The Gospel *of* Germs

Men, Women, and the Microbe in American Life

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Introduction: The Gospel of Germs

In 1989, a woman wrote the columnist Ann Landers asking for advice. Her fiancé had insisted on inviting a friend who had AIDS to their wedding, and even though she knew none of her guests could catch the virus simply by being in the same room with him, still, she worried, "What if someone should accidentally use R's fork, or drink out of the same glass? What if he should sneeze across the table or, heaven forbid, give me a kiss of congratulations?" The bride-to-be was nervous that if news leaked out that a person with AIDS was attending her wedding, other guests would be afraid to attend.

Like many public health authorities confronted with popular anxieties about HIV, Ann Landers showed no patience with the woman's confusion; she responded testily, "You need to educate yourself."[1] Landers was quite right, of course; HIV is not spread by what public health authorities call "casual" infection, that is, nonintimate contact between the sick and the well. But despite repeated assurances from experts, many Americans continue to worry that any exposure to people with AIDS, or even to the objects they touch, could infect them with the disease. For those who carry the virus, this unshakable faith in the dangers of casual infection has caused untold misery and cruelty.

With no intention of excusing that cruelty, this book nonetheless attempts to understand the fears that have possessed so many Americans in the face of the AIDS epidemic. Although homophobia and racism have played a huge role in their genesis, there is more to those fears than simply ignorance, irrationality, or prejudice. They stem

from fundamental beliefs about contagion and its association with certain behaviors and objects—attitudes that even the most enlightened and humane individuals share. People with AIDS and those who love and care for them also experience the dread that seemingly insignificant forms of contact will spread the disease. This book examines how and why that collective sense of apprehension came to be.[2]

When Ann Landers's bride-to-be expressed anxiety about forks and cups and kisses, she unwittingly gave testimony to what I term the "gospel of germs," that is, the belief that microbes cause disease and can be avoided by certain protective behaviors. Today, we recognize that a wide variety of organisms, referred to colloquially as "germs," are capable of causing disease; they include bacteria, viruses, rickettsiae, parasites, and fungi. Beliefs concerning the existence of germs are among the most widely shared scientific precepts governing everyday life in modern Western societies. Although some may still disagree about the link between a specific microbe and a particular ailment, the general principle that pathogenic microorganisms can cause sickness is rarely disputed. Like the law of gravity or the solar-centered planetary system, the so-called germ theory of disease has the aura of a timeless and universal truth.

As a result, we are taught from a very young age to believe in disease agents that we cannot discern with our own senses and to shun certain contacts with other people—including their sneezes, coughs, and feces—as a way to avoid encountering germs. Parents, teachers, health care professionals, and advertisers all continually reinforce the association between practices such as hand washing or refrigerating food and the preservation of health. The rituals of germ avoidance are so many and so axiomatic that we scarcely can remember when or where we first learned them.[3]

Yet far from being timeless or universal, our beliefs and fears about germs are a relatively recent acquisition. Only a century ago, our grandparents and great-grandparents had no idea that the agents of infectious diseases were microorganisms. The reality that we now take for granted—that we share our bodies and homes, our air and food, with a multiplicity of microorganisms, some of which are quite dangerous—they had to be carefully taught. How Americans came to believe in the existence of germs, and how that understanding changed their lives, is the subject of this book.

We can best appreciate the magnitude of this transformation by contemplating the way that ordinary Americans conceived of disease prior to the late 1800s. Long before the germ theory had gained wide acceptance, Americans were aware that people suffering from certain diseases, such as smallpox or bubonic plague, gave off some sort of intangible substance capable of making others sick. Common wisdom held that the sick person's breath, skin, evacuations, and clothing could all harbor the "seeds" of disease and spread them to those who were well. But the nature of this infective substance remained mysterious. The fact that many diseases spread without any known contact with the ill led many physicians to suspect a more generalized, atmospheric source of infection. This suspicion was often referred to as the "miasma" theory.[4]

Although they avoided those who were ill from smallpox or cholera, most nineteenth-century Americans showed little concern about those forms of casual contact with other people, or contamination of water and food, that are today shunned in the name of health. They shared beds, at home with relatives or in hotels with strangers, without inquiring deeply about their bed partner's health. They exchanged combs, hairbrushes, and even toothbrushes, and fed babies from their mouths and spoons, with no sense of hazard. They coughed, sneezed, and spit with blithe disregard for the health consequences to those around them. They stored and cooked their meals with scant concern for foodborne illness. They drank unfiltered water from wells and streams, often using a common dipper or drinking cup. Last but not least, they urinated and defecated in chamber pots and outdoor privies with little regard for where the contents ended up in relation to the community water supply.[5]

To be sure, some Americans began to shun these promiscuous minglings with other people's bodies long before the germ theory of disease was introduced, but they did so for reasons other than avoiding disease. Ever since the Renaissance period, etiquette books had counseled personal cleanliness and had prohibited behaviors such as spitting and coughing among those seeking social distinction. In the eighteenth century, educated and genteel Americans began to cultivate habits of cleanliness to enhance their well-being and to project a pleasant social persona. The pursuit of gentility and politeness, not the fear of disease, fueled a revolution in cleanliness that began among the colonial elite and gradually spread to the urban middle classes.[6]

Still, for all their growing dedication to soap and water, few Americans prior to the Civil War worried about the daily hazards of infection except during times of epidemic. This lack of concern reflected in part how relatively few illnesses physicians and lay persons classified as "catching" prior to the mid-1800s. Many common diseases that we now know to be communicable were thought to be constitutional in origin, that is, the result of poor heredity complicated by unhealthy living habits. Consumption is a case in point. The disease we now recognize as tuberculosis was endemic during the first two-thirds of the nineteenth century: it caused perhaps as many as one in four deaths and took a particularly heavy toll among young adults. Until the 1880s, consumption was widely attributed to an inherited weakness of the lungs, which could be aggravated by overwork, a damp climate, a neglected cold, or overindulgence in alcohol. Those who suffered from the disease had no conception that the droplets they expelled when spitting or coughing carried the bacteria responsible for the disease.[7]

In retrospect, Americans' lack of awareness about the potential deadliness of their secretions is chilling. In his biography, the physician Edward Trudeau, who later became one of the first American converts to the germ theory of tuberculosis, recalled nursing his consumptive older brother through his final illness in the 1860s. For weeks he tended his brother in a hot, close room, sleeping beside him at night to be close at hand, unaware of the risk to himself. The brother's physician instructed Trudeau to keep the windows tightly shut, a recommendation that only increased his likelihood of infection. Within a few years of his brother's death, Trudeau too developed tuberculosis. Not until 1882, when he read of Robert Koch's discovery of the tubercle bacillus, did Trudeau realize that he had most likely contracted the disease by being such a faithful nurse to his dying brother.[8]

Food handling provides another telling example of how different hygiene standards were before people became schooled in the germ theory. Food producers and consumers alike routinely handled food in ways guaranteed to ensure frequent microbial contamination. Milk was left exposed to air and flies, perishables were stored at uneven temperatures, and cooked food was left on the table between meals. With no knowledge of the healthy carrier concept, seemingly robust cooks and waiters passed on the microorganisms of typhoid and other ailments to those they served.

Given how hard it is to prevent food poisoning even today, we can hardly begin to imagine how frequently Americans suffered from foodborne disease in the nineteenth century. To give but one hair-raising example: in 1891, over sixty people attending a wedding in Lyndon, Kentucky, succumbed to a violent gastrointestinal illness. Six people died, including the bridegroom. Suspicions that a spurned admirer of the bride had poisoned the guests with arsenic led to a full-scale medical investigation. The culprit turned out to be the chicken salad, which had been made from meat cooked two days before the wedding and stored in broth at room temperature.[9]

This innocence, or lack of awareness, regarding practices that we know now can spread deadly disease characterized many aspects of daily life prior to the mid-1800s. In those days, Americans neither thought of casual contact or food contamination as an omnipresent source of infection nor assumed that safety from contagion required constant, unrelenting discipline of their bodies and households. In the absence of that awareness, death rates from infectious diseases such as typhoid and tuberculosis rose precipitously as more and more people moved to cities, lived in closer proximity to one another, and depended upon common supplies of water and food.

The growing threat of mysterious fevers and wasting diseases left no class or ethnic group unscathed. Even the most powerful and respected figures in Anglo-American society knew the humbling experience of deathbed scenes. For example, typhoid fever robbed a war-weary President Lincoln and his wife of their adored son Willie; left Queen Victoria grief-stricken over the death of her husband and the near-death of her eldest son; and smote the mother of a future president, Theodore Roosevelt, the same day that his wife died in childbirth. Although then as now the poor suffered more, wealth and social status offered no protection against what contemporaries often referred to as the "invisible enemies" of disease.[10]

In this climate of loss and anxiety, the germ theory of disease began to attract popular interest even before physicians agreed that it was valid. The idea that living organisms had a role in causing disease had a long and venerable history dating back to classical times, but as of the mid-1800s, what was sometimes referred to as the "animacular hypothesis" was distinctly unpopular among medical men, as I will discuss in Chapter 1. During the 1860s and 1870s, however, experimentalists such as the French chemist Louis Pasteur

and the German physician Robert Koch compiled increasingly convincing proof that distinctive species of microbes were linked with the most deadly diseases of the era. Starting in the late 1870s, the new scientific discipline of bacteriology scored a succession of dramatic discoveries by rapidly identifying the bacteria responsible for cholera, tuberculosis, gonorrhea, typhoid, and scarlet fever. Although many physicians continued to have reservations about the germ theory of disease, the general principle that microorganisms played a central role in causing communicable diseases had by 1900 achieved widespread acceptance in both Europe and America.

Initially bacteriologists had high hopes that their new understanding of disease would yield effective cures and preventive vaccines. But although a few useful measures were discovered—the diphtheria antitoxin and a vaccine for rabies in the 1890s, the arsenical-derivative Salvarsan for syphilis and a vaccination for typhoid in the early 1900s—hopes for reliable chemotherapies were not realized until the 1930s and the 1940s, when sulfa compounds, penicillin, and other antimicrobial drugs were discovered.

For the first fifty years after its acceptance, the germ theory provided its greatest utility as a guide to the *prevention* of disease through modification of individual and collective behavior. Bacteriologists not only identified the specific agents of infection, but also tracked how they spread from the sick to the well. With an increasingly detailed and accurate road map of the circulation of germs, they could better direct public health efforts to interrupt the way the organisms were spread. Gradually, older theories of atmospheric infection gave way to a more modern understanding of how diseases are transmitted by casual contact, food and water contamination, insect vectors, and healthy human carriers.[11]

These revelations prompted a radical expansion of collective public health practices, including municipal sewerage systems, water purification, garbage collection, and food inspection. Our modern conceptions of governmental responsibility for public health date from this period, 1890 to 1930, which is often referred to as the "golden era" of the American public health movement. These same years also represented a period of intense interest in what I think of as the "private side of public health," that is, the reformation of individual and household hygiene. Between the 1880s and the 1920s, Americans of all ages were subjected to aggressive public health

campaigns that taught them the new lessons of the laboratory: that microscopic living particles were the agents of contagion, that sick bodies shed germs into the environment, and that disease spread by seemingly innocuous behaviors such as coughing, sneezing and spitting, sharing common drinking cups, or failing to wash hands before eating.

In retrospect, the task of convincing ordinary Americans that they coexisted with an invisible world of microorganisms—like "Gulliver among the Lilliputians," as one commentator termed it—appears daunting. Germs could not be seen, smelled, or touched. Confirming their existence required gazing down the lens of a microscope, a privilege that many Americans a century ago never enjoyed. The first apostles of the germ faced a considerable challenge in convincing their contemporaries that such an intangible being as a germ existed, much less that it caused potentially deadly illnesses.[12]

At the same time, this leap of faith was perhaps less extreme than it might at first appear. By virtue of their religious heritage, ordinary Americans had been conditioned to believe in an "invisible world" dominated by unseen forces that held the power of life and death; as public health reformers often noted, there were striking similarities between traditional fears of malign spirits and the new views of the germ. In addition, rational or naturalistic explanations for epidemic disease had long assumed the reality of intangible disease agents borne in the unseen miasma or the sick person's breath. What science had done, apostles of the germ argued, was to demonstrate the "true" identity of these invisible, malign agents and to show that they were part of a natural order and thus controllable by human action. Thanks to bacteriology, T. Mitchell Prudden, one of the first Americans trained in the new experimental methods, asserted in 1890, "We no longer grope after some mysterious, intangible thing, before which we must bow down or burn something, as if it were some demon which we would exorcise."[13]

The identification of dread disease with a concrete enemy piqued popular interest in the germ theory from its earliest days. As one commentator observed in *Popular Science Monthly* in 1885, "The germ theory appeals to the average mind: it is something tangible; it may be hunted down, captured, colored, and looked at through a microscope, and then in all its varieties, it can be held directly responsible for so much damage." At the same time, the tones of awe and appre-

hension so frequently apparent in early accounts of the microbial world suggest the lingering influence of religious and magical views of disease. It is no wonder, then, that when the science fiction writer H. G. Wells needed to rescue humankind from an invasion of Martians in his celebrated 1898 short story "The War of the Worlds," he turned to bacteria as the most powerful deus ex machina at his fictional command.[14]

For all its novelty, however, the new germ theory of disease did not immediately displace established ways of thinking about and warding off contagion. Just as people today respond to the AIDS epidemic in terms of current understandings of infection, Americans a century ago tried to incorporate the microbe into old and familiar explanations for disease. In particular, initial understandings of the germ theory were deeply indebted to an older scientific discipline known as "sanitary science," which stressed the ubiquity of airborne infection and the disease-causing properties of human wastes and organic decay.

The first three chapters of *The Gospel of Germs* explore the marriage of sanitary science and germ theory, which shaped the first generation of preventive lessons aimed against the microbe and taught in the 1880s and 1890s. The initial understanding of germ diseases reflected sanitarian beliefs in the existence of what were termed "house diseases," that is, illnesses caused by defective plumbing, ventilation, and housekeeping. As a result, Americans first understood the chief menace of microbes to arise from their toilets and washbasins, which they feared as portals for dangerous bacteria-laden "sewer gas" to enter their homes. This fear led to an obsessive concern with domestic plumbing and ventilation.[15]

With the maturation of bacteriology in the 1890s and early 1900s, there came a second, more expansive version of the gospel of germs, described in Chapter 4. The recognition that consumptives' coughs and sneezes contained the tubercle bacillus intensified attention to the infective discharges of the mouth and nose. Correspondingly, turn-of-the-century preventive education focused increasingly on the exchange of germs through unguarded coughing and sneezing, shared drinking cups, and other common practices that facilitated the transfer of saliva. But the new anxieties about infection via casual contact by no means eclipsed the older focus on "house diseases." For example, bacteriologists found that they could culture the tubercle bacillus from common house dust; thus ridding the home of that dust became a fundamental tenet of tuberculosis prevention. (Only later did further investigations reveal that the germs cultured from dust had little infective power.) Theories of "fomite infection," which held that objects could harbor the dried microbes of disease for months and even years, heightened concerns about household furnishings and clothing. Evidence that houseflies carried the tubercle bacillus and other germ diseases on their feet led to crusades to get window screens in every home. As a result, the house disease concept remained an integral part of the turn-of-the-century gospel of germs.

Bacteriologists' fine-tuning of the preventive lessons of everyday life coincided with the mass dissemination of the gospel of germs during the Progressive period. During the 1880s and 1890s, avoiding germs had been primarily the obsession of prosperous urban families. In the early 1900s, however, reformers sought to bring hygienic enlightenment to all Americans, in order to emancipate the whole society from the fear of infectious diseases. To that end, the gospel of germs was taken up by an impressive array of Progressive-era institutions, including municipal and state health departments, life insurance companies, women's clubs, settlement houses, Boy Scouts and Girl Scouts, YMCAs and YWCAs, labor unions, and agricultural extension programs.

In Chapters 5 and 6, I look at two of the most influential conduits of popular germ-consciousness in the early 1900s, the antituberculosis crusade and the domestic science movement. To get across the message that T.B. was a communicable disease, the antituberculosis movement pioneered methods of health education that were copied widely by other public health workers and that with surprisingly little modification remain in use today. Borrowing overtly and enthusiastically from the new advertising culture of the early 1900s, antituberculosis workers turned out posters, slogans, and other forms of propaganda to "sell" their message of protection against the ubiquitous tubercle bacillus. The domestic science movement, which originated at about the same time as did the antituberculosis crusade, focused more specifically on educating housewives and mothers about germ life in order to make the American home more healthy and productive. During the early twentieth century, an army of new female professionals, including home economists, visiting nurses,

and social workers, dedicated themselves to bringing the insights of "household bacteriology" to every homemaker in the nation.

Although it was portrayed as a set of obligations that both sexes had to honor, the kind of cleanliness required by the gospel of germs clearly had more profound implications for women, both as private citizens and as professionals. Men certainly had their roles to play under the new germ credo, but on a day-to-day basis the bulk of the worry and work fell on women, most of whom were housewives. The gospel of germs turned even humble chores such as dish washing and sweeping into "a fine action, a sort of religion, a step in the conquering of evil, for dirt is sin," to quote the pioneer home economist Ellen Richards. The association between house diseases and housekeeping simultaneously ennobled women's work in the home and made it more physically and emotionally burdensome.[16]

The third section of the book looks more closely at how different groups of Americans began to understand and act upon the gospel of germs. In Chapter 7, I survey the extraordinary range of behaviors that affluent Americans changed between the 1890s and the 1920s in order to evade the germ. Men shaved their beards and women shortened their skirts to eliminate potentially germ-catching appendages. They stripped their homes of allegedly microbe-laden furnishings and embraced as necessities for a germ-free life such household institutions as the white china toilet, the vacuum cleaner, and the refrigerator. They purchased, stored, and cooked their food in new ways designed to retard bacterial contamination. They learned to avoid other people's sneezes and coughs, and to shy away from familiar social customs such as handshaking and baby kissing. This domestic revolution carried over into "homes away from home" such as hotels, railway cars, restaurants, and even funeral parlors. As more and more germ-conscious Americans dined out and traveled, the institutions that served them strove to cater to their sanitary scruples. Hotels began to supply individual cakes of soap and to use extra long sheets so that sleepers might fold them back over potentially germ-ridden blankets. Churches adopted individual communion cups, and cities installed sanitary water fountains to replace the contagion-spreading common cup.

Marketplace forces and mass advertising played a central role in fostering this more "antisepticonscious America." We rarely think of corporate America, particularly advertising agencies, as having much to do with the dissemination of scientific ideas. Yet as both Chapters 3 and 7 make clear, reformers and educators were not the only ones to interpret the germ theory's relevance for the habits of everyday life. From the 1880s onward, entrepreneurs and manufacturers of all sorts realized that the fear of the microbe could be effectively exploited to sell a wealth of goods and services. Under the aegis of the first, sanitarian-dominated gospel of germs, entrepreneurs promoted safeguards against the dangers of sewer gas and polluted water, such as special toilet attachments and household water filters. In response to the second, more bacteriologically informed gospel, the range of aids to combat the microbe expanded dramatically between 1895 and 1915 to include everything from antiseptic floor coverings and wall paint to sanitary dish drainers and fly traps.

Germ-conscious advertising campaigns became an educational force, yet they did not represent a simple extension of the work of the antituberculosis crusaders or the domestic scientists. For all their invocations of laboratory authority to sell their products, manufacturers and advertisers displayed no deep allegiance to the scruples of science. By keeping alive aspects of the gospel of germs that public health experts wished increasingly to jettison, such as the fear of sewer gas, advertising served other, more profit-oriented motives.

Although hygiene reformers and manufacturers both cast the principles of germ protection as universal goods in American society, the expense of sanitary protections placed these aids out of the reach of many Americans well into the 1930s. Working-class families could ill afford even the most basic prerequisites for practicing the gospel of germs, such as flush toilets, clean running water, and a safe milk supply. The ability to conform to "antiseptic" standards of cleanliness differentiated rich from poor, educated from unschooled, American-born from foreign-born. In Chapter 8, I look at some of the consequences of the uneven spread of sanitary boons as it affected two different groups of women on the periphery of middle-class America: immigrant housewives and farm women.

For many middle-class Americans in the early 1900s, the association of poor, immigrant, and non-white citizens with disease germs only deepened their feelings of class prejudice, nativism, and racism. By harping on the menace of contagion, the apostles of the germ inevitably increased the stigmatization of the sick and the poor. The specter of infection served nativists and racists well in their efforts to legitimate immigration restriction and racial segregation.

But simultaneously, the gospel of germs gave rise to other, countervailing pressures toward inclusion and reform. Many converts to the germ theory believed deeply in a "chain of disease," a "socialism of the microbe" that linked all members of American society together. If not for simple humanity, then for this reason alone, they argued, the health problems of the poor and the newcomer had to be addressed. The great disease crusades of the early twentieth century created a common set of assumptions about contagion that crossed class and race lines and became intellectual capital in movements for broad-ranging social change. Chapter 9 explores how labor unionists and African American community activists tried to turn the fear of disease into weapons to do battle for economic and social justice.

