Wikström's experiments showing proton pumping by cytochrome oxidase, published early in 1977. But it was not until 1985 that Mitchell was prepared to accept the evidence presented by Wikström and others, and then only when he had thought up a mechanism (since shown to be incorrect) to accommodate it. In Mitchell's garden of the mind, ideas seem to have deeper roots than facts.

The second attack concerned the chemical mechanism of ATP synthesis. Mitchell's postulate (from which he never wavered) that protons are directly involved in the esterification of ADP by phosphate was challenged by Paul Boyer, Harvey Penefsky and my group, who believed that ATP synthesis is brought about by a conformational change in the ATPase such that ATP, already formed spontaneously on the enzyme, is released. This view led to the Nobel Prize in 1997 for Boyer and John Walker.

Have we reached the end of the story? Not quite. The postulate of a non-phosphorylated high-energy intermediate in the chemical hypothesis is correct; its nature is not. The postulate of the chemiosmotic hypothesis that this intermediate is an electrochemical proton gradient is correct; the way in which it was thought to synthesize ATP is not. The binding-change mechanism of ATP synthesis proposed by Boyer is probably correct; but will the rotary mechanism depicted in the textbooks survive challenges?

I recommend this biography as a scholarly account of the life of one of the giants of late-twentieth-century biochemistry who was also a fascinating, if enigmatic, human being. His amiable character, his eccentricities and his health and emotional problems are fully described. But I still do not think that I really understand the workings of his mind.

Like Tom Blundell, writing in the foreword to this book, I find it quite extraordinary that Mitchell refused to permit Bob Williams to publish their correspondence from before the publication of Mitchell's first paper on the chemiosmotic theory, concerning the possible role of protons in ATP synthesis. The reason given for Mitchell's 1977 reversal of the decision to cease biochemical research — namely that he believed "there was a strong movement among the antagonists of the general chemiosmotic theory... to take advantage of our withdrawal and press new, ill-founded research claims, the effect of which was to undermine the consensus of opinion which we had been working on to promote" — I find even more extraordinary.

But perhaps it is not possible for a mere biochemist to analyse the mind of a genius. ■
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Science in culture

Art after DNA

The double helix has inspired scientists and artists alike.

Lynn Gamwell

No sooner had James Watson and Francis Crick published their seminal paper on DNA in 1953 than artists began depicting the double helix as a cultural icon. Salvador Dalí painted swarms of spiralling DNA molecules in his paintings from the late 1950s, such as *Butterfly Landscape (The Great Masturbator in a Surrealist Landscape with DNA)*, 1957–58, and decades later sculptor Tom Otterness forged a bronze double helix joined by tiny stick figures (*DNA Chain*, 1986). Some artists responded to some of the troubling issues surrounding DNA, such as cloning and stem-cell research. Alexis Rockman, for example, painted a colourful landscape populated with genetically modified plants and animals to warn viewers that the future may contain mutated monsters (*The Farm*, 2000).

Although art about science icons and applied science is interesting, it does not focus on the pure science of DNA. That topic is addressed by artists who express wonder at the highly complex, ever-changing organic processes that are the physical mechanism for the force of life. One example is the British painter Mark Francis, whose *Source* (1992) is a wall-size depiction of sperm cells presented not with clinical accuracy but out of focus, as if seen through a veil. Inspired by microscopy, Francis uses a vocabulary of curved, flat shapes that he inherited from nineteenth-century art nouveau designers — who, in turn, first copied the shapes from stained, transparent slices of tissue prepared between glass plates for viewing with a light microscope. Francis uses a modern electron microscope for his source images, but his forms retain the flat, free-form appearance associated with a century of biomorphic abstract art. In a nod to recent methods of charting complex genomic data, Francis paints the sperm cells hovering above a grid.

In the 50 years since Watson and Crick cracked the structure of DNA, biologists and bioinformaticists, have painstakingly mapped and sequenced the genomes of various species: the fruitfly, the mouse

Sex cells: the view of sperm in *Source* by Mark Francis was inspired largely by microscopy.

Genetic screen: Benjamin Fry's *Valence* uses the BLAST algorithm to create moving patterns.

DNA 2 by Susan Rankaitis is both a stand-alone artwork and a backdrop to the dance of life.

and, in 2001, the human. The computing technology developed for this effort inspired a new generation of video artists, such as Benjamin Fry, a programmer at the Massachusetts Institute of Technology's Media Laboratory, to create visualizations of complex biological data. In *Valence* (2000), Fry has used the BLAST algorithm — a tool for searching through genomes — to produce ever-changing patterns that move rhythmically across a video screen.

The curved free-standing panel *DNA 2*, which measures over 5 metres across, is the result of a collaboration between visual artist Susan Rankaitis, molecular biologist Robert Sinsheimer and choreographer John Pennington. Inspired by the Human Genome Project and tutored by Sinsheimer, Rankaitis combined pictures of DNA with text by the biologist to create her chromosome-shaped collage. It can be viewed alone or used as a backdrop for Pennington, who, attired in coils of pulsing fibre-optic cable, spins across a stage. By projecting flickering light onto her giant chromosome, Rankaitis makes her layered images and text join the dance of life.

Charles Darwin was confident that there was a physical mechanism underlying natural selection, but never found it. Today's artists understand the central role of DNA in this mechanism. It inspires them by embodying Darwin's core idea: that nature is a web of dynamic forces with no predetermined purpose or meaning. Works by artists such as Francis, Fry and Rankaitis resonate with this concept of life, and with the complex, abstract processes that go on silently, systematically and invisibly within the double helix. Lynn Gamwell is director of the Art Museum at the State University of New York, and author of *Exploring the Invisible: Art, Science and the Spiritual* (Princeton University Press, 2002).

B. FRY

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