Disease and the City

The Architecture of Medical Practice

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Abstract

While disease describes a body's pathological state, space of disease is the spatiotemporal condition that allows disease to come into existence. Conceptually speaking, a space of disease both preconditions a disease and holds it in place for a certain time. Historically, disease has flourished in urban environments that rely on large concentrations of bodies and a vast amount of material flows; that is, various urban conditions can be held responsible for the outbreak of epidemics. No matter on what scale we enter these particular spaces of disease (on the scale of a cross-continental trade route, a city, or a building), physical space represents only a potential risk factor, requiring the flow of physical, chemical, and biological components through it to precondition that space for disease. Hence, each disease should be viewed as a spatial flow, which can be described architecturally and operatively. In this arena of disease and the city, the spatial measures that have evolved in response to disease have by necessity pushed space to its limits—space confines, treats, accesses, and cultivates disease, and is itself subject to medication. In the context of this research, the *hospital* serves as the primary representative of the architecture of the city. While the hospital of the Charité in Berlin is the subject of this case study (and its three-hundred-year history defines the time frame of this research), the attempt here is to expand upon the history of the hospital of clinical medicine by framing various spaces of disease and their impact upon the city; by positioning the hospital within the context of the diverse spatial measures that the city historically has implemented against disease; and by analyzing the hospital's move toward greater clinical specialization.

Zusammenfassung

Während die Krankheit einen pathologischen Zustand des Körpers beschreibt, ist der Raum der Krankheit ein spatiotemporaler Zustand, welcher Krankheit ermöglicht. Der Raum der Krankheit schafft die Voraussetzung für Krankheiten und hält diese für einen bestimmten Zeitraum aufrecht. Historisch gesehen blühten Krankheiten in urbaner Umgebung auf – in jener städtischen Umgebung, in der große Konzentrationen von Körpern und Mengen von Materialströmen vorkamen. Das heißt, verschiedene urbane Bedingungen können für den Ausbruch von Epidemien verantwortlich gemacht werden. Ganz gleich, auf welchem Maßstab wir diese Räume der Krankheit betreten (auf der Größenordnung eines überkontinentalen Handelsweges, einer Stadt, oder eines Gebäudes), der physische Raum stellt lediglich einen potenziellen Risikofaktor dar. Erst der Fluss von physischen, chemischen und biologischen Bestandteilen konditioniert den Raum für Krankheiten. Folglich ist jede Krankheit als räumlicher Arbeitsablauf zu begreifen und somit architektonisch und operativ beschreibbar. Auf diesem Schauplatz von Krankheit und Stadt wurde der Raum in Form von räumlichen Maßnahmen notwendigerweise bis zum Äußersten ausgereizt. Raum engt ein, behandelt, erschließt und kultiviert Krankheiten und ist selbst Gegenstand von Medikation. Im Kontext dieser Forschung dient das Krankenhaus als Hauptvertreter der städtischen Architektur. Das Krankenhaus der Charité in Berlin wird hier im Rahmen einer Fallstudie untersucht, ihre 300-jährige Geschichte definiert den Zeitrahmen dieser Forschung. Diese Arbeit ist der Versuch, die Geschichte des Krankenhauses der klinischen Medizin zu erweitern; deshalb werden erstens unterschiedliche Räume von Krankheiten und deren Einfluss auf die Stadt rekonstruiert, zweitens verschiedene räumliche Maßnahmen, welche die Stadt historisch gegen Krankheiten implementierte, im Vergleich zum Krankenhaus kontextualisiert und drittens die einhergehenden Veränderungen des Krankenhauses im Anbetracht zunehmender klinischer Spezialisierung analysiert.

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Berlin, August 2015

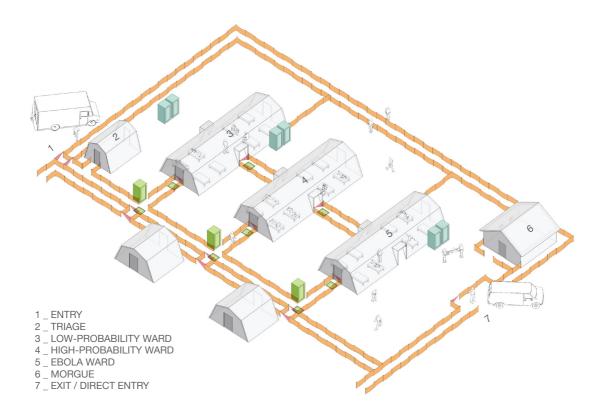


Fig. 0.1. Ebola Treatment Center

Ebola Treatment Center

In the midst of the Ebola outbreak in West Africa, the importance of space as a measure against disease has become acutely apparent. Overall, the Ebola treatment center consists of three spatially segregated wards (fig. 0.1). Patients are assigned to a specific ward depending on their condition and the probability that they are infected. This means patients move through the treatment center in a one-way direction, e.g., a patient suspected of Ebola begins in the low-probability ward, moves to the high-probability ward if symptoms develop further, and may end in the ward for those with confirmed infection. To better grasp the logic of the treatment center's layout, we need to consider all three possible patient conditions upon entry.

Individuals suspected of having fallen ill with Ebola are brought to the treatment center. First, they are asked to enter a small tent, the *Triage* area.² Here, the initial assessment of their health condition is made as medical staff examine any disease-related symptoms and take samples for laboratory tests.³ If a patient displays highly visible symptoms of Ebola infection, he or she is guided directly into the *High-probability Ward*,⁴ while another patient whose symptoms are more ambiguous and who might or might not be infected with Ebola goes into the *Low-probability Ward*.⁵ Both patients wait in their respective wards for the test results. Depending on the location and equipment of the Ebola treatment center, this waiting time can be anything from hours to days. Each of the two

¹ The reproduced schematic is from Doctors Without Borders, the Center for Disease Control and Prevention, and the World Health Organization. Clark Patterson, "An Ebola treatment center," *Washington Post*, Health & Science section, September 22, 2014;

http://apps.washingtonpost.com/g/page/national/an-ebola-treatment-center/1333/ (accessed, 2014).

² Ibid.

³ "Diagnosing Ebola in a person who has been infected for only a few days is difficult because the early symptoms, such as fever, are nonspecific to Ebola infection and often are seen in patients with more common diseases, such as malaria and typhoid fever. [...] Ebola virus is detected in blood only after onset of symptoms, most notably fever, which accompany the rise in circulating virus within the patient's body. It may take up to three days after symptoms start for the virus to reach detectable levels. Laboratory tests used in diagnosis include: Antigen-capture enzymelinked immunosorbent assay (ELISA) testing, IgM ELISA, Polymerase chain reaction (PCR), and Virus isolation." "Ebola—Diagnosis," Center for Disease Control and Prevention website; http://www.cdc.gov/vhf/ebola/diagnosis/ (accessed 2015.)

⁴ Patterson, "An Ebola treatment center," Washington Post.

wards has an assigned, fenced off courtyard, which allows for further space in case of overcrowding. A double fence surrounding the entire treatment center and bordering these courtyards establishes added distance, thereby making communication between patients and visitors safer. If the lab results are negative, the patient leaves the treatment center through the ward exit to the outside. Each ward is equipped with its own exit, which incorporates its own decontamination shower. If, however, the lab results are positive (i.e., the Ebola virus has been detected), the patient is moved directly to the *Ebola Ward*. In the case of the patient waiting in the low-probability ward, he or she passes first through the high-probability ward and then into the Ebola ward. Those individuals arriving at the treatment center displaying clear disease-specific symptoms enter the treatment center through the direct entry at the other side of the treatment center from the triage tent, going directly into the Ebola ward without passing through triage.

Once inside the Ebola ward, each patient is assigned a sickbed where he or she receives supportive care. Since no cure is currently available, medical treatment targets the present symptoms for alleviation, i.e., lowering a fever, thereby increasing the chance of survival. However, that chance is slim; according to the current statistics, three out of four Ebola patients entering a treatment center will die. The bodies of the deceased are temporarily stored in an assigned on-site *Morgue* before being transported to an off-site cemetery and buried. The one out of the four patients who recovers is allowed to exit the Ebola ward. As with those leaving the other two wards, before leaving the premises of the treatment center, the patient is required to take an antiseptic shower and put on clean clothes, which are provided. Having recovered from infection, a patient is expected to carry antibodies against the virus for approximately 10 years.

⁵ Ibid.

⁶ Ibid.

⁷ "Surviving a deadly virus," World Health Organization website; http://www.who.int/features/2014/ebola-survivors/en/ (accessed 2015).

⁸ Patterson, "An Ebola treatment center," Washington Post.

⁹ "Ebola," Doctors Without Borders website;

http://www.doctorswithoutborders.org/our-work/medical-issues/ebola (accessed 2015).

Because no cure exists, various spatial measures are used during an Ebola epidemic for defense against further spreading infection. At the scale of the region and the town, space *cordons off* areas of peak contagion, thereby defending the public at large. At the scale of the treatment center, space *quarantines* those showing a probability of infection and *isolates* those with the disease, as well as being subject to *decontamination* itself, thereby preventing cross-contamination among patients. At the scale of the body, space gives *access* to specimens for examination at microscopic scale to detect disease signs. Further, space in the form of barrier clothing *protects* health workers against the contagion, thereby allowing the medical staff to execute all these measures, which open for those infected a small window of hope.

All these spatial measures against disease evident in the example of the Ebola treatment center are representative of the four spatial concepts found in the city's response to disease. In this study, all four concepts will be identified by exploring a variety of associated spatial measures in detail.



Fig. 0.2. The Space of Disease

Introduction

Just as clothing protects the body, so do buildings. There is essentially no difference between using protective clothing and using built enclosures when it comes to disease control. They are both spatial measures. The German architect and art critic Gottfried Semper etymologically derives *Wand* (enclosure) from *Gewand* (clothing), and thereby points out their shared origin. However, in the arena of disease and the city, the spatial measures that have evolved in response to outbreaks have by necessity pushed space to its limits. In moments of crisis—that is, in moments when epidemics that have not found a medical remedy strike—space is the only defense. The ongoing Ebola virus epidemic in West Africa has been hovering over this research like a shadow. Although this project was in full swing when the epidemic started in Guinea in December 2013, then spread to Sierra Leone and Liberia, the outbreak made vividly apparent the role of space as an agent of medical-therapeutic measures against disease.

While *disease* describes a body's pathological state,² *space of disease* is the spatiotemporal condition that allows disease to come into existence. Conceptually speaking, a space of disease both preconditions a disease and holds it in place for a certain time (fig. 0.2). For example, in the case of the bubonic plague in Europe,

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¹ Here, Semper explains the clothing principle, so-called *Bekleidungsprinzip*. "Das Gewebe (wenden, weben, Gewand, Wand) [...] Hier tritt nun wieder der bemerkenswerthe Fall ein, dass die Lautsprache der Urgeschichte der Künste zur Hülfe dient und die Symbole der Formensprache in ihrem primitiven Auftreten verdeutlicht, die Echtheit der Auslegung die ihnen gegeben wird, bestätigt. In allen germanischen Sprachen erinnert das Wort Wand, (mit Gewand von gleicher Wurzel und gleicher Grundbedeutung) direkt an den alten Ursprung und den Typus des sichtbaren Raumabschlusses. Eben so sind Decke, Bekleidung, Schranke, Zaun (gleich mit Saum) und viele andere technische Ausdrücke nicht etwas spät auf das Bauwesen angewandte Symbole der Sprache, sondern sichere Hindeutungen des textilen Ursprungs dieser Bautheile." Gottfried Semper, *Der Stil in den technischen und tektonischen Künsten*, Band 1, 2. Auflage (München: Friedr. Bruckmann's Verlag, 1878), 89, 214.

² "A definite pathological process having a characteristic set of signs and symptoms. It may affect the whole body or any of its parts, and its etiology, pathology, and prognosis may be known or unkown." Miller-Keane. *Encyclopedia & Dictionary of Medicine, Nursing, & Allied Health* (Philadelphia: W.B. Saunders Company, 1992), 433.

the space of disease persisted for over five centuries. It relied on a number of intermediate hosts operating over great distance, that is, the flow of countless rats (carriers of bacteria-infected fleas) that eventually linked the Mongolian steppes with European cities.³ Once the space of disease expanded to include these cities, the bubonic plague was transformed from a chronic disease in rodent colonies to an epizootic disease, eventually becoming an epidemic disease in human settlements. The space of disease for the plague encompassed a vast realm, from the pathways of the Silk Roads to the cramped quarters of the European cities.

Medicine's aim, now as always, is directed toward not only diagnosing and treating disease in the body, but also apprehending and, if at all possible, dismantling the space of disease; the latter requires interventions beyond the discipline of medicine. The human body remains the primary beneficiary of medical research and practice. Yet, if our built environment allows various spaces of disease to form, treating individual bodies seems like an endless task. In the late nineteenth century, medicine developed greater means to find disease-related evidence, i.e., with advances in microbiology.⁴ Although physicians continue to view the human body as an autonomous and operationally closed system, such evidence suggests that the body is interacting with its environment in ways that are not always obvious. By shifting ever so slightly the focus of medical diagnostics from bodily symptoms to body risk factors, medicine can frame a great number of spaces of disease. Diagnostics originally directed entirely toward the body's abnormal pathological condition accordingly have started to expand in the course of clinical medicine to include the spatio-temporal precondition of a disease. Medicine's investigations and interventions now encompass not only the physical body, but also its genetic history, its social climate, and its environmental context.

Bodies moving, interacting, and coming into physical contact with one another, as well as the mining or growing of materials to be moved, joined with other

³ William H. McNeill, *Plagues and Peoples* (Garden City, NJ: Anchor/Doubleday, 1976), 134.

⁴ Wolfgang Eckart, *Geschichte der Medizin* (Berlin: Springer-Verlag, 2009), 284-326.

materials, and consumed or reshaped to suit a human purpose, are all processes of increasingly meshed complexity. Historically, disease has flourished in environments that emerge out of this blending process. Because urbanization relied on large concentrations of bodies and a vast amount of material flows, it generated spatial conditions that led to the proliferation of disease. Therefore cities were the first places that formed unprecedented habitats for diseases.⁵ Even as certain urban conditions allowed diseases to become endemic, however, the outcome of urbanization, the city, also gave rise to organized medicine with its greater treatment efficacy.

In the context of this research, the *hospital* serves as the primary representative of the architecture of the city. The hospital of the Charité⁶ in Berlin is the subject of this case study, which means its three-hundred-year history defines the time frame of this research. This study attempts to expand upon the history of the hospital in several ways. First, by framing various spaces of disease and their impact upon the city, we essentially excavate the hospital. The meaning of the German word for hospital, Krankenhaus (which literally translates into English as "house of diseased"), points etymologically to the Charité's origin: the hospital was originally established as a place of isolation for infectious patients outside the city. Second, by positioning the hospital within the context of the variety of spatial measures that the city historically implemented against disease, we describe its transformation. Third, we analyze the hospital's move toward greater clinical specialization. As one of the most innovative places within the nineteenth-century city, the hospital of clinical medicine provided an environment for the implementation of a complex array of technological tools and a variety of specialized clinical techniques. By the end of the nineteenth century, the Charité was a focal point for global clinical research and treatment of modern medicine. Throughout the twentieth century, the hospital of clinical medicine represented one of the most essential components of the healthcare infrastructure of the welfare state and began to assume an omnipresent place in our lives (most of us were born in hospitals).

