Chapter 1. Humanity's Debt to Science

Science and medicine have brought seemingly miraculous improvements in both the length and quality of human life. For centuries before the Age of Enlightenment in the 17th and 18th centuries, human life expectancy hovered around 30 years. Even by 1900, it had risen only to 32 years. Since then, global life expectancy has more than doubled, to 73.4 years in 2019. Most of the increase has occurred since 1960, when global life expectancy was only 51 years. Even individuals born today in countries with the lowest life expectancy can expect to live an additional fifteen years, compared to the global average in 1900. This improvement is due primarily to a fall in child mortality, but life expectancy has risen in every age category. Better sanitation and hygiene are part of the reason, but advancements in medical science have been equally important. In 1900, there were no antibiotics, EKGs to detect heart problems, fetal ultrasound, kidney dialysis, pacemakers, sulfa drugs, and so on. There were no vaccines for diphtheria, hepatitis B, Human Papillomavirus (HPV), influenza, measles, mumps, rubella, polio, rabies, tetanus, yellow fever, and whooping cough. The World Health Organisation (WHO) says that of all these medical inventions, vaccines have saved more human lives than any other.

Since the beginning of the 20th century, the quality of human life for many has also improved markedly, though disparities exist within and between nations. At least in advanced countries, people today on average have higher work productivity and more leisure time, higher levels of education and living standards, and higher incomes (adjusted for inflation). Pivotal 20th century inventions are responsible for much of this improvement. A list of those that have had the greatest impact would include the airplane, automobile, computer, electric refrigeration, electronics, paved highways, household appliances, internet, laser, plastics, radar, radio, rural electrification, telephone, television, transistor, and wireless technology.

Every educated person knows the source of these improvements: science. Without it, human life would resemble that of the Middle Ages: nasty, brutish, and short, in the words of philosopher Thomas Hobbes. Given this record, one would think that the first rule for heads of state and their governments would be to follow where the best science leads. But as we will explore in this book, the clear lesson from history is that when science comes up against ideology and ignorance, it often loses. When that happens, the assumption seems to be that a person or government can choose which parts of science to accept and which to reject—and pay no price. But science is like an interwoven tapestry in which each thread supports all the others, strengthening the entire fabric. One cannot

logically reject the findings of one branch of science—pull one thread—because it happens not to fit one's ideology, while accepting all the others. But many abandon logic and do exactly that.

Science is a systematic and logical approach to discovering how the universe works, based on empirical evidence and the testing and refining of hypotheses. Systematic because science follows a proven methodology for getting at the truth. Logical because scientists work with effects and use reason to discover causes. Empirical evidence is that produced by experiment or observation, which scientists then devise hypotheses to explain. They test and revise, choosing the hypothesis that best explains the evidence. As more evidence is gathered and tested, a hypothesis grows stronger and can be promoted to the status of theory.

A critical development in the history of science was the introduction in the seventeenth century of journals in which scientists could share their results. The first in English was the Philosophical Transactions of the Royal Society, which began publication on March 6, 1665. Scientists quickly embraced journal publication not only to establish their priority in discovery but also to describe their methodology so that others could replicate their work, thus confirming its reliability. Journal publication disseminated knowledge widely and launched a burst of discovery that continues to this day.

Science denial, in contrast, is the rejection of settled science despite its endorsement by a broad consensus among scientists. It is motivated by some combination of ideology, politics, personal beliefs, and vested interests. One distinguishing characteristic is that because science denial rests on a rejection of empirical evidence, new facts and discoveries almost never persuade science deniers to change their minds. For them, ideology always trumps facts and often they carry their denial to the grave.

Science deniers sometimes simply declare a theory false, without attempting to replace it with one of their own. Manmade global warming is an example: those who deny it have no other theory to explain why, as fossil fuel emissions and atmospheric CO2 have risen, global temperature has climbed in lockstep. In these cases, science deniers would rather have no theory than one that they find inconvenient or that violates their ideology.

