When our hunter-gatherer ancestors exchanged their timeless wanderings for the momentous opportunities of agriculture, they adopted a lifestyle of which they had had no previous evolutionary experience. This had significant consequences for their nutrition, their reproduction, their susceptibility to infection, and for the development of their children. As they became the dominant life form on the planet, they gained increasing control of the environment, but an understanding of the biology of their own species has eluded them until comparatively recently. In this introductory chapter, we shall explore episodes in our history in which remarkable institutions were established that made possible unprecedented insights into human biology.

Leaving Eden

For more than a hundred millennia our species has roamed the earth multiplying slowly, subsisting on animal and plant food, constantly adapting to changes in climate and to potential prey. We know little of their lives except that the Cro-Magnon people, the immediate ancestors of Europeans, hunted big game with what seems a mystical enthusiasm and buried their dead with some reverence. By the end of the last Ice Age, the herds of deer had dwindled away and human populations were reduced at one point to perhaps just 10,000 pairs, while our Neanderthal cousins became extinct.¹ When the ice receded, the survivors’ frugal existence, dependent on small animals and plant foods, began to improve as they learnt to grow plants and to manage domesticated animals.

In the Euphrates valley, a new kind of grass appeared, with seeds that ripened in ears on a stalk. The seeds were not dispersed by the wind; they
could be harvested efficiently and used to start another crop in the following year. Once our ancestors had learnt to sow, harvest, and store grain, the timeless hunter-gatherer lifestyle gradually ended. Families formed permanent settlements, based on organised cultivation of plant foods, and in the good years, when food was plentiful, they would multiply in a way that was impossible for hunter-gatherers. The new lifestyle conferred substantial benefits, but it had consequences to which our ancestors were ill-adapted. Food rich in calories was there in abundance in the good years, but when they abandoned the highly varied foodstuffs of their hunter-gatherer past, their diet became monotonous and contained fewer micronutrients. The archaeological evidence suggests that calcium-sequestering chemicals such as phytic acid – abundant in cereals and usually removed in modern grain processing – may have weakened their bones. Tooth decay and serious damage to tooth enamel also make their appearance in skeletons of the period, reflecting the use of refined dietary carbohydrate and stone-ground cereals. We know, too, from certain distinctive markings of the skeletons that reflect deficiency of protein, vitamin C, and folic acid\(^2\) that famine was a constant presence. The eternal battle between humans and epidemic-causing microbes started in those times.

Archaeologists can objectively reconstruct the lives of our ancestors from skeletons and artefacts, but these tell us little about the thoughts of ancient people. To add a vivid and recognisably human dimension to those far-off times, we can look at the best-known fable of the origins of humankind, the book of Genesis. This work, of complicated provenance, derives in part from much older Canaanite and Sumerian texts and even from myths that date from the Stone Age. It conveys in a few terse sentences the situation of the first family after the expulsion from Eden (see Fig. 1.1), desperately grubbing a living from the soil, constantly aware of their mortality. However, it is the complicated metaphor of the forbidden fruit, with its strangely prescient conception of the power of knowledge, that is the really curious idea. The serpent promises the first couple an extraordinary revelation if they eat the fruit. “In the day ye eat thereof then your eyes will be opened and ye shall be as Gods knowing good and evil.” The fruit seems to be a visa to an alternative world beyond Eden, full of extraordinary rewards and terrible risks, choices that could be hugely beneficial or catastrophically ugly. Milton, a man profoundly versed in biblical exegesis, had no doubt, in *Paradise Lost*, about the significance of the Tree: “O
The scene – The Garden of Eden in which Adam and Eve, “naked and unashamed,” are destined to live an idyllic and undemanding existence for eternity.

The crime – The Almighty warns Adam and Eve that if they eat the forbidden fruit of the “Tree of Knowledge of Good and Evil,” they will become mortal and inevitably die. The Serpent entices Eve to ignore the warning with the promise, “In the day ye eat thereof then your eyes will be opened and ye shall be as Gods knowing good and evil.”