⁵ Manuel DeLanda, *A Thousand Years of Nonlinear History* (New York: Zone Books, 1997), 157.

 $^{^{\}rm 6}$ Today the hospital is referred to as Charité – University Hospital Berlin.

In light of its title and its object of investigation, this is a study addressing medicine from the perspective of the city. Our subject, the space of disease, requires us to think in a problem-oriented way that goes beyond the singular disciplinary approach of medicine. Instead, the present text, which juxtaposes four historical spaces of disease with four spatial concepts in organized medicine, attempts to stake out an area for further investigation by a variety of disciplines.

The first part of the text, "Spaces of Disease," focuses on four historical diseases in the context of Berlin. Each disease is explored by means of two perspectives: one seeing the urban condition from the point of view of a disease outbreak, and the other reconstructing the space of disease with the benefit of hindsight and present knowledge. Thus, the historical perspective contextualizes the various spatial measures that organized medicine was forced to employ, while the contemporary perspective envisions the complex processes of global trade that underlie urbanization (and hence disease proliferation).

The second part of the text, "Spaces against Disease," addresses various spatial concepts that organized medicine has employed. These fall into four comprehensive categories: Space as Confinement, Space as Treatment, Laboratory Space, and Medicated Space. This chapter details the spatial concept identified in each category by exploring an array of medical measures that attempt to dismantle the space of disease by disengaging the body from the process transmitting the disease. The main question of the chapter is how was space used as agent of therapeutic measures.

The third part of the text, "Space in Clinical Practice," attends to the phenomenon of specialization and departmentalization in the context of clinical practice. The practice of clinical medicine, which employs a complex and intertwined array of techniques and technological tools, has always relied on the diversification and division of labor and associated space. Eventually, clinical specialization enabled physicians to scientifically diagnose and treat ever more diseases. Incorporating

the medical laboratory into the hospital was key to constructing a means to apprehend the space of disease. Thus, only by means of specialization was medicine able to identify the larger cause of disease.

Although these three areas of investigation are for the most part historical, our perspective is unavoidably a contemporary one and indeed (as in the Ebola outbreak in West Africa) one of some urgency. Western Europe is currently at the forefront of an unavoidable paradigm shift. An increasingly aging population means more patients, a proportional rise in chronic diseases, and increased demand for constant medical care. Medical treatments that such diseases require rely only partly (if at all) on the current hospital of clinical medicine (the workhorse of the early welfare state). At the same time, more and more treatments (e.g., immune therapies or hemodialyses) are becoming more costly, driving particular hospitals that are essential for the provision of primary care out of the market. Healthcare systems that are based on the solidarity of the welfare state will soon be unaffordable for societies like those in Western Europe that are undergoing this unprecedented demographic change, which will transform the current polycentric urban landscape even further. While existing healthcare systems rely on the logic of centralized organization, tomorrow's networks will increasingly decentralize by distributing primary care and medical services to multiple centers. The immediate future challenge is leading policy makers to question a wide variety of values that are currently in place regarding the role of patients, 8 doctors, 9 and care providers. In effect, the current healthcare infrastructure must be rethought, above all, in its spatial organization.

 $^{^{7}}$ "The prices for medical services rise more slowly (0.2-1.5%) than the costs incurred (2.5-3.5%).

^[...] Unfortunately, those hospitals driven out of the market are not those that needed to be closed, but those hospitals and clinics that happened to be under bad leadership." Karl Max Einhäupl, "Bis alle Kliniken insolvent sind," *Handelsblatt* no. 24 (February 4, 2015): 4–5. (Author's translation.) Einhäupl is the head of the Charité – University Hospital Berlin.

⁸ "A patient-centered model in medicine leads to patient-oriented research, which focuses on the individualization of results. Thus, treatment effectiveness is assessed by comparing subgroups of patients to individual patients. The goal is to identify which treatment options are more effective for which patient." Harun Badakhshi, "Patient-oriented medicine, an urge?" talk presented at the Symposium for Health & Design, Villa Vigoni, Italy, 2013.

⁹ "While patient-centered care favors shared decision-making, patient-oriented research emphasizes outcome evaluation. Doctors evaluate patients and their disease through analyses of heterogeneity (subgroups identified a priori) and disaggregation, the study of differences." Ibid.

Currently, half of the 2,000 hospitals in Germany suffer financial losses and almost a sixth run the risk of insolvency. About 200 hospitals were closed in Germany last year. With 8.3 hospital beds per 1,000 people, the country is currently oversupplied. That means that many of the remaining hospitals are inefficient due to unused overcapacity, i.e., of the total number of 500,000 hospital beds in Germany, 110,000 beds remained empty on an annual average. However, today's actual problems are much bigger than these numbers are able to convey, since the statistics that produced them rely on a spatial model defined by physical distance. If one dares to map out these deficiencies in the form of a spatio-temporal map (i.e., a space of *stim and dross*), a spiky world of difference appears. The hospital, attempting to become more efficient while at same time keeping pace with clinical innovation, has already started to rework itself from the inside.

The hospital's departmental structure of clinical medicine is currently transforming itself more drastically and more frequently than it has ever done in its history. With further medical and genetic discoveries ahead, we can anticipate an explosion in the catalogue of accessible disease-related signs, requiring that existing disease classifications be redefined so that the physician's description of a disease becomes more patient-specific. At the same time, we can anticipate a rise of further medical specialty departments and associated subspecialties, continuing the last century's trend of exponential growth in clinical departmentalization. This upcoming phase of diversification into ever more clinical specialties is likely to be far more extensive than the specialization started by the implementation of clinical microbiology at the turn of the previous

¹⁰ Karl Blum, Sabine Löffert, Matthias Offermanns, and Petra Steffen, *Krankenhaus Barometer: Umfrage 2014* (Düsseldorf: Deutsches Krankenhaus Institut, 2014), 104–114.

¹¹ Ibid.

¹² Statistics are from the Organisation for Economic Co-operation and Development (OECD), quoted in *Handelsblatt* no. 24 (February 4, 2015): 4–5.

¹³ Ibid.

¹⁴ "In a world dominated by time rather than space, a distinct separation between activity and inactivity appears. This bifurcation is a fundamental aspect of modern life where 24/7 is but an unattainable ambition for the living and is at this point dominated by artificial intelligence—computers never sleep. Stim as in stimulation while dross refers to inaction, nothingness or sleep." Lars Lerup, "Stim & Dross: Rethinking the Metropolis," *Assemblage* 25 (1995): 83–101. ¹⁵ Part 3, "Space in Clinical Practice," will trace the history of departmentalization of clinical practice in the case of the Charité.

century. The appearance of a multidisciplinary department in clinical specialization within the late twentieth century might be an indication that clinical medicine has already begun to *spatially* reorganize the hospital's practice from within. The adoption of multidisciplinary specialty departments eventually will restructure the entire system of today's clinical medicine.

As the current length of patient hospitalizations shortens, the hospital is increasingly shifting toward providing services to outpatients. As the patient's home increasingly replaces the hospital ward, the hospital will require fewer patient rooms with sickbeds, but instead offer a variety of treatment rooms (which might no longer remind the patient of the hospital). For example, the concept of the waiting room (at present a space streamlined primarily by the needs of doctors and clinical staff) will have to be completely rethought—not so much on the basis of pure efficiency, but more in light of adding value for the patient while waiting (e.g., incorporating a variety of choices for the patient). New care models are already under consideration; some favor patient-oriented models, leading to an increased pressure to redesign the current hospital infrastructure. 16

But before we begin to imagine the fading of the hospital's architectural being, we ought to examine its history from a time when the hospital was not as relevant within our cities.

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¹⁶ The responsibility of the federal states needs to shift toward the federal government or, as it has been argued, should be given to the actual payers of medical services, i.e., the health insurance companies.

Part 1

Spaces of Disease

Introduction

The Space of Plague

Plague Framing the Space of Plague

The Space of Cholera

Cholera Framing the Space of Cholera

The Space of Hospital Gangrene

Hospital Gangrene Framing the Space of Hospital Gangrene

The Space of Tuberculosis

Tuberculosis
Framing the Space of Tuberculosis

Four Spaces of Disease

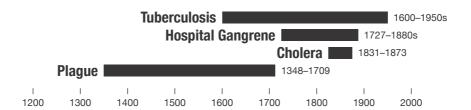


Fig. 1.1. Time Frames of Epidemic Disease Occurrences in Berlin

Introduction

To live means to leave traces.

—Walter Benjamin¹

When an epidemic occurs, whether moving rapidly or slowly, its impact can be more devastating than any war. Unlike in the aftermath of a war, however, the fabric of a city remains largely intact even after an epidemic has run its course. Besides the loss of numerous people and the fearful memories of those who survived, there is no trace of physical destruction within the city. Those traces emerge only later. On a time scale of years, a disease leaves traces within ill bodies, but on a time scale of decades and centuries, a disease leaves traces within our urban practices, which in turn shape and reshape our cities.

This chapter describes the traces that four epidemics, i.e., bubonic plague, cholera, hospital gangrene, and tuberculosis, have left on the urban culture of Berlin. Thus, the investigation reveals some of the enduring effects that epidemics can have on the urban condition at large. Each epidemic is explored from two perspectives: one observes the urban condition from the point of view of a disease outbreak, and the other frames the space of disease with the benefit of hindsight and present knowledge. The historical perspective contextualizes the various spatial measures that organized medicine was forced to employ in its response to the outbreak, while the contemporary perspective explores the complex processes of global trade that underlie urbanization and hence disease proliferation. The text moves chronologically, focusing on the four epidemics according the dates they were quelled (as epidemics, not as diseases per se) in the context of Berlin (figure 1.1).

The period that Charité, Berlin's oldest and Europe's largest university hospital, has been in existence defines our overall time frame of investigation, roughly 300 years. While the Charité was originally founded in reaction to an imminent

¹ Walter Benjamin, "Paris, Capital of the Nineteenth Century," in *Reflections: Essays, Aphorisms, Autobiographical Writing*, trans. Edmund Jephcott (New York: Schocken Books, 1986), 155.

epidemic (the plague), the hospital evolved over the years to become the epicenter of modern medicine at the end of the nineteenth century. Various people who studied, researched, and practiced medicine at the Charité, amongst many others, included Johann Lukas Schönlein, Rudolf Virchow, Robert Koch, and Ernst von Bergmann, all leading figures in the field of clinical research and medicine.

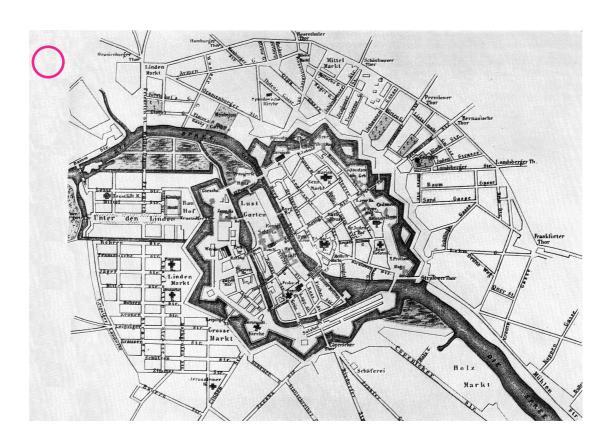


Fig. 1.2. City of Berlin-Cölln in 1710 (site of the Charité encircled)

The Space of Plague

Plague

The year is 1709, and the last epidemic of the plague in Prussia has started in Danzig, killing nearly every second inhabitant.² But before we turn to the looming outbreak of the epidemic and the resulting measures taken by the state, it is useful to contextualize urban life in Prussia at that time.³

Berlin, the newly appointed royal capital and residential city, had been an electoral residence, together with the neighboring city of Cölln, since 1470. By the end of the Thirty Years' War (1618–48), Berlin-Cölln had been fully transformed into a fortress. The city lost almost half of its population due to a general exodus during the war and the widespread deaths caused by four epidemics of the plague in the early part of the seventeenth century. In the following decades, Berlin-Cölln underwent a drastic urbanization process, hugely expanding the population of the residential city of Berlin-Cölln from its estimated 6,000 inhabitants in 1650.

In 1709, the royal capital of Berlin (by now including the new towns of Friedrichwerder, Dorotheenstadt, and Friedrichstadt) encompasses about 55,000 residents. Trade is blossoming, as Berlin has become the center of transport of the entire Mark of Brandenburg. Despite this rapid urbanization, the city's built-up area is restricted almost entirely to the territory defined within the city walls, with some unbuilt plots remaining in the old city districts of Berlin

² Karl-Erik Frandsen, *The Last Plague in the Baltic Region 1709–1713* (Copenhagen: Museum Tusculanum Press, 2010), 24.

³ The following brochure gives a comprehensive overview of the scale of the plague in the context of Berlin, which was very helpful for this research. *Die Pest in Berlin* (Berlin: Verein für Gesunde Umwelt e.V., 1996).

and Cölln. Only the garrison town of Dorotheenstadt and the new town of Friedrichstadt extend westward. According to the descriptions of chronicler Adolf Streckfuß, the urban fabric consists almost entirely of freestanding small wooden buildings with shingle roofs. These houses stand with their gables towards the street, narrow alleys keeping them apart. Only the corner houses of richer citizens are built out of stone and covered with tiled roofs for fire safety reasons. The air of Berlin carries the smell of wood fires from the domestic homes and the prevalent stench of pigsties. Life in the city is dirty. Humans and animals live close to one another. Streets, only partially cobbled, are strewn with dung. A Rats are a part of urban life.

Most of Berlin's citizens are farmers and raisers of livestock. Their life expectancy is thirty years on average. Two to three generations earlier (during the time of the Thirty Years' War), the Prussians had to adapt themselves to chronic scarcities, compensating for the lack of meat and grains in their diets by the regular consumption of vegetables, supplementary cereals, or flour substitutes. No wonder that people now disobey the royal prohibition, which declares that the illicit possession of pigsties in the city will be punished. Pinched by hunger, many attempt desperately to maintain a self-sustaining life. By the second year of failed harvests, the granaries are empty, and Prussia once again is a breeding ground for the plague.

This time around, the epidemic is destined to kill about 200,000 people out of the 600,000 living in East Prussia.⁷ After the epidemic has run its course, entire villages are left abandoned and fields lie to waste. Everywhere are boarded up houses, famished or dying sheep, pigs, and chickens, and the hurried graves of people who died and were buried in place. It will take decades before people can revive these uninhabited regions and before cows will again graze the fields.

