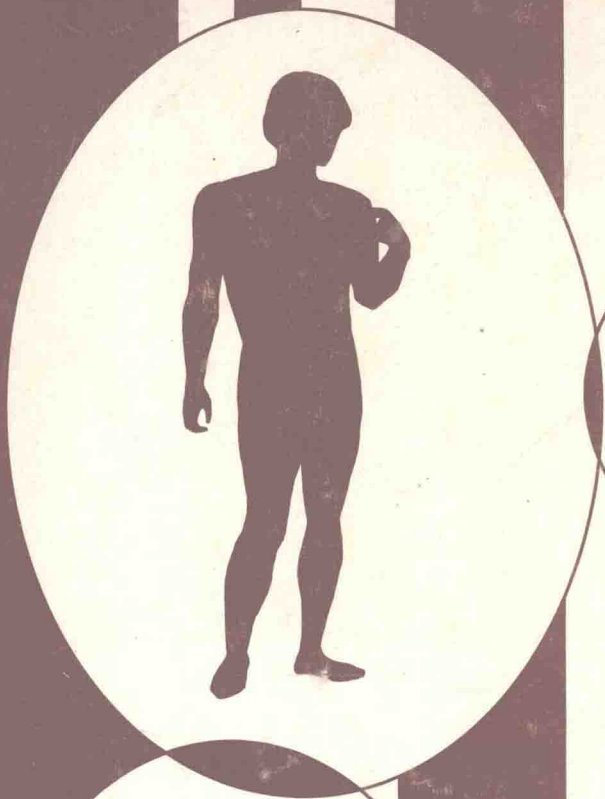

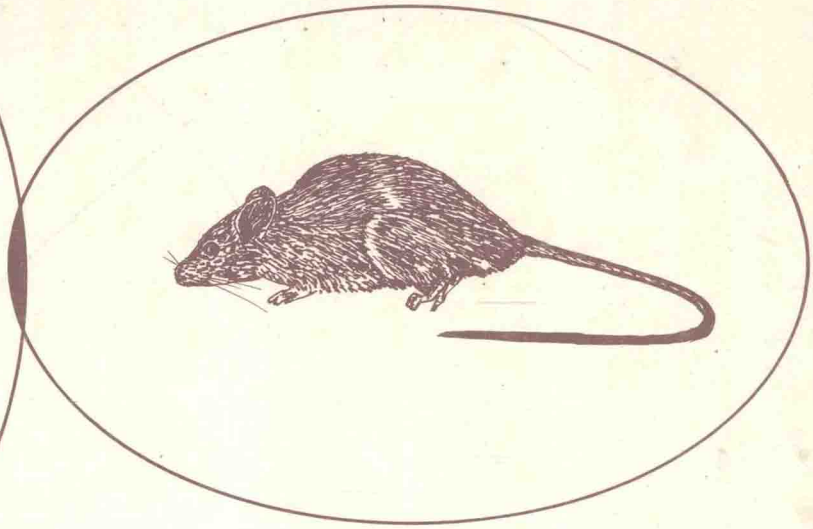

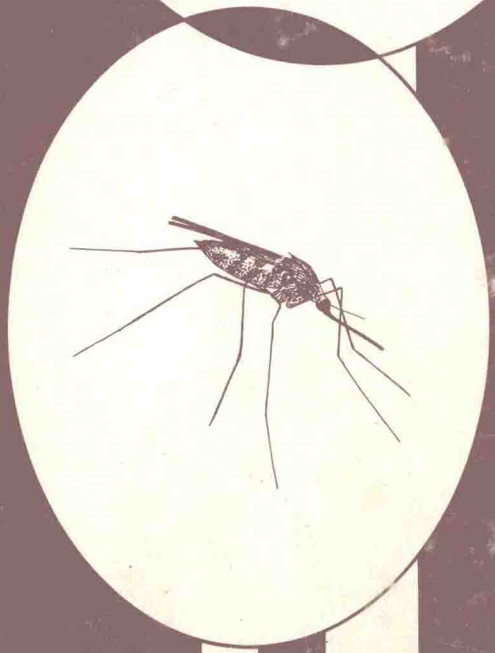

People, Parasites, and Pestilence

An Introduction to the Natural History of Infectious Disease

Wilbur L. Bullock

Burgess Publishing Company

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PREFACE

This book had its origins in a course I have taught at the University of New Hampshire since 1970. The course (Man, Nature, and Disease) is designed to introduce the freshman/sophomore non-science major to the basic natural history of the infectious diseases of humans. No previous college level biology training is required.

Infectious diseases caused by bacteria, viruses, protozoans, and helminths are presented in terms of the causative organism, the method of transmission, and the importance to human populations - past, present, and future. Every effort has been made to be both simple and accurate. Where the use of terms by specialists are overly complicated or controversial I have tried to be reasonably elementary and consistent. For example, I have avoided the trend among many epidemiologists and parasite ecologists to give specifically different meanings to "incidence" and "prevalence". These meanings go beyond the usual dictionary definitions of these words and in part contradict their common usage.

