cannot be more complex than the information available to the agents.

Evolution gets round this principle by the stochastic generation of new states. Stochastic processes can be random so they can generate arbitrary complexity, within physical chemical constraints, because random strings or structures are maximally complex.

Uri Alon's *An Introduction to Systems Biology* is a superb, beautifully written and organized work that takes an engineering approach to systems biology (see also Connections, page 497). Alon provides nicely written appendices to explain the basic mathematical and biological concepts clearly and succinctly without interfering with the main text. He starts with a mathematical description of transcriptional activation and then describes some basic transcription-network motifs (patterns) that can then be combined to form larger networks.

The elegance and simplicity of Alon's book might lead the reader to believe that all the basics of the control of living systems have been worked out. It only remains, it seems, to combine the network motifs to get a total understanding of networks in the dynamics and development of living systems.

All is fine except that in the very first page of the book, Alon defines networks as functions that map inputs to protein production. In other words, the meaning of genomic transcription networks is restricted to the production of proteins or cell parts. Granted, some of these proteins are transcription factors that in turn activate other genes and, thereby, are a key part of the network itself. But this prejudices the enterprise by presupposing that protein states are all there is to understanding life. Such a view is bottom-up in the extreme.

What's missing is a relation between higher-level organizational, functional states and networks. This is indicative of a more fundamental problem. Because Alon focuses on very basic low-level circuits, the global organization and its effects are largely ignored.

In some ways, Bernhard Palsson's *Systems Biology* is a more practical book for those wishing to understand and analyse actual biological data and systems. It directly relates chemistry to networks, processes and functions in living systems. The book's main focus is on metabolic networks of single cells such as bacteria. Palsson argues that classical modelling using differential equations requires complete information about the state of the system. Such data, however, are not available for complex biological systems. Palsson's response is to accept biological uncertainty. The approach is to describe a space of all the possible states of a system or network (relative to a set of dimensions of interest) and then use biological and chemical data to constrain this space. This is similar to the process of entropy reduction described in statistical thermodynamics.

Specifically, Palsson espouses a mathematically ingenious method of formalizing metabolic reactions, pathways and networks, and uses this to formalize uncertainty about biological chemical states. This space of possibilities can then be systematically constrained by high- and low-level information. In this way, he manages to formalize states of uncertainty in a biological system so he can extract useful predictive information about it, despite the fact that many of its parameters and values of variables are unknown.

Unfortunately, Palsson's book is a difficult read. It is not well organized and refers the reader to later chapters to explain concepts needed in earlier ones, and vice versa. Often no explanation of basic concepts is provided; additional appendices would have been helpful. Palsson admits that he had help writing some of the chapters, and the book does feel like the work of a committee. However, it brings together many of Palsson's contributions to metabolic network formalization and analysis and, for this reason, deserves to be part of a systems-biology curriculum. I look forward to improvements in the promised future editions.

Of the three books, Palsson's is the most practical and immediately relevant to modelling low-level metabolic networks. Alon investigates networks at a higher level, including genomic regulatory networks. He does an excellent job of explaining and motivating a useful toolbox of engineering models and methods using network-based controls. Kaneko's book is conceptually deep but further removed from Palsson's chemical networks and even from Alon's more abstract regulatory networks. Even though I am critical of his approach, the book is filled with insights and useful criticisms of some of the standard models and theories used in systems biology, and in biology generally. All three books will be valuable and non-overlapping additions to a systems-biology curriculum. ■

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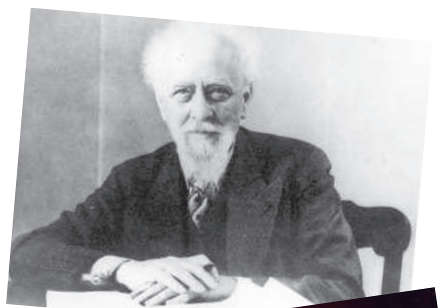
A little movement

Middle World: The Restless Heart of Matter and Life
by Mark Haw
Macmillan Science: 2006. 256 pp. £16.99, $24.95

Tom McLeish

The fascinating tale of brownian motion has been looking for a story-teller for a long time. The tangled threads knot together, rather than begin, in the nineteenth century with botanist Robert Brown's original observations of the random, ceaseless motion of particles in pollen grains of *Clarkia pulchella*. The threads lead back in time to medieval theories of matter that tangled physics with theology — a pattern that ran deep through the work of Galileo and Newton — and further back still to the Epicureans. Going forwards from Brown, they twist through the nineteenth century's ambivalence towards molecular theory and the thermodynamics of Sadi Carnot and Lord Kelvin. Weaving through the kinetic theory of James Clerk Maxwell and the statistical mechanics of Ludwig Boltzmann that finally grasped the physics of randomness, they lead to the complementary beauties of Einstein's theory of brownian motion and Jean Baptiste Perrin's experiments that led to modern soft-matter physics and a new understanding of the role of brownian dynamics in molecular biology. This is a remarkable story of science and scientists that leaves no major science untouched and summons onto the stage a colourful and eminent cast from centuries of endeavour.

In *Middle World*, Mark Haw provides an accessible and racy account that succeeds in opening up technical ideas without losing momentum. Haw is not insensitive to dramatic irony, and makes a satisfying conclusion out of the return of brownian motion to illuminate dynamical processes in biology, where it originated, after spending a century wandering the worlds of physics and physical chemistry. We fleetingly visit the role of brownian motion in polymer physics, oxygen capture by myoglobin, the protein-folding problem and the question of how molecular motors (the cell's cargo transporters) can possibly execute controlled and directed motion in a turbulent brownian world. It's not quite T. S. Eliot, but we are almost back where we began, yet knowing for the first time.