⁴ Adolf Streckfuß, *500 Jahre Berliner Geschichte: Vom Fischerdorf zur Weltstadt*, Vol. 1 (Berlin: 1864), 3.

⁵ Fernand Braudel, *Capitalism and Material Life 1400–1800* (London: Fontana/Collins, 1974), 73.

⁶ Gerhard Jaeckel, *Die Charité* (Berlin: Ullstein, 2010), 11-12.

⁷ Wilhelm Sahm, Geschichte der Pest in Ostpreußen (Leipzig: Duncker & Humblot, 1905), 149.

The plague first appears in August 1710 in Prenzlau, a hundred kilometers north of Berlin.⁸ The looming epidemic alerts the state and terrifies its citizens, whose past memories remain vivid. Within the last four centuries, the plague has made its appearance twenty-nine times.⁹ Besides their fear of the plague, Berliners are worried that once again trade will be restricted, the markets will close, and life will freeze in place.

One reliable source for a description by a contemporary of the plague is the opening of the novel *Il Decamerone* by Giovanni Boccaccio, who frames the collection of tales with the introduction of a group of people relating the stories as they shelter from the plague. Boccaccio describes the symptoms and the rapid progression of the disease: those who have fallen ill die within the short duration of three days. Even though Boccaccio reports upon the plague epidemic that took place in the fourteenth century in the city of Florence, not much has changed in terms of the accumulated knowledge about the disease by the beginning of the eighteenth century, and the disease in particular has not changed. Boccaccio writes:

Not such were they as in the East, where an issue of blood from the nose was a manifest sign of inevitable death; but in men and women alike it first betrayed itself by the emergence of certain tumors in the groin or the armpits, some of which grew as large as a common apple, others as an egg, some more, some less, which the common folk called gavoccioli [pestilential bubo]. From the two said parts of the body this deadly gavocciolo soon began to propagate and spread itself in all directions indifferently; after which the form of the malady began to change, black spots or livid making their appearance in many cases on the arm or the thigh or elsewhere, now few and large, now minute and numerous. And as the gavocciolo had been and still was an infallible token of approaching death, such also were these spots on whomsoever they showed themselves. [...] not merely were those that recovered few, but almost all within three days from the appearance of the said symptoms, sooner or later, died, and in most cases without any fever or other attendant malady.¹⁰

From a present-day perspective, the emerging pestilential buboes (gavoccioli)

⁸ Jaeckel, *Die Charité*, 18.

⁹ Chronological table of occurrences of plague epidemics in Berlin; see *Die Pest in Berlin*, 15.

¹⁰ Giovanni Boccaccio, "Introduction," *Decameron*, English translation; http://people.virginia.edu/~jdk3t/decamintro.htm (accessed 2012).

are "acutely inflamed and painful swellings of the lymph nodes usually in the groin."¹¹ That the disease, however, is accompanied with "chills and fever, [...] vomiting and thirst, generalized pain, headache, and mental dullness"¹² reveals Boccaccio's secondhand experience with bubonic plague. His description about the general course of the disease also reflects the rapid onset of death back then, which takes a little longer in modern times, though the virulence is the same:

Tender, enlarged lymph nodes are usually seen between the second and fifth days. The more virulent cases last five to six days and are usually fatal. If the patient survives past the tenth or twelfth day, there is a good chance of recovery. The mortality rate for untreated cases runs between 25 and 50 percent, but reached as high as 90 percent.¹³

In times of the plague, behaviors thought to provide protection were adopted by all levels of society. These behavioral codes ranged from folkways to letters of indulgence by the church and measures enforced by the state. What seems for sure, though, is that no one was safe from this disease. It affected all age groups and all social classes. It was a common belief, as Boccaccio writes, that the disease would spread through the air "merely by speech or association with the sick." Quite clearly, the miasma theory dictated everything: a common assumption since ancient times, this theory held that diseases, like bubonic plague, were caused by a *miasma* (ancient Greek for "pollution"), released from rotting organic matter. Or as Boccaccio explains:

Moreover, the virulence of the pest was the greater by reason that intercourse was apt to convey it from the sick to the whole, just as fire devours things dry or greasy when they are brought close to it. Nay, the evil went yet further, for not merely by speech or association with the sick was the malady communicated to the healthy with consequent peril of common death; but any that touched the cloth of the sick or aught else that had been touched or used by them, seemed thereby to contract the disease.¹⁵

Similar to the action serving the framework plot in Boccaccio's *Il Decamerone*—young people escaping the city in fear of the plague—physician Konrad

¹¹ Miller-Keane, *Encyclopedia & Dictionary of Medicine, Nursing, & Allied Health* (Philadelphia: W.B. Saunders Company, 1992), 1164–1165.

¹² Ibid.

¹³ Ibid.

¹⁴ Random House Webster's College Dictionary (New York: Random House, 1996), 854.

Schwestermiller recommends in his behavioral codes in times of the plague that people should "flee fast, flee far, and come back late." ¹⁶ Schwestermiller's advice reflected a common belief that only physical escape could offer a secure way to protect oneself against such pestilence. Whoever could not flee was encouraged to fumigate their homes, dash rosewater or vinegar around, and scatter odorous herbs in order to clear the miasmatic air. Whoever could not avoid meeting people was exhorted to carry a vinegar-soaked sponge along to brush over the temples, nostrils, wrists, and chest whenever an offensive odor was detected. Further, Schwestermiller suggests a diet of roasted meals, like roasted fish, with no fruits and no milk. One should avoid bathing and stay away from puddles and dirty public lavatories. As far as medicine was considered, preventive measures recommended bloodletting and laxatives. A physician treating those seeking a therapy for the pestilential bubo would most likely set cupping glasses about two finger breadths below the bubo.

The transition from health to death could take place within twenty-four hours. This rather rapid progression of the disease when the epidemic was raging made people vulnerable on every account, as Boccaccio notes, "[...] whether it was that the disorder was of a nature to defy such treatment, or that the physicians were at fault [...] and, being in ignorance of its source, failed to apply the proper remedies."¹⁷

As the plague spreads through Prussia, the air is filled with the doleful chants that escape from the churches. Since folkways and medicine have failed, Christians now seek shelter with God. In response, the church prescribes prayers and points to those Holy Helpers that the faithful should turn to, especially Saint Sebastian, seen as a protector from the plague. He is the martyr usually depicted pierced by Roman arrows, which have become a symbol of pestilential infection. In 680, Saint Sebastian was held responsible for the fast vanquishing of the plague in Rome. The Prussian people are urged to pray to Saint Sebastian to

¹⁵ Boccaccio, "Introduction," *Decameron*.

¹⁶ Konrad Schwestermiller, "Verhaltensregeln für die Pestzeiten," *Regiment und Lehre wider die schwere Krankheit der Pestilenz* (1484), quoted in *Die Pest in Berlin*.

¹⁷ Giovanni Boccaccio, "Introduction," *Decameron*.

deliver them from sin, and in return they shall receive help and protection from the plague. 18 Such a discipline enjoined by the spiritual authorities rests on the notion that the plague is God's judgment for the commission of sins. It follows that once one falls ill, one shall not rebel against the judgment from above, but accept the punishment without seeking further help in medicine.

In light of the onrushing epidemic, the Prussian king Friedrich I calls together a Collegium sanitatis (consisting of council representatives, physicians, and preachers) and directs them to prepare a comprehensive plague regulation—one that takes into account all experiences with plague epidemics over the previous two centuries. ¹⁹ The plague regulation that results is a substantial change from all the previous regulations, containing more than one hundred specifications regarding the organization of medical measures.²⁰ Some of the spatial measures undertaken are the erection of a plague cordon, which is regulated by various roadblocks. The aim of such a cordon is to cut off all major trading routes between towns. As the state is convinced that countering such pestilence is possible only by establishing order, it adds an act specifying punishment for those trespassing past the plague cordon only a few months after issuing the new plague regulation.²¹ Contrary to Schwestermiller's advice to run to escape from the epidemic, state measures now prohibit people from leaving infected towns and cities, seeing former stampedes as partial causes for the wide dissemination of the plague. All eastward border crossings into East Prussia are blocked and gallows are erected as a deterrent; the death penalty awaits all who attempt to flee out of the areas defined by the plague cordon. Bridges are destroyed and

¹⁸ Another Holy Helper was Saint Roch, who lived before the Black Death of 1477–79 but is often shown displaying the plague bubo in his thigh as a sign of embracing the disease as a chance to imitate Christ's suffering.

¹⁹ Part 3, "Space against Disease," will trace these Prussian state measures back to their origin, i.e., measures taken by Italian city-states between 1350 and 1550. In the following, McNeill describes the vigorous variety of these earlier measures: "In contrast to the rigidities that beset the church, city governments, especially in Italy, responded rather quickly to the challenges presented by devastating disease. Magistrates learned how to cope at the practical level, organizing burials, safeguarding food deliveries, setting up quarantines, hiring doctors, and establishing other regulations for public and private behavior in time of plague." William H. McNeill, Plagues and Peoples (Garden City, NJ: Anchor/Doubleday, 1976), 155. ²⁰ Die Pest in Berlin, 24.

²¹ Ibid.

river ferries are pulled on dry land.²² Thus trade with infected towns is not only prohibited but also made practically impossible.

In August of 1710, once the news from Prenzlau arrives that the plague has broken out, all the city gates in Berlin are immediately bolted. Those seeking to enter must stop two hundred steps in front of the gates, place their passes on the ground, and step back. With a long pair of tongs, a guard then takes the document and holds it over a strongly fuming fire before handing it to the guard commander. If the traveler is allowed to enter, all the money carried with him is washed in vinegar.²³

Each town is now responsible for taking care of its sick, though actions taken are primarily meant to protect its healthy citizens. To establish the desired order, as well as to enforce the punishment maintaining that order, requires staff. The plague regulation authorizes town leaders to appoint these new positions and prescribe their duties. Accordingly, sanitary directors, plague preachers, plague physicians, surgeons, apothecaries, nurses, midwives, alley superintendents, alley masters, alley runners, carriers of the dead, gravediggers, and cleaners are now the arm of the law.²⁴ The underlying concept is one of perfect discipline:

The plague-stricken town, traversed throughout with hierarchy, surveillance, observation, writing; the town immobilized by the functioning of an extensive power that bears in a distinct way over all individual bodies—this is the utopia of the perfectly governed city. The plague (envisaged as a possibility at least) is the trial in the course of which one may define ideally the exercise of disciplinary power. In order to make rights and laws function according to pure theory, the jurists place themselves in imagination in the state of nature; in order to see perfect disciplines functioning, rulers dreamt of the state of plague.²⁵

The new plague regulation further implies that quarantine and lazaretto houses are to be built outside each town. For Berlin, the king allocates a property that is part of the royal estate in the northeast of town, along the banks of the river

²² Jaeckel, *Die Charité*, 10.

²³ Ibid., 18.

²⁴ Die Pest in Berlin, 25.

²⁵ Michel Foucault, *Discipline & Punish* (New York: Vintage Books Edition, 1995), 198–199.

Spree, as the site on which a plague house is to be built. Its history we are about to trace. Berlin, however, will be spared from the plague.

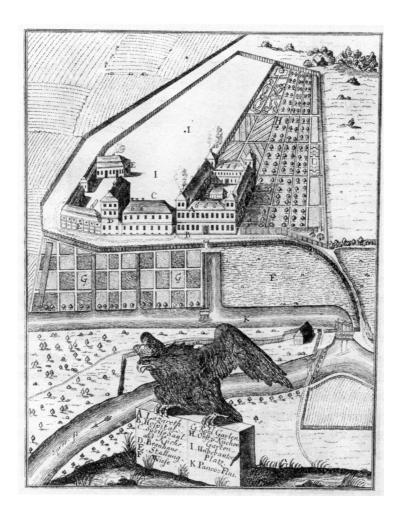


Fig. 1.3. Site of the Charité in 1727

Framing the Space of Plague

Three discoveries made at the turn of the twentieth century allow us to frame the space of plague as a normal biological phenomenon.

In 1894, the bacteriologist Alexandre Émile Jean Yersin, while investigating a new epidemic outbreak of the plague in Hong Kong, discovered the bacillus of bubonic plague—*Pasteurella pestis*, today called *Yersinia pestis*.²⁶ In 1898, the biologist Paul L. Simond outlined the role of fleas²⁷ as intermediary hosts (carriers) transmitting bubonic plague to human hosts. Between 1921 and 1924, an international team of epidemiologists, while investigating an outbreak in Manchuria in the northeast of China, discovered the role played by burrowing rodents of the Eurasian steppe as reservoir hosts of bubonic plague.²⁸ Thus, three independent discoveries made it possible to connect a fatal human disease to a chronic animal disease.

Let us start at the natural habitat of the plague bacillus—the Eurasian steppe. Even today, biologists, bacteriologists, and epidemiologists are unsure about when and how the burrowing rodents of the Eurasian steppe first got infected by *Yersinia pestis*. Historian William McNeill has provided one plausible explanation. He argues, "Mongol movements across previously isolating distances in all probability brought the bacillus *Pasteurella pestis* to the rodents of the Eurasian steppe for the first time."²⁹ It took a long time for the entire steppe to be infected. It took even longer (though running in parallel to this biological process of expansion) for the rodents to develop a chronic infection. Most likely, a mutation of the bacillus, as well as the adaptation of its host (the burrowing rodent), enabled both to form a stable interrelationship that allowed for a permanent habitat of the bacillus to emerge.

²⁶ The bacillus of the bubonic plague was first referred to as *Pasteurella pestis* (in honor of Louis Pasteur), but since 1967 the bacillus has been called *Yersinia pestis* (in honor of its discoverer Alexandre Émile Jean Yersin).

²⁷ In particular, he uncovered the role of the oriental rat flea, called *Xenopsylla cheopis*, in transmitting the bubonic plague to humans.

²⁸ McNeill, *Plagues and Peoples*, 134.

The vast territorial web that the Mongols created with the spread of their empire conjoins with the spread of the disease (McNeill):

[...] Let us consider what probably happened to the distribution of Pasteurella pestis in Eurasia as a consequence of the new patterns of human movement that the Mongols inaugurated. We must assume that prior to the Mongol conquests the plague was endemic in one or more natural foci among communities of burrowing rodents. [...] [The Mongol invaders] presumably infected themselves and thus inadvertently allowed the disease to break through former geographic limits. The superior speed mounted horsemen commanded meant that the infection was able to extend its range of action in the thirteenth century just as it later did in the nineteenth and twentieth centuries.³⁰

With the infection extending "its range of action," the space of disease expanded. Extrapolating from this Mongol movement, we start to understand that men dragged the pathogen of the plague (in the form of fleas as disease carriers) over their trading routes, military campaigns, and pilgrimages, taking it out of its natural habitat and into the human environment of cities and towns. For the distribution of the plague, from ancient times until the outbreak of the epidemic in Prussia in 1709, the Silk Road acted as the main artery. The bacillus spread from caravanserai to caravanserai as camels (as transportation animals) and rats (as feeders on trading goods) picked up fleas from the reservoir hosts of bubonic plague (the burrowing rodents). The camels became infected without falling ill, while the rats compensated for the infection's fatality through their usual high rates of reproduction.³¹ Once the caravanserai arrived at the port cities, the plague bacillus created epizooties (animal epidemics) among the local rat population. Ships leaving for the ports of the Mediterranean cities carried some of these infected rats. McNeill explains:

Before the Black Death could strike as it did, two more conditions had to be fulfilled. First of all, populations of black rats of the kind whose fleas were liable to carry bubonic plague to humans had to spread throughout the European continent. Secondly, a network of shipping had to connect the Mediterranean with northern Europe, so as to be able to carry infected rats

²⁹ Ibid., 134.