Except where indicated the illustrations are my own and have been developed over the years of teaching the course and writing this book. I have tried to use consistent symbols for the flow charts. However, the living world is so overwhelmingly complex that it defies attempts to put everything into neat little boxes.

I acknowledge the most important incentive for developing this course and writing this book. The InterAmerican Fellowship Program in Tropical Medicine, funded by National Institutes of Health and administered through Louisiana State University School of Medicine, provided me with my first face to face experience with the impact of infectious disease on human communities. Seeing children in villages where most of them suffered the effects of hookworm, malnutrition, and an assortment of other human diseases left a lasting impression on me and most of the other participants in this valuable but now defunct program.

I also acknowledge the importance of Richard Fiennes stimulating book: *Man, Nature and Disease*, from which I got the title for my course as well as many other useful ideas. Dr. Fiennes' book was also the first text.

I am grateful to numerous colleagues who gave advice and encouragement throughout this project. I am most grateful to Professors Emery Swan and Patrick Muzzall, as well as to Mr. Wayne Lord, who read and critically edited nearly every chapter in this book. They were most helpful in every stage of the process of putting this book together. Needless to say, the final decisions have been my own and I am responsible for any inadequacies.

Special gratitude and appreciation goes to my wife, Cecilia, who advised, encouraged, edited, and proof read. Without her constant support this project might never have been completed.

Wilbur L. Bullock
Durham, New Hampshire
September, 1981

ACKNOWLEDGMENTS

1. Figure 5.1, 5.2, 5.3, 5.4, 8.1, and 8.3 are from the Burgess Professional Life Science Illustrations, Second Edition.

2. Figure 8.2 is from Bulletin No. 19, U.S.D.A. (1898), *The Inspection of Meats for Animal Parasites.*

3. Figure 8.6 is from: Ransom, B.H. and Foster, W.D., Bulletin of U.S.D.A. No. 817, (1920), Observations on the life history of *Ascaris lumbricoides.*

4. Figure 9.2 is from Circular No. 469, University of Illinois, Agricultural Experiment Station and Extension Service in Agriculture and Home Economics, (1937), *Internal Parasites of Poultry.*

5. Figure 9.3 is from Circular No. 148, U.S.D.A. (1948) *Parasites and Diseases of Horses.*

6. Figure 18.1 is from an unnumbered publication of the University of New Hampshire Cooperative Extension Service, (undated), *Bug Facts: Human Lice.*

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INFECTIOUS DISEASE TODAY:

Some Introductory Concepts

> "Today bacterial diseases are approaching extinction, and viral diseases are coming under control. In the last 20 years, four of the last great killers, malaria, syphilis, tuberculosis, and polio, have been essentially wiped out, thanks to penicillin and sulfa drugs and vaccines and DDT."
>
> John R. Platt (1965)
> *The Step to Man*

The decades following the Second World War (1939-1945) were years of excitement and optimism in regard to control and even eradication, of infectious diseases. Technological advances had provided us with "wonder drugs", newer and more effective pesticides, and a research establishment that was confident it could provide solutions to all of our disease problems. Furthermore, the general public was equally confident and optimistic. Although Dr. Platt's analysis of the impact of science and technology may have been a bit glowing, even for 1965, many medical advances had been made and still others were under way or planned. The sulfa drugs had decreased the menace of many of our bacterial diseases; penicillin and other antibiotics appeared to be the "miracle drugs" that would eliminate all concern over infectious diseases. Vaccines removed or greatly reduced the threat from bacterial diseases such as typhoid fever and diphtheria and from virus diseases such as polio and smallpox. DDT and other insecticides were being used with fantastic success to lower the incidence of major killers such as typhus fever and malaria. In fact, the World Health Organization had launched its ambitious Malaria Eradication Program, and the target date for the total elimination of this dread disease was 1975. When Dr. Platt wrote in 1965, medical biologists and others were actually becoming alarmed because of a rapid rise in population that appeared to be associated with the removal of malaria in many areas!

Unfortunately, the world of the 1980's does not promise to be as disease-free as the optimists anticipated. The infectious organisms that cause gonorrhea and malaria and typhoid fever and pneumonia have become increasingly resistant to the drugs to which they had been succumbing so rapidly. The insecticides that saved so many human lives by killing malaria-transmitting mosquitoes and typhus-carrying lice have been shown to involve some serious hazards. In addition, the mosquitoes and lice have become resistant to insecticides just as bacteria have to antibiotics.

In the developed countries of the world infectious diseases have decreased in importance as leading causes of death. Cancer and heart disease, alcoholism and motor vehicle accidents are the most serious risks to health and life in much of Europe and North America. On the other hand, there has been an alarming increase in venereal disease, an increase attributed to both a drug resistance and to a change in moral standards that has facilitated transmission, especially amongst youth. There have been frequent references in the media to the "epidemic of VD".

