Chapter 1

A Brief History of Advances Toward Health

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Three major discoveries determined the health and history of the human species. The first occurred almost a million years ago, when our hominid precursors discovered how to use fire to cook the meat they had hunted. They found that cooked meat tasted better, it didn't go bad so quickly, and eating it was less likely to make them ill. Our understanding of nutrition, a basic tenet of public health science, and the art of cooking have been improving ever since.

About 12,000 years ago, as the world warmed up after the last Ice Age, two more discoveries transformed human communities forever. Our forebears, perhaps our women ancestors, learned how to domesticate animals for food, milk and clothing. About the same time, they discovered that seed grain could be planted, harvested, and stored from one season to the next, and then used to make flour and thence bread and similar high-density carbohydrate foods. These two great discoveries eliminated dependence on precarious hunting and gathering, and made the founding of permanent human settlements possible. They are the indispensable basis for every human achievement since those ancient times.

The secure food supply led to the first great population surge. Little settlements became villages, which became towns, and towns grew into cities. Before long, civilizations with religions, laws, history, customs, traditions, and sciences arose on fertile plains beside the great rivers in Egypt, the Middle East, India, and China. Our ancestors had begun to climb the long road to health, towards our present situation. (We might ask as we consider the wars, the suffering, the injustices of the world of the early 21st century, "Where did we take a wrong turn?" But that is the story of civilization.)

As humans grew fruitful and multiplied, so did the variety and number of their diseases. Permanent human settlements transformed ecosystems, and abiding by epidemic theory, the probability of respiratory and fecal-oral transmission of infection rose as population density increased. Ecological and evolutionary changes in micro-organisms account for the origins of diarrhea , measles, malaria, smallpox, plague, and many other diseases. Micro-organisms evolve rapidly because of their brief generation time and prolific reproduction rates. Many that previously had lived in symbiosis with animals began to invade humans, where they became pathogenic. Some evolved complex life cycles involving several host species, such as humans and other mammals, humans and arthropods, and humans and freshwater snails. These evolutionary changes in host-parasite relationships occurred at least several millennia before we had created written histories. Our oldest written records that have a bearing on health date back about 4,000 years. The Code of Hammurabi (c. 2000 BCE) contains ideas indicative of insight into the effects on health of diet and behaviour. It also suggests rewards and punishments for physicians who did their jobs well or poorly.

Information about the impact of diseases, especially of epidemic diseases, from those ancient times has come down to us in myths and biblical accounts of pestilences and plagues, although we cannot reliably identify the nature of the epidemics that afflicted ancient populations. The Greek historian Thucydides provided a meticulously careful description of an epidemic that struck the Athenians in the second year of the Peloponnesian War in 426 BCE, from which the forces of Athens perhaps never fully recovered. Modern infectious disease specialists have puzzled over this epidemic. Was it typhus, a virulent form of epidemic streptococcal infection, that is, a variant form of scarlet fever, or something completely different? Similar questions have been raised about other ancient epidemics, for instance the sweating sickness that recurred many times in mediaeval Europe then vanished, never to be seen again, almost 1,000 years ago. There has been debate too about the exact nature of the Black Death, the terrible pandemic that devastated Asia Minor and the whole of Europe in 1347–1350. This is usually attributed to the plague bacillus, *Yersinia pestis*, but revisionist historians and epidemiologists have raised the possibility that other pathogens, for instance, the anthrax bacillus, might have been responsible. Here, as with the plague of the Athenians, the plague of Justinian, the medieval sweating sickness, the accounts of apparent fulminating epidemic syphilis (that may really have been another sexually transmitted disease or may have been caused by a highly virulent variant of the causative organism of syphilis, *Treponema pallidum*, which has slowly lost its extreme virulence and infectivity), and, indeed, as with all other great epidemics of historical times before the rise of modern microbiology, we can only speculate about the exact aetiology and pathogenesis. This is a rather sterile, albeit fascinating, quest.

It is more productive and useful to focus on what we know with reasonable certainty, and it is simplest to describe this knowledge in relation to some of the heroic figures who have contributed to advances in our understanding of epidemics and other diseases that have helped to shape history. This account therefore concentrates on a handful of the heroes of public health through the course of written history.