³⁰ Ibid., 140–142.

 $^{^{31}}$ A rat can give birth up to twenty times a year (depending on the climate) with a gestation period of approximately 21 days.

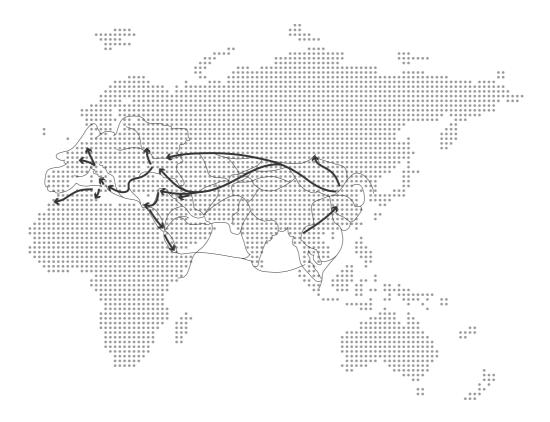


Fig. 1.4. Eurasian Trading Routes in the 14th Century

and fleas to all the ports of the Continent. Very likely the spread of black rats into northern Europe was itself a result of the intensification of shipping contacts between the Mediterranean and northern ports.³²

Hence, two interrelated processes needed to unfold before an epidemic could strike. While the intensification of shipping contacts between the Mediterranean and the northern ports represents a cultural process, the expansion of the population of black rats is a biological process. Thus, urbanization enhances the spread of disease by relying heavily on the expansion of trade.

The epidemic of the plague in 1709 was both the outcome of human development and a natural biological phenomenon. If it were not for the Mongolian horsemen, the camels of caravanserai, the large population of rats on the ships and in the cities, and the close proximity of humans and rats with their fleas in the homes of those cities, the space of disease would not have expanded to Europe. This new extended space of disease—relying on the coexistence of flea carriers and human and rat communities—provided a habitat for bubonic plague, with epidemic consequences for both rats and humans. All it took was an epizooty among rats to increase the risk for human infection and eventually trigger an outbreak of bubonic plague in humans in the form of an epidemic.³³

Then why has the epidemic of bubonic plague disappeared since the eighteenth century in Europe? None of the previously discussed European folkways and religious measures turned out to be effective. To fumigate the homes might have chased away a few rats, but those rats that were already ill and living inside the wooden walls or those dying on the wooden shingle roofs stayed, making it easy for the flea (desperate to survive and so searching for a new host) to transfer to humans. Neither can we hold the expansion of a new species of rat through most

³² McNeill, *Plagues and Peoples*, 146.

³³ However, recent calculation models demonstrate that bubonic plague was able to maintain itself even within a rather small rat population; i.e., 3,000 rats per half a square kilometer are supposed to be sufficient. A metapopulation of 50,000 rats can build a disease reservoir able to last for years. If, however, the reproduction rate of rats falls, single populations die out, fleas go on the move, and the risk for human infection increases. See Matthew J. Keeling and Chris A. Gilligan, "Bubonic plague: a metapopulation modell of a zoonosis," *Nature* 407 (2000): 903–906.

parts of Europe during the eighteenth century responsible.³⁴ Nor were further epidemics thwarted by the well-defined quarantine regulations implemented in northern European port cities—routines that the Christian ports of the Mediterranean had been employing since the late fifteenth century:

Quarantine regulations became institutionalized, first at Ragusa (1465), then at Venice (1485). [...] The requirement that any ship arriving from a port suspected of plague had to anchor in a secluded place and remain for forty days without communication with the land was not always enforced, and even when enforced, rats and fleas could sometimes come ashore while human beings were prevented from doing so. [...] If isolation could be achieved, forty days was quite enough to allow a chain of infection to burn itself out within any ship's company. The quarantine rules which became general in Christian ports of the Mediterranean in the sixteenth century were therefore well founded.³⁵

Since rats prefer to stay within a few hundred meters of their homes, unless going farther is indispensable³⁶ or when they and their nests are moved unaware by humans as part of trading goods, it is possible to imagine some of the ameliorating impacts that the new plague regulations in Prussia might have had. They were hardly true prophylactic measures, but in some rare cases, they most likely halted the expansion of bubonic plague to an area on the scale of a region or town—enforcing an epizooty of rats, after which the resulting epidemic would run its course. For example, within the cordoned off city of Königsberg, 9,827 deaths had been recorded—about a quarter of the population.³⁷

In 1901, the bacteriologist Robert Koch considered the existing administrative regulations for plague control at the ports to be insufficient. He openly criticized the ship inspections for having failed to detect cases of the plague, referring to

³⁴ The new species (the so-called brown rat) was a wilder version of the black house rat, and it preferred to live in burrows instead of the roofs and walls of the houses, therefore widening the distance between rats and humans. McNeill writes further, "There is, however, no ground for the common assertion that the invading gray rat was not susceptible to the plague bacillus; hence the argument that attributes the disappearance of plague to the supplanting of black by gray rats in most of Europe is epidemiologically faulty—as well as anachronistic, since the new rat species only reached western Europe toward the close of the eighteenth century." McNeill, *Plagues and Peoples*, 153.

³⁵ Ibid., 151.

³⁶ Ibid., 153.

³⁷ Wilhelm Sahm, Geschichte der Pest in Ostpreußen (Leipzig: Duncker & Humboldt, 1905), 10–13.

those cases detected in hospitals as entirely incidental. Koch also remarked that fighting against the plague would succeed only with the simultaneous termination of the rats on ships arriving in port.³⁸ Seventy years after his remark, the legal basis for international trade, including specific preventive measures to block the transmission of the plague, was outlined in the International Health Regulations of the World Health Organization. As one consequence of these regulations, it is nowadays standard practice to derat international trading ships.³⁹

However, we still have not been able to answer our question of why the bubonic plague epidemics disappeared in Europe after the eighteenth century. None of the conscious efforts taken against the disease seem able to explain this phenomenon. As suddenly as the plague appeared, it abruptly disappeared, presenting a mystery that would mislead pestilential treatment measures for a long time to come. The answer that seems so logical to us today should provoke a slight feeling of discomfort. Towards the end of the seventeenth century, with quickly expanding ocean navigation, the Silk Road became less important and eventually was displaced by the faster mode of transportation. The space of disease that had led to the outbreaks of the epidemics in Europe was thus interrupted. Although we are able to reconstruct a complex chain of causation, our framing of the space of plague demonstrates, above all, how dazzlingly intertwined our human actions are with the self-organizing processes steered by nature.

The natural habitat of the disease, however, was not constrained. The outbreak of bubonic plague in Hong Kong in 1894 proves this (it also brings us back to our three discoveries that were needed to reconstruct the space of plague). Although bacteriology identified the cause of the disease, the mortality of those infected by the late nineteenth century remained between 60 and 70 percent—there was not much that clinical hospital care could remediate.⁴⁰

³⁸ Die Pest in Berlin, 32.

³⁹ Ibid., 38.

⁴⁰ McNeill, *Plagues and Peoples*, 149.

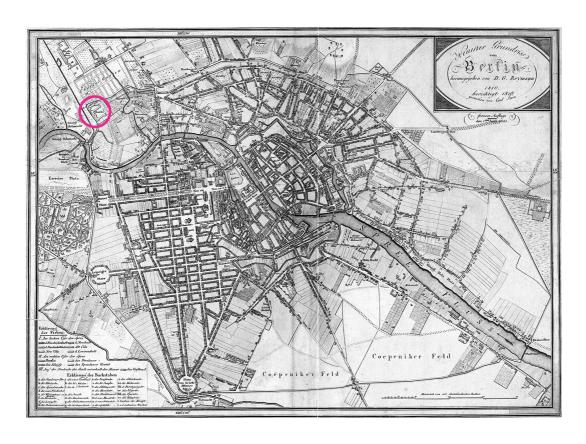


Fig. 1.5. City of Berlin in 1818 (site of the Charité encircled)

The Space of Cholera

Cholera

The year is 1831, and postmortem examinations of five bodies have led physicians to undeniably diagnose cholera as the cause of death. Two days later, on September 1, the civil defense commission announces that the city of Berlin is "infected."⁴¹ It is the first outbreak of cholera in Berlin. Throughout the next five months, 2,271 citizens will fall ill, and of that group, 1,426 will die. Cholera epidemics will go on to recur twelve more times within the next forty years, claiming 28,657 lives in Berlin alone.

Throughout the eighteenth century, Berlin—the royal capital and residential city of Prussia—gained politico-military importance. The city's population (now almost 240,000) increased fivefold in a hundred years. Ranking among the largest European cities, Berlin expanded far beyond the old rampart in all directions. To surveil trade and to collect the royal excise tax, a wooden customs wall was erected (1734–37) and later rebuilt out of stone to a height of four meters (1786–1802). In the 1830s, most of the fourteen city gates shine with a new splendor. Within the city, new cultural buildings (like the theater and the museum for the royal family's art collection) are representative of a soon-to-arrive bourgeois society.

⁴¹ Announcement, *Prussian State Newspaper* (*Preußische Staatszeitung*), no. 243, September 2, 1831, quoted in Barbara Dettke, *Die Asiatische Hydra* (Berlin: Walter de Gruyter, 1995). ⁴² "Do not underestimate the presence of a garrison as a city-building agent. In 1740 [as throughout the most part of the eighteenth century] the military population of Berlin numbered 21,309 out of a total of about 90,000 people: almost a quarter. The presence of this mass of mechanized and obedience-conditioned human beings necessarily touched every other aspect of life. The army supplied the model in its discipline for other forms of political coercion: people got into the habit of accepting the aggressive bark of the drill sergeant and the arrogant brutal manners of the upper classes: they were copied by the new industrialists, who governed their factories like absolute despots." Lewis Mumford, *The Culture of Cities* (New York: A Harvest Book, 1970), 89.

At the turn of the nineteenth century, more and more streets of the inner city are cobbled and lined with granite sidewalks. Yet, as chronicler Adolf Streckfuß describes, kitchen scraps and the contents of chamber pots still land in the gutter between the sidewalks and the streets, washing into the canals and eventually into the river Spree. To add to this contamination, each night the river is fed with the contents of latrines. Hundreds of buckets of feces (collected from the cesspools of the houses) are eventually dumped into the river. As a contemporary, the poet Friedrich Rückert, puts it, "the Spree enters Berlin as a swan and exits it as a pig." On hot days the whole city is encased in a pungent smell. Even though the pigsties are gone, city life remains filthy. Drinking water is withdrawn not from the river (of course) but from the groundwater—lifted by pumps from numerous wells and carried by buckets to the houses.

The majority of Berlin's inhabitants are poverty stricken. Their life expectancy is thirty-eight years on average. Ever since freedom of trade (1810) was implemented, more and more cabinetmakers, tailors, and shoemakers have slowly become impoverished, many forced to work as day laborers, as market prices for their craft decline. After the textile industries (the economic mainstay of the city) relocate to the rural suburbs to reduce their production costs, many former weavers are unemployed and depend on the poor law board for assistance to feed their families. Furthermore, since the abolition of serfdom, lots of ruined peasants from the provinces of Brandenburg and Silesia have resettled in the city. For the last ten years, the rents have been rising (by 1840 they will have doubled within twenty years), leading to even more crowded housing in the city.⁴³

About a twenty-minute walk from the Charité, a building complex consisting of seven family homes within the Voigtland district (part of the Rosenthaler suburb) attracts a great deal of attention from the district authorities. Nowhere else in Berlin have more people fallen ill with infectious diseases, like measles,

⁴³ Lothar Baar, "Die Berliner Industrie in der industriellen Revolution," in Barbara Dettke, *Die Asiatische Hydra* (Berlin: Walter de Gruyter, 1995), 170.

scarlet fever, and smallpox. Cholera rages in this district as well. Thus, the district's life expectancy remains below the city's average. Nowhere else in the city do people live in more cramped conditions. Often more than ten people have to share one room in which they work, sleep, and cook. A total of 1,500 residents share the facilities of two courtyards, which contain two wells for drinking water and forty-eight toilets. All wastewater runs into overflowing cesspools, causing the courtyards to swamp.⁴⁴

Until now, none of the high-ranking representatives of the medical discipline had ever been confronted with cholera. However, some Prussian physicians had been sent to study earlier cholera outbreaks in Moscow and Petersburg, so at least they know what to expect. Once someone has fallen ill, the body passes through three phases over the course of the disease. During the first, victims experience extreme muscle cramps and a severe form of diarrhea with vomiting. The disease strikes literally without prior symptoms: suddenly sharp pains make arms and legs twitch, and the body releases a rice-water-like diarrhea. 45 During the second phase, the diarrhea and vomiting attacks completely fade away. While the eyes recede deep into the eye sockets, the cheekbones protrude as the victim's face grows haggard and turns darker than the hands. Eventually a cholera victim's skin appears bluish-gray; from a present-day perspective, this coloration results from dehydration and electrolyte imbalance. The depleted body hardly allows for a reading of the pulse, which is only slightly accelerated, yet people remain conscious. During the third phase, the pulseless body falls into a dazed condition (sometimes even into a coma-like state) and its temperature drops to about 33 degrees Celsius. Cholera makes "the living look as dead and the dead as alive."46

Professor Johann Nepomuk Rust (Prussia's chief medical officer of health) performs a postmortem examination of the first body believed to come from a cholera victim. The autopsy takes place at the Smallpox House of the Charité. The

⁴⁴ Barbara Dettke, *Die Asiatische Hydra* (Berlin: Walter de Gruyter, 1995), 180–182.

⁴⁵ Jaeckel, Die Charité, 269-272.

