testosterone

sex, power, and the will to win

JOE HERBERT

TESTOSTERONE

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For my friend
T. C. Anand Kumar (1936–2010)
with whom I ate, drank, laughed and argued for more than 40 years.

PREFACE

There are, I suppose, many reasons why professional scientists, who normally write highly technical articles, should be tempted to write a book such as this. Scientists, like painters, musicians, and many others, are obsessed with their subject. This doesn't always make them very good at being members of a family, let alone companions at a dinner table. But one feature of an obsession is the desire to share it with others. Something so fascinating and self-absorbing, the reasoning goes, must surely be as interesting to anybody else. Hence the existence of those pub-bar bores. And yet: science is so central to everybody's life, so omnipresent in our world, so influential on everything we do, that any scientist's urge to tell the world about what he or she does is irresistible. The media encourage such a view: no day passes without a headline story about science of some sort. The growth of professional scientific journalism is testament to the public hunger for science: what is happening and will it affect me?

So if these writers exist, why would someone like me, a scientist and not a journalist, write a book about my subject? A simple reason: someone reporting on a subject is not the same as someone doing it. Journalists are incredible: they pick up a story about which they may know nothing to begin with, quickly and effectively, and write lucidly and informatively about it. But it's not the same. A scientist hasn't thought about his subject for a few days, or weeks, but for years. So a scientist has a point of view: moreover, he/she knows that science is not simple, and there are often many points of view about a particular piece of scientific research. Mulling over your subject results in a state of mind that is not easily reproduced in any other way: a sort of maturation of thought. That doesn't mean that the scientist is necessarily right in his/her views; in fact, one of the important endpoints of this state of mind is the realization of what is not known, and how far what we think we know is incomplete or uncertain. It's also the ability to recognize the next big question. So writing a book such as this is not simply an account of the facts, but an interpretation and an acknowledgment that, in any part of science, there are huge pieces missing from the puzzle. You tell a story, but one full of twists and turns. No simple message or bottom line.

Hormones are fascinating. These chemicals, produced in tiny amounts, exert powerful influences on our lives, and their discovery was a huge landmark in biology and medicine. The fact that they also have powerful effects on the brain make them all the more fascinating, for the brain itself, that crucible of humanity, cannot fail to interest us, who are largely what are brains are. Since our understanding of the brain is so incomplete (a very mild way of putting our ignorance) the interaction between hormones and brains becomes that more intriguing. So I want you to share in my fascination, and I hope I have the skill to enable you to do so. But do not expect a complete story: the gaps are too wide to be disguised. Scientists are sometimes not too good at admitting ignorance (a favourite phrase in the scientific literature is that something is 'not fully understood' which actually means 'we havn't a clue'). Of all the powerful hormones, none is more influential than testosterone, or so I will try and persuade you. We know enough to know that.

I have to take responsibility for my book, but it's been greatly enhanced by my friends who have taken time to read chapters, give me ideas and suggest numerous improvements. They include Alan Dixson, Barry Everitt, Mick Hastings, Barry Keverne, and Scarlett Pinnock, all distinguished scientists and collaborators; Richard Green, Jay Schulkin, and Tirril Harris, luminaries in their field; Jeremy

Prynne, a notable poet and critic; and John Bancroft, who has written the definitive book on sexual disorders. My son Daniel, making his way as a writer in New York, has given me valuable guidance on style and clarity. My other son, Oliver, busy as a young doctor, helps me to stay in touch with clinical matters. Latha Menon and Emma Ma, of OUP, have made the process of editing this book a pleasure and an education. Finally, I have, for most of my career, been immersed in the stimulating environment of the University of Cambridge and my college, Gonville and Caius, where, almost every day, one learns something new; to all these colleagues, friends and acquaintances, I express my thanks and admiration. My ever-patient wife, Rachel Meller, has, as always, tolerated my mental and physical absences with kindness, understanding and support, and the clarity of her writing has been a model.

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Testosterone and Human Evolution

It takes millions of years to perfect a dramatically new animal model, and the pioneer forms are usually very odd mixtures indeed. The naked ape is such a mixture. His whole body, his way of life, was geared to a forest existence, and then suddenly (in evolutionary terms) he was jettisoned into a world where he could survive only if he began to live like a brainy, weapon-toting wolf.