In the developing countries, however, infectious diseases still constitute a major problem. These are the nations with the most rapidly expanding populations and that presently account for over two thirds of the world's people. Here millions die each year from diseases whose causes and methods of transmission are known. However, because of lack of pure drinking water and lack of even the most elimentary sanitary facilities in many places we find much sickness and premature death. Infant diarrhea, typhoid fever, dysentery, intestinal parasites, malaria, and a host of diseases with awe-

inspiring names contribute to this sickness and early death. Recently, the World Health Organization targeted six diseases for special attention in their "Special Programme for Research and Training in Tropical Disease". These diseases include malaria and schistosomiasis, two diseases that are often fatal and that are actually increasing more rapidly than world population. The other four diseases (trypansomiasis, leishmaniasis, filariasis, and leprosy) have been and continue to be major deterrents to health and progress in large areas of the world.

A recent poll of Americans indicated that most of them believe that the major scientific research effort should be to cure cancer and, secondly, to solve the energy problem. Because of this attitude Americans do not worry about infectious diseases, especially the diseases of other parts of the world. Even recognizing infectious diseases as only minor contributors to death in the more affluent, developed countries, we still have a vital stake in the health of the rest of the world. In addition to the moral principles involved we also have a practical interest in the health of Africa, Asia, and Latin America. These far-flung corners of the earth are sources of many of our vital raw materials. For better or for worse, through foreign investments and multinational corporations we are economically linked to these regions and to their people. The health of the oil field worker in Saudi Arabia, the coffee plantation worker in Colombia, and the peanut grower in Nigeria is of concern to us.

However, when we compare the amount of research funding for the prevention and control of cancer (a major disease in affluent nations) with the amount spent on diseases of the developing world we see a pronounced inequity. When we consider the actual numbers of people involved, the inequity becomes gross injustice, as can be seen in Table 1.1., which was assembled a few years ago by Kenneth Warren of the Rockefeller Foundation.

TABLE 1.1. Disparity Between Rich World and Poor World:
Prevalence of Disease and Research Funding

Disease	Prevalence # of people (millions)	Funding # of Dollars (millions)
CANCER	10	815*
SCHISTOSOMIASIS	200	3
MALARIA	300	5
FILARIASIS	300	<1
AMEBIASIS	400	<1
ASCARIASIS	1,000	<1

* Of this amount, $800 million comes from the U.S. alone.

The World Health Organization estimates that 97% of world funding for disease research is spent in developed countries with less than 25% of the world's population; only 3% is spent on the poor countries of the world. Furthermore, as a result of our affluence more Americans are travelling to exotic but unhealthy places. By air travel we can be in areas of malaria, cholera, and plague within hours of our homes. On that basis, both those of us who travel and the medical professionals who care for us need to be more aware of the global aspects of disease than we have been in the past.

In succeeding chapters we examine the natural history of human disease from a worldwide perspective. We look first at two sample diseases that, although very different in their biology and their relationships to human populations in recorded history, are diseases that are having a profound impact and will provide a real challenge to the health professions in the years ahead. We then survey the various groups of *infectious* (disease-causing) organisms and some of the diseases they cause. Following this survey we examine the basic aspects of the disease process as it occurs in individuals and in populations. Finally, we look at a series of important diseases that have had disastrous impact on humans in the past, are significant threats to people today, or both. Along the way we consider some of the economic, political, moral, religious, and legal implications

of human disease. We also survey the role of disease in human affairs, some of the dramatic successes as well as the significant failures in our battle against disease.

Interspecific Associations in Disease

Infectious diseases involve two or more species in association with one another. The species which is the victim of such an association is the *host*. The infectious organism is referred to by various terms. It is a *parasite* as we emphasize that the disease-causing agent is metabolically dependent upon its host, i.e. it depends on the host for its basic life functions. In many instances this dependence is an absolute biological requirement and we have *obligatory parasitism*. Viruses, for example, cannot live and multiply outside of living cells and thus are *obligate, intra-cellular parasites*. Some bacteria, some protozoans, and even a few worms are able to multiply outside of any host although, under certain conditions, they can infect a human or an animal host; these are *facultative parasites*. Other kinds of host-parasite relationships will be considered later.

Infectious organisms are also described as *pathogenic*; they cause (*gen*) disease (*patho*). Bacteria and protozoans, because of their microscopic nature are often called *microbes* or *micro-organisms*, an indication of their small size. Both microbes and micro-organisms can be harmless, free-living organisms as well as pathogens or parasites. Finally, when we want to speak in the most general terms about the cause of any disease, whether an infectious disease or not, we speak of an *etiological agent*. Thus certain viruses are etiological agents of the common cold, radiation is the etiological agent of certain forms of leukemia.

All organisms that live in or on a host, however, do not cause disease. *Commensals* are organisms that live in or on their hosts, that do not harm the host, but that gain benefit from their host. The word "commensal" literally means "together at the table" and such an interspecific association was quaintly illustrated by the title of P. J. Van Beneden's fascinating book of a hundred years ago: *Animal Parasites and Messmates*. There are numerous species of bacteria, protozoans, and worms that live in the intestine of animals, which derive their nourishment from the host intestine, but which are harmless commensals.