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THE NATURAL HISTORY MUSEUM, LONDON

Jean Baptiste Perrin (above) provided a new understanding of Robert Brown's notion of random motion.

Although it is a fitting window onto a selection of hot topics in current science, the final 'contemporary' section drops the connected storyline of the preceding historical material.

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I wonder if the role of diffusion in the molecular biology of plant reproduction might have connected this coda more strongly to the earlier narrative.

The research is mostly thorough: Haw has picked up on subtleties often glossed over, such as the prescient role of Michael Faraday in advocating a correct reading of Brown's work, the correct early kinetic theory of the unfortunate John Waterston, who disappeared from science following its rejection, and the extraordinary timeliness of Einstein's molecular theory for the diffusion constant published earlier by the largely overlooked William Sutherland. But the reader has to stay alert — a cost of the narrative's unflagging pace is that people and places flash by all too quickly. I wish we had the time to get to know Perrin, and the shadowy figure of Brown himself, rather better.

Another aspect of the thirst for satisfying narrative is that history seems sometimes to be squeezed into the story's form, rather than the converse. So our sole representative of the middle ages is Hieronymous Bosch, whose portrayals of chaos conveniently prepare the stage for a sea change to order in the enlightened following act starring Galileo and Newton. The plot thickens with a return to calculated chaos in statistical mechanics, and so on. A case could be made more strongly for a highly ordered medieval theory of matter than for a chaotic one, and Galileo's corpuscular theory of matter in *The Assayer* in 1623 surely anticipates the underlying chaos of kinetic theory. But perhaps such complaints are churlish: a good yarn withers from too much of "on the other hand".

Such strong selection in historical interpretation, as well as some under-development of character, could well be the results of zealous editing with a younger lay readership in mind. In places the author gives the impression that he would have liked to say more. Perhaps the ambiguity in target readership is also reflected in the uneven style, which alternates ambitious alliteration with colloquialism (it was my first non-fiction read containing, as an entire sentence, "Not."). But these are pitfalls for all authors and publishers of 'popular science', and I would hope there is something for everyone in this highly enjoyable little book. ■

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A Turkish revolution

Turkey's Modernization: Refugees from Nazism and Atatürk's Vision
by Arnold Reisman
New Academia: 2006. 572 pp. $28

Martin Harwit

Looking out of the window facing Prague's main railway station that evening, I saw a soldier in an unfamiliar uniform standing guard in the snow. The Germans had arrived. It was 15 March 1939, less than a week after my eighth birthday. By the end of the month, my parents, my sister and I were on a train to Istanbul. My father, whom the Germans had dismissed from his professorship at Charles University, had been offered the chair of biochemistry at Istanbul University. None of the Jewish members of our family who stayed behind survived the German occupation.

Our journey to Istanbul was not unique. Arnold Reisman's insightful book *Turkey's Modernization* documents how, starting in 1933, Turkey provided shelter to more than a hundred eminent European academics and their families, all victims of Nazi persecution. The task of the professors was to initiate the country's first modern university and train a generation of young Turkish scholars able to further expand higher education.

Two men spearheaded the drive to establish Istanbul University. The vision was provided by Mustafa Kemal Atatürk, who founded the modern Turkish Republic on the shards of a crumbled Ottoman empire. As a young military officer in the First World War, Mustafa Kemal had become a hero to his countrymen, first for repulsing the Allies at the Dardanelles, and later for recapturing the territories that define modern Turkey today. Once in power, he decreed that Turkey would discard its Ottoman past and become a modern state modelled on European lines. A new constitution and newly enacted laws affected every aspect of life.

Men were prohibited from wearing the traditional fez. Women were forbidden from hiding their faces behind veils. Polygamy was abolished. Everyone had to adopt a family name; for himself, Mustafa Kemal chose 'Atatürk' — father of the Turks. To eradicate widespread illiteracy, every child now had to be schooled. Arabic script was outlawed and replaced by a Roman alphabet. The caliphate — the office of the head of the Muslim religion — was dismissed to make Turkey secular. And on 31 July 1933, to complete the transformation, Atatürk closed down Istanbul's institution of traditional higher learning, the darülfünun, dismissing the entire faculty. On the same premises, the very next day, he installed a new Western-style university with a distinguished faculty.

Assembling this faculty required a second, quite different architect, one cognizant of scholarship and competence. That man was Philipp Schwartz, a Hungarian-born pathologist who had been dismissed by the Nazis from his position in Frankfurt and had fled to Switzerland. There he had founded the Notgemeinschaft Deutscher Wissenschaftler im Ausland, which compiled and maintained a roster of leading scholars seeking to escape Nazi oppression. Schwartz persuaded the Turkish government that his organization could staff an entire university — so many outstanding academics were being persecuted that they could select the very best.

As Reisman recounts, Istanbul University embraced a wide range of disciplines, although the heart of the university was the medical faculty. Foreign academics had to start at the most elementary level. Before medicine could be taught, a Turkish medical vocabulary had to be devised. Only then could the first modern texts be written in Turkish and medical students taught in their own language. The nation was in dire need of physicians, especially in remote regions of Anatolia. The university trained thousands of young doctors who, in exchange for free schooling, were obliged to provide medical services in understaffed parts of the country for several years after graduation.

The book captures the spirit of the times, the resistance the foreign scholars faced as they sought to modernize Turkey's institutions of higher education, the worries brought on by the war, and the family outings in which foreigners often compared notes and tried to laugh at the sometimes ludicrous problems they faced. What remains with me from these outings, so many years later, is the interest the

Open-door policy: in the Second World War, Istanbul University welcomed foreign academics fleeing Nazi persecution.

M. BOURKE-WHITE/TIME & LIFE/GETTY IMAGES

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