BIOPHYSICS

DNA dynamos

A look at how life's mechanics are deciphered at the molecular level fascinates **Mark Haw**.

For all its triumphs, physics has yet to answer the most personal question about our Universe: what is it that makes us? Peter Hoffmann's *Life's Ratchet* surveys how the field is squaring up to this challenge.

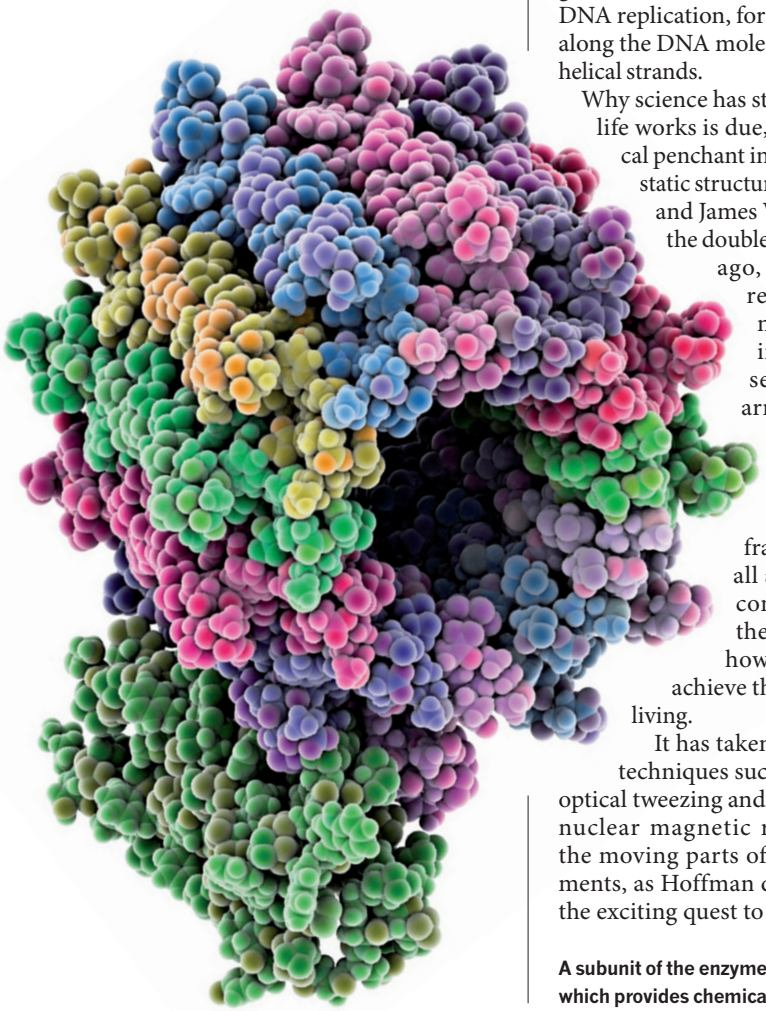
Everything is made of atoms. So why can I think, write, even develop new models of my own existence, while the chair I'm sitting on cannot? Somehow, in living things, matter makes molecular mechanisms with the ability to harvest the energy to organize, maintain and propagate themselves. That opens up a world of potent complexity that leads to cells, plants, animals and humans. One example of this mastery over energy is the molecular 'ratchet' of Hoffman's title.

This is a physicochemical mechanism by which molecules such as proteins convert otherwise inaccessible, random fluctuations in chemical energy into useful work, enabling molecules to move, construct, deconstruct and generally carry out the nanometre-scale activities that keep us alive. Exactly why the molecules in biological entities can do this and the stuff in the chemistry laboratory's test tubes cannot is the theme of the book, more or less successfully introducing a popular audience to the latest science on how life works.

Life's Ratchet starts, like my own book *Middle World* (Macmillan, 2007), with a somewhat revolutionary premise. This is that life is a dynamic process, a thing of moving parts, not a question of frozen chemical formulae, DNA sequences or abstract genetic information. Proteins involved in DNA replication, for example, must move along the DNA molecule to 'unzip' its two helical strands.

Why science has struggled to solve how life works is due, in part, to a historical penchant in biology to study life's static structure. Since Francis Crick and James Watson's discovery of the double helix almost 60 years ago, many a career has rested on the expert measurement and interpretation of the sequence and spatial arrangement of amino acids in this or that protein. Such information is vital, of course — X-ray diffraction patterns tell us all about the sculptural complexity of life. But they shed little light on how molecules move to achieve the tasks necessary for living.

It has taken the development of techniques such as single-molecule optical tweezing and fast, high-resolution nuclear magnetic resonance to probe the moving parts of life. Such measurements, as Hoffman describes, are part of the exciting quest to take biology beyond nineteenth-century theories of equilibrium thermodynamics and into a molecular world shaped by the interplay of randomness and physical interactions.



A subunit of the enzyme ATP synthase, which provides chemical energy to cells.

LAGUNA DESIGN/SPL

Life's Ratchet: How Molecular Machines Extract Order from Chaos
PETER M. HOFFMANN
Basic Books: 2012. 288 pp. $27.99, £18.99

The continual harvest and conversion of energy by molecules, on their own or in concert, is necessary for all life processes — to transport signals and biomolecular cargo (such as nutrients across cell membranes), to chemically synthesize and to chemically destroy. Equilibrium thermodynamics safely ignores energy fluctuations. But experiments done during the past ten years or so show with startling directness that such fluctuations are required for, say, a motor protein to transport its chemical cargo within a cell.

Life's Ratchet engagingly tells the story of how science has begun to realize the potential for matter to spontaneously construct complex processes, such as those inherent to living systems. The book is a good mix of history and the latest concepts, straightforwardly explained. A few too many personal anecdotes add little to the story — the sign, maybe, of an editor trying a bit too hard to follow the 'standard model' of popular science.

But the book's important message is that there is a revolution brewing. This revolution will not tell us what matter is made of. Instead, as described in *Life's Ratchet*, it will tell us how matter and energy combine to make me and you. ■

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CORRECTION

A review of 'Ghosts in the Machine' (J. Glausiusz *Nature* **488,** 279; 2012) reiterated incorrect information provided by the exhibition that Alan Turing underwent orgone therapy to 'cure' his homosexuality; he was in fact treated with hormones. Furthermore, Einstein did not actually pronounce the orgone energy accumulator "a dud" (for details, see his letter of 7 February 1941 in W. Reich *The Einstein Affair* Orgone Institute Press; 1953).