Another relationship is *mutualism*. In this association the host is benefitted by the presence of the other organisms, and often the two species are dependent upon each other for survival. For example, the termites that eat the wood of our houses are unable to digest the major component of wood, cellulose. However, within their digestive tracts are numerous species of flagellated protozoans that have the proper enzymes. When deprived of the flagellates the termites starve to death, even though their intestines may be full of wood.

Biological Names

A difficulty we all have as we approach subjects with which we are unfamiliar is the problem of terminology. We will attempt to keep specialized vocabulary to a minimum. The names of the parts of a worm or even a virus may, at first encounter, sound as overpowering as the parts of an automobile to a city dweller who has only used public transportation. However, "spark plug" and "disc brake", "cercaria" and "scolex" are far more effective in communication than "thing-a-ma-bob" and "whatch-macallit". We often have difficulty with people's names and it is only natural that we have problems with the so-called scientific or technical names of living creatures. In spite of the fact that these names may seem difficult, they are given under an international code of rules whose major purpose is to clarify communications. Living organisms are thus named by the *binomial system of nomenclature*. Each organism has a first and a second name; the first is the *genus* grouping to which it belongs and this name is always spelled with a capital letter, the second is the *trivial* or *species* name. Thus the human blood flukes (Chapter 3) all belong to the genus *Schistosoma*. There are three kinds or species: *Schistosoma haematobium, S. mansoni,* and *S. japonicum*. Note that after a genus has been named in a publication further references usually use only the capitalized first letter followed by a period. These three species also illustrate three common sources of technical names:

S. haematobium refers to the fact that schistosomes live in the blood; *S. mansoni* refers to and honors a person associated with the study of the animal group or discipline (in this case Patrick Manson, an important contributor to our knowledge of tropical diseases); *S. japonicum* refers to the geographic locality in which an organism was first found.

In studying infectious diseases it is helpful to distinguish the name of the disease from the name of the organism that causes it. For example, amebic dysentery (the disease) is caused by *Entamoeba histolytica,* malaria (the disease) is caused by one of several species of *Plasmodium,* trichinosis (the disease) is caused by the nematode worm *(Trichinella spiralis).* Sometimes we find similar organisms that cause different diseases: *Trypanosoma gambiense* causes African sleeping sickness, *T. cruzi* causes Chagas' disease; *Entamoeba histolytica* causes amebic dysentery, *Entamoeba coli* is a harmless ameba of the human intestine and causes no disease. Finally, we need to recognize that some disease names refer to a characteristic group of symptoms and may be caused by a variety of different organisms: dysentery (severe diarrhea) may be caused by blood flukes *(Schistosoma mansoni),* amebae *(Entamoeba histolytica),* or bacteria *(Shigella dysenteriae);* pneumonia (inflammation of the lungs) may be caused by bacteria (*Diplococcus pneumoniae*), viruses, or even by parasitic worms (hookworm and *Ascaris*).

2

CHOLERA:
An Acute Disease

> "To see individuals well in the morning and buried before night, retiring apparently well and dead in the morning is something which is appalling to the boldest hearts."
>
> Diary of a Young Man in Albany, July 18, 1832
> Manuscript Division, New York Historical Society

Because of the rapidity with which the disease has frequently progressed in infected individuals cholera is probably one of the most frightening of the classic epidemic diseases. As Charles Rosenberg so graphically expressed it in *The Cholera Years:*

> "It was not easy for survivors to forget a cholera epidemic. The symptoms of cholera are spectacular; they could not be ignored or romanticized as were the physical manifestations of malaria and tuberculosis. . . The onset of cholera is marked by diarrhea, acute spasmodic vomiting, and painful cramps. Consequent dehydration, often accompanied by cyanosis, gives to the sufferer a characteristic and disquieting appearance: his face is blue and pinched, his extremities cold and darkened, the skin of his hands and feet drawn and puckered. . . Death may intervene within a day, sometimes within hours of the appearance of the first symptoms. And these first symptoms appear with little or no warning. He felt no premonition of cholera at all, reported a New Yorker in 1832, until he pitched forward in the street, 'as if knocked down with an axe'.
>
> "The abrupt onset and fearful symptoms of cholera made Americans apprehensive and reflective -- as they were not by the equally deadly, but more deliberate, ravages of tuberculosis or malaria."

On the basis of such a short period of time during which the infected individual is sick, cholera is a dramatic example of an *acute* disease, a disease that runs its course quickly; the patient either recovers or dies within a few days or even hours. By contrast, a disease that afflicts an individual over a longer period of time, months or even years, would be a *chronic* disease. However, there is no sharp line of distinction between these two time parameters of a disease and some diseases may present themselves in either form.

The Causative Organism and the Disease

Cholera is caused by a microscopic, comma-shaped bacterial organism, *Vibrio cholerae*. Each vibrio is actively motile by means of a single whiplike structure or *flagellum* that propels the bacterium through its watery environment (Figure 2.1).

V. cholerae was first discovered by the German bacteriologist, Robert Koch, in Egypt in 1883; its association with the disease was confirmed by him the following year in India. Some medical workers at first challenged Koch's claims, but within a few years his "comma bacillus" was accepted as the causative organism. Since then there have been significant advances in our understanding of the nature of the disease process in cholera as well as our knowledge of the method of its transmission from person to person.