Desmond Morris (1967), *The Naked Ape*. Jonathan Cape, London

Humans are talking primates, but in fact their behavior is not very different from that of chimpanzees. People engage in verbal fights, provocative or impressive word displays, protesting interruptions, conciliatory remarks, and many other patterns of verbal activity that chimpanzees perform without an accompanying text. When humans resort to actions instead of words the resemblance is even greater. Chimpanzees scream and shout, bang doors, throw objects, call for help, and afterward they may make up by a friendly touch or embrace.

F. de Waal (1998), *Chimpanzee Politics*. Revised edition. Johns Hopkins University Press, Baltimore

We are born into our modern world with a brain that was developed for a more primeval one. Early humans had little control over their world. Their brain had evolved to cope with the exigencies of surviving in that harsh environment. Getting food and water, keeping warm/cool, finding shelter, beating off rivals, avoiding becoming prey: all required the adaptive qualities that Darwin and the renowned neuroscientist Ramon y Cajal recognized as necessary for the struggle for survival.*

Everything we call 'human' depends on the evolution of the human brain. Look at our closest relatives: chimpanzees and gorillas. Their brains look, at a casual first glance, very similar to a human one. But history tells us that this is deceptive. Each night, a chimpanzee builds a sleeping nest. If we were to roll back time for 10,000 years, we would see chimpanzees doing much the same thing. Of course, they can adapt. But chimpanzees (like any other primate) have no technical or cultural history that bears any resemblance to ours. We change our surroundings and the conditions in which we live: we invent tools, machines and agriculture; ensure adequate supplies of easy-to-get food and clean, accessible water. The habitations of humans 10,000 years ago (or even 1,000 years ago) were very different from those of today.[1] Though there are examples of other species doing vaguely similar actions—made much of by those who want to emphasize the commonalities between humans and other species—no other species comes close to man in technical or conceptual ability. Charles Darwin wrote:

* 'From a teleological point of view, we may think of the nervous system as entrusted with several tasks: collecting a large number of external stimuli; classifying them as to kind; and communicating them with great speed, range, and precision to motor systems, while simultaneously minimizing unproductive, diffuse, or inappropriate responses. Moreover, we can see that it has the added responsibility of maintaining the harmony and integrity of the various related parts of the organism by restraining and directing the entire ensemble in a manner best suited for its survival and refinement. It is the instrument of improvement, and without it animals would hardly rise above plants.' S. Ramon y Cajal (1911), *Histology of the Nervous System*, trans. N. Swanson and L. W. Swanson, Oxford University Press, New York.

> There can be no doubt that the difference between the mind of the lowest man and that of the highest animal is immense... Nevertheless the difference... great as it is, certainly is one of degree and not of kind.
>
> Charles Darwin (1871), *The Descent of Man, and Selection in Relation to Sex*

A Japanese (female) monkey invented a way to separate food grains from sand (throwing handfuls into the sea); chimpanzees invented a method of collecting water by using moss as sponges. These are remarkable but exceptional events. Intelligent as they undoubtedly are, monkeys and apes don't invent much, though they may adapt rather wonderfully to living close to us (Figs 1 and 2). No other animal on earth has, or ever will, invent computers, husbandry on a massive scale, cars, houses, let alone write a poem or compose a symphony (although chimpanzees have produced paintings, it's not really clear that this involved truly artistic or aesthetic processes). Furthermore, the human brain endows us with the ability to ask questions about the natural world and about ourselves, and, through the invention of science, to supply at least partial answers, enabling progressive technical and social development. Edmund Wilson writes:

> No matter how sophisticated our science and technology, advanced our culture, or powerful our robotic auxiliaries, *Homo sapiens* remains... a relatively unchanged biological species. Therein lies our strength, and our weakness. It is the nature of all biological species to multiply and expand heedlessly until the environment bites back. The bite consists of feedback loops—disease, famine, war and competition for scarce resources—which intensify until pressure on the environment is eased. Add to them the one feedback loop uniquely available to *Homo sapiens* that can damp all the rest: conscious restraint.
>
> Edmund O. Wilson (2002), *The Future of Life*. Little, Brown, London.

