How to avoid disease, how to breed successfully, and how to live to a reasonable age are questions that have perplexed mankind throughout history. This book explores our progress in understanding these challenges and the risks and rewards involved in our attempts to find solutions. Nutritional experiences and exposure to microbes and alien chemicals may have consequences that are etched into our cells and genomes. Such events have a crucial impact on development in utero and in childhood and later affect the way we age, how we respond to infection, and the likelihood of our developing chronic diseases, including cancer. The issues covered include the powerful influence of infectious disease on human society, the burden of our genetic legacy, and the lottery of procreation. The author discusses how prospects for human life might continually improve as biomedicine addresses these problems and also examines the ethical checkpoints encountered.

Michael G. Sargent is a research scientist in developmental biology at the National Institute for Medical Research at Mill Hill, London.
Biomedicine and the Human Condition

Challenges, Risks, and Rewards

Michael G. Sargent
The National Institute for Medical Research
Mill Hill, UK
To Jean and Catherine

who brighten the dullest day
Contents

Preface • xi

1 Challenges, Risks, and Rewards: Learning to Control Our Biological Fate • 1
  Leaving Eden • Challenges, Risks, and Rewards – Introducing a Theme • George Bernard Shaw’s Misgivings – Twentieth-Century Optimism • The Great Philanthropists • Investment in the New Biology • Questions from a Sceptical Public • Biomedicine Comes of Age

2 Learning to Breed Successfully • 20
  “In Sorrow Thou Shalt Bring Forth Children” • Changing Reproductive Habits • Surviving Childhood • Birth Control • Assisting Reproduction • Challenges, Risks, and Rewards – a Summary

3 How Life is Handed On • 45
  DNA Transmits Genetic Information • Nucleic Acids and Heredity • Genetic Contributions to a Fertilised Egg • What Is a Gene? • Dark Secrets of DNA • How Life Experience and Heredity Affect Health • Challenges, Risks, and Rewards – a Summary

4 Cells in Sickness and Health • 69
  The Architecture of Cells • A Cell for Every Purpose – Specialists and Stem Cells • Cells Communicating – Growth Factors and Their Receptors • The Death of Cells • Cells and Immortality • Challenges, Risks, and Rewards – a Summary

5 Experiences in Utero Affect Later Life • 90
  The Perfect Nursery? • Perils of Embryonic Life • How Nutritional Experiences in Utero Affect Adult Health • Premature Birth – the
CONTENTS

Danger of Arriving Early • From Birth to Maturity • Challenges, Risks, and Rewards – a Summary

6 Infection, Nutrition, and Poisons: Avoiding an Unhealthy Life • 112
Microbes – Historic Enemies • How Can We Know What We Should Eat? • Toxicological Dangers – Living in a Chemical Zoo • Challenges, Risks, and Rewards – a Summary

7 Signs of Ageing: When Renovation Slows • 132
Life Span and Ageing • What Happens as We Age? • Longevity, Life Experience, and the Genome • How Cells Grow Old • Stopping the Clock • Challenges, Risks, and Rewards – a Summary

8 Cancer and the Body Plan: A Darwinian Struggle • 153
Twentieth-Century Nightmare • Six Steps to Chaos • Life Experience and Cancer – Six Major Risks • Control and Prevention of Cancer • Challenges, Risks, and Rewards – a Summary

9 Fighting Infection • 174
Historic Epidemics • Vaccines • Magic Bullets – Antibiotics • Why Microbes Will Always Be a Threat • Challenges, Risks, and Rewards – a Summary

10 Are Devastating Epidemics Still Possible? • 199
Should We Worry about Unknown Infectious Enemies? • Influenza • AIDS • Prion Diseases • Mosquito-borne Diseases • The Threat of Bioterrorism • Challenges, Risks, and Rewards – a Summary

11 Discovering Medicines: Infinite Variety through Chemistry • 220
The Power of Chemistry • Lessons from Nature • Making New Drugs • Quacks, Carelessness, and Misadventure • Challenges, Risks, and Rewards – a Summary

12 Protein Medicines from Gene Technology • 244
Genetically Engineered Insulin • Gene Technology Becomes an Industry • Making Novel Protein Medicines • Challenges, Risks, and Rewards – a Summary
Preface

How to breed successfully, how to avoid disease, and how to live to a decent age are questions that have perplexed our ancestors throughout recorded time. As humans explored new lifestyles and habitats, each new challenge – whether it was agriculture, urban living, colonisation of new territories, domestication of animals, or industrialisation – could have notable rewards but was usually fraught with unpredictable physiological penalties. The history of our species is marked by technical solutions that have made these problems of human biology bearable. Some originated in common sense – the piped water and closed sewers of the nineteenth-century metropolis – and others in the application of science, but even these could sometimes produce less-than-satisfactory outcomes and, in some instances, disaster.