The main body of the book ends in the 1920s, when the intensity of efforts to spread the gospel of germs began to fade. With further bacteriological scrutiny, the frequency of infection by dust and fomites came into question; instead, experts placed increasing emphasis on the importance for disease control of contact infection and healthy carriers of disease. Practitioners of the so-called new public health advocated more attention to identifying and isolating the sick and distanced themselves from the expansive social concerns and evangelical fervor of their predecessors' educational crusades.

At the same time, many of the basic tenets associated with the gospel of germs remain the foundation of public health practice to this day. The idea that germs may survive months and even years in dust and on fomites may have been discarded, but most other principles of the preventive code have been preserved. As one reads through the latest edition of the American Public Health Association's standard handbook on the control of infectious diseases, it is evident that droplet infection via sneezing and coughs, casual contact, fecal contamination of water and food, insect vectors, and improper food handling are still recognized as the most common ways that infectious diseases spread.[17]

But after World War I, personal and household hygiene practices gradually came to be less essential to the control of deadly disease. The gospel of germs declined in importance, largely due to the steady decline in mortality rates from infectious diseases and a strengthening of collective protections against germs, such as water filtration and food regulation. By the late 1920s, heart disease, kidney disease, and cancer had replaced respiratory and gastrointestinal

infections as the leading causes of death. Understandably then, both scientific interest and public health initiatives turned increasingly to the prevention of chronic, noninfectious ailments that now constituted the chief threat to American health. Still, as Chapter 10 makes evident, germ consciousness remained strong until the 1950s, largely due to the polio menace and the influence of advertising. Not until the widespread availability of antibacterial drugs after World War II did the gospel of germs truly fade into insignificance as a road map for avoiding deadly disease—at least until the AIDS epidemic. I suggest in the Epilogue that the gospel of germs has taken on new relevance since 1980, as Americans have been confronted with a new generation of "superbugs," chief among them the human immunodeficiency virus.

The "triumph" of the germ theory of disease has long been a central theme in both medical and social history. Reams of paper have been devoted to the scientific antecedents and experimental discoveries that gave rise to the modern view of infection. There are many fine studies of the changing thought of individual scientists and of conceptions of specific diseases, such as cholera and tuberculosis. Historians of public health, of women, of advertising, and of architecture have all noted the fact that Americans became extraordinarily germ conscious at the turn of the century. Yet surprisingly little has been written about the collective dimensions of this great watershed in thinking about disease, and the ways in which the "lessons of the laboratory," as I term them, became part of the fabric of everyday life.[18]

In tracking that collective consciousness, I have been inspired by historians of science such as John Burnham, Roger Cooter, Bruno Latour, and Martin Pernick, who have drawn new attention to the historical processes by which popular understandings of disease are constructed. Like them, I prefer to think of popularization not as a hierarchical, top-down process where the focus is on what the public gets "right" or "wrong," but as a dynamic where ideas and images are traded among different audiences, including laboratory scientists, practicing physicians, hygiene reformers, and interested lay people. Instead of treating popular views as merely pale, distorted images of the "real" knowledge generated by "real" scientists, such a model allows for ideas to travel in more than one direction, to accommo-

date, for example, the influence of sanitarian thought on early formulations of the germ theory. This approach also helps to describe what interests me most, that is, how scientific precepts become a part of the working hypotheses of everyday life, or what is sometimes termed "ethnoscience."[19]

Although I have sought to avoid a hierarchical view of popularization, I have tried not to gloss over the simplifications and distortions that inevitably occurred as bacteriological knowledge moved from the laboratory to the parlor, so to speak. Judged as a rational process of education, there is no doubt that the great disease crusades of the early twentieth century fell short. To the extent that many public health reformers ceased trying to convey any comprehensive understanding of disease and focused only on teaching health habits, the gospel of germs became what John Burnham has termed the "functional equivalent of superstition." Shorn of its scientific underpinnings, the new germ credo all too easily turned into another form of magic to be followed blindly and mechanically. When that magic failed and illness could not be avoided, its practitioners were left with a heavy load of anxiety and pain, which easily became fodder for the sorts of irrational hatreds and prejudice directed toward consumptives a century ago, or toward AIDS patients today.[20]

At the same time I acknowledge the dark consequences of the gospel of germs, I also tell another side of the story that has been given less attention by historians. The great disease crusades of the early twentieth century did not succeed in giving every American an accurate understanding of the germ theory of disease, yet they nonetheless did a remarkable job of inducing people from varied backgrounds to change fundamental personal behaviors. Even if practiced only as a form of health "superstition," the rules of germ avoidance still served a useful function; a family need not understand the principles of the germ theory of disease in order to abandon household practices that spread fecal contamination and thereby enjoy less risk of cholera or typhoid.

My interest in individual and household *practices*—that is, the habits that ordinary Americans associated with disease prevention—takes this book in directions rather different from those followed by previous historians of public health. For many years, the golden age of public health has been equated with the collective, state-legislated measures enacted at the turn of the century. The popular education

campaigns of the same time have been comparatively neglected, in large part due to the assumption that what they taught did not matter very much. That dismissive view dates back to the 1910s and 1920s, when proponents of the new public health began to extol the triumph of "real" science over the "bogus" precepts of their predecessors—a view enshrined in popular works such as Sinclair Lewis's novel *Arrowsmith* and Paul de Kruif's *The Microbe Hunters*.[21]

Until recently, historical demographers tended to reinforce the assumption that changing personal and household practices had little to do with the decline in mortality rates from infectious disease that began in the nineteenth century. Here the work of the English physician Thomas McKeown was especially influential. In the 1960s and 1970s, McKeown argued that the great mortality transition was an unintended outcome of better nutrition and higher living standards, rather than a result of the interventions of either organized medicine or the public health movement.[22]

When I first began this book, I will admit that I too was inclined to see the personal health practices that I was tracking as having little demographic significance. But I soon came to accord my subject more respect, for two reasons. First, I was continually reminded by current events how these same practices were still promoted as fundamental forms of disease control. In the precautions urged on New Yorkers during the T.B. mini-epidemic of the early 1990s, and the rules of safe meat handling issued by the U.S. Department of Agriculture, I could see the direct descendants of the lessons in tuberculosis control and household bacteriology that I was studying.

I was also profoundly influenced by the growing interest in personal health practices shown by a new generation of historical demographers and medical historians. Scholars such as Gretchen Condran, Anne Hardy, Samuel Preston, and Simon Szreter have begun lately to suggest that voluntary changes in health behavior contributed more to the mortality decline than the so-called McKeown thesis allowed. This new work points out that death rates began to diminish decades before citywide public health works had ensured safe sewage systems, water purity, and food supplies. Had individuals and families begun to practice some of the sanitarians' recommendations, such as avoiding fecal contamination, boiling drinking water, and practicing isolation procedures while nursing sick relatives in the home, it is conceivable that they could have improved their families' chances of survival.[23]

Prior to 1900, the demographic effect of such household-level changes probably remained modest, especially in reducing rates of infant and child mortality. But the work of Douglas Ewbank and Samuel Preston suggests that between 1900 and 1930 popular health crusades aimed at teaching principles of milk purification and childhood disease management to mothers contributed to a striking drop in death rates among the young. The demographic data, they conclude, suggest that "changing personal health practices may have been an important contributor to the decline in infant and child mortality" in both the United States and Britain.[24]

My study does not pretend to make any definitive contribution to this complex demographic debate. Knowing that those debates are going on, however, has strongly affirmed my conviction that the revolution in personal hygiene behavior is far more worthy of serious analysis than the work of Lewis and de Kruif allowed. This conviction has been further strengthened by my appreciation of the gendered dimensions of this revolution. As the new demographic work suggests, much of the germ theory's relevance for personal health practices fell in the realm of housecleaning, childcare, and food preparation, domains traditionally designated women's work and consequently ignored or trivialized. One of my goals in writing this book has been to challenge the implicitly gendered division of knowledge that regards as significant what Pasteur did in the laboratory but dismisses as inconsequential what a public health nurse or housewife did with his insights.

Taking personal hygiene behaviors seriously as forms of disease prevention inevitably puts my interpretation at odds with another long scholarly tradition, that of analyzing germ fears primarily as cultural artifacts. In their influential accounts of cleanliness behaviors, the German sociologist Norbert Elias and the English anthropologist Mary Douglas formulated a position that many scholars have followed ever since: that the apprehensions about disease expressed in the pursuit of cleanliness are a mere rationalization for, in Douglas's words, "gestures of separation and classification" that serve other, more powerful needs to create and maintain social order. As Douglas put it in her 1966 classic *Purity and Danger,* "In chasing dirt, in papering, decorating, tidying we are not governed by anxiety to escape disease, but are positively re-ordering our environment, making it conform to an idea."[25]

This perspective has led to a much needed appreciation of the cultural dimensions of cleanliness and has certainly shaped my own understanding of the gospel of germs. I agree with the premise that no disease is ever observed in a totally unbiased way; there is always a scrim of culture affecting our perceptions of and attempts to treat illness. Yet taken too far, the Douglas approach too easily discounts fear of disease as a motivation for specific cleanliness behaviors. The perspective of *Purity and Danger* reflects the confidence of the 1960s, the same era in which the U.S. surgeon general decreed that infectious diseases no longer constituted a serious threat to the public's health. Without denying that the cultural construction of dirt reflects more than just the fear of disease, my interpretation emphasizes how everyday encounters with illness and death reinforced the lessons of germ avoidance.[26]

To use a modern parallel, imagine an anthropologist writing a hundred years from now about the AIDS epidemic and interpreting such preventive measures as using condoms and disinfecting needles with bleach purely as "gestures of separation and classification" aimed at homosexual men and intravenous drug users. Such a position would strike us as ludicrous. Even the most ardent proponents of the cultural construction of disease are unlikely to deny that safe sex and clean needles save lives. Dismissing late-nineteenth-century reformers' efforts to convince people to prevent fecal contamination of their water supply or to eliminate pathogenic microorganisms from their food as merely attempts to act out middle-class status anxieties or to stigmatize certain groups of Americans is equally simpleminded.

My historical analysis seeks to strike a balance, then, that honors both the cultural construction of cleanliness and the biological dimension of disease. Ailments such as typhoid and tuberculosis do have a biological reality, a set of distinctive pathological features that shape the cultural meanings attached to them. Fears of their dangerousness are founded in painful experiences of illness and death that must not be overlooked. Bringing this "biological body" back into the historical narrative is essential to understanding the transformations wrought by changing disease theories a century ago.[27]

My narrative also questions the widespread tendency to blame the acceptance of the germ theory for the limitations of the modern biomedical model of disease. The growing authority of bacteriology

as a scientific discipline is usually portrayed as a conservative development that inevitably narrowed the scope of American medicine and encouraged new forms of discrimination. The germ theory is often linked with images of inspection, exclusion, and incarceration: the Ellis Island inspectors using buttonhooks to check immigrants' eyelids for trachoma, the health officials sending poor consumptives off to the sanitarium to die, or the sad figure of Typhoid Mary banished to North Brother Island for over thirty years.[28]

These developments were certainly one consequence of the germ theory's acceptance, but they do not represent its sole legacy to American politics and culture. Although historians have traditionally highlighted their invocation in campaigns for immigration restriction and racial segregation, the "truths" of the germ theory were also invoked in less conservative movements for economic justice and social equality. By looking closely at these latter efforts, I want to emphasize that the discovery of the germ had no fixed moral or social message; there was nothing inherently narrow or discriminatory in the germ theory of disease itself. Its meanings for everyday life were susceptible to multiple interpretations and were deployed in competing arguments about the problems of American society. If certain views gained more influence than others, we must look to the political and cultural context of the debate, and not to the theory itself, for an explanation of that fact.[29]

Although this study focuses only on the United States, it is important to acknowledge that similar public health crusades occurred during the same time period in other Western countries such as England and France. Through the influence of colonial rule, the gospel of germs was also exported to many non-Western nations such as China, India, and the Philippines. Any systematic comparison of these movements is beyond the scope of this already overly ambitious study. But on the basis of my limited forays into other national scenes, I would like to emphasize two aspects of the American health crusades that I believe to be distinctive.[30]

First, I would point to the heavy influence of advertising methods and consumer-oriented approaches. Recent studies of advertising and popular culture have underlined their precocious and dominant effects on American society. My work suggests that this influence carried over into the public health movement as well. American hygiene reformers displayed a precocious interest in and talent for

exploiting the new forms of mass communication and persuasion available in the early twentieth century. Conceptions of "selling" health were central to their programs of popular education. Second, I believe that crusades against disease have played a special role in American political culture. Although other nations have certainly invoked health as a common civic goal above the fray of party politics, that vision has loomed especially large in the United States. In a democratic society riven by gender, racial, ethnic, and class differences, notions of public health citizenship have offered a seemingly neutral ground for building consensus, for purposes of both exclusion and inclusion.[31]

Although I seek to challenge some of the conventional academic wisdom about the effects of the germ theory on American medicine and popular culture, let me be the first to point out that I commit some major sins of overgeneralization of my own. It is impossible to write about the evolution of ideas about germs without imposing more order on that process than actually existed. When I interpret the meanings assigned to phrases such as "the germ theory of disease" or the "gospel of germs," I endow them with more coherence and consistency than they ever really had. Rather than place those phrases in quotation marks throughout the whole text, I warn the reader now that I use them as a form of historical shorthand to track a very untidy set of ideas.

I have tried also to avoid using terms such as "popularization," "mass education," or "the public" as if any such unitary processes or collective entities existed. In the time period of my study, the 1870s to the 1920s, Americans were, as they are now, a highly heterogenous people. Their diversity requires that we look carefully at how different groups responded to the same set of ideas. I have thus tried to balance sweeping generalizations with in-depth case studies that bring a wide range of voices into the narrative.

Likewise, I want to acknowledge the importance of *individual* variance. Members of the same gender, ethnic, class, or racial group may hold very different opinions on matters of health. One member of a family might be very anxious about the threat of radon gas, whereas another might dismiss it as an overblown fear. The same was undoubtedly true in the period of my study. Some individuals shrugged off the dire warnings about germ dangers, whereas others worried about them incessantly. These varying degrees of germ consciousness were

shaped by factors such as parental views about cleanliness, personal experiences with illness, and basic traits of personality that I as a historian cannot easily assess. At best what I have done here is to track a cluster of beliefs and behaviors concerning infection that were held by many, if not all, Americans in the decades between 1870 and 1930.

One final note on terminology: technically, the terms "infectious," "contagious," "communicable," and "epidemic" have different meanings when applied to disease. "Infectious" denotes a disease that may spread from person to person without actual contact between them; in contrast, a contagious disease is directly transmitted from person to person. "Communicable" is a more general term that covers both infectious and contagious diseases. Epidemic diseases spread rapidly from a few cases to a large number of people, then gradually disappear; endemic diseases exist more or less constantly in the population.

These terms had similar meanings in the late nineteenth century. In actual use, however, the distinctions are and were difficult to maintain. In the time period of my study, medical authorities frequently admitted the hopelessness of precision in the usage of these terms, especially the futility of maintaining the distinction between infectious and contagious diseases. In the *Transactions of the American Medical Association* for 1866, one physician expressed the general sense of frustration: "The three appellatives, Epidemic, Contagion, and Infection, not infrequently confuse the investigator, and the boundary line between them seems even more imaginary than the equator."[32] With all due respect to the technical differences between infectious and contagious, which I know to exist, I have also chosen to "ignore the equator" and use those terms interchangeably in this book.

· I ·

The Gospel Emergent, 1870–1890

1 · Apostles of the Germ

On a cold, damp day in February 1884, the children of Martha Bulloch Roosevelt were summoned to attend at her deathbed. A few days earlier, Martha, the widow of the prominent New York City philanthropist Theodore Roosevelt, Senior, had developed what had appeared to be a slight cold. As her condition rapidly worsened, her doctor diagnosed her illness as typhoid fever, an often fatal gastrointestinal disorder. Telegrams were sent to her daughter Corinne in Baltimore and to her son Theodore in Albany, urging them to come quickly to their mother's elegant home on West Fifty-Seventh Street. For Theodore, the summons had a second somber purpose: in the same house lay his wife, Alice, who had just given birth to their first child and was gravely ill from a kidney ailment known as Bright's disease. At three o'clock in the morning on February 14, Martha Roosevelt died, surrounded by her children. Alice Roosevelt soon followed, dying in her husband's arms less than twelve hours later. Years afterward, Corinne could recall the words that her brother Elliott spoke to her as she arrived home that night: "There is a curse on this house."[1]

The affluent mourners who crowded the Fifth Avenue church for the double funeral of Martha and Alice Roosevelt must have pondered the "strange and terrible fate," as Theodore put it, that so prematurely took their lives. Martha was only forty-eight and Alice but twenty-two years old. Family and friends no doubt regarded Alice's demise as the more tragic, given the newborn daughter she left behind, yet in one sense it was the more understandable. The

rigors of childbirth claimed many women's lives, and one who had an undiagnosed kidney disease, as Alice did, would be especially vulnerable.[2]

Martha Bulloch Roosevelt's death was a different matter. She succumbed to what by the early 1880s had been clearly typed as a "filth disease," that is, an illness spread by fecal contamination. As such, typhoid fever was considered eminently preventable by the practice of proper domestic sanitation. We now know that Martha Roosevelt could easily have contracted typhoid outside her home from eating contaminated seafood in a restaurant or from coming in contact with a healthy person who carried the bacillus, such as the infamous cook "Typhoid Mary" Mallon. But as of 1884, these modes of infection had yet to be discovered, and public health authorities thought that typhoid spread via defective household plumbing, which tainted air and water with the disease "poison."[3]

At the time of Martha Roosevelt's death, the precise nature of the typhoid poison was in dispute. The majority of physicians thought the disease agent was a chemical substance produced by decaying fecal matter. In contrast, a small but growing number of public health experts believed that the chief danger came not from the fecal matter but from the living microorganisms it contained. In 1880, two German physicians had isolated a species of bacteria, subsequently referred to as "Eberth's bacillus," that they believed caused typhoid fever. The same year that Martha Bulloch Roosevelt died, the New York City Department of Health issued the *Handbook of Sanitary Information for Householders*, which warned that "the greatest danger . . . in the breathing of sewer-air is that of inhaling with it the living particles (bacilli, etc.) contained or developed in the excreta of diseased persons."[4]

But although experts argued over the causal agent, no one questioned that typhoid fever's appearance in any home should prompt close scrutiny of its sanitary arrangements. Therein lay the mystery of the Roosevelts' tragedy. The mansion on West Fifty-Seventh Street, which Theodore Senior had built in the 1870s, had been designed by the leading architects of the day and equipped with the finest fixtures and appointments. Moreover, Martha Roosevelt, familiarly known as "Mittie," was excessively concerned about cleanliness, to a point that family and friends considered almost obsessive. She moved from rural Georgia to New York City after her marriage in 1853 and was

never reconciled to the extraordinary filth of that rapidly growing metropolis. To combat it, Mittie developed a rigorous set of cleanliness rituals, which included bathing daily with two changes of water, putting a sheet on the floor when she knelt to pray at night, and wearing white clothing even in winter so that no speck of dirt could escape her scrutiny. With the assistance of a small army of servants, she kept her home equally pristine. A family friend recalled reading a many-paged set of housekeeping instructions prepared for her daughter-in-law Alice, outlining an exacting regimen of polishing, scrubbing, sweeping, and dusting. For example, each morning the cook was required to greet the ash man with a bucket of boiling water to scald his ash can before it entered the house.[5]

Yet for all these heroic efforts to keep herself and her home spotlessly clean, Martha Roosevelt succumbed to what public health experts knew to be a "filth disease." Such a fastidious woman would surely have died of shame, had the typhoid fever not killed her, to discover that she had contracted a disease spread by fecal contamination. Martha Roosevelt's death from typhoid epitomized the uncertainties that beset even the most conscientiously clean households of the Gilded Age: no one, not even the most careful, seemed to be safe from the invisible agents of disease.[6]

The heated scientific debates of the 1870s and 1880s over the identity of those invisible enemies coincided with a period of intense anxiety about rising disease rates in both the United States and Europe. The mortality statistics collected by municipal authorities confirmed what personal experiences such as the Roosevelts' had suggested—that rates of illness and death had risen alarmingly in the nineteenth century, making large cities very unhealthy places to live. Not only were inhabitants thrown into periodic crisis by recurrent epidemics of diseases like cholera and smallpox, but they were also harried by endemic diseases such as typhoid and pneumonia that killed steadily year after year. The young were particularly at risk: in Martha Roosevelt's New York City, for example, one-fifth of all infants died before the age of one, often of the dreaded "summer complaint," or infant diarrhea, and those lucky enough to survive until adulthood still faced nearly a one in four chance of dying between the ages of twenty and thirty.[7]

As a result, late-nineteenth-century Americans of all classes had an intimate knowledge of ailments that are rarely seen today, even by

specialists in infectious disease. They were familiar, for example, with the blue skin and rice-water discharges of cholera and the high fever and rash that signaled typhoid. They could recognize the characteristic skin eruptions of smallpox, and the sore throat, strawberry tongue, and sunburn-like rash of scarlet fever. They could differentiate the coughs associated with whooping cough, pneumonia, and consumption. They knew too well the chronic diarrhea and wasting that indicated the "summer complaint" and the labored respiration and blocked airways produced by diphtheria.