Hippocrates (460–370 BCE), the father of medicine, was also the father of public health. He practised and taught in a school of medicine at the Temple of Asklepios, near Epidaurus in Greece, and alone or with members of his school, laid the foundations of rational clinical medicine with careful descriptions of diseases and common sense ideas about ways to manage them. The Hippocratic writings contain rich medical wisdom based on careful observation of sick and healthy people and their habits and habitats. *Epidemics* is a series of case records of incidents of diseases, many of which we now know to be caused by infectious agents. The accounts of tetanus, rabies, and mumps, for instance, could have been written by a modern clinician. *Airs, Waters, Places* outlines environmental health as it was understood two-and-a-half thousand years ago. The relationships of environment, social conditions, and behaviours to health and sickness is made explicit in the timeless advice of the opening paragraph:

> Whoever would study medicine must learn of the following. First, consider the effect of each of the seasons . . . and the differences between them. . . . Study the warm and cold winds . . . and the effect of water on health . . . When a physician comes to a district previously unknown to him he should consider its situation and its aspect to the winds . . . and the nature of its water supply . . . Whether the land be bare and waterless or thickly covered with vegetation and well-watered, whether in a hollow and stifling, or exposed and cold. Lastly, consider the life of the inhabitants—are they heavy drinkers and eaters and consequently unable to stand fatigue, or being fond of work and exercise, eat wisely but drink sparely.

In short, study environment and life style, which are very modern concepts.

For well over a thousand years after Hippocrates' lifetime, human communities were afflicted with ever-present respiratory and gastrointestinal infections that cut deeply into the lives of everyone, and most deeply, as a rule, into the lives of young children who all too often died before they reached adolescence, carried off by measles, scarlet fever, diphtheria, bronchitis, croup, pneumonia, gastroenteritis, or typhoid. From time to time, this steady drain on long life and good health was punctuated by great and terrifying epidemics—smallpox, typhus, influenza, and, most terrible of all, the plague, or the "black death." The causes of these periodic devastations, the contributing reasons to why they happened, were a mystery. Many at the time believed they were God's punishment for sin, or the work of evil spirits. Ideas about contagion were rudimentary, even though it had been dimly understood since antiquity that leprosy, perhaps the least contagious of all the infectious diseases, was associated with propinquity and uncleanliness.

The 16th century Italian monk, Fracastorius, recognized some ways infection can spread. His conclusion, that disease could pass by intimate direct contact from one person to others, was easy to draw because he saw the dramatic epidemic of syphilis that was so obviously spread by sexual intercourse. He described this in a mock heroic poem, *Syphilis, sive morbis Gallicus* (1530) about the swineherd Syphilis, and how he got and passed on to others the "French disease" then raging in Europe. His anti-hero, of course, gave us the name of the disease.

Fracastorius's other concepts, contamination by droplet spread and by way of shared contaminated articles, such as clothing and kitchen utensils, were published in *De Contagione* in 1546. Fracastorius is important because he made a conceptual breakthrough—he brought about what Thomas Kuhn calls a paradigm shift in understanding of infection and some ways to control it.

After Fracastorius, the pathfinders on the road to health became numerous, but mention here will be made of only a handful of public health heroes: Paracelsus, John Graunt, Antoni van Leeuwenhoek, Bernardino Ramazzini, James Lind, Edward Jenner, Johann Peter Frank, John Snow, Ignaz Semmelweiss, and Louis Pasteur.

The Swiss alchemist Theophrastus Bombastus von Hohenheim, known as Paracelsus (1493–1541), occupies the junction of medieval alchemy with scientific chemistry, pharmacy, medicine, and environmental health. He was a colourful character, a foul-mouthed drunkard who insulted and sometimes fought those who disagreed with him, whom he considered superstitious nincompoops. He recognized the relationship of goitre to cretinism, the fact that inhaled dusts caused lung disease, and that some common mental disorders were diseases, not caused by witchcraft or 'possession' by evil spirits. He experimented with chemical remedies containing compounds of mercury, lead, and other galenicals, observed their effects, and, thus, could be considered also a founding figure of pharmacology.