In many instances, however, science deniers adopt an alternative explanation that amounts to pseudoscience: a claim for which there is no empirical evidence, was not reached via a rigorous methodology, is widely rejected by the scientific community, and has never been endorsed in a peer-reviewed scientific article. The best-known example is biblical creationism: the belief that a divine being

created the universe and all living organisms. Those who adopt it reject Darwin's widely accepted theory of evolution, even though it is supported by overwhelming scientific evidence. Other examples of pseudoscience include astrology, crystal healing, dowsing (using a stick or medal rod to detect underground water), the flat earth, homeopathy (the claim that highly diluted materials can heal), folk-medicine, and anti-vaccination.

One example of pseudoscience that will loom large in this book is the belief that traits acquired during life can be passed on to subsequent generations, known as the inheritance of acquired characteristics. An alleged example is the giraffe, whose necks are claimed to have elongated over generations as they stretch to reach leaves high in trees. They then pass on this acquired trait to their offspring. But it is genes, and not traits gained in life, that are inherited.

Even though disproven by genetics, inheritance of acquired characteristics became the basis for state science policy in the USSR and the People's Republic of China. These are the first two cases we will take up. They are examples of how state science policy can be imposed top-down by an all-powerful dictator. In the USSR, though Stalin believed in the inheritance of acquired characteristics for all his life, he did not impose it directly on Soviet biology, but rather through a convenient agent named Trofim Lysenko, whom he praised publicly and anointed as a Hero of the Soviet Union. Mao's Red China would adopt Lysenkoism in its entirety, with catastrophic effects. Lysenkoism in the USSR has produced an entire field of scholarship and a voluminous literature, making it the canonical example of state science denial. We have far more information about Lysenkoism than any of the other historical examples, so it is appropriate to give it detailed attention in this book.

Adolf Hitler made state policy of Nazi eugenics, a pseudoscientific concept which held that some races have more intelligence and other desirable traits than inferior ones. Germans were allegedly descended from a Master Race (Herrenrasse), the Aryans, an obsolete group of Indo-Europeans who migrated into the Indian Subcontinent. Aryan supremacy justified the sterilization, and eventually the murder, of those deemed undesirable. Typical Aryan traits were supposedly fair skin, light hair-color, and blue eyes. These features were glorified as the epitome of beauty and racial superiority, despite their absence among the top Nazis. Hitler imposed a state policy that denied Jews positions in universities and research institutes, which led many to flee Germany for Allied nations, whose war effort they aided. The Holocaust had its beginning in Nazi eugenics.

But science denial and pseudoscience can become state policy not only in cruel dictatorships, but also in democracies. In South Africa, President Thabo Mbeki conducted his own internet research and concluded that HIV did not cause AIDS and that folk remedies were preferable to anti-retroviral drugs. Through delay and inaction, and by those he appointed as ministers, he made AIDS denial and pseudoscientific therapies the effective policy of South Africa, at the cost of hundreds of thousands of lives.

Brazil and the United States provide additional examples of a policy of science denial set by democratically elected leaders. Both Presidents Jair Bolsonaro and Donald Trump downplayed the danger of the COVID-19 virus and discouraged protective measures. Both called it nothing more than a flu. Trump deserves credit for promoting the rapid development of vaccines against the virus, but large numbers of Americans ignored his advice and adopted anti-vax pseudoscience. Eventually, he joined them. In this case, it was the people who in effect set a state policy of science denial and the leader who followed.

The rejection of manmade global warming, either directly or through inaction and delay, threatens more deaths than all other examples of science denial put together. Those who deny it, which includes nearly every elected Republican, are betting their grandchildren's future on the transparently false belief that the world community of scientists is wrong about a matter of science and they are right.

With global warming, the ultimate cost of state science denial has become frighteningly clear. Nations and their leaders have a choice: either learn from the examples we review in this book, trust scientists and act on their advice, or cripple the lives of coming generations.