This all-too-everyday experience with disease and death left many urban Americans with a profound sense of dread. Even the "best" households seemed under siege from mysterious fevers and wasting diseases that came and went with little predictability. On the surface, the everyday life of affluent Victorians appeared comfortable and well ordered; compared to their grandparents and parents, for example, Martha Bulloch Roosevelt's generation had achieved an unprecedented degree of gentility. Yet they still fell prey to diseases of uncleanness. This sense of vulnerability created the backdrop for the growing debate over the germ theory of disease, a theory that its advocates felt explained the mystery of why the determined pursuit of cleanliness had failed to protect Martha Roosevelt and her contemporaries.

A World of Unseen Dangers

In an 1880 paper delivered to the San Francisco Medical Society, imposingly titled "On the Supposed Identity of the Poisons of Diphtheria, Scarlatina, Typhoid Fever, and Puerperal Fever," a physician named William H. Mays began emphatically, "I will state at the outset that I am an ardent germ-theorist, viewing any doctrine that conflicts with that theory much as I would an attempt to controvert Newton's law of gravitation." In catechism style, he spelled out the tenets of his faith in these terms:

> I hold that every contagious disease is caused by the introduction into the system of a living organism or microzyme, capable of reproducing its kind and minute beyond all reach of sense. I hold that as all life on our planet is the result of antecedent life, so is all specific disease the result of antecedent specific disease. I hold that as no germ can originate *de novo,* neither can a scarlet fever come into existence spontaneously. I hold that as an oak comes from an oak, a grape from a grape, so does a typhoid fever come from a typhoid germ, a diphtheria from a diphtheria germ; and that a scarlatina could no more proceed from a typhoid germ than could a sea-gull from a pigeon's egg.[8]

Read over a century later, when the germ theory of disease is viewed as a scientific truth on the order of Isaac Newton's law of gravitation or Charles Darwin's theory of evolution (to which Dr. Mays also subscribed), this declaration of faith sounds decidedly strange. Whatever controversies may exist today about the nature of infectious diseases, scientists no longer debate whether the streptococcus responsible for scarlet fever can generate spontaneously, much less turn into the bacillus that causes typhoid fever. But May's litany of beliefs captures precisely what it meant to believe in this new theory of disease when the majority of doctors in Europe and the United States still believed that a seagull could hatch from a pigeon's egg, so to speak.[9]

As of 1880, the majority of Anglo-American physicians found these radical ideas about disease causation hard to accept. The medical world was firm in its allegiance to another explanation, the so-called zymotic theory of disease, which rested on a different set of convictions: that the disease agents were chemical ferments produced by decaying filth, and that they could generate spontaneously given the right atmospheric circumstances. Moreover, they were more than satisfied with the progress of preventive medicine, or "sanitary science" as it was often called, in suggesting ways that the zymotic diseases might be brought under better control.[10]

Given the widespread satisfaction at the time with the zymotic theory and sanitary science, it is little wonder that advocates of the germ theory expressed their new faith with such bravado. In the 1870s, believing in the germ theory was often likened to a religious conversion. Its adherents referred to themselves as "converts" to the new "doctrine" and presented the tenets of their creed in catechism form, as did William Mays. Like born-again Christians, ardent germ theorists saw the world with new eyes, as a place where air, water, and soil teemed with invisible life and their own skin and secretions swarmed with microbes. As the microscopist Lionel Beale put it, "the

higher life is everywhere interpenetrated by the lower life," locked in a microscopic survival of the fittest.[11]

The English word "germ," which derives from the Latin verb "to sprout," had long been used to refer to the intangible "seeds" of contagion. Advocates of the new theory adopted the term to signify any microscopic organism capable of causing human or animal disease. Researchers would eventually be able to distinguish among the larger and more complex organisms, such as bacteria, fungi, and parasites, and the much smaller viruses and rickettsiae. But in the 1870s, the individual agents lumped under the category of "germ" or "microbe" were not so well known, and early expositions of the germ theory employed a bewildering variety of terms to describe them, including "vibrio," "algae," "cryptograms," "microzymes," and "schizophytes."[12]

Conversion to this way of looking at infectious disease required faith in a new mode of scientific investigation. Traditionally, physicians had based their theories about disease on observations of illness in the individual and the community, or what today we would term clinical and epidemiological evidence. In contrast, belief in the germ theory rested on evidence derived from the laboratory. Experimental methods for linking germs and disease began to develop in the 1860s and 1870s, most brilliantly in the work of the French chemist Louis Pasteur and the German physician Robert Koch. For adherents of the germ theory, the evidence that experimentalists gathered from microscopic examinations, test-tube cultures, and animal experiments provided a new kind of divination into the fundamental nature of disease.

But for most of their contemporaries, the new experimentalism seemed little reason to abandon insights derived from decades of clinical and epidemiological observation, insights that supported the validity of the zymotic theory and sanitary science. As a result, from 1865 to 1895 Western medicine underwent a virtual civil war over the truth of the germ theory. In both Europe and the United States, the profession divided into hostile camps that jousted across countless pages of medical journals and textbooks. In the end, advocates of the germ theory triumphed: by the 1890s, medical students were being educated to revere the germ theory as scientific orthodoxy and to regard Pasteur and Koch as heroes.[13]

But in the 1870s and early 1880s, when the new view of disease was first introduced to both medical and popular audiences, it had yet to

ascend to that privileged status. Instead, the germ theory was often linked to an ancient and discredited tradition in medicine referred to as the "animacular hypothesis." As its advocates knew well, the proposition that the agents of infection were living beings had a long history. In a widely read 1874 article on the germ theory, Karl Liebermeister noted that "positive indications of such an idea are to be found among the writers of antiquity." In succeeding centuries, observers periodically hypothesized that a mysterious *contagium vivum* might account for the spread of epidemic diseases such as the bubonic plague.[14]

With Antoni van Leeuwenhoek's invention of a simple microscope in the late 1600s, Liebermeister continued, "some sort of an actual basis for such theories was furnished by the microscopical demonstration of very minute living organisms, invisible to the naked eye." In a series of widely reported observations, the Dutch merchant detailed a world of microscopic characters, many of which lived in or on the human body, who seemed likely candidates for the elusive contagium vivum. Unfortunately, eighteenth century believers got carried away with their microscopic imaginations. Despite the crudeness of their instruments, they devised elaborate identities and family trees for the different microorganisms and produced detailed drawings of creatures with "crooked bills and pointed claws," which some proposed shooting out of the sky with cannons. It was entirely understandable, Liebermeister observed, "that such fantastic ideas should bring down ridicule upon the whole theory," and the weight of medical opinion turned in favor of an atmospheric theory of infection.[15]

The cholera epidemics of the 1830s revived interest in the contagium vivum theory, especially after the English physicians John Snow and William Budd demonstrated that the disease was spread by water polluted with the bowel evacuations of the sick. In 1840, Budd declared his belief that the cholera poison was a living organism. Still, few of his contemporaries were converted to that view, and Liebermeister noted that of this older generation, the German physician Friedrich Gustav Jacob Henle, writing in 1853, was "perhaps the last who elaborated the theory of a *contagium vivum.*" During the middle decades of the nineteenth century, the zymotic theory of disease held virtually undisputed sway in Western medicine.[16]

Still, many naturalists and physicians continued to study microorganisms. Their ability to do so was greatly enhanced in the late 1820s

by the introduction of the achromatic compound microscope, invented by an English wine merchant named Joseph Jackson Lister; the new instrument eliminated the problems of distortion at high magnification that had long hampered microscopic observations. As better and cheaper instruments became available, microscopy became a popular pastime among physicians and lay people in both England and the United States. Their growing familiarity with the microscopic world helped set the stage for the rebirth of the old animacular hypothesis as the new germ theory of disease.[17]

This metamorphosis began in the late 1850s and early 1860s with the work of Louis Pasteur. At first glance, it may seem curious that a chemist rather than a physician played the pivotal role in starting a revolution in medical thinking, yet chemistry and medicine had long been intimately related. The zymotic theory of disease was associated with the German chemist Justus von Liebig, whose work had helped popularize the analogy between disease and fermentation. In taking up his research on fermentation, Pasteur knew that his studies had potential significance for theories of disease.[18]

Trained in chemistry at the Ecole Normale Supérieure in Paris, Pasteur first established his scientific reputation in the field of crystallography. In the mid-1850s, while teaching chemistry at a university in Lille, a center of the beet-sugar distilling industry, he became increasingly interested in the process of fermentation. Pasteur's microscopic researches convinced him of an observation that his countryman Cagniard de la Tour had advanced as early as 1835: that the agents of both fermentation and putrefaction were different species of living microorganisms. Working with brewers, vintners, and vinegar makers, all of whose livelihoods turned out to hinge on the successful management of these curious microscopic creatures, he became an expert on the applied science of fermentation. Using his microscope to examine cultures grown in flasks of clear broth, he learned to distinguish between microbial species that produced good beer, fine wine, and flavorful vinegar and those that produced nothing but slimy, revolting messes. He discovered that some species were aerobic, or needed air to live, whereas others were anaerobic and throve in its absence.

Pasteur immediately perceived that his research on fermentation had a significance beyond its usefulness to French industry. The leading medical authorities of the day believed that infectious diseases

were caused by chemical ferments, and he had shown the agents of fermentation to be living microorganisms. The implications seemed clear: infectious diseases might be caused by these same microbes. As early as 1859, Pasteur wrote in a paper on microorganisms and fermentation that "everything indicates that contagious diseases owe their existence to similar causes." A few years later, in an 1861 treatise, he suggested that microscopic examination of airborne dust and dirt might provide valuable insight into the spread of epidemics.[19]

Pasteur's work embroiled him in a long-standing scientific controversy over the possibility of spontaneous generation, a debate closely linked to theories about epidemic disease. For centuries, philosophers had debated whether living creatures could originate from nonliving matter. The observation of microscopic life became a central element in the debate; commentators reasoned that if these most primitive forms of being could be generated in sterile flasks of broth, life could arise spontaneously. By analogy, the same reasoning suggested that epidemics could originate de novo—without any connection with a prior outbreak of disease.[20]

In a famous experimental duel with the naturalist Félix-Archimède Pouchet, the most prominent French advocate of spontaneous generation, Pasteur challenged the truth of this ancient doctrine. By an ingenious series of investigations, Pasteur proved that if "ordinary air" (air laden with common dust and dirt) was excluded from contact with a flask of nutritive broth, the broth remained pure and clear. But within a short period of exposure either to unpurified air or to a drop of water filled with microorganisms, the same sterile solution was soon teeming with life. Pasteur suggested that Pouchet and other exponents of spontaneous generation achieved contrary results because their experimental methods were not exacting enough to keep out the ever-present germ matter in the air.[21]

In retrospect, the connections between Pasteur's early work and the germ theory of disease that emerged around 1870 seem obvious. But in the late 1850s and early 1860s, Pasteur was primarily interested in the general problems of fermentation and spontaneous generation, not the specific relationship between microbes and disease. Only in the mid-1860s did he begin to investigate an actual disease, an ailment of silkworms called *pébrine*; not until the 1870s, after the germ theory of disease had already been articulated, did he start his celebrated research on anthrax and rabies.[22]

Although it is often credited to Pasteur, the modern germ theory of disease actually emerged through a far more collaborative sharing of ideas and research. In the 1860s and early 1870s, a small group of natural scientists and physicians, following their own interests or inspired by early reports of Pasteur's work, began to investigate the relationship between microbes and disease. As reports of their work appeared in medical and scientific journals, they gradually came to be seen, and to see themselves, as proponents of a cohesive doctrine regarding the agency of microbes in causing human and animal diseases.

The most numerous group of researchers, which included the French physician Casimir Davaine, the English physician John Burdon Sanderson, and the German physician Robert Koch, used experimental methods to study the process of infection. From blood or other matter extracted from a person or animal suffering from a disease, they tried to isolate the infective agent and then inject it into a healthy animal, a procedure that they hoped would produce the same ailment. By the mid-1870s, experiments of this sort suggested that tuberculosis, diphtheria, septicemia, cattle plague, and anthrax were "inoculable," meaning they could be passed from one creature to another.[23]

The germ theory also gained legitimacy from previous research that had convincingly demonstrated that living parasites caused muscardine, a disease of silkworms, as well as localized skin diseases such as favus and scabies. In the 1850s, investigators showed that an intestinal worm, *Trichinella spiralis*, was able to enter the human digestive tract via partly cooked pork, where it reproduced and sent colonies to burrow into other parts of the body. This "new revelation," as one expositor of the germ theory explained, "showed that the whole system, as well as a particular organ or tissue, might suffer from the effects of parasitic contamination." The model of parasitic behavior provided a useful way of understanding the relationship between microbe and host.[24]

Yet curiously, in the earliest accounts of the germ theory, investigations of actual diseases were often overshadowed by experiments that verified Pasteur's observations about the infective properties of air. Here the work of the English physicist John Tyndall was particularly important in shaping Anglo-American opinion. While conducting research on gases and radiant light, Tyndall became aware of the

enormous amount of "floating matter" in the air. Upon reading of Pasteur's work, he became convinced that this matter contained disease germs. To prove it, he did a number of his own experiments and engaged in a long debate with the leading English proponent of the spontaneous generation theory, Henry Charlton Bastian. Tyndall, an accomplished popular lecturer and author, became one of the most important English-speaking advocates of the germ theory during the 1870s.[25]

Another extremely important type of evidence adduced in favor of the fledgling germ theory came not from the laboratory but from the operating room. Like Tyndall, the surgeon Joseph Lister, son of the Lister who invented the achromatic compound microscope, read of Pasteur's speculations about the infective matter in the air and wondered if it might be the source of the postoperative infections that made surgery such a risky enterprise. To neutralize the air's infective properties, Lister began to use carbolic acid as an antiseptic spray and wound dressing; the result was a dramatic reduction in his rates of postoperative infections. Although skeptics claimed that the so-called antiseptic method worked simply because it counteracted the infective properties of the air itself, not the living germs it contained, Lister presented his surgical experience as proof of Pasteur's theory.[26]

The phrase "germ theory of disease," which came into common use in the English-language medical literature around 1870, was scientific shorthand for propositions associated with the work not only of Pasteur, but also of Koch, Tyndall, Lister, and other investigators. Put simply, the germ theory consisted of two related propositions: first, that animal and human diseases were caused by distinctive species of microorganisms, which were widely present in the air and water; and second, that these germs could not generate spontaneously, but rather always came from a previous case of exactly the same disease.[27]

It should be noted that not everyone who swore allegiance to the germ theory of disease endorsed the second proposition. Many early converts accepted the causal link between microbes and disease while continuing to believe that under the right environmental conditions, disease germs might originate de novo and then spread from person to person. As the British physician Thomas J. MacLagan insisted in *Lancet*, "That every germ must originate from a pre-existing one may

be true; but such a belief forms no essential part of the germ theory of disease." In addition, many early adherents of the germ theory assumed that disease particles required specific conditions to develop, or germinate; thus the disease germ and the mature pathogenic microorganism were not necessarily the same. This assumption was subsequently reinforced by the discovery that some species of bacteria form spores, that is, hardy reproductive cells that under the right environmental circumstances will grow into the mature organisms. Thus there remained considerable diversity of opinion on these points even among professed believers in the new theory.[28]

Early Criticisms of the Germ Theory

As first articulated around 1870, the germ theory was truly a theory, a radical extrapolation from a limited set of experimental observations. Indeed, if one tries to read the early debates over the germ theory impartially, without favoring the side that eventually proved correct, the antigerm theorists appear armed with some formidable arguments. Despite its advocates' appeal to a higher order of experimental evidence, the early laboratory "proofs" offered in favor of the germ theory were few and unconvincing. Even its most fervent advocates freely admitted that essential aspects of the hypothesis remained unproven. Believing in the germ theory, as it was initially formulated from the experimental evidence available in the 1870s, required a considerable leap of faith that most physicians simply could not make.[29]

Objections came not just from poorly educated or marginal physicians, but also from some of the most intelligent, systematic thinkers of the period. Many physicians committed to making medicine more scientific were deeply suspicious of overly simplistic theories of any sort, which they felt harkened back to the sterile hypothesizing of eighteenth-century medicine. Reducing the whole complex origin of an epidemic to the agency of a microbe struck them as a step backward, not forward, in medical thinking. Others objected to the premises of experimentalism itself. To their way of thinking, the behavior of test tube cultures or experimental animals bore no useful analogy to human disease; close observation of many cases of illness provided a much more authoritative body of evidence about the nature of illness. Still others objected not to the validity of laboratory evidence,

but rather to its interpretation. Skeptics such as Félix Pouchet and Henry Charlton Bastian fought fire with fire by devising their own experiments to show that microbes could be generated in fluids even after boiling, a process known to kill microorganisms. Particularly in the 1870s, when experimental methods were still relatively crude, the antigerm theory camp could offer experimental results that seemed no less authoritative than those provided by the theory's supporters.[30]

Thoughtful observers also raised a host of objections to the germ theory that could not be easily answered given the available research methods. The very ubiquity claimed for the germ made it difficult for physicians to accept its causal role in disease. Microscopists routinely found many microbial forms on the body and in the secretions of healthy people, so it seemed obvious that the presence of germs alone did not cause illness. As Massachusetts physician Edward P. Hurd remarked in an 1874 review of the evidence for the germ theory, "All the higher organisms seem to be indifferent to them," at least so long as they remained in good overall health.[31]

Moreover, skeptics argued, the growth of unusual bacteria in the secretions of the sick could be the consequence rather than the cause of their illness. The zymotic theory held that when people ingested the chemical ferments of disease, their bodies began to manufacture the by-products of decay that such bacteria needed to grow. As Hurd put it, "There is no proof" that the "lower cryptograms," as he called them, "are not accompaniments, or effects, and not causes of the diseased conditions with which they are found associated." The same problem was raised concerning the animal experiments offered in favor of the germ theory. Early investigators could not easily separate the microorganisms from the blood or tissue of the diseased animal; thus critics argued that some other chemical substance in the inoculated material might have caused the symptoms. As Hurd noted, "It is quite impossible to introduce bacteria into the blood of a healthy animal without at the same time introducing with them septic or putrescent matters which might initiate disastrous changes in the blood, and become the elements of contagion."[32]

Those assumptions about the aerial spread of disease germs common to the early work of Pasteur, Lister, and Tyndall also met with skepticism. If disease germs floated in atmospheric clouds, it was logical to assume that the air surrounding sick people would be

heavily laden with distinctive germs. But when investigators sampled sickroom air or exposed microscopic slides to the breath and saliva of patients sick from highly contagious diseases, they recovered microbes that looked no different from those found in their parlors or offices. A Chicago physician who compared the air of sick rooms and ordinary habitations concluded in 1871, "We were unable to detect the slightest particle of any kind in one, which was not equally present in the other."[33]

Moreover, opponents of the germ theory could point to numerous well-publicized cases in which early microscopical enthusiasts supposedly isolated the living agent of a deadly disease from secretions of the ill, only to have the germ in question turn out to be some innocent organism. A case in point was the American physician James H. Salisbury, who claimed in the 1860s to have found the fungal causes of measles, typhoid, malaria, and other fevers. Salisbury developed some ingenious proofs to associate the microscopic *palmella* plant with malaria; for example, he had volunteers sleep in rooms with boxes of palmella-infused soil on their window sills and observed that they soon fell ill of the fever. Other investigators found it easy to disprove the palmella thesis by showing that it existed in regions that had no malaria. Anticipating Max von Pettenkoffer's famous cholera cocktail of the 1890s, the Philadelphia physician Horatio C. Wood even drank a glass of water infused with the microscopic organism to show that it caused no ill effect.[34]

Salisbury's claims about palmella and malaria represented but one example of many unconvincing attempts to link specific microorganisms with specific diseases. Liebermeister noted regretfully in 1874 that contemporary enthusiasts had done as much harm to the germ theory with their premature claims as their eighteenth-century predecessors had done with their fanciful drawings and cannon shootings. "The utter lack of critical discernment and method which have characterized some of the works in this field, and, on the other hand, the recklessness with which facts of uncertain significance have been proclaimed certain proofs, have also in our time driven away many an earnest investigator," he lamented.[35]

Skeptics like Edward Hurd insisted, quite understandably, that "till, then, more convincing experiments shall have been performed, the poison theory of the older pathologists will hold against the living ferment theory of the newer." He concluded, "In rejecting the Germ Theory as untenable, we have either to confess our ignorance of the causes of all febrile and inflammatory contagious diseases . . . or, guided by analogy, to accept the alternative that the principle of contagion is a subtle chemical ferment, an organic poison, generated in the body of the diseased individual."[36]

The experimental work on anthrax, also called splenic fever, proved crucial to resolving these objections to the germ theory of disease. Anthrax was the first disease that experimenters could convincingly link to a specific microorganism. Primarily a disease of cattle, sheep, and horses that occasionally spread to humans, it caused painful boils, fever, and congested lungs. In 1876, while still a country doctor, Robert Koch identified the *Bacillus anthracis*, a large and relatively easy to grow rod-shaped bacillus. Using microorganisms cultured in a special medium, in this case the aqueous humor of cattle eyes, Koch showed by repeated experiments that the anthrax bacillus did not exist in the blood of healthy animals but when injected into them consistently produced the disease's distinctive symptoms.[37]

In addition, Koch discovered that the anthrax bacillus had two forms. The mature bacillus, a slender filament, did not survive long after the death of its host, but it produced spores—small, black, seed-like capsules—that were capable of surviving extreme cold or heat. Koch's findings helped to explain why anthrax was confined to certain localities and appeared and disappeared so mysteriously: the anthrax spores remained in the soil and only ripened into maturity under a precise set of environmental conditions. This discovery helped to explain why competent experimentalists could get fermentation in boiled solutions; the heat killed the bacteria but not the hardier spores.[38]

As it turned out, this cycle of bacillus and soilborne spore proved unusual among pathogenic microorganisms; besides anthrax, it was found only in the family of organisms responsible for tetanus, gas gangrene, and botulism. The microbes that caused the vast majority of common communicable diseases, including typhoid and tuberculosis, formed no such resilient spores. Yet in the late 1870s and early 1880s, the anthrax model was widely invoked to explain the origin and spread of germ diseases in general. By chance, the first disease-causing bacteria clearly identified by experimentalists confirmed the perception that the microbial "seeds" of disease were widely dis-

persed in the air and soil and required only the right conditions to germinate. The soilborne anthrax spore powerfully reinforced the association of dirt and disease germs. These assumptions, that pathogenic microorganisms were extremely hardy and widely broadcast in the environment, strongly colored the first generation of preventive strategies advocated in the name of the germ theory.