John Graunt (1620–1674), a London merchant haberdasher, was an amateur scientist and an early Fellow of the Royal Society. He was interested in the impact of epidemics, especially the plague, and how plague outbreaks caused the numbers of deaths, and the age at death, to vary from one year to another. For over 100 years before his time, parishes had kept records of baptisms and deaths, and what was then understood about causes of death was inscribed in the Bills of Mortality. Graunt collected and analyzed these Bills of Mortality. He demonstrated statistical differences between males and females, between London and rural areas, and the ebb and flow of epidemics of plague. He published his work in *Natural and Political Observations ... upon the Bills of Mortality* (London, 1662). This work was the foundation for the science of vital statistics. John Graunt demonstrated the importance of gathering facts in a systematic manner, to identify, characterize and classify health conditions of public health importance. The diagnostic categories in the Bills of Mortality tell us what was understood 400 years ago about the variety of human ailments and their causes.

The nature of diseases caused by things not visible to the naked eye was long a mystery that began to unravel when Antoni van Leeuwenhoek (1632–1723), a Dutch linen draper and amateur lens-grinder in Delft, perfected the first functioning microscopes, with which he viewed drops of water, vaginal secretions, feces, his own semen, and the detailed structures of plants and insects. He lacked any formal scholarly training but in a series of 165 letters to the Royal Society of London, he described accurately and in detail all that he saw. He did not suggest that the tiny creatures he was the first to see with his microscope were capable of causing diseases, but he is nonetheless regarded as the first of the 'microbe hunters' who sought and identified the pathogenic micro-organisms responsible for many diseases.

Bernardino Ramazzini (1633–1714) was an Italian physician who observed and classified workers in many occupations, and reported his observations and conclusions about the diseases to which workers in each of these were vulnerable in De *morbis artificum diatribe* (On the diseases of workers, 1713). It is a tour de force, a masterly account in the form of sweeping generalizations, and although the evidence supporting these generalizations was often flimsy, Ramazzini introduced a new way of thinking about ways in which work conditions can affect health.

James Lind (1716–1794) was born and educated in Edinburgh. He was apprenticed to a surgeon when he was 15, and spent nine years as a naval surgeon, during which time he saw many cases of scurvy, a disease that disabled and often killed sailors on long ocean voyages. Lind thought this disease might be caused by a diet lacking fresh fruit and vegetables. He conducted an experiment, giving different diets to each of several pairs of sailors. This was the first clinical trial ever conducted—although the sample sizes were very small, there was no random allocation, and no informed consent was obtained from the sailors. The two sailors who received fresh oranges and lemons recovered rapidly from the scurvy, the others did not, or got worse. Lind also initiated the first effective measures aimed at enhancing hygiene in the British navy, but he is best known for his work on scurvy, reported in *A Treatise of the Scurvy* (1753). Not only was this the first reported clinical trial, it also was proof that a dietary deficiency can cause disease, that a well-balanced diet is essential for good health. Thus Lind, like Fracastorius, was responsible for an important paradigm shift in the understanding of causes and control of disease.

Johann Peter Frank (1745–1821) studied medicine in Heidelberg and Strasburg, was a professor of medicine at Göttingen and Pavia, and taught in many other centres of learning including St Petersburg, before he ended his career in Vienna where he was professor of medicine at the Allegemeines Krankenhaus. Early in his career he began writing *System einer vollständigen medicinischen Polizey*, his great work on ways to improve population health. This appeared in a series of nine volumes from 1779 to 1827. It was, as the title indicates, a system dealing with every then-known way to protect and preserve good health, including community hygiene, personal health protection by cleanliness, and a suggested set of laws and regulations to govern the control of conditions in lodging houses and inns, medical inspection of prostitutes, and so on.

Edward Jenner (1749–1823) was an English family doctor who practised throughout his life in the village of Berkeley, Gloucestershire. In his days, smallpox was a ubiquitous threat to life and health. In severe epidemics, it killed up to a quarter of all it attacked. When it did not kill, it often left disfiguring facial pockmarks and if it infected the eyes it caused blindness.