Figure 2.1 *Vibrio cholerae*, the cause of cholera

As can be seen from the previously quoted description of the disease by Rosenberg, the most marked features of cholera are diarrhea and vomiting. Indeed both are so severe that dehydration (fluid loss) and drastic reduction of body sodium and potassium (electrolytes) are the primary causes of death. Some patients lose more than their body weight in fluids during the course of the disease; fluid loss has also been measured at 8 to 15 quarts per day. Such a large amount of fluid is considerably more than all of the fluids normally poured into the digestive tract by all of the associated glands. Therefore, this fantastic fluid loss must involve more than a failure of the digestive tract, especially the colon or large intestine, to carry on its normal water and salt reabsorbing activities. Such a failure was earlier thought to be the main part of the disease process. In recent years it has been shown that enormous quantities of fluids are actually secreted from the tissues of the wall of the small intestine into the intestinal cavity or *lumen*. Furthermore, the view of early workers that there was drastic destruction of the intestinal lining has been shown to be in error. In fact, a microscopic study of the intestine, even with the high powers of the electron microscope, has failed to reveal significant changes in the structure of the cells lining the intestinal wall. It has been shown that disease production is by means of a poisonous substance or *toxin* that is produced by the vibrios. It is this toxin that so drastically upsets the normal functioning of the digestive system. The rapidity of the progress of cholera infections is caused by the high rate of the multiplication of the vibrios in the small intestine in conjunction with the high potency of the toxin these vibrios produce.

Transmission

Cholera is an example of a disease in which there is *direct transmission* (Figure 2.2). In contrast to many diseases, no other living organism is required to pass the vibrios from one human to another. (See next chapter). However, cholera is not *contagious* in the same sense as this term applies to sicknesses like the common cold in which one individual immediately passes on the disease to another. In fact, during epidemics physicians and nurses rarely acquire the disease when treating cholera patients.

Cholera is almost entirely a disease of poor sanitation. Such poor sanitation is commonly the result of persistent poverty that fails to provide pure drinking water or adequate sewage disposal. Poor sanitation may also be the result of temporary breakdown of sanitary facilities following natural disasters or war.

The vibrios, which are passed with the feces and vomit of infected individuals, are quite delicate and unable to survive the rigors of the outside world. They may be able to live for a while in moist, soiled bedclothes, but even under the best of conditions - for the vibrios! - the organisms will die within a few days. They are readily killed by sunlight and by chlorination. The usual method whereby a person picks up cholera is through contaminated drinking water. Mostly the source of such water is from wells, rivers, and streams which are grossly contaminated with human feces. However, in the

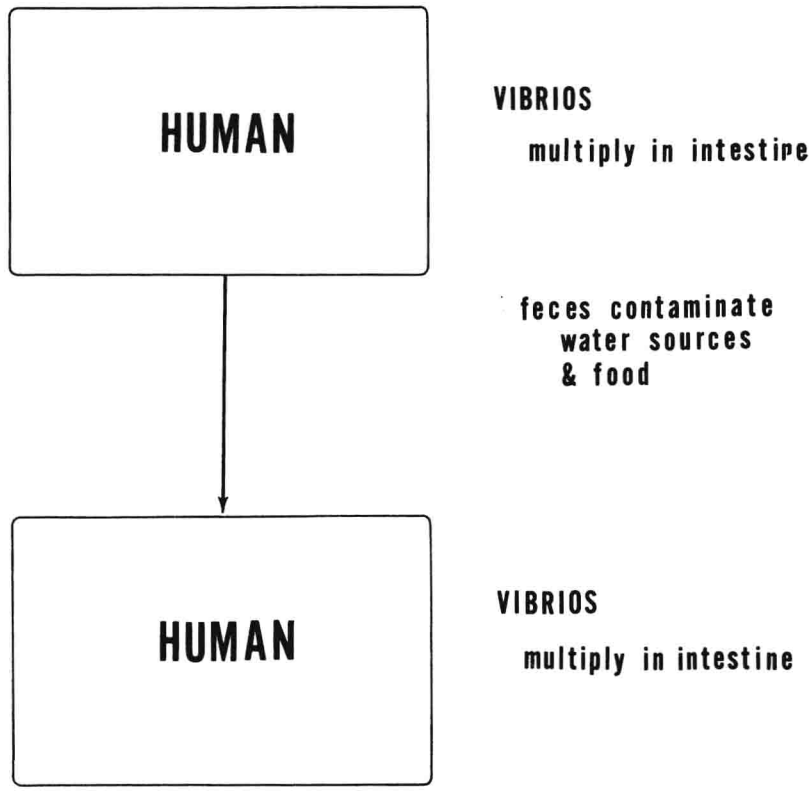

Figure 2.2 The Natural History of Cholera. Direct transmission by poor sanitation.

