that genetic factors might partly determine the mind, he attacks the idea of the existence of innate, pre-programmed cognitive modules. I find this argument incoherent. Modularity theorists do not suggest that modules can function and develop without experience any more than geneticists believe that genes can function without an environment. If you accept that there are genes that can build brain structures, why not at least remain open to the possibility that genes can build mental modules?

And finally, while Hobson's groundbreaking studies of individuals with congenital blindness, or Michael Rutter's seminal studies of the Romanian orphans, have shown us that the effects of early deprivation can resemble autism, might this be no more than a surface similarity? We should be careful not to assume that just because two church bells are ringing simultaneously they are causally connected by the same rope.

Hobson's own important studies of emotion perception in autism are nicely described in this book, and in many ways were ahead of their time. There is no question that this major figure in the field of developmental psychopathology will continue to stimulate healthy debate. ■

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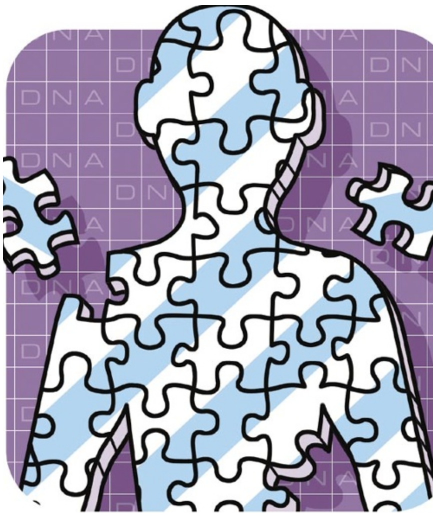
Improving on humanity?

Redesigning Humans: Our Inevitable Genetic Future
by Gregory Stock
Houghton Mifflin: 2002. 288 pp. $24

Robert Winston

William Thomson (later Lord Kelvin) entered Glasgow University at the age of ten, achieved a first in mathematics at Cambridge, published over 600 scientific papers, and became president of the Royal Society in 1890. He was a pioneering physicist but, like many competent scientists, he was not a brilliant futurologist. Less than ten years before the Wright brothers flew he said: "I can state flatly that heavier-than-air flying machines are impossible." And he once claimed: "X-rays will prove to be a hoax." Given his views on creationism — "overwhelming strong proofs of intelligent and benevolent design lie around us" — one wonders what he might of made of the implications of modern molecular biology.

Our imperfect knowledge of DNA and the human genome raises more unanswered questions than any other aspect of science. People from all walks of life are nervous



about the implications of genetic knowledge and genetic manipulation. The heat of debates on reproductive cloning and genetic testing is evidence of the anxieties of so many people. This carries a salutary lesson. If scientists misrepresent or exaggerate the power of these technologies, or are not scrupulously objective, the pursuit of knowledge is threatened. Unlike those relatively uncritical golden days of Lord Kelvin, our pronouncements will have a profound effect on public perception and the health of science, and thus on society.

One oddity about the debate on the interface between genetics and human embryology is that it has often been wrongly focused. Given the risks of producing an abnormal child — and the litigation that would ensue — I cannot believe, for example, that human cloning will be attempted in any significant way. So the crucial issue is the use of transgenic technology. We can make transgenic animals with relative ease; and we can add, modify or knock out genes in intact mammals. The key question is whether these technologies might be used in humans.

Gregory Stock of the UCLA School of Medicine bravely predicts this future for humanity. He is undeterred by the poor record of futurology, believing that it is only a matter of time before human germline modification becomes a fact. His new book, *Redesigning Humans: Our Inevitable Genetic Future*, is a distillate of opinions he has publicly expressed for some years. He writes with a clear, lucid style that lends plausibility to his views. Yet many readers will wonder whether the assertions about reproductive technology that are crucial to his argument are accurate. For example, he makes claims for the profound global impact of contraceptive technology. Without the worldwide access to birth control, Stock asserts, birth rates would not be falling. But this does not stand up to scrutiny. Falling birth rates are more to do with improved social infrastructure — better hygiene, education, decreasing infant mortality and changing social attitudes — than with his technocentric approach.