The practice of variolation, inoculation into the skin of dried secretions from a smallpox bleb, was invented in China about 1000 years ago and spread along the silk route, reaching Asia Minor in the 17th century. Lady Mary Wortley Montague, wife of the British ambassador to Constantinople, described the practice in a letter dated April 1, 1717, and imported the idea to England when she came home. By the time Jenner was a child, variolation had become popular among educated English families as a way to provide some protection against smallpox.

Jenner knew the popular belief in Gloucestershire that people who had been infected with cowpox, a mild disease acquired from cattle, did not get smallpox. He reasoned that since smallpox in mild form was transmitted by variolation, it might be possible similarly to transmit cowpox. A smallpox outbreak in 1792 gave him an opportunity to confirm this notion. In 1796 he began a courageous and unprecedented experiment—one that would now be unethical, but that has had incalculable benefit for humankind. He inoculated a boy, James Phipps, with secretions from a cowpox lesion. In succeeding months, until the summer of 1798, he inoculated others, most of them children, to a total of 23. All survived unharmed, and none got smallpox.

Jenner published *An Inquiry into the Causes and Effects of the Variolae Vaccinae* in 1798—perhaps the most influential public health treatise of all time. The importance of Jenner's work was immediately recognized and although there were sceptics and hostile opponents, vaccination programs began at once. The frequency and ferocity of smallpox epidemics began to decline early in the 19th century, but the disease remained a menace until the mid-20th century. In 1949, the American epidemiologist Donald Soper worked out the strategy of containment, in other words, vaccinating all known contacts of every diagnosed case. In 1966, WHO embarked on a global campaign to eradicate smallpox. The last naturally occurring case was a girl in Somalia in 1977. In 1980, the World Health Assembly proclaimed that smallpox, one of the most deadly scourges of mankind, had been eradicated. At the beginning of the new millennium, samples of smallpox virus are preserved in secure biological laboratories in several countries, but, thanks to Edward Jenner, this terrible disease need never again take a human life—unless it is used illegally in biological warfare.

John Snow (1813–1858) was a London physician, and a founding father of modern epidemiology. (He was also a pioneer anesthetist who invented a new kind of mask to administer chloroform, which he gave to Queen Victoria to assist at the births of her two youngest children.)

Snow's work on cholera demonstrated fundamental intellectual steps that must be part of every epidemiological investigation. He began with a logical analysis of the available facts, which proved that cholera could not be caused by a 'miasma' (emanations from rotting organic matter) as proposed in a theory popular at that time, but must be caused by a transmissible agent, most probably in drinking water. He confirmed the proof with two epidemiological investigations into the great cholera epidemic of 1854. He studied a severe localized epidemic in Soho, using analysis of descriptive epidemiological data and spot maps to demonstrate that the cause was polluted water from a pump in Broad Street. His investigation of a more widespread epidemic in South London involved an inquiry into the source of drinking water used in over 700 households. He compared the water source in houses where cholera had occurred with that in others where it had not. His analysis of the information about cases and their sources of drinking water showed beyond doubt that the cause of the cholera outbreak was water that was being supplied to houses by the Southwark and Vauxhall water company, which drew its water from the Thames downriver, where many effluent discharges polluted the water. Very few cases occurred in households supplied with water by the Lambeth company, which collected water upstream from London, where there was little or no pollution. John Snow reasoned correctly that the cholera must be caused by some sort of agent in the contaminated water supply. This was a remarkable feat, completed 30 years before Robert Koch identified the cholera bacillus. Snow published his work in a monograph, *On the Mode of Communication of Cholera* (1855). This book has been reprinted in modern editions and is still used as a teaching text.

The Hungarian physician Ignaz Semmelweiss (1818–1865) was a great but tragic figure. Working in the obstetric wards of the Allgemeines Krankenhaus in Vienna, he tried to transform traditional but ineffective treatment methods by using logic and statistical analysis to demonstrate the efficacy, or lack of it, when he compared treatment regimens. He believed in the germ theory of disease and was convinced that the terrible death rates from puerperal sepsis must be caused by germs introduced into the raw uterine tissues by birth attendants who did not disinfect their hands. He carried out a meticulous comparative mortality study in his own wards, where he insisted that all birth attendants must cleanse their hands in a disinfectant solution of bleach, and other wards run by senior obstetricians where hand-washing was not routine. His senior colleagues regarded his findings as a gross insult to their professional competence. Semmelweiss's rather abrasive nature and his Jewish origins in the anti-Semitic atmosphere of 19th century Vienna made matters worse for him. He was hounded out of his hospital post, and ended his life in a mental hospital. His belatedly published comparative statistical analyses of the death rates from puerperal sepsis in his own and other wards of the Allgemeines Krankenhaus are a model of how to conduct such studies, but, unfortunately, no one in Vienna heeded him and young women continued to die of childbed fever for another generation.