⁴⁶ Professor Johann Nepomuk Rust, letter to Alexander von Humboldt (while residing as Prussian diplomat in Paris), in Jaeckel, *Die Charité*, 279.

most striking features of the body are the dried out blood vessels: the arteries are bloodless, and the veins release only a light, thin liquid. Their inner walls stick together as if joined by a dark red paste. The glands of the inner intestinal walls are swollen and inflamed. The stomach appears as if bleached. In short, all the pathological changes that the studies from Moscow and Petersburg had reported are identifiable here. Undeniably, this corpse is infected with cholera.⁴⁷

On identifying cases of cholera, the medical profession is in unison. Diseaserelated symptoms are specific, and the course the disease takes is distinctive. However, by the 1830s two oppositional medical theories have formed that point towards different causes of the disease. The theory of contagion supports the belief that the disease is spread by contact between organisms. In the case of cholera, the disease is suspected to spread primarily through human contact. The theory of contagion, however, does not include environmental factors. The miasma theory, on the other hand, sees all causes of disease as lying within the environment. Accordingly, the foul air of unsanitary spaces is suspected as cholera's source. Professor Rust, the director of the Charité, is a convinced contagionist. He believes that people, particularly those who have moved from India into Russia, are responsible for this outbreak of cholera. And it is Rust who earlier had advised the king to cordon off the eastern borders of Prussia. Anyone traveling without a legitimation card who approached Prussia from the east (from Russia or Poland) was denied entry. Trade was similarly restricted. Each bridge over the Oder, each ferryboat, and each road leading into Prussia was controlled by roadblocks and armed guards. Rust believed that these measures would insure that Berlin would be spared from the epidemic.⁴⁸ By enforcing a cordon sanitaire, Prussian authorities anticipated they would halt the westward course of the epidemic. But now, as the postmortem proves Berlin has been infected, Rust has to admit that these attempts have failed.

A Prussian cordon sanitaire consists of various spatial as well as administrative measures, including road and bridge blockings, quarantine houses (so-called

⁴⁷ Jaeckel, Die Charité, 279-280.

⁴⁸ Jaeckel quotes Rust saying, "Berlin will be spared from the pestilence." Jaeckel, *Die Charité*, 270.

Kontumaz), viewing platforms, and cordon patrols. Once an epidemic leaps over the line, a cordon sanitaire is terminated. Traffic blocks and quarantine measures for travelers (*Kontumaz*) are suspended, and the associated quarantine houses are converted into lazarettos for the diseased. In the case of this epidemic, the *Kontumaz* facilities along the border to Poland remain, and each foreign traveler is quarantined for five days. Only couriers are allowed to travel and cross the border. Traffic within the monarchy also remains restricted and requires legitimation cards.⁴⁹

Before the outbreak of the cholera epidemic in Prussia, physicians had received guidelines, the so-called Therapeutic Measures for Asiatic Cholera, outlining sixteen essential measures used to treat a cholera patient. These guidelines, however, include only medicine's usual remedies, like bloodletting (a minimum of one pound of blood should be drawn); a variety of medications to calm down the stomach are listed, and an embrocation of *Spiritus vini gallici* (rubbing alcohol) is advised for application with a scrubber.⁵⁰

The debate between the contagionists and the miasmatists is carried out in publications of the day. The *Berliner Cholera Paper* functions as the official governmental newspaper and defends the contagion theory by publishing the articles of established medicinal civil servants, while the *Journal about the Behavior of Malignant Cholera in Berlin* proposes to trace the disease "free and independently" for "purely scientific" reasons and is run by a twenty-eight-year-old Jewish physician.⁵¹ Unsurprisingly, affluent citizens agree with the official contagion theory and obey the cholera regulation passed by the state, which advises them to live a moderate life, avoid excesses, stay on a strict diet (to eat foods not too fat and not too acidic), keep out of the streets at night, close the window when the sun shines, and only air their homes at night. Their servants are asked to sprinkle vinegar when the air is hot and disinfect the incoming and outgoing mail.⁵²

⁴⁹ Dettke, *Die Asiatische Hydra*, 193.

⁵⁰ Jaeckel, *Die Charité*, 274–275.

⁵¹ Dettke, Die Asiatische Hydra, 198-204.

⁵² Jaeckel, Die Charité, 292-293.

Now that the cholera epidemic has emerged, the city is divided into sixty-one civil defense commissions. Each division is equipped with a defense command. Their purpose is to enforce the primary rules of the cholera regulation: isolate the diseased and those who have been in contact with the diseased, as well as transport and bury the dead.⁵³ The diseased are transported to one of Berlin's five quarantine-lazarettos for treatment and, more importantly, isolation from everyone else. The dead bodies are brought to one of the three cholera cemeteries outside the custom wall.⁵⁴ Since the majority of those who fall ill die within hours and since their numbers are rapidly rising, most attempts to transport the diseased fail.

Establishing a barrier around the quarantine-lazaretto and keeping its residents isolated also soon turns out to be an impossible task. The civil defense commands are simply to few in number to enforce such a quarantine. Moreover, many of the diseased cannot be transported, depending upon their phase of disease. So the authorities shift their efforts to installing at least some barriers around affected dwellings. Their aim is to quarantine only specific apartments within a building instead. Residents who have been in contact with the diseased are kept imprisoned in their rooms for twenty days. Doors are nailed up, while windows remain open. Entire houses are disinfected with chlorinated lime and sulfuric acid. 55 All these efforts deviate strongly from the quarantine measures of the original cholera regulations. Further abandonment of protocol occurs as food shortages cause turmoil among residents. The civil defense commissions are now forced to patrol those districts where the upheavals are most disruptive. Gradually all quarantine measures start to fail in their implementation—the cholera regulations eventually become obsolete. 56

By the end of October 1831, the civil defense commission has waived even the

⁵³ Ibid., 276.

⁵⁴ Four of the quarantine-lazarettos were established after the outbreak of the epidemic, since the Smallpox House of the Charité accommodated only thirteen beds. Soldiers are treated differently from civilians and are sent to one of the four military lazarettos. Dettke, *Die Asiatische Hydra*, 176–179.

⁵⁵ Jaeckel, Die Charité, 286.

⁵⁶ Dettke, *Die Asiatische Hydra*, 194–195.

rule for barriers around infected dwellings within a building. The remaining enforcement efforts focus on disinfection. Thus, residents or family members who have been in contact with a diseased person are subjected to fumigation, but are no longer quarantined. Affected rooms are fumigated for one to two days. Objects that have been in contact with a diseased person who has died are placed with the dead body into a cholera coffin (a wax-clothed crate).⁵⁷ Beds are transported to cleaning institutions and cut open so their feathers can be fumigated for four to six hours inside a closed box and then boiled out.⁵⁸ The civil defense command, its soldiers encased in wax-clothed coats, carry out all these measures. As an act of deterrent, they ring a handbell when moving through the streets of the inner city, alerting citizens that the cholera is passing through.⁵⁹

On February 9, 1832, ten days after the convalescence of the last cholera patient at the Charité, the sanitary committee announces that the city of Berlin is "clean and unsuspicious," and thus all previous regulations and restrictions are rescinded. By the end of February, the cholera epidemic has vanished everywhere in Prussia.

Framing the Space of Cholera

To describe the chain of causation that formed the space of cholera, we will move chronologically.

Europeans first took notice of cholera in 1817 when a terrible pandemic broke out in the region of Calcutta. Therefore, cholera was commonly referred to as the "Asiatic" cholera. What the Europeans did not know (at the time) was that the cause of the disease was endemic to the natural flora of brackish water found in the tidal-washed estuaries of the Ganges-Brahmaputra delta in the former geographical region of Bengal in South Asia:

⁵⁷ Ibid., 195-196.

⁵⁸ Ibid.

⁵⁹ Ibid.

⁶⁰ Announcement by the Gesundheits-Komitee, in Dettke, *Die Asiatische Hydra*, 205.

What seems to have happened is that an old and well-established pattern for spreading cholera across the Indian landscape intersected new, Britishimposed patterns of trade and military movement. The result was that the cholera overleaped its familiar bounds and burst into new and unfamiliar territories, where human resistance and customary reactions to its presence were totally lacking. [...] British troops fighting a series of campaigns along India's northern frontiers between 1816 and 1818 carried the cholera with them from their headquarters in Bengal, and communicated the disease to their Nepalese and Afghan enemies. Far more dramatic were the movements by sea. Ships carried cholera to Ceylon, Indonesia, the southern Asian mainland, China, and Japan between 1820 and 1822. [...] The episode proved only a foretaste of the far more extensive wanderings of the cholera bacillus in the 1830s, making the disease genuinely global. A new cholera epidemic emerged from Bengal in 1826 and quickly retraced its previous path into southern Russia's wars against Persia (1826-28) and Turkey (1828-29) and the Polish revolt of 1830-31, carried the cholera to the Baltic by 1831, whence it spread by ship to England.61

In 1832, after the quarantine measures applied by the Prussian health authorities had failed, even diehard contagionists had to admit that they were unable to document a single case of a direct transmission of the disease from human to human. Consequently, arguments supporting the germ theory of cholera contagion started to wane. As chief medical officer of health, Ernst Ludwig von Koenen stated: "as a medical civil servant, I consider the disease contagious, [but] as a practicing physician, I have to say, no, the disease is not."62 Given this slowly accumulating disbelief by the Prussians, along with the discrediting of contagionism by the most prestigious European medical culture at the time (the French medical school), it is no wonder that the arguments for the germ theory of transmission had fallen silent.63

One of the authorities on cholera in the German-speaking world of the nineteenth century was Max von Pettenkofer. As early as 1836, Pettenkofer

⁶¹ McNeill, *Plagues and Peoples*, 232–233.

⁶² "als Medizinalbeamter halte ich die Krankheit für ansteckend, als praktischer Arzt sage ich jedoch: Nein, sie ist es nicht." Ober-Medizinalrat Koenen, quoted in Dettke, *Die Asiatische Hydra*, 201

⁶³ "[...] when yellow fever broke out in Barcelona (in 1822), French experts, led by Nicholas Chervin, organized systematic and careful study of how the disease occurred—they seized the opportunity to make a definitive test of the contagionist as against the miasmatic school of thought. They concluded that there was no possibility of contact among the different persons who came down with yellow fever in Barcelona." McNeill, *Plagues and Peoples*, 235.

realized that the recurring cholera epidemics in Munich were the result of the insufficient supply of water and poor disposal of wastewater in the city. In his publication Investigations and Observations of the Transmission Mode of Cholera (1855), Pettenkofer evaluates the epidemic by introducing local inspections and extensive statistical data (techniques that are nowadays indispensible in epidemiology). In addition to Munich, Pettenkofer analyzed and compared eight further cities to measure the differences in their outbreaks of cholera. As a proponent of the miasma theory, Pettenkofer argued that the local spread of an epidemic depends on the soil condition. Locations where cholera emerged exhibited a rather porous soil, permeable by water and air. He further observed that lower districts were more frequently affected by the epidemic than elevated parts of towns. The city that Pettenkofer evaluated as "most favorable," or most resistant to a cholera outbreak, was Würzburg. Erected primarily on bedrock, the city features sloped ground that provides natural drainage—furthermore, canalization channels were carved into the rock and the drainage canals were built of brick. The houses were equipped with wastewater pipes also built out of stone (wooden pipes were more common back then).⁶⁴ However, Pettenkofer's attempts to establish a systemic water supply as well as water disposal infrastructure for the city of Munich in the 1850s failed due to the lack of money and little local political interest.

In 1854, Filippo Pacini, an Italian physician (chair of general and topographical anatomy at the University of Florence), first discovered the bacillus *Virbio cholerae* during a cholera epidemic in Florence. Pacini clearly described the microorganism as the causative agent of cholera. Inconceivable as this is to us, his publication *Microscopical Observation and Pathological Deductions on Cholera* went unnoticed within the medical community, which shows how detached and mutually exclusive (how national) the European discourse in medicine was. If such a microscopic discovery had been made twenty-three years earlier in Berlin, while Rust dissected cholera-diseased bodies during the first cholera epidemic in 1831, Pacini's finding of the bacillus would have been concurrent

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⁶⁴ Max Pettenkofer, *Untersuchungen und Beobachtungen über die Verbreitungsart der Cholera* (München: J.G. Cotta'schen Buchhandlung, 1855), 113–114.

with the predominant medical theory (contagionism) at the time and therefore widely noted.⁶⁵ But instead, the resurgent medical orthodoxy that clung to the miasma theory was unreceptive towards his astonishing discovery.⁶⁶

From our contemporary perspective, we know that both miasmatists and contagionists failed to suspect that cholera might be a waterborne disease. Their dispute arose because the cause of the disease is not identical with the outbreak of the disease. Thus, the mere fact that the pathogen found a habitat within an urban environment (most likely carried in by a human host) does not account for the outbreak of an epidemic. However, a lack of hygiene that allows for the contamination of drinking water with the pathogen, that is, that lets previously separated paths of water—infected sewage and drinking water—cross, does account for such an epidemic. The bacillus *Vibrio cholerae* settles inside human intestines and, in the usual case of an epidemic, reaches other humans through water contaminated by the excrement of disease victims in the sewage. In rare cases, the bacillus can also spread when humans come in direct contact with the intestinal contents of a cholera-diseased person, most likely during nursing care or when washing infected cloths.

Again, it seems inconceivable to us today that an English physician by the name of John Snow made the conceptual link between the outbreak of cholera and drinking water as a causal carrier of contamination as early as 1854, yet was once more ignored by the medical community during his time. How did Snow make this connection? He was unaware that Pacini had discovered the cholera

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⁶⁵ In 1546 (De Contagione et Contagiosis Morbis), Girolamo Fracastoro, a physician from Verona, proposed that infectious diseases could be spread by transferable tiny particles or 'spores' that could transmit by direct or indirect contact. Wolfgang Eckart, *Geschichte der Medizin* (Berlin: Springer-Verlag, 2009), 112-113.

⁶⁶ "Miasma turns out to be a classic case of what Freud, in another context, called 'overdetermination.' It was theory that drew its persuasive power not from any single fact but rather from its location at the intersection of so many separate but compatible elements, like a network of isolated streams that suddenly converges to form a river. The weight of tradition, the evolutionary history of disgust, technological limitations in microscopy, social prejudice [...] The river of intellectual progress is not defined purely by the steady flow of good ideas begetting better ones; it follows the topography that has been carved out for it by external forces. Sometimes that topography throws up so many barricades that the river backs up for a while. Such was the case with miasma in the mid-nineteenth century." Steven Johnson, *The Ghost Map* (New York: Riverhead Books, 2006), 134–135.

bacillus in the same year, but Snow was a physician after all. He therefore analyzed cholera according to traces that the disease left inside the human body. To him, cholera displayed symptoms of a bodily (i.e., gastro-intestinal) disease. Consequently, he concluded that the disease could not have arrived from something that one might have inhaled; the carrier had to be something swallowed. Being a proponent of the germ theory, Snow entered the cholera scene with that theory in mind and so suspected drinking water as the contaminated source. The cholera outbreak during the summer of 1854 in central London provided the case study he had been waiting for.