Going Public

Although increasingly sophisticated experimental methods gradually filled in the gaps of what researchers could prove about the germ theory, its advocates did not wait for incontrovertible laboratory evidence before trying to convert others to their views. From the outset of the debate, critics and champions of the germ theory alike actively sought out public forums for rehearsing their arguments. In so doing, they followed a long tradition of "public science" in which even the most elite scientists courted legitimacy by giving public demonstrations of their ideas and experiments. The terminology and style used in these public discourses were far less formal and abstruse than they would become even a few years later. Early commentaries on the germ theory of disease were often delivered in simple language and embellished with colorful imagery that an educated lay person as well as a physician could understand. In the pages of medical journals, in public lectures reprinted for wide distribution, and in magazines such as the *Popular Science Monthly,* early converts to the germ theory explained the new lessons of the laboratory using everyday experiences of baking and brewing, spoiled food, and dust motes dancing in a sunbeam.[39]

These imaginative modes of describing the microscopic world were particularly useful for introducing the germ theory of disease to a wider audience. Well in advance of winning the divisive medical battle over the issue, advocates of the germ theory sought out audiences of mostly middle-class, city-dwelling men and women who took an avid interest in matters of health. In the popular health literature, favorable notices of the germ theory began to appear in the 1870s, when many physicians were still either hostile to or unacquainted with it. Thus the scientific arguments and "proofs" initially offered on the germ theory's behalf were quickly incorporated into popular writings on health and disease.

Explaining the significance of the experiment was an important feature of these early accounts of the germ theory. Although the germ theory's advocates used all sorts of reasoning and evidence to make their case, they presented the laboratory as the source of a new and special kind of knowledge. At the same time, there were relatively few experiments presented on the germ theory's behalf in the 1870s that a serious amateur could not replicate. Early accounts of laboratory life in the writings of such popularists as John Tyndall were a curious mix of the familiar and the awesome. The experimental materials and methods described in them had a homely cast; investigators lovingly recounted how they constructed the air chambers for their test tubes from household materials; prepared culture media from turnips, herring, or beef tea; and warmed their microbial broths over a kitchen stove. (Tyndall once reported that he took a set of test tubes to a Turkish bath in order to incubate them.)[40]

Yet such ordinary, everyday materials as a basin of turnip slices or the juice from a mutton chop produced dramatic results. Commentators used vivid language to describe the bacteria's transformative effects on liquid or solid media: meat or soup initially described as "sweet," "pure," or "limpid" became "slimy," "putrid," or "turbid." One physician experimenter wrote, "My wonder never ceases when I take up one of the flasks and bulbs which have remained barren in my chamber for three or four years, though supplied with air (filtered through cotton-wool) and suitable heat." It was equally amazing, he added, to withdraw the cotton plug and allow the germ-laden dust or water access to the broth: "In a few hours the stillness of years gives place to life and activity."[41]

Experimental accounts also emphasized how one seemingly inconsequential mistake—not rinsing a pipette with sterile water, or failing to sterilize a flask before filling it with the culture medium—could introduce the fertile hordes into a barren environment. By stressing the importance of having an exacting technique, advocates of the germ theory had an all-purpose explanation for why their critics seemed unable to replicate their results: they simply were not careful enough.[42]

Laboratory proofs of the germ theory depended on a willingness to see what happened in the test tube or the experimental animal as a model for what happened in a disease epidemic. The comparisons made were often quite simple. Tyndall pointed out, for example, that

the interval of time between introducing the airborne germs to the culture medium and their multiplication into abundant life neatly corresponded to the latency period physicians had long observed between an individual's exposure to contagion and subsequent development of sickness. Likewise, he noted that different broths nourished the germs to different degrees, just as individual constitutions provided more or less resistance to disease. Watching how a hundred test tubes filled with varied infusions of herring and turnip became turbid at different rates, Tyndall observed how "the whole process bore a striking resemblance to the propagation of a plague among a population, the attacks being successive and of different degrees of virulence."[43]

Advocates of the germ theory continually appealed to their audiences to see the parallels between laboratory experiment and everyday observation. As Pasteur's work on fermentation so well exemplified, the insights of the germ theory had much in common with familiar domestic processes such as bread making and beer brewing. In a Glasgow address reprinted in the *Popular Science Monthly*, Tyndall urged his audience to "observe how these discoveries tally with the common practices of life" and offered examples from his own household, such as his housekeeper's use of brief applications of heat to keep pheasants and milk "sweet." To illustrate the prevalence of germs in the air, he asked his listeners to think about the molds that grew on wet boots or a piece of fruit left exposed to the air and about the dust that appeared in a beam of sunshine after the housemaid cleaned a room. Using his neighbor's efforts to make alcohol from sour cherries as an analogy for the disease process, he explained, "We began with the cherry-cask and beer-vat; we end with the body of man."[44]

Expositors of the new germ theory often struggled to find the right words to describe the "milky way of lower organisms," as the botanist Christian Ehrenberg once called it, that the microscope revealed. First there was problem of terminology; as mentioned before, observers used an exotic array of terms to describe these organisms, such as "monad," "cryptogram," and "infusoria." Individual species had their own strange names such as the "micrococcus" and the *Bacillus subtilis*. Then there was the challenge of describing their various shapes and movements. Commentators resorted to all sorts of analogies to convey the vagaries of microbial forms: this species

resembled a eel, that one a "string of beads," another a "twirling wheel"; their movements across the microscope's field of vision were described as "leaping," "darting," and "springing."[45]

In the *Popular Science Monthly*, the botanist Ferdinand Cohn, whose scheme for classifying bacteria according to their shape (spherical, oblong, rodlike, and spiral) gradually became the accepted standard, commented on the organisms' antics: "When they swarm in a drop of water, they present an attractive spectacle, similar to that of a swarm of gnats, or an ant-hill." Their patterns of movement were endlessly fascinating. "At one time they advance with the rapidity of an arrow, at another they turn upon themselves like a top; sometimes they remain motionless for a long time, and then dart off like a flash," he observed.[46]

Those who had seen these microscopic marvels continually marveled at how small and fertile they were. In an 1878 lecture delivered to the Philadelphia Social Science Association, the microscopist Joseph Richardson invented some dramatic numbers to convey their minuteness. Disease "spores" were "so small," he wrote, "that 20,000 of them placed end to end, would measure less than one inch in length, and a mass the diameter of one of the periods (.) upon this printed page might contain 50,000,000." Each of these 50 million seeds, he added, was "capable, under favorable circumstances, of reproducing its own kind with almost inconceivable rapidity."[47]

Commentators sought to fit these minute beings into the classifications that naturalists had already developed to describe animals higher up on the evolutionary scale. In their great biological chain of being, microbes occupied the lowest niche as the most "primitive" form of life. They were so primitive, writers often noted, that they reproduced not by the mating of male and female, but by budding, dividing, or producing spores. Their physical structures were remarkably simple—a cell wall enclosing a largely undifferentiated mass of protoplasm—and when not moving, they often could not be distinguished from crystals or other inanimate forms of matter.

In compiling their microscopic bestiaries, early chroniclers divided the microbial world into friends and foes. Much as Victorian naturalists characterized the lion as a noble beast and condemned the wolf as a savage predator, late-nineteenth-century commentators sorted the various species of microorganism into good and bad microbes.

The good species enriched human society, making it possible for people to enjoy bread, wine, and beer, and they played an essential role in breaking down dead matter into elements that could be used by new forms of life. As the American physician George Sternberg wrote dramatically, "But for the power of these little giants to pull to pieces dead animal matter, we should have dead bodies piled up on all sides of us in as perfect a state of preservation as canned lobster or pickled tongue."[48]

Only a few species of "bad" microbes preyed upon humans and animals, yet their potential for creating havoc was impressive. Converts to the germ theory often painted a chilling picture of an environment saturated with these invisible enemies. Bacterial clouds floated about in the atmosphere, carried along by shifting air currents and dropping into the water supply, until eventually they found a receptive media, the human equivalent of the turnip infusion or the beef tea. As Ferdinand Papillon wrote in the *Popular Science Monthly*, "Our atmosphere . . . is the receptacle for myriads of germs of microscopic beings, which play an important part in the organized world." These "penetrating agents of decay, baneful toilers for disease," he observed, "lie ever in wait for the chance to pierce the internal machinery of animals and plants, and create slight or grave disturbances within it."[49]

To describe how germs found a suitable host, germ theorists frequently resorted to comparisons between germs and seeds. Since antiquity, physicians had used the "seed and soil" metaphor, drawn from the New Testament parable of the sower, to describe how the interplay between one's individual constitution and an external disease agent determined one's susceptibility to disease. Exponents of the germ theory found that image particularly well suited for their purposes: the germ or "seed" required suitable "soil"—that is, a weakened constitution—for its full development. The seed and soil metaphor also worked well to underline the *specificity* of disease agents. Just as a farmer expected to get wheat when he sowed wheat and corn when he sowed corn, the scarlet fever germ only gave rise to scarlet fever and the smallpox germ to smallpox. Nor did the farmer anticipate a crop of wheat or corn to grow where he had sowed no seed at all, as advocates of spontaneous generation had asserted.[50]

Commentators also likened microbes to insects and worms, using the examples of the tiny insect responsible for scabies, or the trichinae worms carried in uncooked pork, to explain the parasitical nature of germs. In a lecture on "the origin and propagation of disease" delivered at the New York Academy of Medicine in 1873, the physician John Dalton developed these examples at some length to help his audience comprehend the unfamiliar world of bacteria and disease. The great potential of the germ theory, he argued, lay in its ability to harmonize with natural science as a whole, "for it will show how large a part of human pathology is connected with the general physiology of vegetative life."[51]

Other expositions of the germ theory used a more feral imagery to describe the microbial parasite. William Mays told his audience that germs "hunt in packs," and another physician referred to them as "atmospheric vultures." Microbes were often described in martial terms as attacking, invading, and conquering their human hosts. Joseph Richardson combined both the botanic and feral images in his 1878 speech to the Social Science Association when he explained that contagious diseases were caused by "the transplanting of microscopically visible spores, or seeds, which have a separate vitality of their own, each after its kind, and which are to be escaped, just as we would escape hordes of animal[s], or swarms of insect pests, by shutting them out or killing them before they can succeed in fastening upon our bodies."[52]

The Microbial Survival of the Fittest

Early accounts of the germ theory, with their frequent use of the terms "higher" and "lower" organisms and their references to microscopic predators and parasites, purposefully conjured up images of a microbial survival of the fittest. To a generation of medical and lay readers familiar with evolutionary theory—Charles Darwin's *Origin of Species* had been published in 1859, and Herbert Spencer's *Principles of Biology* had introduced the term "survival of the fittest" in 1861—these were potent analogies. The strong overlap in language between Darwinian theory and germ theory was not accidental. Many of the leading figures in the English debate were committed supporters of Charles Darwin. John Scott Burdon Sanderson was a good friend and frequent correspondent of Darwin. John Tyndall first gained national renown for his defense of evolutionary theory; his rival, Henry Charlton Bastian, also was a Darwinist.

As Bastian's case suggests, professed Darwinians could be found on both sides of the germ theory debate. The implications of evolutionary theory for microbial behavior and vice versa were by no means clear-cut, especially in regard to the vexed subject of spontaneous generation. Still, although advocates of the germ theory had no exclusive claim on evolutionary theory, its growing popularity probably did more for their cause than for their opponents' because the image of a "microbial survival of the fittest" proved to be such a powerful model for the relationship between microbe and host.[53]

At the simplest level, many commentators likened the species of microbes to the distinctive species evident among more complex plant and animal life forms. The popularity in early accounts of the germ theory of adages about seagulls not hatching from pigeons' eggs or horses not foaling donkeys invoked a broader conception of natural law that limited miraculous or unexpected transformations. For physicians intent on making medicine more scientific, this evolutionary perspective on disease had enormous appeal. As Henry Gradle, a professor of physiology at Chicago Medical College, noted, "It eliminates the factor 'accident' from the consideration of disease, and assigns disease a place in the Darwinian programme of nature."[54]

Gradle made explicit the "survival of the fittest" themes that ran through many early accounts of the germ theory. "In the light of the germ theory," he wrote in 1883 in *Bacteria and the Germ Theory of Disease,* "Diseases are to be considered as *a struggle between the organism and the parasites invading it.*" The contest between microbes and higher life forms was similar to parasitical relations throughout nature in which a smaller species preyed upon the body of a larger creature. He concluded, "We are again ignorant as to the weapons of the contending armies, we do not know yet how the warfare is carried on between the hostile vegetable and animal cells, but that the struggle exists is evident, and it must terminate in the victory of one or the other side."[55]

Although Darwin himself resolutely avoided seeking moral meanings in the workings of evolution, many of his contemporaries observed no such restraint and implied a conscious malevolence to disease germs. Using highly charged adjectives such as "foreign," "base," "murderous," and "cunning," they endowed microbes with a frightening will to destroy their biologically superior competitors. The recognition that "these lowest of created things" worked out

their destiny by wreaking disease and death on the human race was both humbling and terrifying.[56]

Yet on the whole, the tone of these early accounts of the germ theory was overwhelming optimistic. Converts portrayed the new discipline of the laboratory as a royal road to safety: by identifying the true agents of disease, their modes of travel, and their sure methods of destruction, the insights of the germ theory would make it easier to outwit the invisible agents of disease. A Philadelphia medical student writing in 1885 captured that sense of optimism, asserting that "after centuries of silent resignation, mankind enlightened by science at last begins to recognize its relentless and hitherto mysterious enemies." He asked rhetorically, "Shall we then continue indefinitely yielding up the inumerable [sic] victims that yearly succumb to the attacks of foes whose only force lies in their minuteness?" and answered dramatically, "No! Man is no more made to become their prey than that of the wild beasts among whom he had to fight his way in the infancy of the race and whom he has conquered or destroyed by his industry, intelligence, and work."[57]

Paths to Conquest

The most glamorous of these vistas of progress was the potential for discovering new vaccines and drugs. Inspired by the known value of the smallpox vaccination, converts to the germ theory dreamed of devising concoctions of tamed germs that would confer similar protection against other deadly diseases. In the 1870s and 1880s, Louis Pasteur devoted himself to developing vaccines against anthrax, chicken cholera, and rabies. In the 1890s, Robert Koch touted his "tuberculin" as a cure for tuberculosis. Many lesser-known researchers and clinicians experimented with "internal antiseptics," or chemical substances that when ingested would kill microbial invaders.[58]

But from the 1870s to the early 1900s, such hopes were repeatedly dashed. With a few exceptions, such as the rabies vaccine and the diphtheria antitoxin, none of the measures developed in the first flush of enthusiasm for the germ theory stood the test of time. Laboratory scientists continued searching for the fabled "magic bullet," which did eventually materialize—first in the discovery in 1909 of Salvarsan, which cured syphilis, and several decades later in the

discovery of sulfa drugs and penicillin. Yet prior to 1900, the therapeutic promise of the germ theory remained elusive.

Far more immediate and useful were the insights about hygiene and sanitation derived from the germ theory. Here the apostles of the germ did not have to break such hard, new ground as they did in searching for magic bullets. Early understandings of the germ, which emphasized its ubiquitous presence in air and water and its hardiness outside the body, neatly harmonized with already accepted modes of protection against zymotic disease. As a result, the first version of the gospel of germs represented a surprisingly successful marriage between the old sanitary science and the new germ theory.[59]

That such a happy union could come about was not immediately apparent to the older generation of public health reformers. Such eminent figures as Benjamin Richardson, Florence Nightingale, and Elizabeth Blackwell expressed fears that acceptance of the germ theory would undercut the achievements of sanitary science. They were profoundly uncomfortable with the moral randomness they perceived in the germ theory; if contact with a microbe was the sole cause of disease, then living a virtuous, clean life did not necessarily protect one from its ravages.[60]

In response, early advocates of the germ theory sought to reassure the older sanitarians that the new disease faith only verified the great "truths" of sanitary science. Indeed, for all the controversy that the germ theory engendered in medical circles, its implications for preventive action initially seemed to be consistent with existing tenets of private and public hygiene. In 1873, after reviewing the debates over the germ theory, the president of Columbia University, F. A. P. Barnard, concluded gratefully that when it came to preventive medicine, "The champions of conflicting theories, however freely they may splinter lances in the arena of controversy," could be found "in the face of the common enemy, marching harmoniously side by side."[61]

Certainly when it came to the practice of personal and domestic cleanliness, the new experimental evidence about germs countenanced no slackening off in the zeal required by traditional sanitary science. The reconceptualization of disease ferments as minute living creatures able to replicate in the millions from a single speck only heightened the importance of exacting precautions against their spread. Likewise, the anthrax model of bacterial spores capable of surviving high heat and normal disinfectant processes pointed up the need for increasingly rigorous forms of cleanliness.

Pasteur's own reputation for meticulous cleanliness exemplified how acceptance of the germ theory went hand in hand with vigilance to hygienic detail. Having lost two daughters to typhoid fever, he knew intimately the havoc that so-called filth diseases could wreak on a household. Perhaps for this reason, he carried over into his personal life the rituals of cleanliness that he practiced in the laboratory. His son-in-law and biographer René Vallery-Radot wrote that whether dining at home or out "he never used a plate or a glass without examining them minutely and wiping them carefully; no microscopic speck of dust escaped his short-sighted eyes." He was "more than difficult to please in that respect," causing him to be a terror to his hostesses. It was Pasteur's long acquaintance with the microbial world that caused him to bring "such minute care into daily life," concluded Vallery-Radot. If a speck of dust could generate a veritable horde of bacteria in a flask of beef broth, what could it do in a soup tureen?[62]

The lore of the laboratory reinforced the point that seemingly inconsequential actions, such as failing to sterilize a flask or a pipette, could bring about rampant germ life. Carried over into everyday life, that mentality pointed toward an even more exacting practice of domestic cleanliness. The practical lessons that advocates of the germ theory derived from the laboratory only underlined the urgency of the sanitarians' warnings that utmost care needed to be taken to evade the domestic sources of disease. Here at last was an explanation for tragedies such as the death of Martha Bulloch Roosevelt. Her rituals of cleanliness had simply not been precise enough to counteract the depredations of the wily typhoid germ.

The new lessons of the laboratory thus contributed to a widening effort by public health reformers to "pathologize" the home because they invested ordinary behaviors and objects with the capacity to cause or prevent deadly illnesses. Acceptance of the germ theory fed into a revolution in personal and domestic behavior already under way by the 1870s. Commandeering the established truths of sanitary science, apostles of the germ synthesized old and new beliefs about contagion into a new code of protection for the American home. When it came to domestic rituals of purification, the dramatic insights of the germ theory turned out to be so much new wine in old bottles.