1974 outbreak in Portugal, bottled water was found to be the source in a number of cases; two of the springs used by a bottling factory near Lisbon were infected with vibrios! Fresh fruits and vegetables can also be a source since farmers will often "freshen up" their produce on the way to market. Water for this operation will frequently come from infected sources. Other intestinal diseases are spread the same way!

John Snow and the Broad Street Pump

Thirty years before Koch's discovery of the vibrio, John Snow, an English physician who is also noted for his research in general anaesthetics, carried out one of the classic studies in the history of *epidemiology*, the science of the spread and transmission of disease. At that time, water was supplied to the residents of London by several private companies, two of which differed obviously from each other in the quality of the water supplied. One company provided water from a portion of the Thames river that was grossly polluted with London sewage; the other was less contaminated although definitely unacceptable by modern American and European standards. Strangely enough the people seemed to raise no objections to the poor quality of the water; their major concern was the low quantity! Both companies sold their water to rich and poor; many of the customers of the one company were in close proximity to the customers of the other. With over "300,000 people of both sexes, of every age and occupation, and of every rank and station from gentle folks down to the very poor" this was a nearly ideal format for a controlled scientific study. The cholera death rate was 14 times higher in those people supplied by

the Southwalk and Vauxhall Company (with the more obvious sewage) than those supplied by the purer (relatively) water of the Lambeth Company. On the basis of this study Snow concluded that a specific poison was present in the excreta of cholera victims, that these particles were dispersed in the water with the sewage, and that these particles caused cholera by multiplying in the next victim after ingestion with contaminated water. Snow may not have seen vibrios or conceived a "germ theory" of disease but he was amazingly close to the real truth concerning the cause and transmission of cholera.

Snow is probably best remembered for a recommendation, made at about the same time and on the basis of the above study, for the control of a limited regional outbreak of cholera in the Broad Street section of London. At this time, the middle of the nineteenth century, the poor people of the cities of Europe and America got their water from pumps located in the streets. At these pumps, there was both the unrealized hazard of contaminated water and the inadequate supply; people had to wait in line, sometimes for hours, for small quantities of water. Such limitations meant that there was almost never enough water for washing. In the Broad Street area the medical authorities observed a marked increase in the number of cholera cases when compared with other sections of the city. When consulted, Snow gave his famous, brief reply: "Remove the pump handle". This was done and the outbreak slacked off. Whether this was a coincidence, as some have suggested, or not, an investigation of the area showed that the pump was near the cesspool of a house in which a cholera victim lived.

Treatment, Prevention, and Control

Until recently the treatment of cholera was ineffective due to the rapid course of the disease. Over the past two decades, however, relatively simple and inexpensive means of treatment have been developed. Since the cause of death from cholera is dehydration and salt (electrolyte) loss, the replenishment of these losses with the precisely proper balance of sodium and potassium is an obvious form of treatment. Intravenous replacement of fluid, potassium, sodium, and bicarbonate has proven highly effective. More recently oral intake of similar mixtures has proven helpful although intravenous treatment is necessary in advanced cases. One complication of this treatment is that the fluid and electrolyte loss pattern of children differs from that of adults; different formulae of electrolyte mixtures must be packaged and available for these two age groups. Furthermore, although this method of treatment is remarkably effective, the quantities of properly mixed electrolytes are not always present in the underdeveloped areas where cholera is likely to occur. However, the amazing effectiveness of this simple treatment can be seen in the different mortality rates. For untreated cholera as many as 75% of the sick will die whereas with electrolyte therapy this death rate is reduced to less than 1%.

Tetracycline and other antibiotics are also helpful in treating cholera patients in addition to the electrolyte therapy. Such antibiotics are valuable in eliminating the vibrios from people who are not sick but who maintain the bacteria in their intestines and gall bladder. Such people pass vibrios in their feces and thus are sources of infection to others when they contaminate water because of unsanitary conditions. Infected persons without symptoms that continue to pass infectious organisms are known as *carriers*; they occur in many diseases.

Prevention and control consists of improvement of sanitation, especially the disposal of human feces, provision of pure water through adequate water supply systems or boiling water, and careful, sanitary processing of food, especially raw fruits and vegetables. Immunization is available but is of short duration (a few months) and is probably only about 50% effective. However, such immunization is recommended for anyone travelling into a high risk area.

Cholera and History

Of all of the aspects of the biology of *Vibrio cholera*, its impact on human history is one of the most fascinating. Prior to 1816 the only known epidemics of cholera occurred in a very restricted range that included India, what is now Bangladesh, and parts

of Burma and South China (Figure 2.3). Then began a series of extensive and often devastating epidemics that ultimately included a large proportion of the earth. Dramatic outbreaks of disease that encompass large geographical areas are known as *pandemics*, and cholera, along with influenza, has become one of the prime examples of potentially pandemic disease. In contrast to the large geographic scope of a pandemic an *epidemic* is a significant increase in the occurrence of a disease in a limited geographical area. When a disease is more or less constantly present in a given area it is *endemic*. As in the case of "acute" and "chronic" there are no rigid limitations on these definitions when applied to specific diseases but they are important relative terms. From these definitions we can see that India is involved at all three levels of cholera: endemic, epidemic, and pandemic.

