then triumphantly displayed is one of the truly exciting adventures of science.

This is from Isaac Asimov's *The Neutrino* (1966), an early predecessor of Nickolas Solomey's new book, *The Elusive Neutrino*. Asimov does tell an exciting story, speeding through much of the history of science to explain what conservation laws are and why they are important. Only then does he describe how three such laws — the conservation of energy, momentum and angular momentum — led Wolfgang Pauli to postulate the existence of the neutrino in 1931.

The biggest problem of the day in particle physics was that the energy and momentum sums in beta decay (a form of radioactivity) didn't add up. Pauli realized that the problem could be solved by assuming that a new particle was escaping undetected from experiments, carrying away energy, momentum and angular momentum, but with no charge and little or no mass. The neutrino (little neutral one) came to be a vital part of particle physics, and eventually any lingering discomfort at this 'cheat' was removed when physicists detected the particle directly. That detection paved the way for neutrino astronomy, which was just beginning in 1966.

In the 30 years since Asimov's book, a revolution in fundamental physics has taken place. In the Standard Model of particle physics, three types of neutrino, three types of electron and six types of quark interact by exchanging various force-carrying particles. And neutrino astronomy has produced results: a puzzling deficit of observed neutrinos from the Sun is well established, and, as Asimov hoped, neutrinos have been seen from a supernova (in 1987).

In the past couple of years, there have even been hints that neutrinos have mass, a property that could explain the solar neutrino deficit and the large-scale structure of the Universe and would constitute a step beyond the Standard Model.

In *The Elusive Neutrino*, Solomey's goals are necessarily greater than Asimov's because of these huge advances in our understanding. In any case, Asimov has few peers as a science writer, so it is unfair to compare the new book with the earlier. Unfair, but irresistible.

More than halfway though *The Neutrino* comes chapter seven, "Enter the neutrino". At that point in the proofs, Asimov's editor wrote "At last!". But that's the way it stayed. Solomey's book might have benefited from similar restraint. Asimov knew that his readers needed educating before they could understand the significance of the neutrino, as shown by his chapter titles: "Momentum", "Energy", "Atomic structure", "Mass-energy", "Electric charge". Solomey, instead, skates over the basics in chapter one, getting all the way to Fermi's four-point theory of beta decay. Then in chapter two he plunges straight into one of the more speculative topics in the book, "Cosmology and the neutrino mass". Perhaps Solomey thought a long introduction would bore the reader.

Another problem is that, like beta decay, parts of the book do not add up: vital particles of meaning seem to be escaping undetectably. Explanations are routinely let down by the language. It is not just a matter of distracting infelicities ("somewhat close proximity", "not as fully complete", "was impinged on the fluorescent screen"); it is often language careless enough to confuse or misinform the lay reader.

In the introduction, Solomey mentions the electron, proton and neutron, and then "particles that are even more elementary: quarks and leptons". The electron is a lepton, so here it is rendered more elementary than itself. Time reversal for macroscopic objects is "forbidden outright" (to contrast with "might not be plausible" for particles) and then in the next paragraph becomes "not a plausible occurrence". Later we read that "Because [random number generators] never repeat a sequence of numbers, they are as unpredictable as a roulette wheel". That is just nonsense.

The book is wide-ranging and, for the most part, informative — enough to make it fairly interesting. The only parts I found dull might reasonably interest an experimental physicist: Solomey is meticulous in apportioning credit for the various discoveries, and he describes scores of experiments in detail. He also discusses many of the experiments that got it wrong, or were not sensitive enough to be definitive. Surely two or three of these would have been enough to make the point that science is a messy process? □

Stephen Battersby is an assistant editor at Nature.