The human brain, together with an elaborate hand and a complex vocal apparatus, thus enables us to develop language, invent and make things and—equally important—develop complex and highly varied

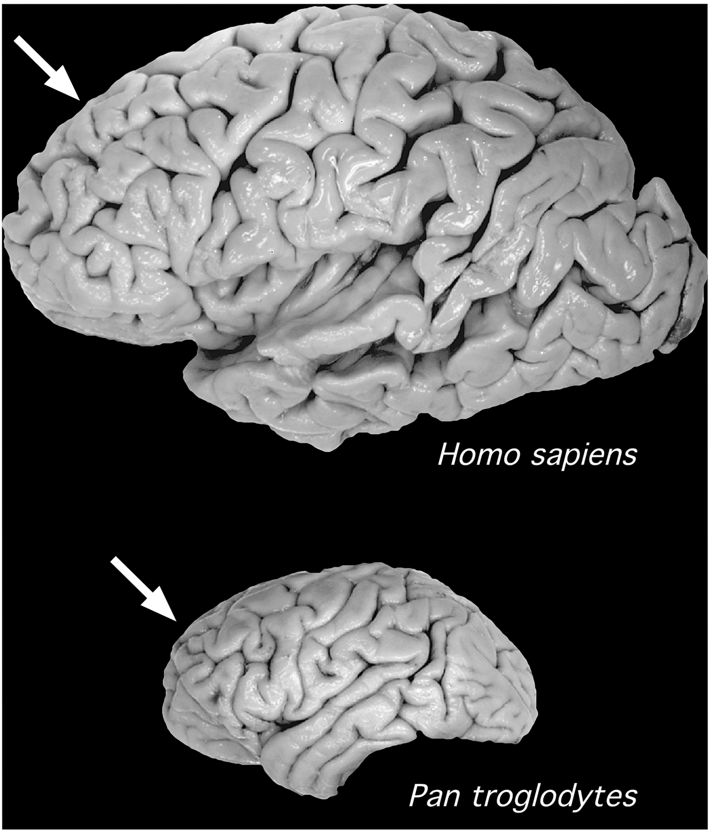

Fig. 1. The relative proportions of chimpanzee and human brains. Note the marked difference in the size of the frontal lobes (arrows) as well as the more elaborate patterns of folds in the human (indicating relatively more cortex). See Chapter 10 for more discussion of the human brain.

social structures. It also allows us to transmit to the next generation not only our genes, but through the invention of spoken and written languages the inventions, knowledge, and societal rules and traditions that may have been developed by previous generations. We don't fully understand the selection pressures that encouraged the enormous development of the human brain and thus these human attributes.

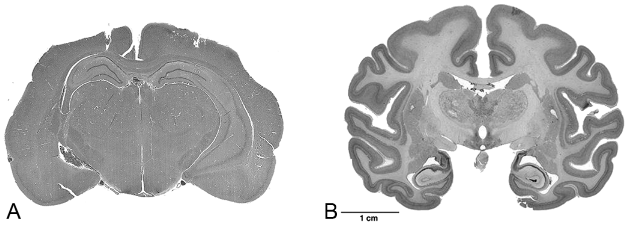

Fig. 2. Cross-sections (equalized for size) through (A) a rodent and (B) a primate brain. Note the increased complexity of the cortex in the primate, and its larger size relative to the rest of the brain compared to the rodent.

After all, other very successful species—rats are one obvious example, not to mention insects—do very well without needing a huge brain. Darwin himself was puzzled.

> More than one writer has asked, why have some animals had their mental powers more highly developed than others, as such development would be advantageous to all? Why have not apes acquired the intellectual powers of man? Various causes could be assigned; but they are conjectural, and their relative probability cannot be weighed.
>
> Charles Darwin (1872), *The Origin of Species* (sixth edition), edited by R. E. Leakey. Hill and Wang, New York.