But without evidence of the existence of cholera-linked bacteria at hand, it was impossible to convince the oppositional majority of British liberals who generally saw the germ theory as a Roman Catholic superstition. Because it was commonly believed that cholera was caused by atmospheric pollution, quarantine regulations were considered an "irrational infringement of the principle of free trade."67 In the upcoming era of the natural sciences, where empirical evidence would be a prerequisite, convincing somebody of the existence of an invisible germ was unlikely. Imagine holding a glass of water infested with cholera bacteria in your hand. None of our biologically given human senses can help us to detect the bacteria. We can neither see nor smell nor taste the bacteria in the water. As if that were not enough, the theory that "all smell is disease" further prejudiced most scientific minds and measures.⁶⁸ Snow needed a new approach. So he started a map that combined time and space attempting to make visible an otherwise invisible pattern. Snow's map redrew the neighborhood according to actual walking time (like a Voronoi diagram) and reorganized the death toll data according to specific street addresses. Instead of observing the phenomenon of cholera (its fatal attacks and resulting deaths) solely over the vector of time (in the format of a chronological tablet), Snow lined up black bars for each cholera death next to specific street addresses, allowing

⁶⁷ McNeill, *Plagues and Peoples*, 235.

⁶⁸ In his 1846 testimony to a parliamentary committee investigation of the problem of London's sewage, the sanitation commissioner, Edwin Chadwick, stated: "All smell is, if it be intense, immediate acute disease; and eventually we may say that, by depressing the system and rendering it susceptible to the action of other causes, all smell is disease." Johnson, *The Ghost Map*, 114.

the data to be read geographically. By reformatting the data, he enabled the space of the epidemic outbreak to appear. That, in turn, drew attention to a particular water pump on Broad Street, the neighborhood's preferred source of drinking water. Snow's map turned out to be significant later on, even it if did not leave an immediate impact:

As the waterborne theory of cholera became increasingly accepted, the map was regularly invoked as a shorthand explanation of the science behind the theory. It was easier to point to those black bars emanating ominously from the pump than it was to explain the whole idea of microorganisms invisible to the human eye. The map may not have had the impact on its immediate audience that Snow would have liked, but something about it reverberated in the culture. Like the cholera itself, it had a certain quality that made people inclined to reproduce it, and through that reproduction, the map spread the waterborne theory more broadly. In the long run, the map was a triumph of marketing as much as empirical science. It helped a good idea find a wide audience.⁶⁹

The circumstances that led to the implementation of sewer networks in central London is a story that is often told wrong. One of the most ambitious engineering projects of the nineteenth century was not installed as a preventive measure against cholera (even though in retrospect it seems logical to assume so, since Snow already referred to cholera as a waterborne disease). Instead the implementation of sewer lines was the outcome of a reaction to what the press labeled as the *Great Stink*—the smelliest summer in London's history. Until 1858, all the sewer lines of the city emptied directly into the Thames, filling the air with a noxious smell and contaminating the water. The visionary behind this complex infrastructural project was the engineer Joseph Bazalgette, who had been preparing these plans for years. His concept was to carry the waste and surface water of central London way outside to the east of the city before depositing them into the river Thames.⁷⁰ In 1859, when construction of the 132 kilometers of sewers started, London (unlike Berlin) held a population of three million. Although a greater metropolitan scale was not perceivable at the time, Bazalgette envisioned a still further increase of London's population and so specified an oversized diameter for the sewers. Six years later, most parts of the sewer

⁶⁹ Johnson, The Ghost Map, 198-199.

network were operational. In one of the districts where the sewer system remained incomplete, a cholera epidemic struck London for the last time in 1866.

In 1869, only four years after London had completed most of its canalization, James Hobrecht was commissioned to plan twelve radial systems for sewage collection in Berlin. Hobrecht, who had established the binding land use plan for the city in 1862, scheduled construction to begin in 1873—the year that the last cholera epidemic struck Berlin. One of the strongest proponents of this infrastructural project was Rudolf Virchow (medical advisor for the project and the founder of modern pathology). Virchow did not support the growing belief that cholera was a waterborne disease, but he still encouraged the authorities to enforce the large project, arguing that such a sewer network would improve the sanitary condition of the city. He based his support on the same argument Pettenkofer had so vehemently defended for years, that is, atmospheric pollution (miasmatic air), water, and soil conditions were responsible for cholera.

Over the course of twenty years, twelve separate radial systems for sewage collection were installed. Each consisted of various underground channels and a pump station. Their purpose was to pump waste and surface water through pressurized lines from the inner city to irrigation fields far outside of the city. The aim of this sewage system was to relieve the river and city canals from contamination. After its implementation, the sewage system successfully achieved this goal. By means of mechanical-biological treatment, sewage was used to irrigate a large area of pebbly grounds, which made the water reusable. With the benefit of hindsight and present knowledge, we know that this kind of irrigation led to acidification of the soil, followed by heavy metal poisoning of lower soil layers, which eliminated future agricultural use of these areas. So, by relocating its original problem, the city of Berlin did not eliminate it. The implementation of the sewage system, however, lessened the overall risk factor that the polluted water presented within the dense urban context.

 $^{^{70}}$ It was only in 1887 that the sewage was directed into a clarifying basin, where a mechanical-biological and chemical purification of the water took place.

When in 1883 a cholera epidemic erupted in Egypt, Europeans decided to collaborate with Egyptian authorities, sending out Robert Koch (one of the leading bacteriologists at the time) with a group of researchers to Alexandria. After dissecting several cholera-diseased persons, Koch and his team rediscovered Pacini's bacillus. Hence, thirty years apart and independently of one another, Pacini and Koch discovered the cholera bacillus *Vibrio cholera* (many believed Koch to be the first to discover the bacillus). However, at that time, Koch and his team could not confirm if the bacillus was causal or consequential. All they knew was that the bacillus only appeared in the intestinal mucosa of those who had died of cholera. For identifying a disease-causing agent, Koch together with Friedrich Loeffler developed a framework (Koch's Postulates), which are less relevant in microbiology and parasitology today:72

(1) The microorganism must be found in every case of the disease. (2) It must be isolated and cultivated in pure culture. (3) Inoculation of such culture must produce the disease in susceptible animals. (4) It must be observed in, and recovered from, the experimentally diseased animal.⁷³

In 1884, Koch's team continued their research in Calcutta, where Koch was finally able to successfully isolate the bacillus in pure culture. When he was unable to reproduce the outbreak of cholera in animals, Koch speculated (accurately) that animals are immune to the cholera bacillus. This consequently led Koch to abandon his first postulate. Reporting back to the scientific community in Germany, Koch explained that the bacillus is extensively present in the diarrhea (rice-water-like stool) of a cholera-diseased person. With this evidence at hand, Koch opened the door for a plausible explanation of how the disease is able to spread and how a rapid outbreak of an epidemic is able to emerge:

⁷¹ Ralph R. Frerichs, "Who first discovered *Vibrio cholerae*?" Web-archive of Professor Ralph R. Frerichs at the department of epidemiology of the University of California in Los Angeles; www.ph.ucla.edu/epi/snow.html (assessed 2013).

⁷² Eckart, Geschichte der Medizin, 215.

⁷³ Miller-Keane, Encyclopedia & Dictionary of Medicine, Nursing, & Allied Health, 820.

⁷⁴ Alfred S. Evans, "Causation and disease: the Henle-Koch postulates revisited," *Yale Journal of Biology and Medicine* 49, no. 2 (May 1976): 175–195.

With Koch's findings, the tide of scientific and public opinion began to increasingly change, although slowly. Scientists were divided in Germany, almost entirely negative to Koch's theory in France, and nearly so in England. In the international sanitary conference of 1885 attended by Robert Koch along with representatives of 28 countries, the British delegation successfully blocked any "theoretical discussion on the etiology of cholera," thereby denying evidence that British John Snow had so carefully described in his 1855 book, Italian Filippo Pacini had witnessed in his microscopic studies, and German Robert Koch had cultured in his field and laboratory studies.⁷⁵

One of Koch's toughest opponents in Germany was Pettenkofer. After Koch had provided the undeniable evidence of the existence of the cholera bacillus, Pettenkofer started to slightly adjust his earlier cholera theory. He now postulated three soil criteria as the epidemic cause: "first, the physical aggregation of soil particles (permeability for water and air), second, the water content and the water holding capacity of the soil (groundwater conditions), and third, nutrients for pathogenic microorganisms in the soil (ground contamination)."⁷⁶ Even though Pettenkofer incorporated the cholera bacillus into his theory, he continued to vehemently deny the bacillus's relation to cholera as cause of disease. Pettenkofer even went so far as to drink a cup of water infected with cholera bacilli to demonstrate the misconception of the germ theory. His failure to fall ill—a triumph for Pettenkofer—stirred further debates and gave rise to uncertainties about the bacillus and its role in the transmission of the cholera infection.

The last major cholera epidemic in Germany took place in greater Hamburg in 1892. This tragedy took 8,600 lives, yet the epidemic also provided a window of opportunity to compare (not theoretically but actually) the impact of two urban sanitary strategies. Hamburg, a self-governed city, obtained its drinking water supply from the river Elbe without special treatment. Altona, an adjacent Prussian town, obtained its drinking water from a water-filtration plant whose implementation had been enforced by the Prussian authority of the Imperial Department of Health (with Robert Koch as its director). The result speaks for

⁷⁵ Frerichs, "Who first discovered Vibrio cholerae?"

 $^{^{76}\,\}mathrm{Max}$ Pettenkofer, Zum gegenwärtigen Stand der Cholerafrage (München: R. Oldenbourg, 1887), 520.

itself:77

In 1892, when cholera broke out in Hamburg, it ran down one side of the street dividing the two cities and spared the other completely. Since air and earth—the explanations preferred by the miasmatists [like Pettenkofer] were identical across the boundary between the two cities, a more clear-cut demonstration of the importance of the water supply in defining where the disease struck could not have been devised. Doubters were silenced; and cholera has, in fact, never returned to European cities since, thanks to systematic purification of urban water supplies from bacteriological contamination.⁷⁸

From our present-day perspective, we are able to comprehend how cholera spread rapidly from India (1826) into Europe (1831) due to the speed of the steamships and railroads connecting the countries (fig. 2.5).⁷⁹ We are also able to understand how a cholera epidemic managed to emerge thirteen times within a city like Berlin (1831–73). The causal agent of cholera, the bacillus *Vibrio cholerae*, was carried in by human hosts (perhaps more than thirteen times) and spread throughout the urban population by means of contaminated drinking water. But for an epidemic outbreak to occur, two conditions had to be met. First, the bacillus needed to find an endemic habitat—cesspools filled with the raw sewage. Second, the contaminated sewage deposit, i.e., human excrement contaminated with cholera bacillus, needed to mix with the drinking water supply, causing the groundwater wells to become infected with cholera bacillus. Insufficient sanitary living conditions were ultimately the primary ingredient for cholera epidemics. The rapid urban densification process of Berlin (mirrored by

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^{77 &}quot;Da nun ausserdem in den folgenden Jahren das regelmäßige Vorkommen der Cholerabakterien bei echter Cholera asiatica in verschiedenen Epidemien, welche sich im Laufe der Zeit in Frankreich, Italien, Spanien, Südamerika entwickelten, tausendfach bestätigt wurde, und da auch alle Erfahrungen der jetztigen Epidemie dasselbe gelehrt haben, so können wir es jetzt wohl als eine feststehende Thatsache ansehen, dass die Cholerabakterien unzertrennliche Begleiter der asiatischen Cholera sind und dass der Nachweis derselben das Vorhandensein dieser Krankheit mit unfehlbarer Sicherheit beweist." Robert Koch, "Über den augenblicklichen Stand der bakteriologischen Choleradiagnose," *Zeitschrift für Hygiene und Infectionskrankheiten* (Berlin) 14 (1893): 319.

⁷⁸ McNeill, *Plagues and Peoples*, 242.

⁷⁹ While writing this paragraph, I am watching a video that has animated the emergence of all the global ocean shipping lines that were established in the mid-nineteenth century. Observing all of these navigational trading routes unfolding, I see the world as a single circuit board—a conveyer belt of germs. "Shipping maps and how states see," *Sapping Attention*, online blog; http://sappingattention.blogspot.com.au/2014/03/shipping-maps-and-how-states-see.html (accessed 2013)

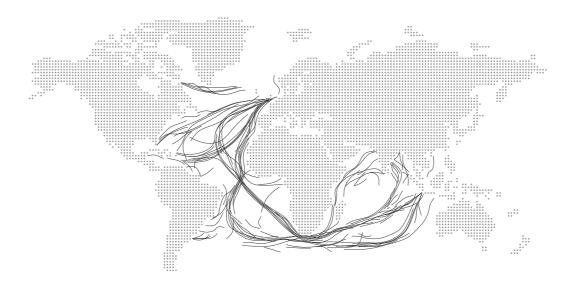


Fig. 1.6. Steam Boat Shipping Routes 1800-1850

so many major European cities at the time) turned parts of the city into an *intermediate host*—a carrier of the vital disease. The European culture that globalized trade to build cities at an unprecedented speed was not accustomed to Bengali folkways in India (the natural foci of the cholera bacillus), including the practice that water should only be consumed after boiling. Consequently, one could argue that a city that relied on globalized trade eventually would need to upgrade its urban folkways. Implementing a sewage system represents one of many urban folkways we commonly file under urban quality of life, while in fact, more than that, such upgraded folkways were adaptive and essential strategies of *urban survival*.

We are left with one question: Why did the epidemic that emerged in August 1831 end as abruptly as it did in February 1832? The answer lies in the realm of biology. The bacillus *Vibrio cholerae* is not fond of cold temperatures. Its natural habitat requires an ambient temperature of 10–43 degrees Celsius.⁸⁰ Hence, the bacillus died once its endemic habitat (the cesspools of Berlin's tenements) could not provide its necessary living conditions.

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⁸⁰ According to the *U.S. National Library of Medicine, Cholera* is caused by: the bacterium *Vibrio cholerae*. These bacteria release a toxin that causes an increased amount of water to be released from cells that line the intestines. The increase in water produces severe diarrhea. http://www.nlm.nih.gov/medlineplus/ency/article/000303.htm (accessed 2013)

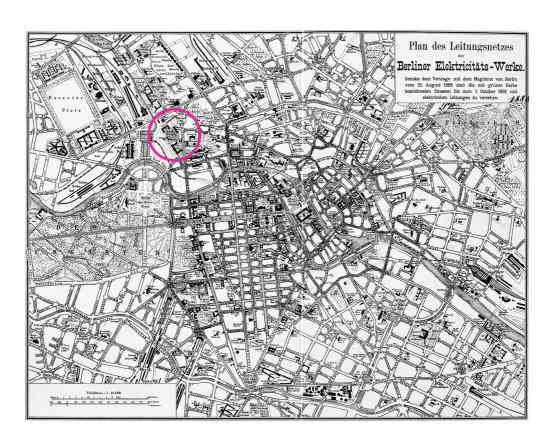


Fig. 1.7. City of Berlin in 1888 (site of the Charité encircled)

The Space of Hospital Gangrene

Hospital Gangrene

The year is 1864, and no matter which major hospital in Europe patients enter, they find a very large number of nosocomial infections, so-called hospital gangrene. At the Charité in Berlin, an average of 40 percent of patients die from these postsurgical infections. The mortality rate at the Kantonsspital in Zurich is even higher, about 46 percent, and an alarming 60 percent of all surgical cases lead to the fatal infection at the Hôtel de Dieu in Paris.⁸¹

Berlin's rapid urbanization unavoidably had led to disproportional growth among social classes. Amid the growing urban population, the class of wage earners increased the most. As a consequence of the limited housing available to such workers noted earlier, an ever-growing number of people were forced into unreasonable living conditions. And as discussed just previously, with nonexistent municipal sewage and waste management, urban life itself posed a dangerous threat. After the first cholera outbreak in 1831, nine further epidemics followed, and the largest cholera outbreak in the history of Berlin was yet waiting to happen.

