clear, as are his discussions of drift and measures of diversity. Some of these ideas will be familiar to readers of his earlier book *Genetics and the Search for Modern Human Origins* (Wiley, 2001).

He does make one glaring error, however, in his discussion of ancient DNA sequences, stating that nuclear DNA degrades too quickly to be reliably extracted from fossils, and that this is why most studies resort to amplification of mitochondrial sequences. He misses the point that it is target template number (2% of the genome bulk is in multi-copy mitochondrial DNA, providing broad comparative possibilities), not quality of DNA, that accounts for the concentration of research effort on maternal gene genealogies.

This book would be an excellent choice for a seminar introducing advanced undergraduates in molecular biology to topics in anthropological genetics, or anthropology graduate students to genetics and historical analyses. Not flashy, far too cautious for my taste, straining to keep the lid on things, he is the exact opposite of Wells. Read them together. ■

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Crossing the species barrier

How the Cows Turned Mad

by Maxime Schwartz

transl. Edward Schneider

University of California Press: 2003. 238 pp.

\$24.95, £17.95

Richard E. Race

Until 1996, the diseases of animals known as transmissible spongiform encephalopathies (TSEs), such as scrapie and bovine spongiform encephalopathy (BSE, or 'mad cow disease'), were regarded as agricultural problems with no known medical implications for humans. But then it became apparent that BSE had done what no other animal TSE had done before: transmit to humans. Suddenly, TSE diseases were of great interest to scientists and the public, who wanted to know which other TSE diseases might also pose a risk to people, and how significant the BSE problem would be.

In *How the Cows Turned Mad*, Maxime Schwartz, a molecular biologist at the Pasteur Institute in Paris, develops the history of TSE as a mystery novel. Beginning with clinical descriptions of sheep scrapie three centuries ago, he follows the chronology of TSE evolution through to BSE and its human form, variant Creutzfeldt-Jakob disease (vCJD). Schwartz poses questions, suggests possible

A change in structure turned a harmless prion protein into a fibril that causes scrapie.

answers, and then describes the scientific advances that produced the answers. The book, which was first published in French in 2001, should appeal to a wide range of readers.

Schwartz discusses the basic science behind these discoveries in numerous asides. The general public will find these diversions informative, but those with a reasonable knowledge of TSE diseases might find them distracting. They might also be concerned by the limited bibliography and the oversimplifications that are used to explain many of the controversies that still exist in the TSE field. These oversimplifications include discussions about the nature of the causative agent, the mechanisms of agent replication, the importance of various cell organelles, how infectious aggregates form, and the concept of 'spontaneous' disease. In many cases, seminal research has been omitted and the research of some scientists has been misattributed. Several TSE issues also warrant further comment.

The public's greatest concern regarding TSE diseases is the risk of transmission from animals to people. On this topic, the author is inconsistent, stating on one occasion that TSEs are easily transmitted from one species to another, but elsewhere he suggests that the likelihood is remote. In general, TSE diseases will cross the species barrier if brain homogenates from one species are inoculated directly into the brain of a different species. However, transmission is more difficult or impossible if the material is presented in a natural way, such as by being fed to the second species.

So far, knowledge about which TSE agents are transmissible to which other species has been based on epidemiological observations over the past decades or centuries. But a cell-free analysis that allows the determination of which cross-species transmissions are possible has been developed by my colleague Byron Caughey of the

Rocky Mountain Laboratories in Hamilton, Montana, who has produced results that mimic previous empirical observations very closely. This important work, which is not mentioned in the book, is the basis for recommendations of the World Health Organization and the Centers for Disease Control and Prevention on TSE issues.

The book is also vague about the mechanism by which infectious aggregates of abnormal prion protein are formed. Schwartz mentions two ideas that predominate: one theory suggests that infectious aggregates start off with monomers and dimers of prion protein, whereas the second theory favours a nucleation event. The latter theory is more consistent with the experimental data and is more widely accepted by scientists working on molecular aspects of TSE disease.

A large portion of the discussion involves the idea that, in some situations, normal prion protein can spontaneously convert to abnormal prion protein. Some scientists believe that this phenomenon accounts for cases of sporadic CJD. It seems unnecessary to me to invoke such a mechanism, because it is known that sporadic CJD is infectious and can be transmitted to non-human primates or humans by organ grafts. It is unlikely that we could determine the circumstances of infection, as the incubation periods may be decades and the disease has an incidence of one in a million. This is no reason to believe that an infectious event did not occur.

The author also misrepresents the status of chronic wasting disease (CWD) in wild elk. Although the incidence of CWD in captive or farmed elk can be quite high, it currently affects fewer than 1% of wild elk, even in areas where CWD is endemic. In wild cervids the disease primarily affects mule and white-tailed deer, with variable incidence.

Schwartz wonders why BSE occurred in Britain instead of, or in addition to, other countries with large sheep populations, such as the United States. There are several potential explanations for the lack of BSE in the United States. First, there are far fewer sheep in the United States than in Britain. Second, scrapie has been present in US sheep populations in low numbers only since 1947, compared with more than 200 years in Europe. Finally, the United States has had scrapie-eradication programmes in effect since 1952.