2 · Whited Sepulchers

In 1883, the year before Martha Roosevelt's death, an article that read almost like a prognostication of her fate, entitled "The Unsanitary Homes of the Rich," appeared in the *North American Review.* "Much has been written and said of late years about the wretched homes of the poor of New York, their squalor, their filth, and the moral and physical degradation of their occupants," the author, Charles Wingate, noted. Few of the city's inhabitants realized that the sumptuous mansions being built all over Manhattan were filled with hidden dangers that made them as unhealthy as the worst tenement house. Wingate might have been describing the Roosevelts' home on Fifty-Seventh Street when he referred to dwellings "of imposing dimensions, palatial in their adornments, and seeming to lack nothing to promote comfort, enjoyment, and health." Yet due to their faulty plumbing, he concluded, "a large number of these houses are mere whited sepulchers, and their luxurious inmates are exposed to constant risk of disease and death."[1]

Assuming that his readers would be well acquainted with the New Testament, Wingate's use of the phrase "whited sepulcher" was meant to conjure up the image of the Pharisees, who, like a whitewashed tomb that disguised the decaying bodies inside, appeared righteous, but actually were riddled with sin. It was a shocking allusion, but one frequently used by late-nineteenth-century health reformers for it drove home the point, literally as well as figuratively, that sanitary sins were to be found among the highborn as well as the lowborn, and that the whole of American society needed hygienic redemption.[2]

The "whited sepulcher" image also underlines how deeply concerned Wingate's generation was about the domestic origins of disease. Long before the agency of the germ was suspected, popular belief held that the sick left behind the "seeds" of their disease in the houses where they had died and on the objects that they had touched. In the nineteenth century, sanitarians expanded on the association of houses and disease, blaming damp cellars, poor ventilation, and defective plumbing for the fearsome increase in zymotic diseases. Under their relentless proddings, many middle-class Americans began in the mid-1800s to make major changes in the design of their homes and in how they performed household chores.

The new revelations about microbes and disease were thus introduced against the backdrop of a household revolution already in progress. The germ theory of disease entered the popular discourse about disease prevention at a time when the majority of Americans, physicians and lay people alike, believed quite fervently in the reality of what we would today call "sick buildings." The first gospel of germs, which emerged gradually in the 1880s, simply superimposed the menace of the microbe onto existing mappings of disease dangers in the household. The initial measures encouraging Americans to "germ-proof" their homes therefore owed much of their success to a pregerm gospel of domestic disease prevention widely disseminated in the 1860s and 1870s.[3]

The Origins of Domestic Disease Prevention

The code of scrupulous household cleanliness that emerged in the late nineteenth century, first under the aegis of sanitary science, then in tandem with the new germ theory of disease, built upon traditional methods for warding off infection during times of epidemic. Essentially, hygiene reformers took the exacting measures once demanded only during a visitation of dread disease and recast them as everyday protections against the growing menace of endemic, or "ordinary," fevers.

Nineteenth-century Americans were heir to a long tradition of precautions developed to combat epidemic diseases such as bubonic plague and smallpox. For centuries, outbreaks of disease had prompted rituals of household purification designed to guard against the dangers of both a corrupt atmosphere and direct conta-

gion from the sick. When an epidemic threatened, individuals tried to stay warm, well fed, and rested, the better to resist the disease; they also cleaned their homes and yards of any filth or stagnant water that might breed an infective atmosphere. As soon as the epidemic broke out, they avoided contact with other people, and if possible, fled the area.[4]

Simple observation suggested that contact with someone already sick often preceded an illness such as smallpox. Popular belief held that the breath, spit, skin particles, and bodily evacuations of the sick were all capable of spreading the disease. Invisible bits of contagious matter could supposedly adhere to bed linen, clothing, papers, and even household pets; these objects, or "fomites," seemed to retain the power to infect others for months and even years. Lay people were more likely than physicians to believe that epidemics spread by direct contagion and fomite transmission, rather than by the more elusive agency of atmospheric infection. As a result, they frequently shunned the sick and their belongings during times of unusual illness.[5]

Containing the spread of this contagious matter necessitated exacting home nursing practices, especially because so few hospitals existed prior to 1860 (and even those often refused to take patients with contagious diseases). During an epidemic, every household functioned essentially as a hospital, and the measures taken there to reduce the spread of infection were regarded as vitally important. Families were expected to isolate sick members and to disinfect their sick rooms and personal belongings in order to destroy the seeds of disease. Those who failed to exercise such care faced severe censure from neighbors and municipal authorities.[6]

Although epidemics certainly reinforced the association between disease avoidance and domestic prevention, once the crisis had passed, the heroic efforts at personal and household reformation it had inspired soon dissipated. Starting in the eighteenth century, advocates of a new science of public health began to advocate more long-term changes such as land drainage, sewer construction, and the like, to reduce the threat of disease. But there remained little an individual or private household could do to stave off epidemics. In eighteenth- and early nineteenth-century personal hygiene manuals, there were many more pages devoted to avoiding "constitutional" diseases such as dyspepsia or gout than there were to preventing the spread of infectious diseases. The Philadelphia physician Benjamin

Rush perhaps summed up conventional wisdom best when he wrote his wife during the 1793 yellow fever epidemic, "There is but one preventative that is certain, and that is 'to fly from it.'"[7]

Beginning in the mid-1800s, this calculus of responsibility began to change. By attributing the rising incidence of fevers to the extraordinary filthiness of cities and habitations, sanitary science brought the control of zymotic diseases within the sphere of individual as well as collective action. The experience of sanitary reformers during the Civil War strengthened the conviction that higher standards of cleanliness contributed directly to the saving of lives. At first, reformers focused primarily on the poorest homes and neighborhoods of the city, assuming, as a sanitary survey of New York City during the Civil War concluded, that the "nuisances" found there were sufficient to "pollute the atmosphere of the entire city." But by the 1870s, hygiene reformers were increasingly questioning the presumed sanitary superiority of the prosperous classes. As they traced the complex routes of atmospheric and water pollution, they found that dangerous defects in domestic hygiene were common in even the best homes.[8]

The chief culprit, sanitarians agreed, was household plumbing. In the 1840s, affluent families began to move their toilets indoors and to use water to flush the contents away. The increasing volume of discharges from these new "water closets" had overwhelmed existing cesspools and earthenware sewer lines, impregnating cellars and yards with liquid wastes. Improving municipal sewer lines solved the soil saturation problem, but it presented a new hazard: unless households installed airtight "sewer traps" on every toilet or washbasin, the connection with the public sewer provided multiple points of ingress for potentially deadly gases given off by decaying fecal matter.[9]

The frequency with which damp cellars, foul odors, and untrapped drains could be found in even the best of homes convinced sanitarians that the crusade against zymotic diseases had to enlist the rich as well as the poor. To make that point, public health reformers often invoked the tragedies that beset the British royal family. Queen Victoria's husband, the prince consort, died of typhoid in 1861, and their son Edward, the prince of Wales, nearly succumbed to the same disease in 1872. Investigations into both cases blamed faulty domestic plumbing in royal residences for the outbreaks. In the United States, a comparable sanitary scandal arose in 1881 over the condition of the White House, a controversy that will be looked at more closely in

Chapter 3. Such well-publicized cases of sanitary negligence in the symbolic first homes of the land underscored the same message inherent in Martha Bulloch Roosevelt's death: no one was safe.[10]

The sanitarian crusade was couched in religious as well as scientific terms. Equating God's law with natural law, hygiene reformers called on all citizens to embrace a sanitary gospel of redemptive cleanliness. In an 1875 lecture to the graduating class of the University of Michigan Medical School, Professor R. C. Kedzie explained, "The old superstitions which connected unusual sickness with the wrath of offended Deity have faded in the light of science." He continued, "The 'mysterious providences' about which we have heard so much are resolving themselves into 'defective drainage,' 'sewage contamination,' 'unwholesome food,' 'poisoned walls,''no ventilation,' etc." With this knowledge in mind, Kedzie exhorted his listeners not to "flout our filth in the face of Deity, and say that these afflictions come from His hand," but to be "clean in your person, and homes, the food you eat, the water you drink and the air you breathe."[11]

But however religiously sanitarians promoted the private observance of cleanliness, they never conceived of it as sufficient in and of itself. The reform of individual households was always linked with the need for strong public health boards and municipal sanitary reforms. Sanitarians nevertheless recognized that as of the 1870s and 1880s, the state's public health powers were still very rudimentary, so that even the wealthiest homeowners could not count on having safe municipal water supplies or sewerage systems. In an era of undependable municipal services, the installation of household-level protections, such as sewer traps or water filtration systems, restored a sense of control to the individual homeowner. As Joseph Edwards put it in his 1882 manual, "You cannot look into the [public] sewer and see whether it is clean or not. But, into all the arrangements of your own individual house you can peer at all times, and can plainly see whether they are right."[12]

Channels of Influence

The commitment to popular education so pronounced among late-nineteenth century domestic reformers coincided with changes in technology and marketing that made available increasingly inexpensive forms of print culture. From the mid-1860s onward, the multiplying host of medical and lay authors seeking to instruct the Victorian pater and mater in domestic disease prevention found a variety of channels at their command. The volume and variety of publications devoted to home hygiene in the last quarter of the nineteenth century testifies to the extraordinary interest in the topic.[13]

As the physician and public health authority Henry Bowditch remarked in 1876, "Sanitary discussion seems to interest many persons as much as the pages of the novel attract others." At a time when genteel folk customarily avoided plain talk about bodily parts or functions, he marveled at their eagerness to purchase and read detailed accounts of toilets, sewer gas, and fecalborne disease. Referring to the success of a series on household plumbing in the *Atlantic Monthly,* Bowditch was astonished at the way the sanitary engineer George Waring "discusses sewerage . . . with infinite gusto, and apparently to the satisfaction of all readers of this popular monthly."[14]

The treatment of home hygiene ranged from highly technical tomes that thoroughly expounded the rationale for their recommendations to short, simple summaries that supplied only the most rudimentary explanations for the suggested precautions. At one end of the spectrum were treatises on specialized subjects, such as William Eassie's *Sanitary Arrangements for Dwellings* (1874), an English volume frequently cited in the United States and "intended for the use of officers of health, architects, builders, and householders." More general manuals such as Henry Hartshorne's *Our Homes* (1880) treated a wider range of topics, from building or choosing a home to creating a "home hospital" for the care of contagious illness, and were conveniently sized for armchair or bedside use. Bulkier domestic encyclopedias and family medical guides, such as *Wood's Household Practice of Medicine, Hygiene, and Surgery* (1880), intended for the use of "families, travelers, seamen, miners, and others," contained greatly condensed versions of sanitarian doctrine.[15]

The interest in domestic hygiene carried over into the periodical literature, including ladies' magazines, popular science journals, and even literary reviews. The venerable *Godey's Ladies Book* contained short homilies on home health matters, and the more up-to-date *Ladies' Home Journal,* which began publication in 1883, had regular features on the prevention and management of infectious diseases. From its first issue in 1872, the *Popular Science Monthly* carried frequent articles on sanitary plumbing, disinfection, and the germ the-

ory of disease. Periodicals of general interest such as *Frank Leslie's Monthly* and *Scribner's* soon followed suit. In 1875, the *Atlantic Monthly* scored its great success with George Waring's series on domestic plumbing gas, and by the early 1890s, even weekly religious newspapers such as the *Independent* had columnists covering public health issues.[16]

The gospel of home hygiene also reached poorer audiences, albeit less frequently and in greatly condensed form, through broadsides and circulars. When epidemics of cholera, smallpox, or diphtheria threatened, local and state health departments often printed instructions about disease prevention that were distributed in poor neighborhoods and published in newspapers. These two- or three-page circulars, which presented short, simple versions of the sanitarian gospel, were no doubt the chief way that detailed information about disease prevention reached working-class families prior to 1900. In addition, local "sanitary associations" in large cities sold pamphlets on home hygiene for a few cents. In the South, the Hampton Institute, a Virginia school established for former slaves, prepared "Tracts for the People," which included one on "preventable diseases" written by Mary Armstrong, wife of the school's superintendent.[17]

But given that even a nickel was a prohibitive sum for many working-class families, we may safely assume that the readership for domestic hygiene writings remained limited prior to 1900. Although reformers' rhetoric emphasized the universality of their gospel, their educational methods inevitably circumscribed distribution of their message to the literate, affluent, and leisured. If and when circulars did come into their hands, working-class families often lacked both the time and the money to implement their suggestions. Many did not own their own homes and thus had little power to improve them. As a result, in the late 1800s sanitary knowledge and practice remained largely the province of middle- and upper-class families.

The People's Germ Theory

Given the growing interest in the subject of house diseases, domestic hygiene writers were quick to report on the new scientific speculations linking microbes and disease. Long before physicians had reached any consensus on its validity, discussions of the germ theory had begun to appear in popular advice literature. These accounts

suggest that the authors had some familiarity with the scientific debates described in Chapter 1. Yet even into the 1880s, when researchers began to identify and describe specific microorganisms such as Eberth's bacillus for typhoid, or the comma bacillus for cholera, popular advice givers still tended to refer simply to "disease germs" as an undifferentiated group. Most also ignored the battle against spontaneous generation fought by Louis Pasteur and John Tyndall and assumed that germs could originate de novo from decaying matter.

One of the earliest accounts of the germ theory to be found in the American advice literature, the 1875 *Household Manual,* suggests how complex arguments were simplified for a general audience. In language similar to that used by John Tyndall, the anonymous author of the manual distinguished between good and bad microbes and appealed to commonsense observations. The text defined germs as "little animals—animalculae—and the seeds of microscopic plants" that entered the body through the lungs and stomach and found their way into the bloodstream. "Here they develop and multiply to a remarkable extent, and with astonishing rapidity. Some kinds are very deadly; others are much less so, and some again seem to be almost harmless." In the spirit of Tyndall, the author advised the reader to look at the "motes, dancing in the sunbeam" to see the more benign germs, and added, "These are the agents which cause bread to rise, malt and wine to ferment, and the housewife's carefully hoarded canned food to spoil." In contrast, "All kinds of putrid matter, whether of animal or vegetable origin, send out immense quantities of germs which are of a much more poisonous character than those just referred to."[18]

The "seed and soil" metaphor also found special favor among popular interpreters of the germ theory. In an 1874 article the *New York Times* observed, "The thought itself is an impressive and natural one, that there may be a 'cholera seed' or 'scarlet-fever germ' or 'typhoid sporule' floating through the air, just as there are floating seeds of thistles or dandelions, or germs of tulip-trees or limes, or scores of the nameless plants which sow themselves wherever there is the slightest bit of soil or moisture favoring." Echoing Tyndall's image of bacterial clouds, the article concluded, "No doubt in this City there is an invisible cloud of 'scarlet-fever germs,' 'typhoid seeds,' and cholera or 'diphtheria spores,' always drifting over from

the densely-crowded poor quarters into those of the wealthy, filling the houses and garments, and lying *perdu* until the favorable moment in the organism of some child or delicate person gives them the chance to spring up into vigorous growth."[19]

The germ theory harmonized well with traditional beliefs that the bodies of the ill, as well as the objects they touched, had the capacity to spread disease. In her 1878 tract, Mary Armstrong assured her readers, "Many great men have, of late, devoted themselves to studying the causes of diseases, and they have almost beyond question, established the fact that all contagious diseases, that is all diseases which can be taken by contact with the sick person, or carried in clothing, or left in bedding, furniture, etc. are caused by germs, that is infinitesimally small living organisms which are thrown off from the body of the sick person." She explained further, "They are found in the breath from the lungs and in the secretions and excretions of the body, in fact the whole atmosphere surrounding a person who is ill with what we call a contagious disease, as for example, scarlet fever, diphtheria, or measles, is full of these germs which possess the power of multiplying themselves with inconceivable rapidity." Armstrong concluded, "Now it seems to me, that as soon as this is understood, the first impulse of every reasonable person will be to get rid of these poisonous organisms, to kill them and cleanse the air from their dangerous presence."[20]

Although popular authors' renderings of the germ theory remained rather crude, the precocity of their interest still bears emphasis given the reservations still common among physicians well into the 1880s. Whereas doctors debated among themselves about the sufficiency of microorganisms to cause disease, lay hygiene writers had little trouble accepting the equation of dirt, infection, and germs. As a simple rule of thumb, the further removed the author was from the medical establishment, the more likely he or she was to accept the germ theory as a credible and important scientific discovery. In a typical burst of excitement, Emma Hewitt reported in her text, *Queen of the Home,* "The study of the theory of germ proliferation has yielded amazing results in the way of furnishing the means of checking epidemics." In contrast, most physicians penning hygiene advice in the 1870s and early 1880s presented the germ theory as a controversial thesis. For example, in his 1880 manual, physician George Wilson characterized the germ theory as an unproven hypothesis and concluded tepidly, "Of far greater importance is to know that, whatever be the origin or mode of propagation of these diseases, they are to a very large extent controllable."[21]

Invisible Enemies in the Home

In the late 1870s and 1880s, the germ theory was easily incorporated into popular advice literature precisely because it seemed to justify widely accepted precautions of ventilation, disinfection, isolation of the ill, and general cleanliness. The first incarnation of the gospel of germs simply bestowed germicidal rationales on already trusted strategies of protection: the same practices adopted to defend against the dangers of damp cellars and impure air also worked to defeat malevolent germs.

This union of the old sanitary science and the new germ theory of disease was facilitated by a shared vision of the human body as a potent source of pollution. As Mary Armstrong explained, "Everything which is thrown out from the human body is unclean, and becomes at once dangerous to human life." Common wisdom held that human bodies polluted, or "vitiated," indoor air with gases respired by the lungs such as "carbonic acid" (carbon dioxide) and sulfureted hydrogen, as well as with the "sewer gas" arising from decaying excrement. Human fecal matter also polluted the water directly. Under normal circumstances, the environment contained sufficient natural disinfectants—that is, sunlight, air, and soil—to purify these bodily by-products. But when too many people were packed into too little space, these natural processes of purification were overwhelmed. Dangerous accumulations of filth thus poisoned the air and water, providing the ideal breeding ground for germs. This imbalance was potentially dangerous wherever it occurred, but particularly so in the home, where people spent so much of their time.[22]

Henry Hartshorne, the first professor of hygiene at the University of Pennsylvania Medical School, eloquently summed up the problem in his domestic manual, *Our Homes,* published in 1880. "Apart from human interference, there is in nature a balance of formation and destruction, of life and death, food and waste, making a perfect natural economy everywhere," he wrote. Then "Man comes in with his artificial constructions, and sweeps away much of this economy of

nature," resulting in "foulness of the earth, water, and air; stench, miasma, pestilence." Hartshorne concluded, "A guerilla warfare seems to be waged all around the invader of nature." In order to become healthy again, communities must "restore the original balance of primeval nature, by providing for the reappropriation of the products of life and the results of death and decay around us."[23]

Early converts to the germ theory simply added microbes to this already dangerous state of pollution. Wherever foul air and water were allowed to accumulate, they argued, germs were sure to follow. The result was a two-pronged assault on human health: prolonged exposure to vitiated air and impure water weakened the body's overall resistance, making it easier prey for microbial enemies; then, when disease germs were introduced, the inhabitants had little chance to escape illness and death.[24]

The first generation of preventive strategies promoted in the name of the germ theory simply commandeered the sanitarians' longstanding obsessions with domestic architecture, particularly as it related to ventilation and plumbing. In this regard, disease prevention began literally with the home's foundations; Victorian homeowners were urged to build their dwellings on dry soil, to prevent the dampness that encouraged decay and germ life, and to maximize their exposure to the "natural disinfectants" inimical to bacteria, namely fresh air and sunshine.[25]

In the older manuals, the need for ventilation was presented as a defense against accumulations of the gases thrown off from the lungs. Domestic guides contained precise directions concerning the proper ventilation and proportioning of rooms, especially sleeping chambers, to ensure that enough cubic feet of air per occupant was available to dilute organic matter in the air. Many included instructions on how to rig windows with simple "ventilators" made of wedges and boards to circulate fresh air without creating dangerous drafts. The newer, more germ-oriented manuals contained exactly the same recommendations regarding ventilation, but their instructions were endowed with the additional virtue of diffusing the bacterial "clouds" in the air. T. J. MacLagan put the premise simply in the *Popular Science Monthly:* "Keep the windows shut, and you keep the germs in; open them, and they pass out with the changing air."[26]

The obsession about ventilation went hand in hand with a preoccupation with household plumbing. "Ours is the Age of Plumbing,"

emphasized Henry Hartshorne, and hygiene writers continually emphasized that if a family did not attend to its toilets, the rest of its protective rituals would be rendered worthless. Even the simplest domestic hygiene manuals included lengthy, detailed discussions of the complexities of traps, water closets, and soil pipes needed to prevent fecal contamination of the domestic water and air supply. Initially advocated as a defense against dangerous sewer gases, these measures were subsequently transformed into protections against the bacteria that these gases supposedly carried into the home.[27]

Late-nineteenth-century hygienists advocated as the bare minimum of precautions against sewer gas and its accompanying germ life: complete separation of the drinking and waste water systems; water closets that flushed thoroughly to prevent the accumulation of wastes; watertight pipes to conduct wastes into the sewer; traps on all drains to prevent the discharge of sewer gas back into the room; and a special soil pipe running up the side of the house and venting above roof level to allow the safe conduct of gases away from the home. Writing in a Staten Island missionary paper in 1878, one author confidently claimed of the soil pipe, "With one of these simple appliances out-of-doors, a cellar tight and dry, and indoor drain pipes without material leakage, domestic life would be secure from the worst of its invaders."[28]