Two years earlier, in 1862, the engineer James Hobrecht had established an extensive land-use plan for the city (1859–62), which envisioned the urban area as increasing fivefold. It will take five years from 1864 for the city to commission Hobrecht again to plan twelve radial systems for sewage collection; another nine years for its construction to begin; and another fourteen years for eight private companies to complete each their own independent rail network and terminal

 $^{^{81}}$ An open fracture of the lower leg is often an indication enough for amputation. For statistics of mortality rate, see Jaeckel, *Die Charité*, 494.

station. However, unlike in the market economy, which would foster the competitive behavior of eight rail networks, a centralized bureaucratic action concerning public health was called for. Around this time, therefore, the state began to take responsibility for protecting the health and well-being of its citizens.

At the end of the eighteenth century, the hospital had been considered only one among many other measures of poverty relief, but the limited possibilities that the infrastructure of almshouses offered the poor eventually proved no longer sufficient. By the mid-nineteenth century, it was the institution of the hospital that sought to meet the demands of the city's social-charitable obligations. This necessitated changes: better care required buildings that allowed for differentiated spatial divisions, like separating groups of patients according to their disease or gender. As the hospital became more and more a pivotal space for medical and nursing care, the medical discipline more and more depended upon the hospital, which allowed clinical practice to advance its diagnostics and therapies.

The impulse to reform the care of the sick originated in England. Florence Nightingale has already denounced poor urban living conditions as a common cause of disease when in 1863, in her famous book *Notes on Hospitals*, she goes even further, publicly criticizing the insufficient conditions of contemporary hospitals themselves. She observes that wards are overcrowded with patients who have fallen ill with symptoms of many different diseases. Rooms are poorly ventilated and dimly lit. Sickbeds are often assigned to more than one patient. In addition to this criticism of physical conditions in hospitals, Nightingale takes the view that medical knowledge needs to be paired with nursing knowledge. In her writings, she lays out a theory and an educational model for independently taught nursing.

A representative of this new nursing model had emerged as early as 1847 within the urban infrastructure of Berlin. The Diakonissenkrankenhaus Bethanien (Deaconess Hospital), a three-wing building complex that allowed for

approximately 350 beds, was a Protestant social-charitable institution dedicated to nursing and nursing education. Following the example set by the community hospital in Bamberg, the Bethanien established new hospital standards within the city of Berlin. Small spatial zones allowed for toilettes, tea kitchens, and nursing staff rooms. These new zones alternated between hospital rooms. No more than ten sickbeds were positioned in the rather spacious patient wards. As a motherhouse, the Bethanien hospital served as a prime training place for the education of nurses (deaconesses).

The impulse to reform the medical discipline originated in Germany the following year. In 1848 a left-liberal doctor at the Charité, Rudolf Virchow, propagated "radical reforms" within medicine. His proposal put forth two feasible reforms. The first proclaimed reform aimed to expand the responsibilities of the medical discipline. According to Virchow, everyone has "the right to health," which, for him, represented a natural law. Therefore, Virchow directed his criticism directly towards the Prussian civil service ministry, which to date had been unable to develop any principle of public healthcare. In the weekly socio-political newspaper *Medicinische Reform* (published by Virchow and Rudolf Leubuscher), Virchow postulates his vision: "[...] medicine is a social science, and politics nothing more than medicine on a large scale."82 Clearly, Virchow here assigns no limits to the medical sphere of activities. His proposed reform thus included a centralized bureaucracy of health experts devoting themselves to urban and societal problems. The second proclaimed reform was directed towards the practice of the medical discipline. Virchow wanted to reorient medicine into a scientific-theoretical practice. Only a consistent implementation of a "hypothetico-deductive method," Virchow argues, will allow the medical discipline to be transformed into a scienceoriented medicine.83 Towards that end, Virchow had conducted a search for

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⁸² "[...] die Medicin ist eine sociale Wissenschaft, und die Politik ist weiter nichts, als Medicin im Grossen." Rudolf Virchow, editorial, *Die medicinische Reform,* Nov. 3, 1848. Since Virchow took on a professorship in pathological anatomy at the University of Würzburg in 1849, the publication of this newspaper was short-lived (from July 1848 until June 1849).

⁸³ According to *Merriam-Webster's Dictionary*, the medical definition of *hypothetico-deductive* is: "of or relating to scientific method in which hypotheses suggested by the facts of observation are proposed and consequences deduced from them so as to test the hypotheses and evaluate the

evidence of cellular structures within the human organism, in the course of which he started an archive at the Charité, collecting malignant organ alterations. Virchow focused on the origination process of cells, thus comparing the cell's physiological as well as pathological conditions. As a consequence of these investigations, Virchow in 1858 developed the concept of cellular pathology, namely that "each physiological disorder has a definable local beginning, an anatomically identifiable seat." With cellular pathology, clinical medicine now had a theorem available by which all pathological conditions of the organism can be attributed to morbid changes of the human cell.

The redevelopment of the Charité up until the middle of the nineteenth century vividly mirrored these transformations within the medical discipline (fig. 1.8). Beginning in 1785, the original building of the Charité (1710) had been gradually demolished and eventually replaced by a three-wing building complex (referred to as the "old Charité," Alte Charité). The new hospital held many times the number of sickbeds (a total of 680 beds)⁸⁵ as in the original building. For financial reasons, the northwest wing (1788) and southeast wing (1794) of the hospital were constructed as double-loaded corridor buildings. After strong objections by the medical doctors to this earlier design, the connecting wing (1800), the central and last completed section of the construction, was built meeting the contemporary hospital standards (which the community hospital in Bamberg and the deaconess hospital in Berlin represented). The wing was laid out as a single-loaded corridor, with the corridor oriented towards the northeast. In 1833, a second main building (referred to as the "new Charité," Neue Charité), consisting of eight autonomous clinics (a total of 526 beds), 86 was added in the northern part of the Charité campus. The former Smallpox House, built in 1837, had been used since 1854 as the delivery ward. In 1847 a washhouse was

consequences." http://www.merriam-webster.com/dictionary/hypothetico-deductive (accessed 2013).

⁸⁴ Wolfgang Eckart, *Geschichte der Medizin* (Berlin: Springer-Verlag, 1990), 186–188. Author's translation.

Bernd Halbach, "Universitätsklinika," in Peter Güttler u. Klaus Schulte, Berlin und seine Bauten,
 Teil 7, Krankenhäuser (Berlin: Imhof, 1998), 185.
 Ibid.

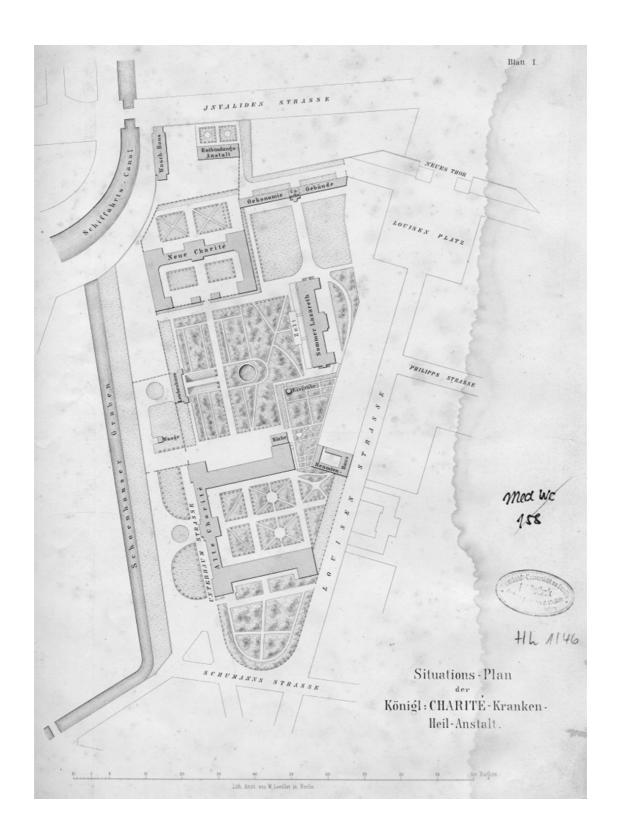


Fig. 1.8. Charité Campus in 1865

opened, and in 1852 a summer lazaretto with 265 beds was opened.⁸⁷ The building for the department of pathology was added in 1857.

Despite all this medical progress, nosocomial infections are common in all major hospitals across Europe in 1864. While more than a decade ago, the introduction of inhalation anesthesia had eliminated the patient's pain during surgery, the most difficult obstacle remains: the postsurgical phase in which hospital gangrene emerges. The disease is hard to control. The origin of its contagion as well as its cure is cloaked in ambiguity. Fearing the disease's development, surgeons therefore limit their interventions to amputations, hernia repairs, minor gynecological interventions, and bladder stone removal. The first big epidemics of hospital gangrene were observed in Spain back in 1813–15, the first time the disease as such was recognized as an epidemic and categorized accordingly as a contagious wound infection. Birected at surgeons and army doctors, the medical department of the Royal Prussian War Ministry describes the purulent and ulcerous form of hospital gangrene as follows:

The wound, no matter what its original shape, soon took on a circular form; its hard, projecting, jagged margins gave it a cup-shaped appearance; individual spots on these margins turned dirty yellow, while the base of the wound was streaked with a chewy blackish smut. [...] The disease progressed with the result that, for example, a wound that in the morning only concerned the middle finger would at night extend to the neighboring healthy fingers and within less than twelve hours would occupy the whole hand; and yet the original wound remained as the central point of this spreading circular ulcer; the discharge was dark-colored and foul-smelling, and the pain was extremely sharp. While the gangrene [in German referred to as "wound fire" spread, larger rotten pieces were quickly expelled, filling up and surmounting the cup-shaped wound as it deepened; the rose-like coloration and blistering of the surrounding skin went out of control, and streaks of inflamed lymphatic vessels reached out from the wound towards the neighboring glands, which likewise became inflamed, suppurated, and often formed a new nest for the gangrene. [...] The disease has the characteristic, when left to its own devices, of never healing.89

As described above, hospital gangrene passes rather quickly through four stages.

⁸⁷ Ibid.

⁸⁸ Bock und Hasenknopf, *Kriegschirurgen und Feldärzte der ersten Hälfte des 19. Jahrhunderts* 1795–1848 (Berlin: Verlag von August Hirschwald, 1901), 91.

⁸⁹ Ibid., 91–92. Author's translation.

During the first stage, the wound becomes infected (*Inflammatio nosocomialis*). Secondly, the wound opens up (*Exulceratio nosocomialis*). Hospital gangrene is in full swing (*Gangraena nosocomialis*) at the third stage. And during the final and fourth stage, mortified or gangrenous parts of cell tissue start to break away (*Sphacelus nosocomialis*). Those who fall ill are marked by their suffering and display the following disease-related symptoms. Their faces appear fearful and eerie. Their eyes are stained intensely yellow and appear sunk into hollows. Their tongues are coated with a brown, almost black, smut. Their skin is covered with a clammy sweat. Their pulses steadily lose strength, while increasing their rate. Their body temperatures steeply decline, though periodic fever attacks occur. Their bodily constitutions are extremely weak. Their behaviors are irritable. Their appetites are missing entirely. The spaces they occupy emanate a pungent odor.⁹⁰

Although hospital gangrene is commonly categorized in 1864 as an airborne disease, medical measures against the infection vary widely. In Paris, Guerin at the Hôtel-Dieu covers the wounds of his patients with caoutchouc (rubber) and uses pumps to suck off wound fluids and air, while Velpeau at the Hôspital de la Charité also allows no air at the wounds but conducts a wet wound treatment on his gangrene patients. In Vienna, von Kern at the community hospital refuses to use any form of bandages and instead conducts an open wound treatment. In Montpellier, Bouisson at the Hôtel-Dieu Saint-Éloi lets air blow at the wounds, encouraging the wound to dry out quickly and the blood to congeal into a scab. In Berlin, Bernhard von Langenbeck in the surgical department of the university hospital of the Charité prescribes lukewarm continuous baths for wounded limbs, while Johann Christian Jüngken in the surgical department of the military hospital of the Charité favors elaborate bandages with compresses stuffed into the wound. A further measure used in Jüngken's department against hospital gangrene is cautery. To destroy the infectious tissue, a branding iron at white

⁹⁰ Ibid.

⁹¹ Jaeckel, Die Charité, 497-498.

⁹² Ibid.

⁹³ Ibid.

⁹⁴ Ibid.

heat is pressed deep into the wound. Afterwards, the wound is stuffed with compresses and encased with bandages. If after these measures the infection returns, "when destructions are so severe that the recovery is not possible," surgeons are forced to amputate. This is a last resort: as Herrmann Fischer will later write in the *Textbook of General War Surgery* (1868), "one must not abandon the infested limb too early, because even the largest defects occasionally compensate advantageously and the amputation stump not uncommonly gets infested once more with hospital gangrene." These dire circumstances have led more and more surgeons to question the purpose of the pus present during wound healing. While classical medicine assigned a central role to the "good and praiseworthy pus" (*Pus bonum et laudabile*), the benign nature of the pus is now being called into question, and the purulence during the secondary infection is ascribed to the spatial conditions of the hospital.

Von Langenbeck, not only the director of the surgical department of the university hospital at the Charité, but also the surgical authority in Prussia, had earlier launched extensive attempts to unravel the etiology of hospital gangrene. He, as most of his colleagues did, suspected that two substances were responsible for the infection of the wounds: the miasma and the contagium:

The miasma is especially generated by everything that encourages the decay of animal substance, e.g., heat and moisture. That is why the disease easily breaks out in low, swampy, moist, and poorly ventilated spaces in which no sunlight enters. Once the miasma has developed, an infection takes place (1) by miasmatic air transfer, and (2) by the contagium-containing secretion of a hospital gangrene-seized wound, as if it were done by inoculation via contact. Such infection can be transmitted by contact with the surgeon's fingers, which previously applied bandages to those fallen ill with hospital gangrene and continued with the treatment of other wound patients; and further by contaminated instruments and by bandaging material, cloths, and bed sheets when these have been contaminated previously with the pus of hospital gangrene patients.⁹⁷

By critically evaluating the space of the hospital as a potential cause of miasmatic

⁹⁵ Bock und Hasenknopf, Kriegschirurgen und Feldärzte, 95.