We do know that the human brain had to develop its modern form before mankind began to alter his environment by building ever more elaborate shelters, get food by using ever more elaborate tools and weapons, and protect himself against cold by more elaborate clothing, and so on.[2] The rapid evolution of man since he developed his enormous brain has been cultural and technological, rather than physical. The latter took millennia: the former only a fraction of this timescale. But the important point is this: the human brain developed originally in response to the natural world, whereas the modern human brain shapes that world in a manner that promotes the well-being and survival of mankind. So while the composition of the natural, ancient world owes nothing to the human brain, the (human) modern world owes practically everything.† And here is the essential consequence: we bring to our modern world some of the properties of the brain that served us so well in that ancient one. But they have to operate in a very different environment from that for which they were originally developed and to which the human brain was first adapted.[3]

> We must, however, acknowledge, as it seems to me, that man with all his noble qualities, with sympathy which feels for the most debased, with benevolence which extends not only to other men but to the humblest living creature, with his god-like intellect which has penetrated into the movements and constitution of the solar system—with all these exalted powers—man still bears in his bodily frame the indelible stamp of his lowly origin.
>
> Charles Darwin (1871), *The Descent of Man, and Selection in Relation to Sex*

Reproduction is an obvious and prominent example. Successful reproduction is the endpoint of successful adaptation. 'Fitness', the hallmark of evolutionary success, is measured by an ability to transmit genes to subsequent generations: that is, successful reproduction. Reproduction is a complex process in all mammalian species, including ours. It involves fertility: the ability to produce viable sperm or eggs (gametes); mate selection: a competitive process that itself plays a role in the evolution of fitness; mating: to ensure that these gametes are fertilized; pregnancy: the development of the foetus; birth: production of live young; lactation; sustenance of those young; parental behaviour, to protect and nurture the newborn. Each part of this

† 'Long before the human species appeared, the pinnacle of evolution was already the brain... Animals with simple and primitive or no nervous systems have been champions at surviving, reproducing, and distributing themselves but they have limited behavioral repertoires. The essence of evolution is the production and replication of diversity—and more than anything else, diversity in behavior.' T Bullock (1984), quoted by E. M. Hull, R. L. Meisel, B. D. Sachs (2002), 'Male sexual behavior'. In: *Hormones, Brain and Behavior*, D. W. Pfaff, A. P. Arnold, A. M. Etgen, S. E. Farhbach, R. T. Rubin (eds). Academic Press, Amsterdam, pp. 3–135.

sequence carries risks and cost to both parents and young. One might imagine that, once this complex interlocking series of events had evolved to be a success, it would have become standard throughout the mammalian order.

But this is not the case. Although the objective of reproduction (biologists call this the 'ultimate' cause) is the same for all mammalian species, the way that it is accomplished (the 'proximate' cause) is astonishingly different. Reproduction is remarkable for being so varied between even mammalian species. Examine this more closely, and it is apparent that this variation lies mostly with the females (Fig. 3). For example, female rats have an ovarian cycle that lasts 4–5 days, dominated by the production of oestrogen alone. They ovulate at this frequency then become sexually active (and attractive) for a few hours (in 'heat' or 'oestrous'). They produce progesterone, the other major ovarian hormone in small amounts (it's important for making female rats sexually receptive), but in much greater amounts if they mate. After a short gestation period, large numbers of very immature young are born, most of which will not survive. This is mass production and high infant risk. It serves rats very well indeed. Rabbits (and cats) also have a similar strategy, but it operates differently. These females can remain in heat (oestrous) for long periods, and only ovulate if they mate; in this way, they maximize the chances of becoming pregnant. Then the rest of the sequence (progesterone secretion) is activated, as in the rat, and they produce large litters, with a high risk of non-survival. Other species have different strategies. Species that produce many young, but are likely to lose many (i.e. high infant risk) are said to adopt an 'r' strategy. The alternative—higher investment in fewer offspring—is a 'k' strategy. Both have advantages and disadvantages, and they overlap somewhat. Sheep, for example, produce only one or two young, and have a rather long cycle with a correspondingly protracted period of sexual activity. They don't need to mate or to become pregnant to secrete progesterone, which in their case is important for activating sexuality. They look after their young for comparatively long periods. Female monkeys and apes do likewise, though they don't need progesterone to enable sexual activity. Their cycle is rather like that of human females. There is a wide spectrum of variation between species in the way that females become fertile and mate. This carries on into pregnancy and parenthood.[4]