Medical science advanced rapidly in the second half of the 19^{th} century, applying the exciting discoveries of a new science, bacteriology, which transformed public health. The great bacteriologists of the late 19^{th} century identified many pathogenic bacteria, classified them, developed ways to cultivate them, and, most important, worked out ways to control their harmful effects, using sera, vaccines, and "magic bullets" such as the arsenical preparations that Ehrlich developed to treat syphilis. It would be useful to discuss each of them, but I will focus on just one, Louis Pasteur (1822–1895). This French chemist evolved into a bacteriologist, and was a towering figure of 19^{th} century bacteriology and preventive medicine. In 1854, he had recently been appointed professor of chemistry in Lille, and was invited to solve the problem of aberrant fermentation of beer that caused it to taste bad and made it undrinkable. He showed that the problem was caused by bacteria that were killed by heat. In this way he invented the process for heat treatment to kill harmful bacteria, first applied to fermentation of beer, then to milk—the process known ever since as pasteurization that has saved innumerable children from an untimely death. He went on to study and solve many other bacteriological problems in industry and animal husbandry. He developed attenuated vaccines, first to prevent chicken cholera, then, in 1881, to control anthrax, which was a serious threat to livestock and, as well, occasionally to humans. Before this, in 1880, he began experiments on rabies, seeking a vaccine to control this disease, which without treatment is invariably fatal.

As a result of the success of the anthrax vaccine, he believed that an attenuated rabies vaccine could be made. This, of course, was many decades before the virus was visualized. He prepared and successfully tested his rabies vaccine in 1885 on a boy, Joseph Meister, who had been bitten by a rabid dog. Pasteur became not just a national but an international celebrity.

Born in the same year as Louis Pasteur, the Austro–Hungarian monk Gregor Mendel (1822–1884) was another amateur scientist, a botanist. Experimenting with varieties of garden peas, he cross-pollinated them and observed and recorded the results. Unfortunately, he published his findings in an obscure journal where they remained un-noticed for many years, but when they were unearthed about 15 years after his death, Gregor Mendel was retroactively honoured as the father of a new science, genetics, which soon found many applications in clinical medicine, with the recognition of the fact that many inherited diseases were caused by genetic disorders. Almost 100 years after Mendel's death, other discoveries with great public health relevance include development of genetically modified sterile insect vectors of disease, genetically resistant strains of rice, wheat, and so on, and applications of genetic engineering to limit and even control and prevent some recessive inherited disorders.

Pasteur, Henle, Koch, Virchow, and, soon after, battalions of bacteriologists and pathologists firmly established the fact that micro-organisms caused many diseases—the germ theory was a proven fact, not theory. However, many germ diseases require much more than germs before they can cause their worst damage. Tuberculosis is caused by the tubercle bacillus acting in conjunction with poverty, ignorance, overcrowding, poor nutrition, adverse social and economic circumstances, and other enabling and predisposing factors.

The diarrheal diseases, including cholera, are caused by various micro-organisms, but these get into the gut when ingested with contaminated water or food, that is, they are really caused by poor sanitary and hygienic practices.

By late in the 19th century, many of these factors had been clarified. The stage was set for the health reforms that included the sanitary revolution, the beginnings of a social safety net, provision of immunizations, nutritional supplements for school children, prenatal care for pregnant women, and other essential public health functions we take for granted 100 years later. It required a dedicated army of public health workers to achieve all this.