Plumbing of this complexity required outside assistance. Sanitary authorities recommended that homeowners hire only the best plumbers and carefully supervise their work. J. Pridgin Teale designed his popular "pictorial guide to domestic sanitary defects" so that the homeowner might "test every sanitary point, one by one, and as he goes round book in hand, . . . catechise his plumber, his mason, or his joiner." Those renting or buying a home were advised to use the "peppermint test," which involved introducing oil of peppermint into a water closet and sniffing to see if the aromatic odor leaked out elsewhere in the house. The appearance of its telltale scent indicated the presence of plumbing defects that might taint the domestic air with sewer gas or germs.[29]

Domestic guides included other instructions for testing and purifying the household water supply. Warning that appearance, taste, and smell were not enough to determine water's safety, they urged householders to filter or boil all drinking water in order to remove noxious organic matter and kill disease germs. Many manuals in-

cluded instructions for constructing simple home filters of sand, charcoal, and cloth. "But really suspicious water should, before using it for drinking or cooking, be boiled as well as filtered," advised Hartshorne in 1880.[30]

In general, a high level of household cleanliness was recommended as a safeguard for domestic health. Under the old sanitarian code, any accumulation of decaying matter or dirt, especially in association with damp and darkness, was regarded as a potential breeding ground for the invisible agents of disease. The association of airborne dust, soilborne spores, and pathogenic microbes in early conceptions of the germ theory only intensified the menace of household dust and dirt. As a domestic manual compiled in 1887 for the Association of College Alumnae explained, "The general acceptance of the germ theory of disease makes it imperative for every housekeeper to guard against all accumulations of dust, since such accumulations may harbor dangerous germs." Echoing earlier hygiene reformers, the ACA manual urged women to break with the dominant Victorian aesthetic and choose less dust- and germ-friendly home furnishings: "To propitiate the goddess of health we can well afford to sacrifice on her altar the superfluous draperies, carpets, and ornaments of our living and sleeping rooms."[31]

Even more extreme precautions were required when nursing family members through an infectious ailment. Hygiene manuals routinely included a chapter spelling out the proper conduct of a "home hospital." To aid the patient's recovery as well as protect others from contagion, homeowners were urged to choose a light and airy chamber, strip it of carpeting and drapes, and hang a sheet drenched in a strong disinfectant, preferably carbolic acid, at the doorway. Manuals stressed that the patient's evacuations should be immediately disinfected and removed from the house. The careful observance of such isolation measures was portrayed as a duty not only to one's own family but also to the whole community. As T. J. MacLagan concluded in his article on typhoid fever, "It rests with those who have such ailments in their houses to carry into effect the measures calculated to destroy and get rid of the poison, before it has had time or opportunity to be a source of danger to those around."[32]

Traditional concerns about "fomites," a term applied to any object thought capable of conveying infectious material, were greatly heightened by the germ theory of disease. Hygiene reformers

warned that many common objects could harbor the particles of disease for long periods of time. For example, a circular on scarlet fever distributed by the Massachusetts State Board of Health cautioned that the contagion could be transmitted by "air, food, clothing, sheets, blankets, whiskers, hair, furniture, toys, library-books, wallpaper, curtains, cats, [and] dogs." The discovery of disease "spores" only reinforced the popular belief that disease particles could lie dormant for many years. In his book *Health in Our Homes* (1887), Joseph Perry told a standard cautionary tale about a cap that had hung in the room of a boy who died of scarlet fever and had been "put away in a closely covered tin box without disinfecting." When his younger brother wore the cap two years later, he promptly fell sick of the same disease, furnishing conclusive proof of the contagion's "tenacity," in Perry's words. To avoid such tragedies, parents were warned to destroy clothing and toys used by sick children, a practice immortalized in Margery Williams's classic children's story, *The Velveteen Rabbit*.[33]

At a time of high mortality rates for children, disease prevention in the nursery consumed whole chapters of many domestic advice manuals. The importance of location was illustrated by a story in Emma Hewitt's 1888 manual about a woman whose children kept having "recurring diphtheric symptoms" because she kept them in a basement workroom during the day; after the family physician advised her to move the children's daytime nursery upstairs, "the change was almost magical." Hygiene writers instructed parents to place the nursery on an upper floor, to furnish it sparsely, and to keep their children out-of-doors as much as possible. At night, they were to be placed in single beds so that their "exhalations" would not mingle (a recommendation also given for adult sleeping arrangements). As a precaution against illness, particularly the dreaded "summer complaint," or infant diarrhea, feeding utensils, especially for infants, had to be kept scrupulously clean and their drinking water boiled or filtered. Because milk was thought to be particularly susceptible to absorbing airborne impurities, including germs, parents were admonished to seek a clean, fresh milk supply.[34]

Before and after germs entered the preventive equation, disinfectant use figured prominently in domestic advice as both a special protection in the sick room and a daily precaution against disease. Circulars and home hygiene manuals described at length the prop-

erties of various disinfectants and supplied recipes for inexpensive solutions to be made up as needed. Disinfectants were advocated for a multiplicity of uses: to purify the air of a sickroom, bathe the patient's skin, disinfect excreta, fumigate clothing and linens, wash down a corpse, and cleanse household plumbing systems. Frequent, systematic disinfection was presented as one of the most important precautions that householders could practice, lest, according to an 1885 New Hampshire State Board of Health circular, "by neglect the health of the family may suffer."[35]

Victorian Women and the Cultural Work of Cleanliness

In the late 1800s, public health experts and lay hygiene reformers wrote countless pages elaborating on the need for domestic disease prevention. How widely or deeply their message cut into the popular consciousness is not easy to determine; the volume of advice on a given subject is no sure guarantee that it was followed. But the gospel of germs developed at a time when affluent Americans set great store by cleanliness and when the image of the "whited sepulcher" had deeper cultural meanings that resonated with the dire warnings about house diseases. Hygienists' laments about the hidden sources of infection in the home were heard by a peculiarly body-conscious and house-proud generation of Americans. Over the course of the nineteenth century, a meticulous attention to personal and domestic cleanliness had become an important marker of high class standing. By assaulting the middle and upper classes' sense of sanitary superiority, hygiene reformers had attacked a cherished aspect of their identity.[36]

The ability to maintain an exacting level of cleanliness, both of the body and of the home, was an essential prerequisite of gentility. A popular 1878 etiquette manual informed its female readers concerning personal hygiene, "On this head, fastidiousness cannot be carried too far. Cleanliness is the outward sign of inward purity." At a time when housing was frequently invoked in class designations, as in references to the "shanty Irish," the "tenement house poor," or the "brownstone classes," social standing was closely tied to a certain style of domestic life, which necessitated not only the latest in modern plumbing but also careful attention to household cleanliness.[37]

In pursuit of gentility, middle- and upper-class families invested heavily in their houses in terms of time, money, and anxiety. The home functioned as a stage for both the intense family life and the elaborate social customs so characteristic of the Victorian era; the necessary props included many difficult-to-clean items, including ornate furniture, plush upholstery, heavy draperies, and wall-to-wall carpeting. The service of formal meals involved maintaining extensive collections of china, glassware, silver, and table linen. Personal hygiene required the installation and maintenance of what were discretely referred to as "modern conveniences," such as water closets, bathtubs, and bedroom washstands. In sum, by the 1870s and 1880s, Victorian Americans had invested heavily in a way of life that stressed the surface cleanliness and order of the home. Thus they were very disturbed when public health experts informed them that their dwellings, particularly the new modern conveniences of toilet and washbasin, were harboring death-dealing agents of disease.[38]

The house disease concept exposed the Achilles' heel of Victorian gentility: by dint of great effort and a horde of servants, individuals and households could acquire the appearance of cleanliness. Yet underneath the most meticulous exterior there always existed the disorderly body, constantly exuding different sorts of "filth." Whatever one's class standing, the physiology of living required the "coarseness" of producing sweat, feces, urine, saliva, and for women, menstrual blood. Although they were quite willing to blame the poor for epidemics, the Victorian gentleman and lady knew in their heart of hearts that the unsanitary enemy was also themselves. Their fears of pollution ultimately stemmed from a basic distrust of all human bodies, including their own.

With these twin themes—the deceptiveness of appearances and the ubiquity of filth—the Victorian social system resonated in powerful ways with the dominant views of infection and disease. Just as the smooth-talking stranger's fine clothes and manners might give no hint of his potential for social perfidy, the cleanest-looking gentleman or lady might also harbor some seed of disease. Likewise the finely kept mansion might give no sign, on the surface, of the dangers that lay within its plumbing or "hidden work." Both the dark and damp parts of the body, and the areas of the house most closely associated with them, figured as natural breeding grounds for disease.[39]

The looming specter of infectious disease turned the sanctuary of the middle-class home into a space fraught with peril. As the New York physician Robert Tomes wrote in the *Bazar Book of Health,* the man who felt secure in his unsanitary "castle" only "shuts himself up in it with his worst enemies." Similarly, an 1874 editorial in the *Sanitarian* presented a frightening antithesis to the image of "Home, Sweet Home" by warning, "From the cellar, store-room, pantry, bedroom, sitting room and parlor; from decaying vegetables, fruits, meats, soiled clothing, old garments, old furniture, refuse of kitchen, mouldy walls, everywhere, a microscopic germ is propagating."[40]

The "whited sepulcher" image had a particularly keen edge for women of the genteel classes. For centuries male artists and moralists had used that trope to describe the female body, to claim that woman's exterior beauty masked hidden filth and disease inside. Although the nineteenth-century "cult of true womanhood" promoted a radically different image of middle-class women as exemplars of moral authority and purity, traditional conceptions of women's bodies as dirty and dangerous lingered. As society's appointed guardians of moral virtue and class standards, middle- and upper-class women had to struggle to rise above their "baser" physical nature, with all its anxiety-laden associations to sexual desire and its disruptive consequences. Through rituals of personal and household cleanliness such as those that Martha Roosevelt embraced, many sought to distance themselves from the image of the "whited sepulcher." To a disproportionate degree, the work of cleanliness, both in symbolic and practical terms, landed squarely in women's cultural domain.[41]

Hygiene manuals placed enormous importance on small details of housekeeping. Stressing the need for exacting sanitary observances, Harriette Plunkett stated in her 1885 text, "Eternal vigilance is the price of everything worth the having or keeping." The careless woman, she warned, only came to comprehend the importance of hygiene "when, too late, she stands beside the still form of some precious one, slain by some one of those preventible diseases that, in the coming sanitary millennium, will be reckoned akin to murders." Joseph Perry echoed this sentiment in his 1887 manual: "Many, very likely, will say that it is too much trouble to take the preventive measures advised." But "in the lives of all who study convenience so closely," he replied rhetorically, "there may come a time when, had

those simple hints been observed, serious illnesses would have been averted, and possibly lives been spared."[42]

Such heavy-handed attempts to inspire guilt and anxiety were not likely to affect the two sexes equally. To be sure, hygiene reformers emphasized that men had important hygienic roles to perform. The use of masculine and feminine pronouns in the texts suggests that men were expected to attend to the general construction and repair of the home, including the plumbing and the cellar, whereas women had charge of home nursing, child care, and general housekeeping. Of course, in middle- and upper-class households, both sexes had ways that they could delegate these responsibilities. Men could employ plumbers or architects to make the house safe, and their wives had domestic servants to do the heavy cleaning. But on a daily basis, the oversight of sanitary practice fell most heavily and unrelentingly on the women in the family.[43]

Both men and women advice givers assumed that female readers had a greater responsibility for and interest in preserving health because their lives were more closely tied to home and family. Even in the more technical areas of plumbing, women were urged to take an active role. In an 1885 treatise, the sanitary engineer George Waring explained that the housewife's work did not end "when her husband has paid a good round sum to the engineer and to the plumbers." Domestic plumbing, he wrote, was either "a means of safety, or an engine of destruction, according as she performs her duty, or neglects it." Along similar lines, Harriette Plunkett's 1885 text, aptly named *Women, Plumbers, and Doctors,* urged her female readers to conquer their fears of "dark, damp spaces" and take charge of the cellar, that "weird, forbidding, and uncanny" region that "belonged naturally to the gentlemen of a household."[44]

Given the continuing scientific controversy about how infectious diseases actually originated and spread, domestic hygiene authors in the 1870s and 1880s placed a surprisingly high level of responsibility on individual households to prevent disease. To the extent that they accepted this responsibility, middle-class women likely found the gospel of domestic prevention to be a mixed blessing. On the one hand, hygiene reformers promised wives and mothers that the scourge of illness could be greatly lightened by scrupulous adherence to a detailed hygienic code of behavior. On the other hand, it potentially laid the blame for illness and death squarely on their shoulders.

As their frequently repeated tales of germ-laden caps and diphtheric rooms made evident, failure to follow hygienists' recommendations could have the most terrible of consequences for mothers: a sick or dead child. In an era when one-fifth of all children died before their first birthday, this emphasis on the preventability of disease had the potential to generate a powerful sense of culpability. The heightened intensity with which Victorian parents mourned their children, a trend often attributed to the smaller size of their families, may also have reflected these determined efforts to cultivate greater parental, and chiefly maternal, responsibility to prevent "house diseases."[45]

The equation of meticulous housekeeping with disease prevention also helps to explain the often strident tone privileged women brought to their already tense relations with their working-class servants. Lapses in cleaning not only transgressed the code of gentility and endangered the family's social standing; they also put the household at risk from potentially mortal "filth" diseases. Underlying the late-nineteenth-century "servant problem" so endlessly bemoaned in the popular women's literature lay the special burdens of safeguarding the home against infection that the concept of "house diseases" placed on both mistress and servant.[46]

For some middle-class women, this sense of responsibility for guarding the home ultimately impelled them to forsake its limited domain; the gendered division of labor that cast men as experts and lawmakers and women as vigilant wives and mothers proved too confining. Like Plunkett, some began writing about public health issues in domestic manuals and newspaper columns as a way of educating other women about disease prevention; others became active in neighborhood sanitary associations and reform politics. For a few, the emphasis on women's obligations to prevent disease became a rationale for pursuing professional careers, as I will discuss further in Chapter 6. As Plunkett correctly foresaw in 1885, for women, "a new sphere of usefulness and efficiency opens with the knowledge that in sanitary matters an ounce of prevention is worth a ton of cure."[47]

Through varied types of print media, the basic concepts of domestic disease prevention were widely disseminated among the affluent urban classes by the late 1880s and early 1890s. The sanitarians' long-standing efforts to pathologize the home led to the relatively rapid

notice of the germ theory, which in turn reinforced the basic tenets of the sanitary gospel. Although hygienic measures of ventilation, sanitary plumbing, disinfection, and water purification were widely accepted before the invocation of the germ theory, the added threat of the microbe gave them renewed force in the late 1800s. Contrary to the worst fears of older sanitarians, the gospel of germs did not weaken the connection between a clean, moral life and safety from disease. Instead, in the words of Emma Hewitt, the new scientific discoveries "placed in the hands of every one, if not the power of destroying these germs, at least the power to prevent their proliferation" by the practice of "antiseptic cleanliness" in the home. For Victorian women, this new knowledge brought both a new sense of power and a heavy load of guilt.[48]

3 · Entrepreneurs of the Germ

In mid-August 1881, the well-known sanitary engineer George E. Waring arrived in Washington, D.C., on a mission of national importance. The preceding July 2, the President of the United States, James A. Garfield, had been shot in the back by a would-be assassin named Charles Guiteau. Installed in a "home hospital" set up for him in the White House, the President seemed to improve briefly, then began to run a persistent fever that slowly sapped his strength. The distinguished medical men treating Garfield attributed the fever to the gunshot wound, but as he steadily weakened, the press as well as some of his advisers began to wonder if his health was being undermined by another, more subtle danger, one that required a specialist to detect. Thus George Waring was called to the White House to determine if the President was being poisoned by sewer gas arising from the mansion's antiquated plumbing.[1]

Today, Waring's mission seems ridiculous. From a modern perspective, it appears obvious that Garfield died from the consequences of his bullet wound, not from sewer gas exposure. But the White House sanitary scandal shows how differently late-nineteenth-century Americans understood the nature of infectious disease and the role of houses in spreading it. As of 1881, the sewer gas menace was so widely appreciated that both sensation-seeking journalists and respectable sanitary engineers regarded it as a plausible explanation for the President's declining health. Thus the White House story provides a good starting point for examining how the threat of house

diseases was understood and acted upon in the late-nineteenth-century American home.[2]

By the early 1880s, middle-class Americans' apprehensions about their homes had become fertile ground for a new species of entrepreneurship. Like George Waring, inventors, engineers, plumbers, and manufacturers had discovered that disease-proofing houses and other buildings could be a lucrative line of business. The evolution of these commercial services allows us to move beyond advice books to consider how affluent Americans began to act upon their concerns about disease. Given that few Victorian householders confided details of plumbing renovations or disinfectant purchases to their diaries and letters, evidence about such matters found in patent applications, advertising brochures, trade journals, and business records is particularly helpful in tracking hygienic practice. The evolution of sanitary entrepreneurship opens a useful window into the search for security that transformed the landscape of the American home, from the President's house to the tenement house, in the late nineteenth century.[3]

Of course, marketplace trends do not reflect perfectly popular beliefs and behaviors. Entrepreneurs invoked only those lessons of sanitary science and the germ theory that justified the sale of their particular product. Many businessmen sought not only to appeal to what public health experts might regard as reasonable fears, but also to exaggerate and intensify those fears in unscrupulous ways. Yet allowing for this distortion and exaggeration, tracking the rise of domestic sanitary services illuminates how concerns about infectious disease transformed the customs of everyday life.

The growth of sanitary entrepreneurship confirms that well before the germ theory gained widespread acceptance, householders had already started to update their plumbing in response to the zymotic theory of disease. In the 1880s, the sanitary trades began to invoke the discovery of microorganisms chiefly to promote new versions of old sanitary standbys, such as sewer traps and disinfecting devices. In so doing, entrepreneurs shaped their conceptions of the germ to conform to prevailing fears of sewer gas. The initial efforts to "germ-proof" the American home focused primarily on its portals to the sewer system—namely, the modern conveniences of toilet and washbasin.

The White House Plumbers

The White House sanitary scandal provides a dramatic example of the house disease concept in action just at the point when the germ theory of disease began to figure in both public debates and entrepreneurial initiatives. The 1881 controversy capped off decades of concern about the executive mansion's healthfulness. As did the city of Washington itself, the mansion at 1600 Pennsylvania Avenue had a long reputation for breeding fevers due to its proximity to the Potomac marshes. Built in 1817 to replace the original building that the British had burned during the War of 1812, the White House's water closets and sewer lines had been updated in only a piecemeal fashion. By the late 1870s, its plumbing defects had come to seem not only undignified but also positively dangerous.[4]

Several years before the Garfield controversy, the officer in charge of the White House building and grounds had recognized that the President's home fell far short of the sanitary standards observed in the better homes of the era and had begun the work of updating it. Because Congress had to approve any appropriations for its improvement, the officer had to make a strong case for every penny spent. In 1879, he managed to convince a stingy Congress to finance an overhaul of the White House plumbing. Standard devices were added to exclude sewer air, old water closets were replaced with more sanitary models, and an "upright side sash ventilator" was installed above the winding staircase to increase the flow of air to the upper floors.[5]

These repairs did not suffice to give the house a clean bill of health, however. Soon after Garfield was inaugurated in the spring of 1881, the new First Lady, Lucretia Garfield, fell ill of a prolonged and serious fever, which some observers immediately blamed on the house. An indignant *Baltimore American* reported, "The Potomac Flats have . . . filled up so much lately that they back the sewer gas right into the President's House, and Mrs. Garfield is suffering from that form of poisoning." The paper urged that "that old and shabby mansion [be] completely renovated or a new one built." Mrs. Garfield's illness prompted the new officer in charge, Colonel Almon F. Rockwell, who had a degree in medicine as well as engineering, to order more plumbing renovations—including better traps and ventilation of the house's connection with the main sewer line—and to modernize the west-wing bathroom.[6]

Sensing that profits were to be made in "doctoring" houses, sanitary entrepreneurs immediately tried to cash in on Rockwell's renovations by using their Capitol Hill connections. E. E. Rice, the inventor of "Rice's Patented Ventilation System," called in favors from an Iowa Republican, Senator William B. Allison, who wrote Rockwell testifying to what Rice's system had done in his own home; another Republican, former Senator Eppa Hunton, wrote Garfield directly, urging him to make the executive mansion a "healthy habitation" by installing Rice's device. With an unctuous tone, Hunton wrote, "I hope in the multitude of your official cares you will take time to consider the question," and he assured the President that the system would not cost more than $4,000. "I don't think the country quite willing to see [Vice-President] Arthur President and always willing to spend money to secure the health of its Chief Magistrate and his family," he concluded.[7]

But before Rockwell could decide among the many claimants for his sanitary patronage, President Garfield was shot on July 2, 1881, as he prepared to leave the capital for a vacation. He was taken immediately to the White House, where his physicians found that the bullet was lodged too deeply in his back to be removed safely. A lower chamber in the mansion was transformed into a "home hospital," and for a brief time Garfield appeared to rally. Then, in mid-July, he began to run a chronic, wasting fever that worried his medical attendants. In testimony to the widespread appreciation of Lister's work by 1881, critics immediately suggested that antiseptic procedures had not been followed carefully enough in handling the wound, a charge that Garfield's doctors vigorously denied.[8]

Harkening back to Mrs. Garfield's illness, some commentators began to wonder if the President was being harmed by the "malarious influence" exerted by the Potomac Flats. In late July, the *New York Herald* took up the sewer gas issue in its customary sensation-seeking style. For one story, *Herald* reporters interviewed a "well-known plumber" who confidently asserted of Garfield's case that "the real trouble is sewer gas, which is ten times as bad and even more poisonous" than simple foul air and claimed that "there is not a perfect working [sewer] trap in the Executive Mansion." A few days later, another intrepid *Herald* reporter described touring the odoriferous Potomac Flats with a "well known scientific gentleman of this city" and finding "masses of fecal matter and filth" floating in the water.