Retribution – Famously, the guilty pair become conscious of their nakedness and then God summarily ejects them to ensure that they cannot “take also of the Tree of Life, and eat, and live for ever.”

Adam’s curse – “Cursed is the ground for thy sake; in sorrow shalt thou eat of it all the days of thy life. Thorns also and thistles shall it bring forth to thee; and thou shalt eat of the herb of field. In the sweat of thy face shalt thou eat bread till thou return to the ground” (see Chapter 6).

Eve’s curse – “I will greatly multiply thy sorrow and thy conception; in sorrow thou shalt bring forth children; and thy desire shall be to thy husband, and he shall rule over thee” (see Chapter 2).

Figure 1.1. “Your eyes will be opened.”

sacred, wise and wisdom giving plant, Mother of Science, now I feel thy power.”

The first episode after the expulsion – the strange story of Cain and Abel – is more than a tale of a dysfunctional family. It is an allegory that fixes our attention on the clash between a new farming culture and an older nomadic life. Adam and Eve’s sons – Abel, the “keeper of sheep,” and Cain, the “tiller of the ground” – offer to the Almighty the first fruits of their labour, but only Abel’s are “accorded respect.” Cain, in a jealous rage, murders his brother and flees. Adam and Eve put aside their disappointment and start again with their third son, Seth, from whom the patriarchs are descended (Genesis 4:2–15). Apprehensive of the agricultural future, the
narrator’s sympathies are evidently with the herdsman. Similar sentiments inspire ancient Indian texts.

As the stories unfold, we learn how the Hebrews are troubled by fundamental questions about human existence – how to breed sensibly and successfully, how to avoid disease, and how to live to a decent age. With the emergence of Moses as a leader in touch with the Almighty, they get an answer in the form of “the Law.” Fiercely and uncompromisingly, he demands of his followers the strictest obedience or otherwise risk the wrath of the Almighty in the form of pestilence, famine, and infertility. The dire warnings of retribution notwithstanding, “the Law” becomes a patently humane set of rules for organising society, even down to sensible strictures about public health.

In the absence of a better idea, the Judeo-Christian tradition has concluded that natural disaster and personal suffering reflect a divine purpose. Indeed, until the time of Charles Darwin the Christian world considered no other explanation of the vicissitudes of human life. Many people reject the idea that “design” plays any part in the origin of life and yet may say inadvertently that “nature never intended us to…” or “we were not designed to…”, a snare I will explicitly avoid. I follow the conventional evolutionary view that every human physiological function, no matter how miraculous it may seem, has evolved to fit its current role. We will see that these functions are not perfectly “designed” in one important respect; insufficient resources are available to ensure their indefinite maintenance (Chapters 7 and 8).

The Bible has been used frequently as an authority to condemn a variety of human innovations, most notably anaesthetics in childbirth, blood transfusion, heart pacemakers, the use of cadavers for medical research, and heart transplantation. Today, the chief issue in resolving ethical questions is whether harm or benefit might ensue from our actions. Darwin was acutely conscious of how the forces that drove evolution were another kind of explanation of grief and suffering in human life, every bit as dreadful as the arbitrary rage of the Judeo-Christian God. Which view was most comforting was a moot point. In later editions of the *Origin of Species*, he borrowed a phrase from Herbert Spencer, “the survival of the fittest,” which was later used by Social Darwinists to glorify the perpetual competition they believed would bring social progress. Darwin had no sympathy with this view and in *The Descent of Man* asserted that human moral sense differentiated us from every other animal and directed us to support the
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weakest of our species. Although he never developed this position, his philosophy underpins the use of biomedicine to provide solutions to human misfortune.