I have singled out and mentioned a mere handful of the public health pathfinders on the road to good health. Many others could be added, but that would turn this brief chapter into a weighty monograph. Often the physician—pathfinders used their own patients as experimental subjects for their path-finding discoveries. Lind's sailors, Jenner's 23 young friends starting with James Phipps, Pasteur's patient Joseph Meister, and all others known and unknown by name who provided the material for the great discoveries of Robert Koch and other members of the Austrian and German schools of bacteriology, should be remembered and honored too.

Many others belong in their company: The great German pathologist Rudolph Virchow recognized that political action as well as rational science are necessary to initiate effective action to control public health problems; Edwin Chadwick and Lemuel Shattuck reported on the appalling sanitary conditions associated with the unacceptably high infant and child death rates that prevailed in 19th century industrial towns; William Farr established vital statistics in England as a model for other nations to follow. And so the list grows from a handful of public health pathfinders to whole armies.

More was needed than scientific discoveries. Such discoveries had to be applied, and this often required drastic changes in the established social and economic order. So, other pathfinders appear on the road to health. They include politicians, administrators, journalists, creative writers, performing artists, and cartoonists. The journalists, creative writers, and artists who transmit the scientific concepts of public health to the general public and to the politicians are indispensable partners in the team that makes it possible for us to advance up the road to better health. The process continues in modern times with investigative journalism and TV documentaries.

I have identified five essential ingredients of the processes that brought about the public health reforms called the Sanitary Revolution of the late 19th and early 20th century, and have shown that these five features are essential for the control of all public health problems.

1. Awareness that the problem exists. John Graunt began this process with *Natural and Political Observations*. Others consolidated his conceptual breakthrough, and it was applied to great effect after the establishment of formal national vital statistics in England and Wales under the inspired leadership of William Farr. By Farr's time, widespread literacy, the proliferation of daily newspapers, and word of mouth helped to enhance awareness among thoughtful people everywhere that there were massive public health problems in society at that time. Modern computer-based record-keeping and effective health information systems with instantaneous worldwide notification of contagious disease outbreaks with public health significance continue to enhance the process.

2. Understanding the causes. In the second half of the 19th century, understanding rapidly increased, as epidemiology and bacteriology, and nutritional and environmental sciences explored previously unknown landscapes of aetiology and pathogenesis. The new mass media—daily newspapers—propagated this understanding among literate people throughout the country. From the middle of the 20th century, news magazines and TV have ensured that knowledge of causal connections—smoking to cancer, diet and lack of exercise to coronary heart disease, alcohol-impaired driving to traffic fatalities, and many more—are very widely disseminated. This, however, has not necessarily led to effective control measures.

3. Capability to control the causes. With astonishing speed, once the initial breakthroughs had occurred, sera and vaccines were developed to control many of the lethal microbial diseases that had plagued earlier generations. Improved dietary practices, pasteurization of milk, improved personal hygiene and, above all, environmental sanitation to rid drinking water of polluting pathogens, all advanced rapidly in the final quarter of the 19th century and the first few decades of the 20th century. Thus many ancient infectious disease scourges have been controlled, most dramatically being, perhaps , the eradication of smallpox. Unfortunately, new infectious pathogens including the human immunodeficiency virus, viral tropical haemorrhagic fevers, the coronavirus of severe acute respiratory syndrome, and a score or more of others, have emerged to take their place . . .

4. The belief (sense of values) that the problem is important. This is an essential prerequisite to the determination to act upon the problem. It is the most fascinating and challenging aspect of the essential features. This belief is the moral imperative that drives public health reforms. Geoffrey Vickers described the history of public health as a process of redefining the unacceptable—an endless process of identifying conditions, behaviors, and circumstances that individuals, communities, and cultures must no longer tolerate. Throwing the contents of the chamber pot into the street, clearing one's nostrils on the tablecloth, coughing and spitting on the living-room floor, all became unacceptable in the late 19^{th} century. Many people outside the boundaries of traditional medical science and public health practice played a role in this process. In the era of the great reforms of the 19^{th} century, they included social reformers like Edwin Chadwick, journalists like Henry Mayhew and Charles Kingsley, novelists like Charles Dickens, cartoonists in *Punch* and other periodicals—all of whom were aided by the rise of literacy in that period. Collectively, they inspired a mood of public outrage that became an irresistible force for reform. In the second half of the 20^{th} century, this sense of moral outrage found new targets—lighting a cigarette without permission in someone else's home, carrying infant and child passengers in a car without safety equipment, dumping toxic industrial waste where it harms others, and more. Yet, much else remains to be done.