"Your nose is a good and safe guide," the "scientific gentleman" reportedly said, "and it has already told you that the air we are breathing is charged with the germs of disease." That same air, the "doctor" pointed out dramatically, was blowing in the direction of the White House where the feverish President lay in his sick chamber.[9]

Sanitarian-minded well-wishers were quick to respond with suggestions about protecting the President against sewer gas. After reading in the *New York Herald* about the sad state of the White House plumbing, the Sanitary Committee of the Master Plumbers of New York sent Colonel Rockwell a long letter filled with criticisms of the White House sewer traps and offering to help out in the crisis for free, "having the wellfare [sic] of the President and his family at heart." In a similar spirit, various inventors offered their devices for protecting against sewer gas, such as the ornamental street lamp, which was recommended by the firm of Ogilvie and Bennem as "a simple, effectual and economical method of destroying the poisonous gases emanating from sewers, and preventing the transmission of the same into buildings." In a sharper tone, E. E. Rice, whose overtures Rockwell had neglected the previous spring, offered to install his device, observing, "It was unfortunate that my improvements had not been made before the President was shot—it would have saved expense, unpleasant feelings, & accomplished all & more that the present arrangement is claimed to," a reference to the patent air-conditioning device Rockwell had installed to make the President more comfortable.[10]

In public, the President's physicians dismissed the notion that his fever had anything to do with sewer gas. But in private, Garfield's inner circle of advisers worried about the growing controversy. Hoping to put the matter to rest, the Attorney General of the United States, Wayne MacVeigh, finally suggested that George Waring be called in to inspect the White House plumbing. Rockwell agreed to the plan.[11]

Colonel Waring, as he was called in deference to his Civil War service, was a logical choice for this delicate mission. His rapid rise to national prominence attested to the growing salience of the "house disease" problem in the 1870s. Originally a specialist in agricultural drainage, Waring became interested in home sanitation in the late 1860s and gained widespread fame with his writings on the subject in the *Atlantic Monthly* (1875) and *Scribner's* (1876)—articles

that were later reissued in book form. When a devastating yellow fever epidemic hit Memphis, Tennessee, in 1878, President Rutherford B. Hayes sent him to oversee improvements in the city's drainage. Even more relevant to the crisis at hand, Waring was familiar with the capital city's drainage problems. In an 1880 lecture delivered at the Smithsonian Institute, he had warned that sewer gas arising from the city's homes posed a far greater danger to health than did the notorious Potomac Flats, not only because of the gas's "own direct action" but also because "it so often acts as a vehicle for the germs, or causative particles of specific diseases."[12]

On August 23, 1881, Waring delivered a preliminary report on the White House to Rockwell. Without taking up the floors or breaking into the walls, which might have disturbed the ailing President, he stated that he could only guess at the quality of the "hidden work" in its interior. But based on what he could see, the house was in "a very much less unsafe condition than current reports would lead one to expect." Yet Waring confirmed that "the plumbing appliances of the Executive Mansion do not conform to what are now accepted as the necessary sanitary requirements of a safe dwelling." For example, the large basement kitchen had a sink with such a large trap "as to constitute a permanent cesspool." Upstairs, all sorts of improperly trapped pipes prevented the "free discharge of filth." The water tank that supplied the house sat in an upper room that was "practically a water closet" due to contamination from the improperly ventilated bathroom directly below it. Most worrisome, in the light of the President's illness, Waring found that the room next to his sick chamber had a bathroom with an old-fashioned "pan closet" served by an circuitous and unventilated soil pipe. The report concluded with a list of emergency repairs to be done immediately.[13]

The attorney general wrote Rockwell in early September, urging that Waring's report, if "favorable," be summarized and released to the Associated Press. "It would allay, I am sure, much apprehension about the present unhealthy surroundings of the President," he reasoned. But not surprisingly, Rockwell did not comply; although Waring meant his report to be reassuring, his frequent allusions to cesspools, filth, and foul decomposition hardly made the White House seem like a healthy place for the President's recovery.[14]

Although Garfield's medical attendants never gave any public credence to the sewer gas theory, Waring's inability to give the White

House a clean bill of health may have entered into their decision to move the President to his summer home in New Jersey, despite fears he would not survive the trip. Two weeks after Waring submitted his preliminary report, on September 6, Garfield was taken from the White House, but the change did not improve his condition. He died in New Jersey on September 19. The autopsy revealed that the immediate cause of death was a ruptured aneurysm of his splenic artery, damage probably traceable to either the bullet or the probes used to locate it.[15]

But the controversy over the sanitary state of the White House did not end with the President's death. Waring's report was released posthumously, and even the sober *New York Times,* which had steered clear of the *Herald*'s sewer gas crusade, carried long excerpts from the piece. The *Sanitary Engineer* published it in full, along with a scorching editorial lamenting that it had taken "some great calamity," such as "Mrs. Garfield's illness and the President's lingering sufferings," to bring the White House's defects to light. "The blame rests with Congress, who, by their niggardly appropriations, have made it impossible to correct the blunders that for several years have been apparent to those who have been familiar with the White House, but who could not secure the necessary funds to defray the expense of remedying them." The editorial concluded that until the mansion's plumbing "is pulled out and entirely reconstructed, the White House will be behind our better class of tenement-houses in this important particular."[16]

The new President, Chester Arthur, was so convinced of the White House's derelict condition that he refused to live there until the plumbing was redone. Under his watchful eye, Rockwell proceeded with the renovations that Waring had recommended in his preliminary report. But high anxieties and professional rivalries typical of the business of treating house diseases hampered progress on the project. Already committed to a consulting job for the French government, Waring had to oversee the White House renovations from overseas. In his absence, Rockwell decided to use the local plumbing contractor who usually did the White House work rather than the expensive Boston firm Waring had recommended. When Waring learned of the change, he wrote indignantly from Paris that he could not have these all-important repairs done by a "plumber of whom I know nothing" because "my reputation is now involved in the matter and I shall be held accountable for work that I doubt."[17]

No doubt with a nervous Chester Arthur looking over his shoulder, Rockwell compromised with Waring; he agreed to purchase the custom-made materials Waring had ordered and to hire one of Waring's assistants, William Paul Gerhard, to supervise the local plumbers. From then on, the renovations proceeded smoothly, and the White House's antiquated plumbing was replaced with new airtight pipes and state-of-the-art sewer traps and venting systems. The old water closets were replaced with white earthenware toilets that Waring had designed himself. He described his new "Dececo" model as flushing so completely that no "foul matter" could remain. It also stood free from the wall and was surrounded by white tiles instead of being encased in a wooden cabinet, so that "the whole apparatus is in full view" and no filth could accumulate in its hidden work. Seizing the entrepreneurial moment, the companies that manufactured the Dececo toilet and patented sewer trap that Waring had chosen began to advertise their goods with the slogan "recently used at the White House."[18]

In his final report, Warning certified that the White House was now safe to be lived in, but he insisted that more renovations were needed if the first family continued to use the mansion as a residence. Because the very ground on which the house sat had become saturated with sewage, Waring recommended "as a most important sanitary measure" that the whole building be raised on "piers and groined arches . . . to secure a complete separation between the ground and the building." President Arthur used Waring's report to seek Congressional support for a more radical solution—namely, to pull down the White House and rebuild a more sanitary replica, complete with modern plumbing, to the south of its present site.[19]

So powerful was the "house disease" concept that in June 1882, the Senate actually approved $300,000 for the construction of a "good, healthy, and convenient dwelling place" for the President and his family adjacent to the old building. But sentiment in favor of preserving the historic mansion eventually prevailed, and the House of Representatives never passed the bill. Chester Arthur had to be content with a thorough sanitary overhaul of the existing building. The sanitary engineers and plumbers once again took over the White House and replaced the old sewer lines underneath it with sturdy cast-iron pipe. During the four-year Garfield-Arthur administration over $110,000 was spent on the mansion, the largest outlay on its

maintenance since its destruction by the British almost seventy years earlier.[20]

Entrepreneurs Discover the Germ

As the White House controversy reveals, by the time the germ theory of disease had begun to gain widespread public notice, both anxieties about sewer gas and commercial sanitary services were firmly established on the American scene. Much as converts to the germ theory commandeered the truths of sanitary science to craft their own preventive gospel, sanitary "experts" sought to expand their profits by incorporating the germ menace into the already booming business of domestic disease prevention.[21]

To this end, entrepreneurs of the germ sought to convince homeowners who thought their homes were sufficiently disinfected, trapped, and ventilated that they were wrong, that "true" protection required adding a new germicidal element to the home's sanitary defenses. In making this argument, entrepreneurs of the germ employed many of the same arguments found in the popular advice literature of the day. Their appeals illustrate not only how easily the germ sell was incorporated into existing rationales for household disease control, but also how the germ's commercial champions sought to unsettle homeowners' confidence in their existing state of safety from house diseases.

The marketing of disinfection aids illustrates both of these trends. Under the aegis of the zymotic theory, manufacturers had introduced a wide range of new chemical disinfectants that supposedly neutralized disease "ferments" more effectively than did the old lime and sulfur standbys. By the early 1880s, consumers could choose among solutions of carbolic acid, potassium permanganate, sulphate of iron (also known as copperas), and chloride of zinc, as well as patent disinfectants that combined a variety of agents in a unique, "secret" formula. As the germ theory gained recognition, disinfectant manufacturers were quick to use it as a way to gain a competitive advantage in a crowded marketplace. The protective powers of disinfectants had to be redefined to include the capacity to kill germs as well as neutralize chemical impurities in the air. Some companies played the germicidal angle by naming their products "Listerine" or "Pasteur's Marvellous Disinfectant," in homage to prominent figures

associated with the germ theory. Others sprinkled their advertisements with terms such as "germ-destroyer" and "germicide" and claimed that the growing authority of the laboratory supported the merits of their product.[22]

By 1884, the claims for protection were so many and so outrageous that the American Public Health Association appointed a committee, headed by the surgeon George Sternberg, to test the germicidal properties of the disinfectants in common use. Carefully distinguishing a product's effectiveness in killing germs from its efficacy in removing foul odors from the air and in arresting the processes of decay, the committee took as the true test of a disinfectant its ability to kill pathogenic bacteria. By this test, most disinfectants came up sadly wanting.[23]

Sternberg's committee railed against the claims being made for the germicidal properties of disinfectants. For example, Sternberg wrote, "Pasteur's Marvellous Disinfectant" was virtually useless, "yet this fluid is by some contrivance, to be thrown into the water-closet of every germ-fearing citizen when he pulls the handle, so that it may catch the germs on the fly, and extinguish their power for mischief before they reach the sewers." Sternberg stressed the importance of a more modern disinfectant practice, stating, "The time has passed when *pater familias* can complacently congratulate himself upon having disinfected his house with a bottle of carbolic acid, which he has brought in his vest pocket from the corner drug store." But for all his pleas for rigor in evaluating these compounds, Sternberg's committee inadvertently contributed to the growing appeals to "science" in marketing disinfectants. Almost as soon as he published his first study of commercial disinfectants in the 1885 *Medical News,* the makers of Wither's Antizymotic Solution began (falsely, as it turned out) claiming that he had endorsed it as "the best" disinfectant.[24]

Given the complete lack of regulation in the late 1800s, disinfectant manufacturers were free to make any claim that they liked, regardless of its basis in fact. More to the point here is that entrepreneurs moved swiftly and surely to add the promise of germ protection to their list of a product's virtues. At the same time, they did not abandon older claims to neutralize foul smells or arrest the processes of decay. Although public health experts continually denigrated the connection between foul smells and disease, consumers evidently still preferred disinfectants to be powerful deodorants. Thyme, eucalyp-

tus, and pine were particularly favored as antidotes to foul odors and the germs that they supposedly carried. As an advertisement for the "Botsford Automatic Fountain" explained in 1893, "Thymol and eucalyptus are perfect germ destroyers and preventatives of disease from noxious vapors."[25]

Given the prevalent fears of sewer gas, household plumbing devices were another prominent site for germicidal improvements. Entrepreneurs had already discovered that water closets, sewer traps, and the like were a profitable line of trade. As the germ theory gained acceptance, they simply took existing devices for dissipating sewer gas and added chemicals or intense heat to kill disease microbes. Patent applications and advertising copy stressed that these new designs went beyond the mere "mechanical" protection offered by old-style sewer traps to offer a more complete degree of sanitary security. As the brochure for Tayman's Disinfectant and Fumigating Company of Philadelphia explained, "Experience abundantly proves that mechanical devices are insufficient, that we must seek the aid of chemistry and obtain some agent that will antagonize and destroy the seeds of diseases."[26]

In making claims for germ protection, entrepreneurs sought to put germs on an equal footing with the noxious gases that were already considered dangerous. For example, in his 1883 patent for an "apparatus for eradicating sewer-gas and destroying germs," Frederick C. Hubbard explained, "Heretofore all efforts have been directed toward counteracting the odors of sewer-gas, urinals, etc., and no combinations of disinfectants have been combined with agents for destroying the germ that arises from fungus growth in the sewer-pipes." His invention solved that deficiency by continuously dripping a combination of three disinfectants into the water closet. Similarly, George W. Beard's sewer trap and ventilator, patented in January 1886, supposedly neutralized all three dangerous elements in sewer gas—carbonic acid, sulfurated hydrogen, and germs—with a complex system that combined a current of electricity with a gas flame.[27]

No doubt because of the ease of piggybacking the germ danger onto the established threat of sewer gas, the germ sell appeared first and most forcefully in the promotion of toilets, sewer traps, and the like. Entrepreneurs were somewhat slower to develop the commercial potential of household water filtration systems. From a modern perspective, this delay seems odd, because water filtration ultimately

offered greater sanitary protection than did traps for sewer gas. But the dangers of aerial infection had so long dominated both scientific and popular thinking about infection that fears of sewer gas initially overshadowed concerns about waterborne germs. Only gradually, as the bacteriological certainty about waterborne disease increased, did protecting the domestic water supply begin to take on the same importance as neutralizing the dangers of the toilet.[28]

Starting in the mid-1880s, companies in large cities, where concern about public water supplies traditionally was great, began to market domestic filtration systems that saved the trouble of having to boil drinking water. In Philadelphia, for example, where the water gained an especially poor reputation after many visitors to the 1876 centennial celebration developed diarrhea, the Hyatt Pure Water Company marketed filters that could clean from one-and-a-half to eight gallons of water per minute. A list of patrons given in its 1890 brochure included such prominent Philadelphians as the publisher Alexander McClure and the banker Anthony J. Drexel. For less affluent customers, the Sub-Merged Filter Company of Philadelphia sold a simple charcoal and sand filter that could be attached to a water cooler or home water reservoir. The company brochure assured the reader that its filters could remove all the filth from Schuylkill River water, along with "the innumerable minute worms" that throve there. As did purveyors of sewer gas devices, water companies often promoted their services by disparaging the protection offered by competitors. For example, the Hyatt Company, whose filters incorporated a special coagulant to remove bacteria, dismissed filters that lacked that capacity, explaining that "the smallest micro-organisms found in water are about 1/25,000 part of an inch in size, and for these companies to assert that their filters remove them without coagulation is unjustified."[29]

Selling the Germicide

The history of the Germicide Company allows us to see in more detail how one group of entrepreneurs tried to cash in on the revelations of the germ theory. The Germicide was a disinfectant dispenser that attached to a toilet. It was invented and patented in 1880 by Edward J. Mallett, Jr., of New York City, who was described in credit reports as a "g[oo]d square man of considerable ability" making a

comfortable income from patents on his various inventions. His invention attracted the interest of a New York City collection agent, Leopold Cohn, who invested about $8,000 to manufacture and market the device. Leopold's son Casper L. Cohn became general manager of the new Germicide Company, and after it proved successful in New York City, he set up similar companies in Boston, Chicago, Cincinnati, Baltimore, Philadelphia, and Washington, D.C.[30]

The company's first brochure, published in 1882, described the Germicide as a "simple and neat contrivance made of Black Walnut" that dispensed two disinfectants: chloride of zinc, which dripped into the toilet basin and supposedly created a germicidal water-barrier against sewer gas; and thymol, which sprayed into the air to kill bacteria every time the toilet lid opened or closed. The device was rented rather than sold, and thus "requires no attention whatever from the inmates of the house, as it is always under the supervision of the Company's uniformed, experienced inspectors." The cost of installation and monthly service was fifteen dollars a year, a sum the brochure claimed was low enough "to bring it within the means of the most humble householder."[31]

The description of the device was followed by a series of medical testimonies to its efficacy. Appropriately, C. L. Cohn started with a quote from John Tyndall on the germ theory of disease and noted that "although the reception of the germ theory of disease has been gradual, it may now be said to be clearly established in the public mind." Fusing the dangers of sewer gas and the germ, he made the usual arguments about the need for chemical as well as mechanical protections. He assured readers that *"there is no safety or security in any other method"* and that only the Germicide offered real protection "from the insidious foe that stealthily enters our homes and destroys our happiness."[32]

To buttress his claims, Cohn provided lengthy scientific testimonials from various public health authorities. For example, R. Ogden Doremus, a physician and professor of chemistry and toxicology at the Bellevue Hospital Medical College, reported on a series of experiments that he had conducted in 1882 at the New York Academy of Medicine. The experiments demonstrated that the gases commonly found in sewers could pass through brick and brownstone walls, as well as through the water seals used in conventional sewer traps. Doremus stressed the difficulty of detecting this danger, "as I know

and feel most keenly in the recent loss of a beloved member of my family" (a reference to his young son's recent death from typhoid fever). To stop "vile gases and disease-breeding germs" from entering the home, Doremus heartily recommended the rental of a Germicide.[33]

The technical details included in this and subsequent editions of the Germicide brochures indicate that its promoters aimed primarily at a sanitarily sophisticated clientele, that is, the sort of audience who could understand the arguments for chemical over mechanical means of protection. In turn, the endorsements of eminent doctors and scientists were used to impress a less learned public. To this end, the brochures included ever-longer lists of physician patrons in various cities, as well as institutions that had installed the device. The list for Philadelphia included the microscopist Joseph Richardson, an early advocate of the germ theory, as well as the redoubtable hygiene expert Henry Hartshorne; in New York City, the *Herald*, that journalistic scourge of sewer gas, reported that its Germicides gave satisfaction. Humble homeowners who had installed the device could be gratified to know that they were in the same sanitary company as New York's Union Club, Philadelphia's Continental Hotel, and Chicago's Public Library.[34]

A credit report on the Pennsylvania Germicide Company filed in 1884 by an agent of R. G. Dun and Company stated, "The Direction is a very respectable one, composed of leading Lawyers and Physicians[,] and has good prospects of success." An 1886 follow-up concurred that "the officers are men of g[oo]d standing & push this enterprise with zeal," and said of the device, "It is a sanitary remedy that appears to have given consid[erable] satisfaction & is becoming generally extended in its use." Starting in 1884 with $10,000 in cash to cover the manufacturing and servicing costs, the Philadelphia branch installed two thousand Germicides within the first year, doing brisk business among private residences, hotels, and other public institutions. The Pennsylvania Germicide Company continued to prosper until 1888, when problems with the apparatus and the rental arrangement led to customer dissatisfaction. The company was reorganized that year, but no further credit reports were filed so its subsequent history remains unknown.[35]

Whatever its eventual fate, the long-term success of companies such as the Germicide was ultimately limited by the ability of the established

sanitary trades, particularly plumbing manufacturers, to provide similar protective services. A Dun report on a contemporary of Cohn, H. P. Clement—whose company, the New York Scientific Sanitary System, installed a patent device to exclude sewer gas from the home—pointed to this element of competition. "He seems to have uphill work to get his system introduced, although it is said by those having them in their houses to be the only perfect system known for the total exclusion of sewer gas from dwellings," the agent wrote in 1883. He concluded that Clement was "determined to fight it out and get his machines known, although he has the plumbers vs. him."[36]