People will want genetic choice, claims Stock. He seems to believe that human nature will change so much that assisted reproduction could replace procreation on the hearth-rug. We have, he says, now accepted much of what is ethically debatable in the area of genetic choice, by using preimplantation genetic diagnosis (PGD) in embryos. PGD will be "in the vanguard of genetic choice, at least for the next couple of decades," Stock contends. But this is not likely to be even approximately true. Only one-fifth of embryos resulting from *in vitro* fertilization are viable; many, if not most, human embryos are frequently aneuploid or have other cellular abnormalities that are probably incompatible with development. Mosaicism is extremely common — perhaps 75% of morphologically normal human embryos have at least one or two aneuploid cells at around the eight-cell stage. Biopsy of such cells will be likely to give useless clinical results, and PGD biopsy of a normal cell in such an embryo may lead to false diagnosis.

So if *Redesigning Humans* is wide of the mark when discussing technology that has already been used for over a decade, why should futuristic comments about germline modification be any closer to the truth? Stock rightly observes that current transgenic manipulation is unpredictable, but he seems overimpressed by recent developments. It will be relatively easy to introduce auxiliary chromosomes into the germ line, and they could carry large chunks of DNA without the limitations mostly imposed by conventional gene vectors. Genes on these chromosomes could be introduced without changing other parts of the genome and could incorporate a mechanism for terminating expression to improve safety.

Stock argues that this strategy could eventually be used to enhance "desirable" characteristics for single generations and that outdated auxiliary chromosomes could be jettisoned for newer, more up-to-date models. Work in mice, he feels, suggests that this could eventually be done without human harm. But many geneticists will feel queasy; the potential for gene imbalance is huge and the change in phenotype unpredictable.

This is an important debate, but a real moral perspective is missing in this mostly engaging book. Stock favours human genetic enhancement. He quotes James Watson: "If we can make better humans… why shouldn't we?" And he is scathing about the conservative attitude of notable scientists such as French Anderson. To many readers elsewhere, his view will seem centred on privileged North America, taking little cognisance of the appalling inequalities in his and their society which would be increased by this manipulation. We are as much the product of our environment as of our genes, and much should be done first about the poor environment in which so many humans exist. For scientists to advocate channelling resources uncritically, as this book seems to do, is to risk bringing genetic research into public disrepute.

Whatever the true mechanism, perhaps Lord Kelvin was not so misguided after all in his faith in the goodness of "benevolent design". As a Christian he might have asked: if we change the very nature of what it is to be a human, will we still have our humanity? ■

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Flexing our muscle power

Prime Mover: A Natural History of Muscle
by Steven Vogel
W. W. Norton: 2002. 351 pp. $25.95, £19.95

R. McNeill Alexander

Steven Vogel tells us that his professional biases, as a biologist, "start with the belief that we just can't understand history, literature, economics, art, and so forth without taking biology into consideration". Accordingly, in his book he asks what muscle physiology may reveal about human history, prehistory and culture. He is concerned with the human body, with the tools, vehicles and weapons that are powered by our muscles rather than by motors, and with the use that people make of the muscle power of animals.

To do this effectively in a book for general readers, Vogel has to use six of his 15 chapters to describe basic muscle physiology. He explains the sliding-filament mechanism of muscle contraction, the relationship between force, speed of shortening of muscle fibres and power output, and the energy cost and (in)efficiency of muscular work. He tells us about the red muscles, such as the breast meat of pigeons, that can continue working for long periods, and the white muscles of chicken breast, which are good only for short bursts of activity. We learn how the reflexes work, helping us to control movements, and how a slender muscle can exert large forces if it is built from a very large number of short muscle fibres converging on tendons.