Challenges, Risks, and Rewards – Introducing a Theme

This book is the story of a long metaphorical journey from Eden to modern times. Each chapter dwells on different challenges that our biology presents, the initiatives we have launched to reduce their menace, and the rewards or otherwise that followed. Chapter 2 addresses a fundamental question, as important today as in the time of Genesis: how to breed successfully? Why should reproduction – the most important enterprise that people ever undertake – be fraught with such difficulties and uncertainties, and what solutions have we found? The next four chapters concern fundamental issues of biology: how life is handed on, cells in sickness or health, how events in embryonic life affect life after birth, and the requirements to keep us healthy. The middle section examines three great curses that afflict human existence: ageing, cancer, and infection. The final section concerns initiatives and innovations meant to overcome the facts of existence that every species faces, but which only we can see are rather gloomy.

The monumental step that put humans on the agricultural treadmill facilitated the appearance of more dynamic civilisations but was perhaps the first great human misadventure that we know about. Humans were ill adapted to the agricultural life, and it had serious consequences for health, susceptibility to infection, and reproductive physiology. While agriculture could feed more people and support bigger families, the ever-present danger of bad harvests and famine created an unstable balance between the birth rate and the food supply. Insanitary conditions inevitably prevailed in crowded settlements, and the communities became highly vulnerable to epidemics once populations approached a critical density. Later, the population growth rate slowed as the high birth rate was balanced by a high death rate – a time when, in Thomas Hobbes’ unforgettable phrase, “the lives of men were nasty, brutish and short.” Farming families dependent on single staple crops must have suffered from vitamin and protein deficiencies that increased their susceptibility to infection and the severity of disease. We know from contemporary experience that poor nutrition in utero seriously damages the immune system and that chronic enteric infections retard the
The skeletal remains from prehistoric communities indicate people often died pitifully starved, deficient in protein, and with an adult height on average fifteen centimetres smaller than Cro-Magnon man. Indeed, estimates of average dietary protein suggest that levels required for people to grow to the same average height as Cro-Magnon man have been reached only in the last two hundred years.

In the great population explosion that started in mid-eighteenth-century Europe, life span increased significantly and infant mortality decreased, but these advances were also the seeds of another misadventure. Industrialisation thrived on a rapidly growing urban proletariat that inhabited cities fatally flawed by their inadequate sewage disposal systems. Many complex factors contributed to a sustained surge in population growth, including a diminishing threat of infectious disease, improved real incomes, improvements in nutrition, and a reduction in the age at which women could conceive a child. Paradoxically, the most tangible indications of progress were disastrous for the health of the urban poor. In London and other European capitals of the early nineteenth century, unparalleled wealth existed side by side with the most vicious squalor, providing favourable conditions for infectious disease to prosper.

When cholera appeared in Europe for the first time in the 1830s, recurrent epidemics decimated the urban poor because drinking water was contaminated by sewage. The epidemic of tuberculosis that would become the major cause of death in nineteenth-century Europe may have begun in the great factories that were the hub of industrial growth. Rickets, the bow-legged disability caused by soft bones, affected most urban children of Britain and northern Europe, probably because the smoke-darkened skies shielded their skin from sunlight sufficiently to prevent vitamin D from being made. In the absence of effective public hygiene, infectious disease dominated the life of European cities throughout the nineteenth century.

No medical treatment of any kind – except smallpox vaccination – affected the course of any infectious disease. The death rate from every single one, including tuberculosis, and most notably the death rate for infants, started to fall in industrial countries after 1870. The installation of closed sewers, clean water supplies, and the demolition of foetid slums all played an important part, and the appointment of medical officers of health put sanitary regulation at the heart of public administration. Later, improved care of the sick and infants and rising enthusiasm for hygiene contributed importantly to better life expectancy.
As life expectancy began to improve, the birth rate started to fall mysteriously, to the dismay of some authorities. It seems once couples believed that their children would survive infancy, they managed to control their fertility, even if the methods used were far from satisfactory. As the threat of infectious disease subsided, diseases of a much more complicated character (heart disease and cancer) emerged as the next frontier in our pursuit of greater longevity (see Chapters 6 and 8).

In the remainder of this chapter, we will consider how in the early twentieth century, partly through the perspicacity and generosity of philanthropists, biomedical science began to emerge as the great hope for understanding and improving the human condition.