Practical Sanitarians and the Germ Theory

Small entrepreneurs such as Cohn and Clement faced increasing competition as sanitary engineers, plumbing contractors, and plumbing manufacturers all realized the profitability of the germ sell, especially when piggybacked with the fear of sewer gas. The coverage of the germ theory in the *Sanitary Engineer,* the premier journal of the sanitary trades, suggests how easily the microbial menace was added to their approaches to the prevention of filth diseases. Founded in 1878 by Henry C. Meyer, a successful plumbing manufacturer, the publication aimed at keeping plumbers, engineers, architects, physicians, and interested lay people abreast of the latest developments in sanitary science.[37]

To this end, the *Sanitary Engineer* started at around 1880 to include reports on the progress of the germ theory of disease. The reports were not uniformly favorable; for example, the journal expressed reservations (correctly as it turned out) about early claims to have isolated the microbial cause of malaria. Yet on the whole, the *Sanitary Engineer* took a very respectful view of the germ theory's validity. In 1881, the editor acknowledged that the "educated public opinion is demanding more exact knowledge of the causes of disease, and the demand is creating the supply." As an example of the progress of science, he cited the fact that "the announcement by Pasteur, or Koch, or Burdin-Sanderson [sic], of the discovery of a new fact in the life history of some minute and apparently insignificant organism, at once becomes a basis for means of disinfection provided by the chemist or engineer, or for legislation in preventing the spread of disease."[38]

Although it reported favorably on the latest bacteriological discoveries, the *Sanitary Engineer* made clear that engineers already had the necessary technical expertise to deal with the newly discovered threat from disease germs. In response to the kind of arguments presented by C. L. Cohn, the journal staunchly defended the standard sewer traps in use, insisting that water barriers did indeed prevent the passage of germs into the home. In a long, scornful critique of an 1882 *Popular Science Monthly* piece on sewer gas written by Dr. Frank Hamilton, Garfield's onetime surgical consultant, the editor ridiculed the "fallacies" of Doremus's experiments showing that germs could pass through water barriers—experiments that had been cited with such approval in the Germicide brochures.[39]

Plumbing contractors, or "master plumbers," also sought to appropriate the new scientific insights into disease prevention as a way to elevate their prestige and income. Many plumbing firms not only did installations and repairs but also manufactured their own lines of sanitary wares, so it was worth their while to stay up-to-date on the latest theories linking plumbing and disease. Although they had little formal education, many master plumbers prided themselves on being "practical sanitarians" whose hygienic knowledge matched that of their middle-class counterparts in engineering and medicine.[40]

The importance of being up-to-date on matters of sanitary science was stressed at the very first meeting of the National Association of Master Plumbers (NAMP) in 1883. The delegates adopted as one of the group's primary aims "the advancement of the trade in all the latest discoveries of science appertaining to sanitary laws" and set up a sanitary committee to give annual reports on progress in sanitary science. In subsequent years, the NAMP sent a representative to attend meetings of the American Public Health Association and commissioned bacteriological studies of sewer gas.[41]

Compared to the sanitary engineers, the master plumbers were slower to exploit the germ menace, but by the early 1890s, they had clearly begun to incorporate the new views of disease into the justification for their services. After a trip to the American Public Health Association meeting in 1890, Andrew Young assured his fellow delegates, "We stand nearer the health of the home and the sanitation of men's abodes than any others." He contrasted the image of the physician, who arrived at the front door "in broad cloth, silk

hat and gloves" and was treated with every courtesy, with that of the humble plumber, who entered by the back door dressed in "greasy overalls and blouse" and was ignored by servants and family members alike. Yet, Young concluded, it was the plumber who got the real job of disease prevention done, for he was "in the basement, fighting with his skill and scientific knowledge the disease germs invading and threatening the life of the household."[42]

To be sure, many of the changes in plumbing practice came from outside the trade, as cities and towns passed detailed plumbing codes designed to prevent the spread of infectious diseases. Precisely because domestic plumbing became so closely linked to public health, the trade became more tightly regulated after 1880. Although it proved difficult to enforce, a New York law passed in 1881 served as a model of such legislation: it required that the boards of health in New York City and Brooklyn approve all plumbing plans for new housing and maintain a registry of licensed master and journeymen plumbers, and it made violations of the code a misdemeanor subject to fines and imprisonment.[43]

Although they frequently complained that boards of health knew nothing about sanitary plumbing, the master plumbers generally supported the movement toward more stringent codes and registration. By seizing the hygienic high ground, they gained a useful advantage over their less affluent and sanitarily savvy fellow plumbers, who were more likely to run afoul of the regulations. Fostering the image of the "practical sanitarian" allowed plumbing contractors to align themselves with the genteel middle classes whose business they hoped to cultivate, and whose ranks they aspired to, both professionally and socially.

The Triumph of the White China Toilet

Popular anxieties about germ-laden sewer gas and commercial interests bent on assuaging them converged dramatically in the transformation of the late-nineteenth-century bathroom. In its first incarnation, the gospel of germs was perhaps best symbolized by the white china toilet, which became the premier symbol of the bacteria-proof home. George Waring's installation of the Dececo model in the White House proved to be the forerunner of a revolution in design that gave rise to the modern American bathroom.

Prior to the 1880s, bathrooms were designed with the same opulence as other rooms in the home, complete with carpets and heavy drapes. The requisite cast-iron enameled pieces—the water closet, the bath tub, and the washbasin—were encased in wooden cabinetry. In contrast, the new style bathroom abolished cabinetry in favor of a free-standing white porcelain or vitreous china toilet surrounded by white tiles. Not only did this style eliminate the dangers of "hidden work" inside the cabinet areas; it also provided bathroom surfaces that could be scoured more effectively. In addition, the new Dececo model and its imitators had a stronger flushing action, ensuring that no waste materials remained to mar the shiny white interior of the toilet bowl.[44]

The growing identification of the white toilet with state-of-the-art germ protection is neatly illustrated in a tract put out in 1887 by the Sanitary Association of Philadelphia, a group of citizens organized to promote voluntary health reforms. Using a rhetorical device often employed in late-nineteenth-century hygiene literature, the author, identified only as a "Layman," began by addressing a question to the reader: "Have you lost a child, a husband, or other relative from Scarlet Fever, Diphtheria, Typhoid Fever, or other zymotic diseases?" If so, the reader was invited to consider "whether the source of trouble may not be in the water-closet, or in the other plumbing arrangements of your house."[45]

Layman went on to condemn the custom of enclosing the water closet, describing how inside such wooden structures "the organisms escaping with the faeces are carried by the gases into contact with the surfaces surrounding water-closets and may there germinate and decompose, loading the atmosphere with the deadly agents which we have been at so much pains and expense to exclude." To guard against such dangers, Layman called for "skillful mechanics" to turn their ingenuity to making an "ideal water-closet" of porcelain, whose smooth, easily cleaned surfaces would offer no "dangerous lodging places for the invisible foes that sanitary engineers must guard against." Again demonstrating how quickly plumbing contractors picked up on such hygienic suggestions, the Cooper Brass Works of Philadelphia designed just such a toilet in response to the original article, which the Sanitary Association then promoted as a just commercial reward for its civic-mindedness.[46]

In Layman's words, the white china toilet deserved to be regarded as one of the "essential conditions of sanitary arrangements to ex-

clude the germs of typhoid fever and other zymotic diseases." From the 1880s onward, the new style toilet quickly came to embody the cutting edge of hygienic design. In both the popular advice literature and the trade brochures, the more expensive porcelain or china toilet became endowed with superior power to protect its users against both sewer gas and germs. Like the Cooper Brass Works, plumbing contractors gladly responded to the sanitarians' demand by manufacturing and marketing the more expensive new design.[47]

So popular was the new style toilet that it rapidly displaced older models and fueled the rapid growth of the sanitary pottery industry in the 1890s and early 1900s. Companies such as the Trenton Potteries Company (Tepeco) and the Standard Sanitary Manufacturing Company turned handsome profits on the new designs, which required a highly skilled process of casting and polishing the china fixtures. Thus plumbing manufacturers reaped the financial benefits of a fear of sewer gas and germs that more short-lived entrepreneurial ventures such as the Germicide Company had helped to foster.[48]

The privilege of good plumbing, whether embodied in the discrete Germicide attachment or the more obvious show of the white china toilet, became a symbol of the hygienic protections fundamental to a genteel way of life. Those who aspired to that life had to pay a high price: "first-class" sewer traps, toilets, and plumbers did not come cheap, as Colonel Rockwell had learned in renovating the White House. Sanitary goods and services were necessarily used only by those families who had sufficient disposable income to afford them. At a time when the recommended "living wage" for a working-class family, which few actually received, was less than $600, the expense of devices such as the Germicide ($15), the Hyatt water filter ($60), and the white china toilet ($40) undoubtedly confined their use to the more affluent households.[49]

To be sure, there were enough "do-it-yourself" versions of more expensive sanitary measures so that cost alone did not have to limit adherence to sanitary recommendations. For the conscientious homeowner determined to ventilate a room, disinfect a toilet, or install a water filter, a range of alternatives existed at different prices. Yet it was not true, as entrepreneurs such as C. L. Cohn frequently asserted, that sanitary protections cost so little that they were "within the means of the most humble households."[50]

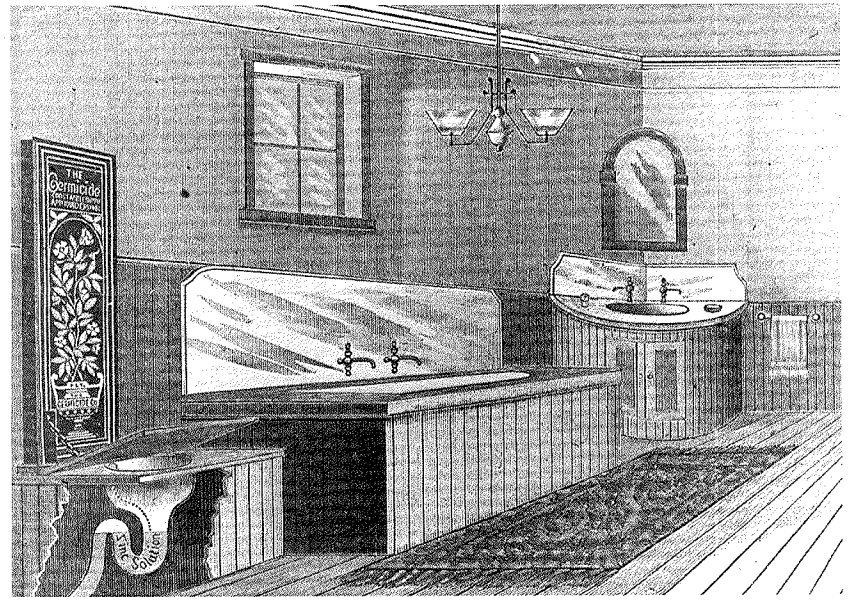
The practice of the more exacting kind of cleanliness fostered first by sanitary science and then by the germ theory remained out of reach for most Americans until the 1920s and 1930s. Although new sanitary goods and services provided affluent families with a greater sense of safety, the vast majority struggled on with the old-style plumbing fixtures that sanitarians associated with certain death. In old-fashioned Calvinist terms, the sanitary "elect" remained few in the late nineteenth century. Not until the early 1900s did the gospel of germs begin to take on more far-reaching forms.

among Christians . . . have been attended with risk to life and health, it only seems fair to assume that experience and common observation would have long observed the danger." But the report obviously did not end the controversy, and the church decided to take a vote on the issue. Two-thirds of the congregation voted in 1898 to adopt the individual cup system, and it was instituted soon after.[57]

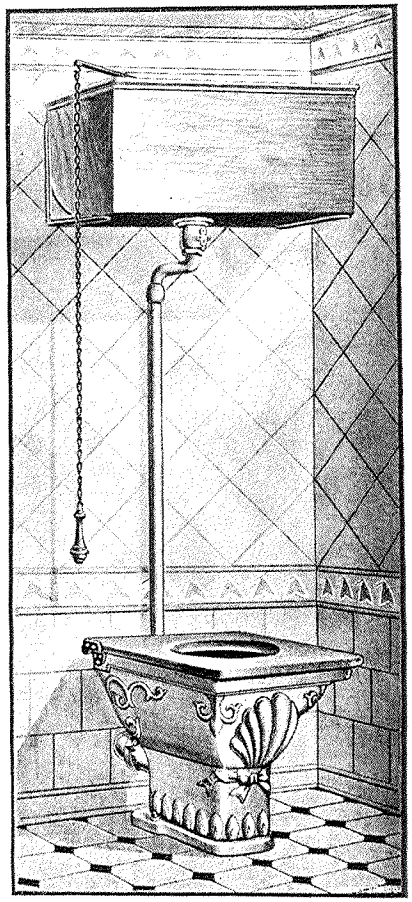
Evidently many Protestant congregations moved in the same direction at the turn of the century. A brochure for the Sanitary Communion Outfit Company of Rochester, published around 1900, listed hundreds of churches across the country that had purchased their patented communion sets, which allowed easy sterilization of individual glass cups and serving trays between uses. The denominations represented included Baptists, Congregationalists, Lutherans, Methodists, Presbyterians, and Universalists. Taking advantage of this trend, the Presbyterian Historical Society acquired a magnificent collection of silver and pewter by simply writing to the Presbyterian churches on the list and asking for their discarded communion sets.[58]

Subsequent generations of Protestants would take their communion wine from those little glasses, unaware of the triumph of hygiene over religious doctrine that they represented. With the advent of tuberculosis religion, spiritual community came to depend upon such discrete but firm separations from its diseased members. As Howard Anders, a vigorous proponent of the individual cup put it, even the pious felt a desire of "preserving one's self from that which is manifestly unclean, unsanitary, unnecessary, unmannerly, and unchristian." The communion controversy illustrates how the gospel of germs fostered a new sense of community that abjured the casual contacts that could spread disease, even in the most holy of ceremonies.[59]

For better and worse, the antituberculosis movement provided Americans with a remarkably expansive set of beliefs about the nature of germs and the need to avoid them. In the process of educating Americans about the white plague, anti-TB societies fostered a sweeping new vision of the "chain of disease" that linked all Americans, sick and well, into the rights and duties of public health citizenship. The "worries and torments" of tuberculosis religion became the foundation for a growing awareness of the germ that would eventually reshape every facet of daily life. And for those who had the disease, a harsh new existence had just begun.

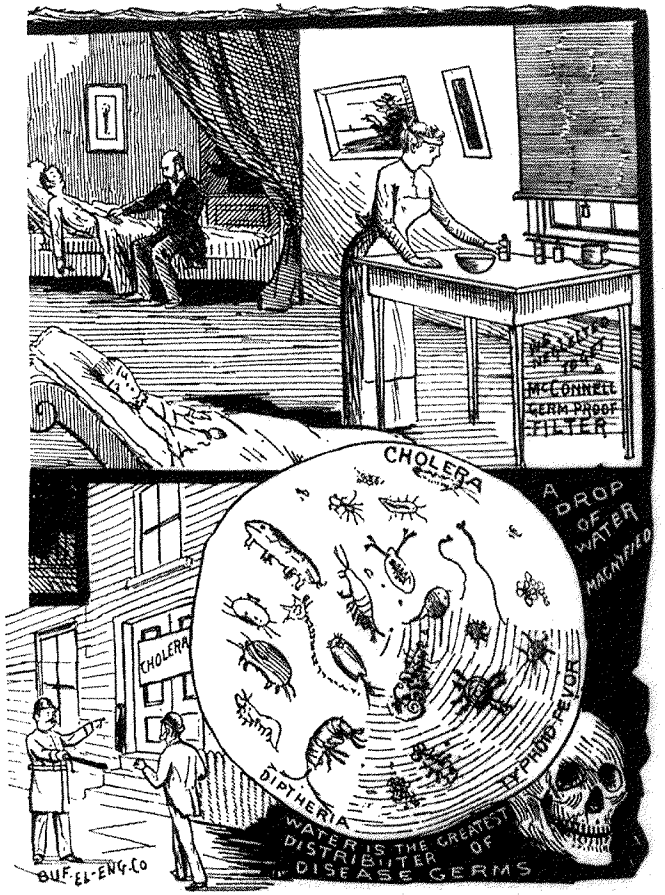


The Germicide, a disinfectant device that attached to the toilet, was one of the many devices marketed as a protection against sewer gas. This illustration from a promotional brochure shows the Germicide installed in a typical middle-class bathroom of the 1880s, which was furnished with wood paneling, wallpaper, and rugs much like other rooms in the house. (From The Germicide Company of New York, *Sewer-Gas and the Remedy* [n.d]. Courtesy of the Warshaw Collection of Business Americana, National Museum of American History, Washington, D.C.)

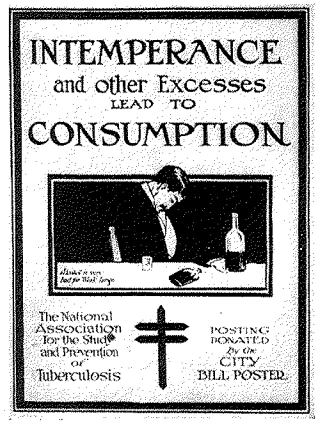


In response to the growing popular awareness of germs, the old, opulent style of the Victorian bath gave way to the smooth, hard look of the modern bathroom. Standing free of wooden cabinetry and surrounded by tiles, the white porcelain toilet shown here supposedly presented no place for filth-loving microbes to accumulate. (From *Guarding the Home: Essential Conditions of Sanitary Arrangements to Exclude the Germs of Typhoid Fever and Other Zymotic Diseases,* 1887. Courtesy of Hagley Museum and Library, Wilmington, Delaware.)

The pursuit of a more "antisepticonscious" style of living led to a growing preference for spare, smooth, easily cleaned surfaces, which profoundly changed the look of the twentieth-century American home. This 1906 advertisement for porcelain enameled ware suggests how the sanitary standards once advocated only for the bathroom expanded to include the kitchen, laundry room, and bedroom. (From *Good Housekeeping Magazine,* July–December 1906. Courtesy of American Standard Inc.)



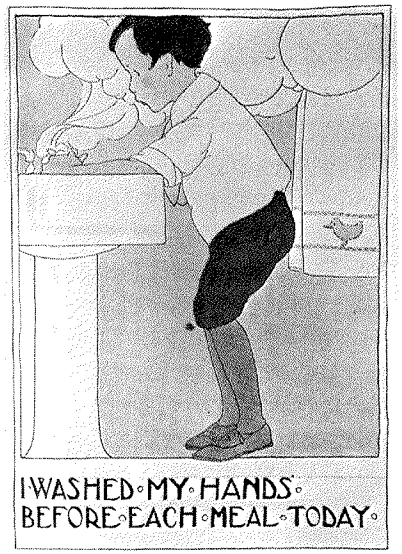
At a time when municipal water supplies were still of dubious purity, many middle-class Americans installed home water filters to protect their households against waterborne disease germs. This drawing from an 1894 trade catalogue portrayed sickness as the inevitable consequence of failing to install such a filter. The fanciful microscopic creatures pictured here vaguely resemble insects, suggesting the ease with which many lay people equated "bugs" and germs. (From McConnell Filter Co., *McConnell Germ-Proof Water Filters, Illustrated Catalogue*, 1894. Courtesy of the Historical Collections of the College of Physicians of Philadelphia.)



The discovery that tuberculosis was a communicable disease spread by coughing and spitting ushered in a more aggressive era of public health education at the turn of the century. These posters, promoting the need for a healthy lifestyle, careful housecleaning methods, and an end to spitting, were designed by the National Tuberculosis Association for a 1910 publicity campaign. (From *Journal of the Outdoor Life*, January 1910. Courtesy of the Historical Collections of the College of Physicians of Philadelphia.)

Borrowing heavily from the advertising and entertainment industries, the National Tuberculosis Association and its affiliates developed many innovative methods of popular health education, including the use of posters, moving pictures, health exhibits, and parades. This photograph shows a parade from the early 1920s, complete with elephants. The publicity methods developed by the American anti-TB movement were widely copied by other health advocacy groups.

Originally introduced in 1915 as part of the Christmas Seal campaign, the National Tuberculosis Association developed the Modern Health Crusade into an ambitious program of child health education. This photograph shows a Modern Health Crusader in full regalia selling Christmas seals to the French war hero, Marshal Ferdinand Foch. (From *Journal of the Outdoor Life*, December 1921. Courtesy of the Historical Collections of the College of Physicians of Philadelphia.)



The theory and practice of modern aseptic surgery brought new awareness of the microbial populations resident on human skin and hair. To combat casual infection, public health authorities promoted frequent hand washing. This poster promoting the hand washing habit was distributed by the Pennsylvania Society for the Prevention of Tuberculosis as part of the Modern Health Crusade. (From *Yearbook of the Pennsylvania Society for the Prevention of Tuberculosis for 1919.* Courtesy of the Historical Collections of the College of Physicians of Philadelphia.)

The recognition that insects could act as carriers of disease germs led to a vigorous crusade against the common housefly. This 1917 poster from the Illinois Tuberculosis Association likened fly control to a patriotic duty. The bombs are labeled with the names of diseases thought to be transmitted by flies: typhoid, tuberculosis, and cholera. (From *Bulletin of the National Association for the Study and Prevention of Tuberculosis*, June 1917. Courtesy of the Historical Collections of the College of Physicians of Philadelphia.)