There is no complete agreement on the number and dates of the various pandemics but there seems to have been five or six pandemics in the nineteenth century and two in the twentieth. As of now we cannot adequately explain what happened in 1816, why cholera's limited distribution gradually, and in successive, somewhat overlapping waves, came to include London, New York, and New Orleans as well as Calcutta in its destructive grasp.

As Rosenberg so poignantly demonstrated, the years 1832, 1849, and 1866 were the critical years for New York City and, to a lesser degree for other parts of the United States. The tenement houses especially of our large cities were the breeding grounds for all kinds of social and biological evil. According to Rosenberg " . . . in the summer of 1849 it was impossible to ignore them [the tenements], impossible to ignore the connection between the fate of those who died in these tenements and the conditions in which they lived. Twenty-two pigs made their home in one New York frame building from which five cholera cases were taken. In Philadelphia, 'a free couple of color', dying of cholera, were removed from the four and a half by seven foot room in which they lived; in a Boston cellar, the tide rose so high that a physician could only approach a patient's bedside by means of planks laid from one stool to another. The dead body of an infant in its coffin floated in another part of the room"

In summarizing the drama of cholera in the nineteenth century we can best return to Rosenberg:

> "Cholera was the classic epidemic disease of the nineteenth century, as plague had been of the fourteenth. When cholera first appeared in the United States in 1832, yellow fever and smallpox, the great epidemic diseases of the previous two centuries, were no longer truly national problems. Yellow fever had disappeared from the north, and vaccination had deprived smallpox of much of its menace. Cholera, on the other hand, appeared in almost every part of the country in the course of the century. It flourished in the great cities, New York, Cincinnati, Chicago; it crossed the continent with the forty-niners; its victims included Iowa dirt farmers and New York longshoremen, Wisconsin lead miners and Negro field hands."

This doesn't even begin to tell the toll in lives in Asia, Africa, and Europe. Nor does it fully reflect the suffering of the thousands of peasants and tenement dwellers as well as even some of the more famous people of the time. The Russian composer, Peter Ilyitch Tschaikovsky, died of cholera November 6, 1893.

Cholera Today

At the time of Rosenberg's book (1962), he could accurately point out that there had not been a case of cholera in the United States for almost fifty years. Others, writing at about the same time, could confidently entitle their chapter on this vibrio-caused disease: "The Rise and Fall of Cholera". The pandemics seemed to be over, and modern medicine and modern sanitation would guarantee that cholera would never again leave its south Asia home to menace the rest of the world. Only travellers to India worried about cholera immunization.