George Bernard Shaw’s Misgivings – Twentieth-Century Optimism

In 1900, children born in Britain (and probably in most of Europe and North America) had an enormously improved life expectancy compared to that of their parents. Their chance of succumbing to an infectious disease was greatly reduced by massive advances in public hygiene and many kinds of social intervention. One of the great intellectuals of the age, George Bernard Shaw, was adamant this had nothing to do with the medical profession and used his art to lampoon them in his play The Doctor’s Dilemma (1906). The preface to the published version of the play (1911) is a hilarious diatribe against physicians and medical scientists and all the manifestations of their trade. Vaccination, patent medicines, experimentation on animals, lack of statistical proof of efficacy of recommended treatments, pointless surgical operations — all are targets of his withering scorn. The otherwise undisputed triumphs of the age — antiseptic surgery, anaesthetics, and the germ theory of disease — he treats with robust contempt. His only concession was to be glad that cleanliness was ousting godliness in public esteem.

Shaw was invincibly ill informed about biomedical developments, but when he wondered why sick people consulted doctors for a fee when so few complaints could be cured, he was raising an interesting question. Medical historians also wonder what strange psychology gripped desperate nineteenth-century minds and usually conclude patients responded to the mystique of the physician’s bedside manner, which worked in much the same way as the placebo effect. (Clinicians conducting drug trials...
often find the control group receiving the placebo – a dummy pill lacking the drug – show unexpected benefits from the trial.)

Shaw’s clowns have a certain prescience. In the year the play was published, the Carnegie Foundation’s investigation of European medical training criticises British clinical teachers for their failure to inculcate scientific attitudes in medical students. His enthusiasm for the “sunshine and soap” creed of the sanitarans – the early nineteenth-century movement dedicated to cleaning up filth, before the importance of germs was fully appreciated – was not misplaced either. Even so, “the germ” had entered the language as the embodiment of a public enemy that needed eradicating with soap and disinfectants, the use of hand washing and handkerchiefs, and campaigns to prevent spitting.

Shaw’s polemic came just at the moment when biological science, as distinct from medicine, was making its debut in human affairs. Seminal ideas that would be massively influential later in the century were being launched in the Edwardian twilight, but they were less newsworthy than the arms race or the rising tide of social unrest. In Cambridge, England, Gowland Hopkins was establishing vitamins as essential components of the mammalian diet necessary for a healthy life. In Germany, a thirty-year odyssey initiated by Paul Ehrlich to find a magic bullet that could cure infectious diseases without adversely affecting human health had started. In Austria, Ludwig Haberlandt was discovering a hormone secreted by the ovaries that governed the menstrual cycle, which, he suggested a decade later, could control fertility and be the basis of a contraceptive pill. In New York, Thomas Morgan was laying the foundation of modern genetics, using an obscure little fly, and Alexis Carrel was conducting the first person-to-person blood transfusions. Peyton Rous was identifying a virus that caused cancer in chickens and that would, almost seventy years later, open the way for the discovery of the oncogenes and their crucial role in malignancy. In London, Archibald Garrod was demonstrating how genetic diseases are inherited biochemical deficiencies. By associating particular organisms with infectious diseases, the first generation of bacteriologists was creating a robust basis for the embryonic discipline of public health.

The impetus for such novel ideas came from the great universities of the world, where the problems of nature were acquiring a new focus. There was confidence in the air that humankind no longer had to accept passively the depredations of disease. In anticipation of important developments from the great successes of Pasteur and Koch, medical research institutes sprang up in the major European capitals, funded by direct donations from the
public. The Institute Pasteur opened in Paris in 1888, and the Koch Institute in Berlin and the Lister Institute in London opened two years later. The British venture lacked serious public support owing to the virulent antivivisectionist propaganda that was prevalent in Britain, in which Shaw played a prominent part. The institute was capitalised with just £64,000, of which half was contributed by a single person. It would have failed quickly had not Lord Iveagh of the Guinness family donated £250,000 a few years later.12