The idea of this book is to examine some of these adventures through the lens of twentieth-century biomedicine and to identify the risks and the rewards involved in each. During the first decade of the last century, crucial developments were afoot; philanthropists and eventually governments were recognising the importance of biomedical science and beginning to devise a financial infrastructure that could support its progress. This process gained an irresistible momentum after the Second World War, when the American government undertook unprecedented investment in the life sciences. Within three decades, profound insights into inheritance and cell biology gave us the powerful tools needed to establish a gene technology industry. At the same time, a better understanding of the glorious mechanics of human biology provided a framework in which the hitherto baffling and intractable mysteries of chronic disease and ageing could be investigated.

I have begun this story of how our species gained such extraordinary control of our biological destiny with the perceptions of an ancient people recorded in the book of Genesis. This may have been unwise, according to a publisher of my acquaintance, because biologists are supposed to...
be neurotically hostile to biblical allusions! Their palpitations notwithstanding, I hope my readers are open-minded enough to empathise with Genesis as a literary artefact that speaks, almost uniquely, of the biological hopes and fears of ancient times and that gives a certain perspective to the narrative. The preoccupations of the ancient Hebrews seem not unlike our own, and their oldest tribal myth indicates that they understood with extraordinary prescience the potential of human intelligence to make choices that could be hugely beneficial or catastrophically ugly. Their conception of an almighty Deity set the ethical framework for a large swathe of humanity for more than two millennia and was taken as the explanation for every cruel twist of fate. Today, secular societies feel no moral obligation to accept the cruelty of fate and indeed believe it is a humane and proper impulse to try to overcome hitherto insoluble biological problems, such as genetic disease and infertility. The acceptability of such innovations is now considered using ethical frameworks generated by public bodies encompassing all strands of society, a process in which the chief issue is whether any individual is harmed by our actions.

What is “biomedicine”? It is a word that evokes glittering prospects for clinical science; a notion that, taken literally, would limit discussion to recent and future developments affecting human health. However, for lack of a better word, I shall stretch its purview to include every influence on human biology that made us the long-lived creatures we are today. In the nineteenth century, this meant the emergence of a political will to control public health and social welfare, which was informed by scientific knowledge only latterly. Whatever benefits the developed world may gain from future clinical successes – promised today with such incontinence – the vast majority of humanity still struggles to recapitulate the biomedical progress made in the industrial world in the last century. A wish list for the Third World would probably place piped water, closed sewers, moderate population growth, sufficient food, and an adequate national income as high as vaccines against HIV and malaria.

The issues discussed here are an outline of some core themes of human biology. Paradoxically, though, students of biology preparing for university entrance in Britain, and probably elsewhere, touch upon many of these matters only tangentially. Their curriculum is a rigorous preparation for specialised university courses such as medicine and biochemistry that dwell on fundamental principles, leaving little space for anthropocentric reflection or frothy ethical debate. One suspects that a substantial proportion of students without focussed ambitions in science, as well as many laypersons,
would welcome the opportunity to consider personally relevant issues of human biology without undertaking rigorous schooling in the entire subject. A rigorous introduction to biology – fascinating and rewarding though this may be – is not necessary to develop an appreciation of how current developments in biology affect society. In another utilitarian age, Charles Dickens began his novel *Hard Times* with Thomas Gradgrind enunciating his singular testament: “Now, what I want is, Facts. Teach these boys and girls nothing but Facts. Facts alone are wanted in life. Plant nothing else and root out everything else. You can only form the minds of reasoning animals upon Facts: nothing else will ever be of any service to them.” One hopes that nothing so grotesque informs education today, but Gradgrind’s spectre remains a baleful presence. In Britain, the Nuffield Foundation is developing a curriculum on the social impact of science, aimed at pre-university students who will not become scientists but who want to acquire a rational and well-informed view of scientific developments. My book was written in a similar spirit, for a general reader interested in learning about biomedical innovation in its historical and cultural context without the burden of detail. For the same general reader, I frequently refer to news articles in *Nature* or *Science*; I hope their succinct and accurate reviews of current issues will satisfy requirements for traceability of key facts not cited. Many more primary sources were consulted than are listed here, but the book would not bear the weight of such documentation. In the text, references are given as numbered superscripts keyed to the reference list.

In acknowledging help received in writing this book, I must particularly thank the historian Professor James C. Riley of the University of Indiana, who politely alerted me to the dangers of triumphalism based on clinical science. His own fascinating and original research into the global history of rising human life expectancy reveals the remarkable variety of ways in which this has been achieved (see p. 144). The resources allocated to the paraphernalia of modern medicine, public health management, and local self-help activities such as improved parenting vary widely from country to country. In some places, remarkably high life expectancy has been achieved without much investment in clinical medicine. I also gratefully acknowledge the constructive criticism of several anonymous reviewers of my original proposal to Cambridge University Press, the expert copyediting of Russell Hahn, and my friends Bill and Judy Webster, who read the manuscript in its entirety. I also greatly appreciate the continued support of Katrina Halliday, Kirk Jensen, and the many people at Cambridge University Press who have made this book possible.