5. Political will. There is always resistance to change, there are always interest groups—often rich and powerful withal—who will do whatever it takes to obstruct necessary improvement. In the era of the sanitary revolution, it was the owners of water companies, factories, and tenement housing who resisted most vigorously. Since the 1950s it has been tobacco companies and a host of manufacturers of toxic petrochemical and other dangerous compounds released into the air and water. Legislation and regulation are almost always necessary, and inevitably generate opposition. Nevertheless, when the other four features—awareness, understanding, capability, and values—are in place, the political will to bring about reforms gathers momentum and usually succeeds eventually.

These five essential ingredients required for public health reforms apply to several public health problems that have waxed and waned over time: tobacco addiction, impaired driving, domestic violence, child abuse, irresponsible domestic and industrial waste disposal, and so on.

Lately, mountainous barriers—of our own making—to maintaining our public health have appeared. The most formidable is a cluster of human-induced changes to global ecosystems and the global commons—the atmosphere, the oceans, wilderness regions, and stocks of biodiversity—that threaten all life and health on earth, not just the life and health of humans.

Another barrier is perhaps an inherent flaw in the human character that leads many individuals and national leaders to believe that disputes can be settled by violent means. Currently, we have so many terrible weapons that violence done by them can and does cause immense suffering, innumerable deaths (80% or more of these deaths, as well as a similar proportion of permanent maiming and disability, are among non-combatants), and appalling damage to ecosystems, the environment, and the fabric of society. Sadly, this is rarely recognized as a public health problem. The very first essential ingredient, awareness of the problem, is lacking. Both these massive public health problems, in my view, are linked to the insatiable human craving for petroleum fuels, an addiction far more pervasive and dangerous to mankind and the earth than addiction to tobacco. So far in our only partially sentient and insightful civilization, this particular addiction is not even recognized as a public health problem.

One public health problem that has been recognized is a worldwide pandemic of tobacco addiction and its many adverse effects on health and long life. Recognition of this problem led the delegates to the World Health Assembly of 2002 to approve the Framework Convention on Tobacco Control. Another universally recognized public health problem is the global pandemic of HIV/AIDS. Tobacco addiction and the HIV/AIDS pandemic are both associated with the values of modern life and social behavior, including the marketing practices of transnational corporations. Surmounting these barriers to health will require social, cultural, and behavioral changes and political action.

I am an optimist. I believe that the pace of scientific advances will be maintained in the future, and that values will continue to shift in favor of essential changes towards global ecosystem sustainability. I do not know whether those who follow us will ever reach the ultimate summit or idealized WHO vision of Halfdan Mahler's "Health for All," but I am confident that they will continue to climb towards it.

REFERENCES

Fracastorii, H. (Fracastorius). (1930). *De contagione et contagiosis morbis et eorum curatione, Libri III.* (W.C. Wright, Trans.) London and New York: Putnams.

Graunt, J. (1662). *Natural and political observations mentioned in a following index and made upon the bills of mortality with reference to the government, religion, trade, growth, air, diseases and the several changes in the said city.* London: John Martyn.

Jenner, E. (1966). *An inquiry into the causes and effects of the variolae vaccinae*. London: Dawsons (Facsimile of the original 1798 edition).

Lind, J. (1753). *A treatise of the scurvy.* Edinburgh: University of Edinburgh Press. (Reprint of the 1753 edition)

Lloyd, G. E. R. (Transl.). (1978). *Hippocratic writings.* Harmondsworth: Penguin.

Ponting, C. (1992). *A green history of the world; the environment and the collapse of great civilizations.* New York: St Martin's Press.

Porter, R. (1997). *The greatest benefit to mankind; a medical history of humanity from antiquity to the present.* London: Harper Collins.

Sigerist, H.E. (1967). *A history of medicine, 1. Primitive and archaic medicine.* New York: Oxford University Press.

Snow, J. (1855). *On the mode of communication of cholera.* London: Churchill.