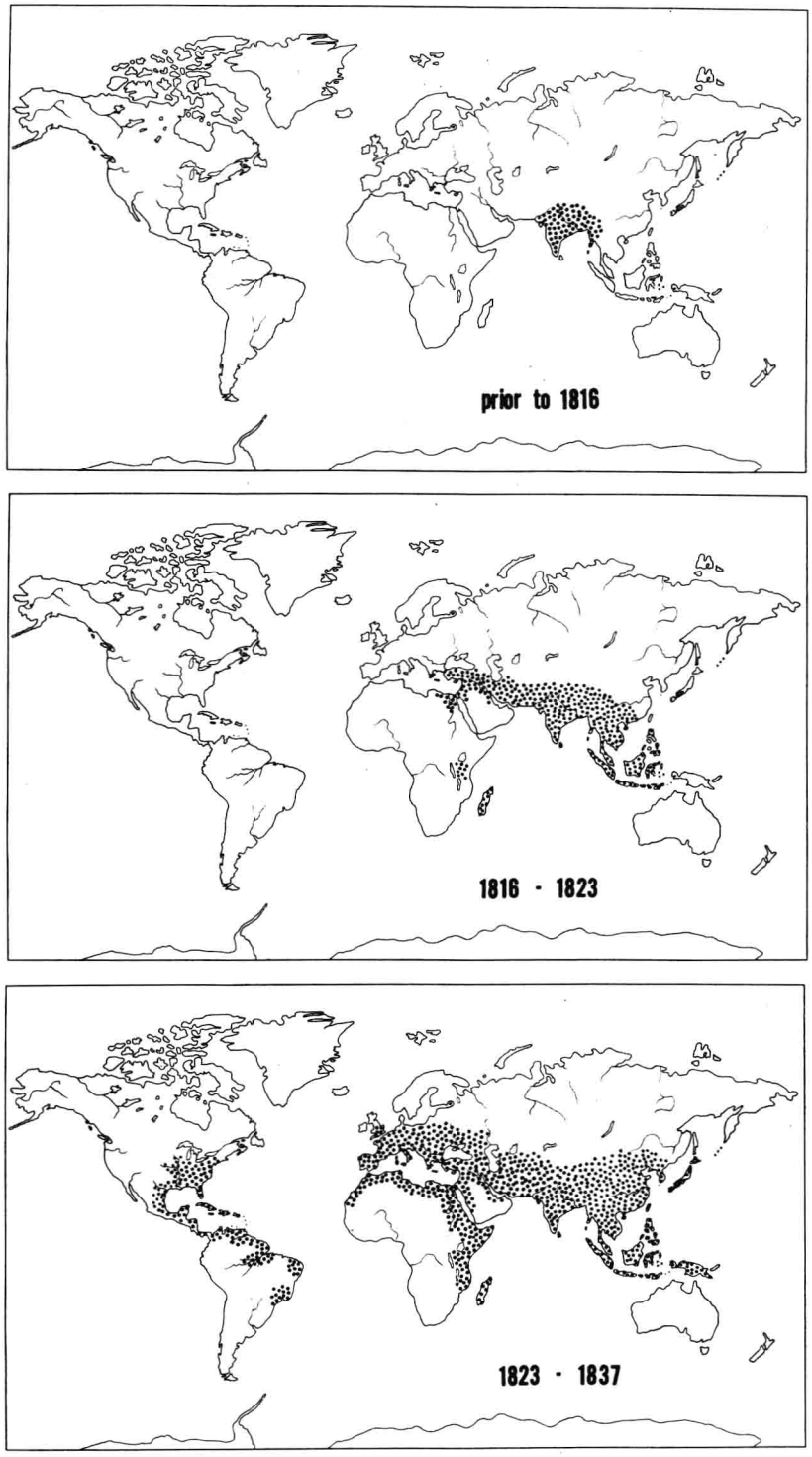

Figure 2.3 The Spread of Cholera in the Nineteenth Century Pandemics. By 1849 the disease afflicted almost the entire inhabited earth.

Then in 1961 cholera appeared in Celebes (Indonesia), developed into epidemic proportions, and gradually began to spread through other regions of the Far East. But this was a different form of an old adversary. The *El Tor type* of the cholera vibrio had been first identified from a small village in the Sinai desert in 1905. Most of the early isolations of this type were from such mildly ill people that for many years most cholera workers assumed that this form of the vibrio was only mildly *pathogenic*, i.e. the producer of only mild disease. Some even claimed that it was a harmless, nonpathogenic variety of vibrio. However, such was not the case. With the outbreak of El Tor cholera in Indonesia, another pandemic (regarded as number seven by most cholera-watchers) had begun.

El Tor cholera spread into Iran and Iraq in 1964. By 1970 it had spread throughout the Middle East and into the Soviet Union as well as North and West Africa. The combination of a catastrophic typhoon (1970) followed by a disastrous war (1971) resulted in thousands of cholera deaths in Bangladesh and in the refugee camps in eastern India. Then by 1973 the disease had spread into Italy and by 1974 into Spain and Portugal. In the latter country there were 2,467 confirmed cases with 48 deaths. More recently, (1978), several cases of cholera have been reported in the United States (Alabama and Louisiana). These are among the first non-introduced cases of cholera in this country in over 50 years.

Not only has cholera once more been acting up but there are some differences between today's pandemic and the classical pandemics of the nineteenth century. The El Tor form of the vibrio is not the nonpathogen it was thought to be for many years. But the disease it causes is definitely milder than the so-called "classical" cholera even though it is still capable of causing death to thousands of people living under conditions of atrocious sanitation.

In contrast to classical cholera, El Tor is more persistent, both in humans and in water. This means that continued poor sanitation is more likely to spread the vibrio than was true in the past. Furthermore, its persistence in people means an increase in the number of carriers, either individuals who have recovered from the disease or the larger number of people who have the vibrios without ever having been sick with cholera.

Another new feature of the present pandemic is its relation to the air travel of the late twentieth century. Records of the spread of the first pandemics of the last century show that the disease advanced largely along overland trade routes. Later pandemics travelled also along shipping lanes and hence crossed the Atlantic from Europe to the Americas. The latest pandemic, while probably still using the old routes, has been spread by air travel as well. The introduction into East and West Africa seems to have occurred by this method.

Spread by air travel raises two unsettling questions. What is the risk to Americans travelling in cholera epidemic areas? What is the risk of cholera epidemics developing in the Western Hemisphere? The first question has probably been best answered by Eugene Gangarosa in *Clinical Tropical Medicine, Volume II*: "The risk is obviously small, much smaller than the risk of being injured in a car accident on the way to the airport". Such a low risk is associated with the likelihood that most Americans travelling in such areas would be immunized and their travel would be brief and done during the period of peak effectiveness of the immunization.

Gangarosa and others have answered the second question in a bit more ominous vein. Air travel makes all regions of the hemisphere vulnerable to the introduction of cholera by infected individuals, especially carriers. The overwhelming majority of these people will be going to cities in which sanitation, even though not perfect, is adequate to prevent the spread of vibrios through the water supply systems. Such introductions probably do not constitute a real threat. However, in many regions of Latin American and the Caribbean there are large areas of poverty and masses of people without adequate sanitation. Such circumstances make these regions, some of which are close to airports and to cities, potential breeding grounds for cholera outbreaks. Modern methods of treatment and control should be effective in limiting these outbreaks unless they occur at a time of social and political turmoil, war, or natural disasters such as hurricanes and earthquakes.