All this is done clearly, in the readable prose that distinguishes Vogel's books, and with an attractive historical perspective. As well as being a distinguished research scientist in the field of biomechanics, Vogel is one of the best semi-popular writers on biology. He has an outstanding ability to be simple and entertaining without being misleading.

By the end of chapter 6, Vogel has got us through the basics. He has also dealt with a few of the implications of the physiology, which are the main topic of his book. For instance, we know about the extraordinary surgical operation of cardiomyoplasty, in which a dispensable shoulder muscle is wrapped around an ailing heart and stimulated to help it pump blood. And we have been shown how the elastic recoil of stretched tendons can save energy in running, or give a catapult-like boost to a jump.

Up to this point, general readers will have learned a lot but physiologists very little. The rest of the book is written at the same non-technical level, but will give almost everyone something to think about. Vogel discusses a wide variety of hand tools, using the physiology explained in the earlier chapters in conjunction with simple engineering mechanics. He discusses our use of tools ranging from pliers to corkscrews, which amplify the force that we can exert. We discover why wood is a good material for axe handles and why modern metal axe heads work better than primitive stone ones. Vogel attributes the success of eighteenth-century American colonists to their invention of axe heads that had the hole for the shaft closer to the cutting edge than in the traditional design at the time; new-style axes were less liable to be twisted by an ill-directed blow. The author tells us why crosscut saws have two kinds of tooth, and big gaps between groups of teeth. And screws, we are told, have right-handed threads because the relative strengths of different arm muscles enable a right-handed person to twist them more forcibly clockwise than anticlockwise. In some places, scientist readers may be frustrated by a lack of detail. For example, they may want a proper explanation of the sweet spot of a hammer or baseball bat, or more information about tests of human strength. However, there are plenty of footnotes and references to the literature.

Vogel regards the wheelbarrow as one of the all-time great inventions. It enables us to move heavier loads than we could carry; it has just three supports, so that it rests steadily on uneven ground; it is highly manoeuvrable; and it offers little resistance to forward movement.

Elsewhere, cycling and rowing are discussed, albeit in less detail than I would have liked, together with less-familiar man-powered vehicles, including the ancient Greek warship known as the trireme, and pedal-powered aircraft.

Vogel gives us a great deal of fascinating discussion of obsolete technology. He discusses the relative merits of horses and oxen as draft animals, and explains the design of harness and of the ingenious whippletree, which makes all the animals in a team pull with equal force. He compares medieval machines for propelling rocks into besieged cities, calculating their ranges and the time needed for reloading. He points out that it would have been best to use the heaviest possible rocks so as to get as much momentum as possible for a given energy input. And he tells us why it made ergonomic sense to cut huge blocks of stone for the pyramids but to make small mud bricks for the Great Wall of China.

Finally, Vogel considers muscle as meat. He compares the energy content of different meats, pointing out the huge differences resulting from their different fat contents. We learn why *filet mignon* (the psoas muscle) is particularly tender, how best to cook squid, and why (according to cannibals) human flesh tastes like pork, but sweeter.

This is a book that should be enjoyed and understood by intelligent non-scientists as much as by scientists. It offers thoughtful insight into a remarkable range of past and present human activities. Physiologists may want to skip the early chapters and may regret the lack of technical detail, but they, too, should find the book entertaining and illuminating. ■

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The tale of the human genome

The Common Thread: A Story of Science, Politics, Ethics and the Human Genome
by John Sulston and Georgina Ferry
Bantam: 2002. 320 pp. £17.99

Sydney Brenner

Much has been written about the human genome and the project to sequence it, but this is the first book by one of the scientists who played a large part in getting it done. John Sulston, former director of the Sanger Centre at Hinxton near Cambridge, UK, where much of the work was done, has written an account of the project. He tells how he moved from organic chemistry to his decisive research on the cell lineage of the nematode *Caenorhabditis elegans*, and then