When Carleton Gajdusek won a Nobel prize in 1976 for his discovery of the transmissibility of kuru, a human TSE, the nature of the infective agent was unknown. Another Nobel prize was awarded to Stanley Prusiner 21 years later for his 'protein-only' theory of TSE aetiology. In his discussion of this theory, Schwartz mentions experiments that support the idea, but leaves out data that suggest other possibilities. He points out that even though the critical experiments to prove the theory have not yet been successful, the

idea has nonetheless been widely accepted by the public and even by scientists who are not familiar with TSEs. I would simply re-iterate that the protein-only theory is still just that: a theory. Several prominent TSE scientists believe that the initial conversion of normal prion protein to an abnormal form is not dependent on protein alone. Perhaps a third Nobel prize in the TSE discipline will be awarded to whoever performs the critical experiments that unequivocally prove or disprove the protein-only theory. ■

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More on prion diseases

The Pathological Protein: Mad Cow, Chronic Wasting, and Other Deadly Prion Diseases

by Philip Yam

Springer: 2003. £21, \$27.50, £29.95

Copernicus Books: 2003. \$27.50

A collection to remember

Memory From A to Z

by Yadin Dudai

Oxford University Press: 2002. 338 pp.

£37.50, \$65

Larry R. Squire

Like many topics in contemporary neuroscience, the study of memory is being approached using a variety of techniques and at many levels of analysis. Work ranges from the molecular and cellular biology of synaptic change in cell culture and brain slices to the analysis of memory in behaving organisms. Mindful of the diverse backgrounds of those who come to the study of memory, neuroscientist Yadin Dudai has written a charming book designed especially for the student. "This book," he writes, "contains terms that I wish my students to know."

What follows is an engaging, informative and sometimes playful collection of essays, each 2–3 pages long, around the topic of memory, arranged in alphabetical order. The topics do move from A to Z (from *a priori* to *Zeitgeist*), but the book is a personal selection of keywords and starting points for discussion, not an encyclopedia. Many letters have multiple entries (there are 20 for C and 13 for P, for example); seven letters (J, K, Q, U, V, X and Y) have no entry at all.

Most of the entries are ones that might be expected in a book about memory and neural plasticity ('synapse', 'glutamate', 'calcium', 'CREB', 'hippocampus', 'long-term potentiation', 'declarative memory', 'forgetting' and 'working memory'), but many of them are

Cinema

Return of the mutants

Science fact is the loose basis for the fantasy in the current spate of movies based on comic-book characters. Peter Parker was bitten by a genetically modified spider last year to become Spider-Man (in the original 1960s' comic the spider was radioactive, but that was a different age).

Director Bryan Singer's latest film, *X-Men 2* (Twentieth Century Fox), is no different, ending with a flowery but accurate description of evolution by punctuated equilibrium. This second adaptation of the popular comic *X-Men* opened worldwide at the beginning of May.

The X-Men are a band of superheroes (*Homo sapiens superior*) who possess a mutated X gene, which has an extraordinarily variable phenotype, allowing some mutants to walk through walls, some to shoot ice from their fingers, and some to perform Moses-like acts of water telekinesis. (The X gene's normal function is not revealed.) The team is led by a powerful telepath, Charles Xavier (played by Patrick Stewart), a benevolent leader who promotes the integration of the mutants into an otherwise hateful society.

Xavier's gang faces two arch-rivals: a human bent on wiping out all of the mutants, and a concentration-camp survivor, Magneto (Ian McKellen), who can control magnetic fields to the point of being able to extract iron from

Cutting-edge science? Remarkable powers of regeneration from a mutated X gene make Wolverine a formidable fighting force.

blood. Magneto fervently believes that mutants are the natural inheritors of the Earth and that mankind should voluntarily go extinct to bring this about.

Themes of biological determinism are touched on in this fun, but perhaps overlong, film. Magneto encourages a young mutant to join him, telling him that his genetic abilities render him "a god amongst insects". The wise Xavier offers a counterpoint later: when his team question why one of their number commits an act of self-sacrifice, he weightily declares that the protagonist, against her nature, "made a choice". ■

Adam Rutherford is the web editor of Nature.

unexpected or even amusing. The entry on 'capacity' provides a thoughtful discussion of what is sometimes called the impossible calculation: how much information-storage capacity does the brain actually have, and does this place any constraint on how much information can be acquired during a lifetime? Entries such as 'artefact', 'controls', 'red herring' and 'Ockham's razor' consider aspects of the scientific method and how science gets done. The entry on 'scoophobia' (fear of being scooped) presents a humorous discussion about issues of competition in science.

The entry on 'palimpsest' is perhaps a stretch, but it forms the basis for a brief account of how new memory representations form in interactions with previously established ones. There are also separate entries for the organisms that have been important to the scientific study of memory: *Aplysia*, *Drosophila*, bird (under 'birdsong'), mouse, rat, monkey and *Homo sapiens sapiens*.

What makes all this work is that the 131 essays that make up the book are scholarly, up-to-date, even-handed and rich in citations

(there are 66 pages of references at the end of the book, along with a full index). Many of the entries begin with an explanation of the classical origins of the terms. Any one of the entries could serve as the basis for classroom discussion and as a starting point for further reading, even for the practising scientist.

A charming feature of the book is that the personal and whimsical list of entries encourages one to try out new ones. For the unused letters, I developed junk DNA, kinase, qualia, quisqualate, ubiquitin, X-rays, *Xenopus*, vestibulo-ocular reflex, virus and the Yerkes Primate Research Center.

In the end, the book describes an associative network of ideas and facts that, for pedagogical purposes, could be extended and recombined indefinitely. This is an engaging format, and it would be interesting to see it tried with other topics. ■

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