Quite soon, the governments of most advanced countries were setting up, on a modest scale, national medical research organisations to tackle important issues of public health and the standardisation of medicine. There was a growing recognition that an understanding of the basis of medical conditions required a deep knowledge of physiology. The first faltering step in this direction was taken, in Britain in 1911, through a footnote to the National Insurance Act. One penny per year for each person paying National Insurance contributions was supposed to generate a fund of £40–50,000 per year to finance medical research through a precursor of the British Medical Research Council (MRC).13 Though less than a fortune, this was almost the first government money in British history to be spent to the benefit of health. The most important priority of the last Liberal government – and indeed, of Edwardian Britain – is evident in another expenditure proposed in the budget of 1909. This was the 5.3 million pounds to be spent on eight “Dreadnought-type” battleships, necessary to satisfy the public’s appetite for nautical hardware.14

During the First World War, the MRC’s finances deteriorated drastically because military personnel were not required to pay their National Insurance contributions.15 After 1918, the situation improved, and research was undertaken on a broad front. Rickets, the misshapen legs that disturbingly characterised British town dwellers at that time, attracted particular attention. Quite quickly, the requirement for vitamin D to prevent bendy bones in children was established. Research quickly gained momentum in many directions, but in an atmosphere of confrontation with the medical establishment as enshrined in the Royal Colleges of Medicine and Surgery.15 Shaw, in The Doctor’s Dilemma, captures brilliantly the foibles of a bunch of contemporary medical luminaries. He presents the Royal Physician, full of oily charm and ignorance, and the fashionable surgeon whose one-fits-all special operation is supposed to cure any kind of ill health, for a fee. Other roles include a grumpy old cynic who believes there is nothing he could usefully learn, and a successful general practitioner whose success is attributed
to promising his patients that “cures were guaranteed.” The crux of the play concerns whether any of them can save from tuberculosis a supremely talented but morally despicable artist. Shaw extracts the maximum of fun from the medical profession, knowing perfectly well that no treatment on offer, anywhere at that time, could cure tuberculosis. One of his protagonists, Sir Colenzo Ridgeon, is based on his “friend” Almroth Wright, the celebrated Edwardian bacteriologist and inventor of the first anti-typhoid vaccine. However, it is Wright’s now-forgotten and fallacious invention, the Opsonic Index – a measure of resistance to disease – that Shaw (usually thought of as a scientific ignoramus) chooses to mock with such daring prescience.

Wright contributed one more footnote to medical history (that Shaw might have appreciated). The spectacular outcome of Florey and Chain’s clinical trial of penicillin in Oxford in 1942 was announced in The Times – rather oddly, without mention of the authors. Wright saw fit to rectify this, according to his perceptions, by a letter to the newspaper. Using the secret language of great men of those days, he suggested that “the laurel wreath should be decreed,” “palmum qui meruit ferat,” to Alexander Fleming.16

Walter Fletcher, the first secretary of the MRC, contending with characters not unlike Shaw’s creations, constantly challenged the suitability of the Royal Colleges to oversee scientific research. With outlooks fashioned in the previous century, they were suspicious of research and saw it as a threat to their professional position. Their last victory was celebrated in the late 1930s, when in the technicalities arising from a cancer bill introduced to Parliament, they persuaded the government to leave cancer research to the voluntary sector.15

The American National Institutes of Health (NIH) emerged rather late in the day (1930) from a small federal bacteriology laboratory founded in 1866. Until then, American biomedicine had relied on its many excellent medical schools and philanthropic patrons. Once in Bethesda, near Washington, it grew in forty years to become a substantial city and the greatest concentration of medical science the world has ever seen.

Fine universities existed in every industrialised country during the nineteenth century, but the system created in the German states was the one most universally admired. Research, both scientific and clinical, was closely associated with teaching. Training for professional researchers was conducted on a scale unheard of elsewhere for the ascendant German chemical industry, which attracted young men of many nations to extend their education in medicine and science. The German system was also the model for other