Many species, particularly those living in more temperate climates, time their births to occur in the spring, the season of increasing warmth and food supply. This requires a second tier of control: females restrict the costs of reproduction to only one part of the year, the breeding season. Females with a short pregnancy will

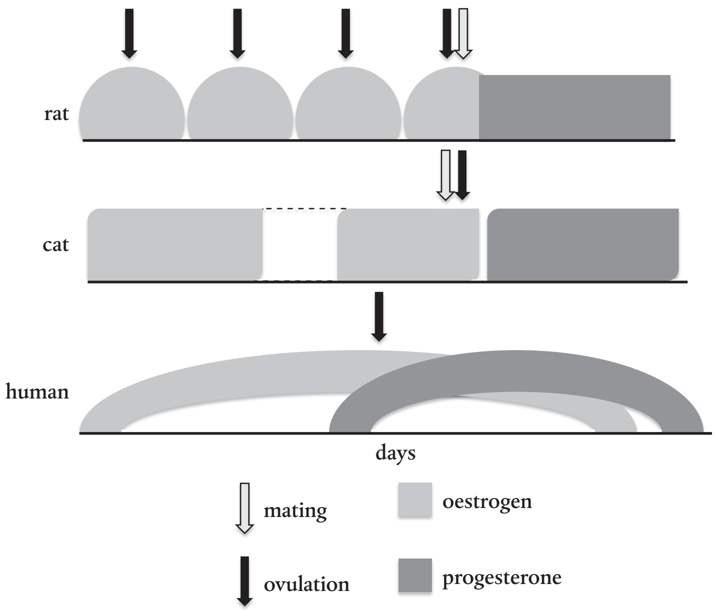

Fig. 3. Diagrams of the oestrous (reproductive) cycles of three female species. The rat has a 4–5-day oestrogen cycle, ovulates spontaneously, but only secretes much progesterone if she mates. The cat has a prolonged, and variable, period of oestrogen secretion: she only ovulates and secretes progesterone if she mates. The human female ovulates spontaneously after about 14 days of oestrogen secretion, and then has a similar period dominated by progesterone.

become fertile early in the spring or late winter: those with a longer gestation (like sheep) will be fertile in the autumn. Some species, such as badgers and some deer, have evolved an even more elaborate timing mechanism: they can carry their fertilized foetus in a state of suspended animation in their womb, and only initiate its development in time for a spring birth. Even different species of non-human primates show highly distinct types of mating systems.[‡]

Human females have no obvious breeding season, though births are more common in the spring and autumn. They have a typical primate cycle, different from rodents and some other species. The first 14 days of each cycle are dominated by oestrogen secretion. Then the female ovulates (produces an egg) without the need to mate, and this is followed by a similar period of progesterone secretion, which prepares the womb for a future embryo. Humans, like other primates, produce one, occasionally more, well-developed young after a long gestation: a very different strategy from the rat and many other species. The growth of a comparatively large infant, particularly a large brain, requires a prolonged pregnancy, so that the newborn is better able to survive. But one consequence of this is a much bigger metabolic demand on primate mothers: the risk is to the mother rather than (or as well as) to the infant.[§] And her investment in each newborn is much greater than in those species adopting the rat-like strategy, because she produces so few. This will be reflected in the

[‡] 'Two important considerations [for defining primate mating systems] are, firstly, whether a female usually mates with one male, or more than one male, during the fertile phase of her ovarian cycle and, secondly, whether her sexual relationships are long-term and relatively exclusive or short-term and non-exclusive. This line of reasoning results in the recognition of five mating systems: 1. Monogamy, 2. Polygyny, 3. Polyandry, 4. Multimale-multifemale, 5. Dispersed or non-gregarious.' A. F. Dixson (1998), *Primate Sexuality*. Oxford University Press, Oxford.

[§] 'The daily energy budget of a nursing mother exceeds that of most men with even a moderately active lifestyle and is topped among women only by marathon runners in training.' Jared Diamond (1997), *Why is Sex Fun?* Weidenfeld & Nicolson, London.