⁹⁶ Herrmann Fischer, *Lehrbuch der allgemeinen Kriegs-Chirurgie* (Erlangen: Verlag von Ferdinand Enke, 1868), 421. Author's translation.

⁹⁷ Bock und Hasenknopf, Kriegschirurgen und Feldärzte, 95. Author's translation.

air and by viewing the infected patient and all the things in contact with the person's wound as a potential contagium, Langenbeck's observations suggested that medical measures should no longer be restricted to interventions performed on the human body but be expanded to include interventions in the hospital space itself. Two kinds of spatial measures were thus enforced. Both turned out to be complementary: while the one practice attempted to *medicate space*, the other used *space as cure*. Thus, while preventive measures were applied within the existing spaces of the hospital, isolation measures required the creation of new spaces in order to set a patient spatially aside.

According to von Langenbeck, the best prophylaxis against the hospital gangrene is "first and foremost the location of the hospital within an airy, unconfined area, as far as possible away from lentic water, swamps, and accumulations of decaying substances."98 These assumptions about what defines a proper location of the hospital were grounded in the theory introduced by Pettenkofer in the 1830s. As a proponent of the miasma theory, Pettenkofer argued that the emergence of miasma depends on the soil condition. Locations where miasmatic air emerged featured a rather porous soil, permeable by water and air. He further observed that lower districts are more frequently affected by miasma than elevated parts of towns. What Pettenkofer in general described for the proper location of a city was now transcribed in particular to the location of the hospital.

Within the hospital, numerous prophylactic efforts are commenced in 1864 to medicate the space suspected of harboring disease, which means the interior space of a hospital is now judged according to its *hygiene*: all preventive measures taken to minimize the emergence as well as the spread of disease become subject to scrutiny. Above all, hygienic measures mean the rigorous enforcement of cleanliness. Floors, walls, and ceilings are therefore subject to new cleaning routines. These measures are taken as seriously as medical interventions. The purpose of these routines is to counteract a hospital's given potential to produce miasmatic atmospheres. Although the cleanliness of their

surfaces is now subject to scrutiny, patient rooms and corridors are still primarily viewed as volumetric air containers (fig. 1.9). Since the stagnant air of enclosed spaces is seen as the "root of all evil," space is now quantified and guidelines in the form of spatial measurements are issued.⁹⁹ To allow for proper air ventilation, patient rooms are confined to a maximum of eighteen sickbeds.¹⁰⁰ The average room height should not exceed five meters.¹⁰¹ These guidelines reaffirm as well as internalize Nightingale's more general propositions made a decade ago.

To prevent hospital gangrene from spreading by contagium (i.e., to meet von Langenbeck's hygienic requirements), the Charité introduces various sanitary measures. Anything in immediate range of the patient, e.g., excrement, used bandages, medical instruments, cloths, and beddings, is seen as a potential contagium. Therefore, new sets of standards are implemented, e.g., scrubbing of various surfaces and instruments, industrial washing methods for laundry, separate disposal of medical waste, and mandatory washing of hands. Thus, the concept of hygiene brings along all kinds of disciplinary measures that had already been fully embraced by the military culture typical of Prussia. The value placed on cleanliness will eventually raise the status of the nursing staff within the hierarchical structure of the hospital.

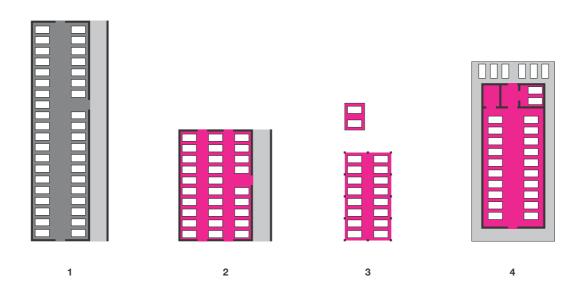
To further fulfill the new hygienic air regulations, a summer lazaretto for a total of 265 sickbeds is constructed. This unheated, single-loaded corridor building offers a total of eight wards. The wards themselves are not much smaller than the original ones—each can hold up to thirty-three sickbeds. However, the summer lazaretto offers relief from the pressure of high occupancy in the main building: with more space available in the lazaretto, the old wards can be cleaned thoroughly and aired out over longer periods (during the summer months).

⁹⁸ Ibid.

⁹⁹ "Not the fumes of the pus, not the accumulation of the sick is to blame, but the crowdedness of ill patients in an enclosed space, the stagnation of the air filled with the gradually decomposing pus is the root of all evil." *Annalen des Charité-Krankenhauses, Zwölfter Band, 1. Heft* (Berlin: Th. Chr. Fr. Enslin, 1864), 47. Author's translation.

¹⁰⁰ Fischer, Lehrbuch der allgemeinen Kriegs-Chirurgie, 300.

¹⁰¹ Ibid.



Transformation of the Patient Room of the Surgical Ward



- 1 Old Charité (1800) 680 sickbeds (total) 40 sickbeds (ward)
- 2 Summer Lazaretto (1852) 265 sickbeds (total) 33 sickbeds (ward)
- Barrack Tent (1864) 16 sickbeds (ward) 2 sickbeds (isolation tent)
- 4 Barrack (1867)
 20 sickbeds (ward)
 2 sickbeds (isolation room)
 6 sickbeds (loggia)

Fig. 1.9. Charité Campus in 1867

But what happens when all preventive measures fail and hospital gangrene emerges? If such a case arises, a patient is supposed to be isolated from the rest. But since even the additional wards of the summer lazaretto still do not offer the proper space for isolating patients with hospital gangrene, immediate alternatives need to be found. And that is how it comes that the first barrack tents are erected on the grounds of the Charité adjacent to the summer lazaretto as military surgeons returning from the war implement their experiences gained at the battlefields with the aim to provide the proper environment for patients during their postsurgical recovery. Thus, the barrack tents offer smaller wards with better air quality (fig. 3.9). Placed a required distance from the barrack tents are several two-man tents, which are intended to isolate those patients who have fallen ill with hospital gangrene (fig. 3.10). As the guidelines prescribe, those fallen ill are to be isolated immediately. Patients with severely advanced hospital gangrene that can be stopped in no other way undergo amputation. Once the amputation is complete, the patient is removed from the two-man tent isolation and reintegrated with other surgical patients within the barrack tents: "It is unavoidable that each amputee is supposed to be removed from the infectious atmosphere."102

The improved air comes at a price. Half barrack (wooden roof and deck) and half tent (canvas walls), these wards are highly dependent upon the weather conditions. Considering the Berlin climate, these barrack tents do not provide a year-round alternative. Consequently, in 1867, a new type of barrack will be introduced. Based on an American model that was implemented during the American Civil War (1861–65), the barrack will be built completely out of wood, so it can be heated and therefore used throughout the year. Raised on stilts, the barrack allows for ideal ventilation. In retrospect, this barrack had a long-lasting impact. As an early prototype of the pavilion hospital, several municipal hospitals, soon to be built in Berlin, will to some extent be based on this barrack pavilion.

¹⁰² Ibid., 332. Author's translation.

Framing the Space of Hospital Gangrene

To describe the chain of causation that formed the space of hospital-acquired infections (referred to as hospital gangrene, historically, and nosocomial infections, today), we will move chronologically according to the events unfolding at the Charité.

Ever since anesthesia had been added to the repertoire of surgical crafts, the range of surgical interventions had slowly expanded. The downside of this progress was that surgeons' inability to successfully treat their patients during the critical postsurgical phase became vividly apparent. In this regard, the introduction of narcosis (beyond its rightful historical appraisal) was a double-edged sword. While the use of narcosis to eliminate a patient's pain during surgery allowed for longer and more invasive surgical interventions, it at the same time exposed the patients' wounds even longer to the surgical environment.

The first who attempted to break the cycle of these hospital-acquired infections within the Charité was professor Heinrich Adolf von Badeleben, who took over the directorship of the department of surgery at the Charité from professor Johann Christian Jüngken in 1868. Immediately after his assumption of office, von Badeleben implemented the antiseptic treatment of wounds. In an article published in 1867 in the medical journal *The Lancet*, a doctor from Glasgow by the name of Joseph Lister reported on a new method that supposedly decreased the cases of postsurgical infection, so-called *antiseptic surgery*.

Based on Louis Pasteur's evidence that fermentation and decomposition are in fact microbiological processes, Lister arrived in his research at the conclusion that postsurgical wound infections are caused by a process of decomposition. According to Lister, small living organisms that are floating in the air—not visible to the eye—are the cause of this decomposition. He therefore introduced a method that attempted to clean the surgical environment of these infectious

germs with carbolic acid (its scientific name is phenol). 104

The discovery that carbolic acid (a smelly by-product of the illuminating gas industry) could eliminate infectious germs and therefore would soon be employed in the field of medicine for disinfection purposes was itself a byproduct. Lister first became aware of the antiseptic capability of carbolic acid in 1864 when a colleague Thomas Anderson (a professor of chemistry at the University of Glasgow) pointed out its efficacy at disinfecting sewage in the town of Carlisle. 105 As early as 1863, the town of Carlisle had already been equipped with modern sewage canalization. As the town began conducting its sewage water out of the city onto irrigation fields (a practice that the city of Berlin would soon start to employ in the 1870s), an upheaval among the adjacent rural parishes started, due to the sewage's offensive odor. A local pharmacist was called upon to investigate solutions that might turn the irrigation fields into an odorless operation. After exhaustive experimentation, the pharmacist discovered that even small amounts of carbolic acid were sufficient to stop the smell. Anderson, reviewing the astonishing discovery from Carlisle, knew that the smell of the sewage was the result of fermentation caused by microbes (he based this knowledge on Pasteur's publication *Recherches sur la putrefaction*). ¹⁰⁶ Therefore, he concluded that carbolic acid must have killed these microbes. Since Lister had postulated that the same fermentation was the reason behind wound sepsis, Anderson consequently speculated that if one would turn carbolic acid against the microbes attacking the surgical wounds, one could perhaps decrease the cases of hospital gangrene.

In 1867, Lister introduced antiseptic surgery—a method that relied on applying carbolic acid. Early stages of these antiseptic measures focused primarily on treating everything that engaged with the immediate space of the wound with carbolic acid. This meant that all surgical instruments, like tweezers, forceps, scalpels, etc., were kept inside a bath of carbolic acid. Wounds were rinsed

¹⁰³ Wolfgang Genschorek, *Wegbereiter der Chirurgie* (Leipzig: Teubner Verlag, 1984), 55.

¹⁰⁴ Carbolic was first produced from coal tar by the German chemist Runge in 1834.

¹⁰⁵ Genschorek, Wegbereiter der Chirurgie, 57.

directly with diluted carbolic acid and covered immediately after surgery with eight layers of gauze that had been previously soaked in carbolic acid. The outer bandage consisted of taffeta impregnated with liquid wax to isolate the wound from the surrounding air. Later stages of Lister's antiseptic measures treated an even larger space—the entire surgical field and, in part, the operating room itself. Still believing that the air was the primary carrier, Lister employed a vaporizer that sprayed carbolic acid into the operating room to clean what he envisioned to be dangerous germs from the air.

In 1868 (just before taking the position at the Charité), von Badeleben visited Lister in Glasgow to convince himself of effectiveness of Lister's measures. Implementing Lister's antiseptic surgery at the Charité encountered some problems, since the available bandaging material in Prussia was far from the quality of Lister's fine cotton gauze. Ordering gauze from England would result in horrendous costs. Yet his first experiments (using Lister's gauze) produced positive results. Even complicated fractures healed without purulence. The mortality rate of amputated patients declined substantially. While Lister continuously refined his antiseptic surgery in the context of the hospital, von Badeleben, serving in the Franco-German War, gathered multiple experiences in the military lazarettos, finding that the application of carbolic acid even for the severest cases, like abdominal wounds, meant the surgery was less likely to lead to peritonitis ("an inflammation (irritation) of the [...] thin tissue that lines the inner wall of the abdomen and covers most of the abdominal organs"). 107 In the years following the introduction of antiseptic surgery at the Charité, the overall mortality rate of patients suffering postsurgical infections decreased by half. Surgeons like von Badeleben ventured further and further, expanding the field of surgical possibilities. Complicated fractures that previously had led most certainly to amputations were considered curable. Abdominal operations (not standard procedure yet) were attempted more and more often.

¹⁰⁶ Dennis Pitt and Jean-Michel Aubin, "Joseph Lister: Father of Modern Surgery," *Canadian Journal of Surgery*, 55 (Oct. 2012): 5.

¹⁰⁷ "Peritonitis," *U.S. National Library of Medicine*, online health information; http://www.nlm.nih.gov/medlineplus/ency/article/001335.htm (accessed 2013).

However, antiseptic surgery brought with it a new danger, as surgeons would soon find out. The ability of carbolic acid to kill microbes but to leave the human body unharmed depended on its dosage. Thus, at the same time that surgeons were collecting evidence of the decreased mortality rate from postsurgical infections, instances of prolonged illnesses and fatalities caused by carbolic acid poisoning began to appear. To perform as an antiseptic agent during surgery, carbolic acid (according to Lister) should be administered in a five-percent solution. Otherwise, carbolic acid was both locally and systemically toxic for the human body, thus posing a risk to human health (phenol injections were employed to execute inmates in the concentration camps during World War Two). Internal exposure severely damages organs, like kidneys, as well as the blood, which in turn affects the cardiovascular system; the central nervous system is also prone to damage. External exposure results in caustic effects that can harm mucosae, skin, and eyes. In the cardiovascular system is also prone to damage.

In 1878, Robert Koch (the microbiologist was then working in Wollstein, a Prussian province of Posen) subjected hospital gangrene to a thorough analysis, investigating the etiology of wound infections. Koch's main research device was the microscope. After acquiring new lighting equipment for his microscope (equipment developed by Ernst Abbé, a physicist at the University of Jena and scientific consultant for optical work at Carl Zeiss), Koch was able to probe even further into the world of microbiology—discovering small bodies at the size of 0.0008 to 0.0001 millimeters. Within a rather short space of time, Koch discovered six disease-causing microorganisms (pathogens) common to wound infection diseases. In order to demonstrate that only a specific pathogen was responsible for a given infection, Koch worked through the aforementioned Koch's Postulates in an analysis that relied on artificially produced wound infections in animals. Blood poisoning and gangrene were induced in mice, and abscess formation, purulent sepsis, non-purulent sepsis, and erysipelas were

¹⁰⁸ Robert Jay Lifton, *The Nazi Doctors: Medical Killing and the Psychology of Genocide* (New York: Basic Books, 1986), 254.

¹⁰⁹ Miller-Keane, *Encyclopedia & Dictionary of Medicine, Nursing, & Allied Health* (Philadelphia: W.B. Saunders Company, 1992), 1145.

¹¹⁰ Jaeckel, *Die Charité*, 518.

reproduced in bunnies. Koch traced each disease back to a distinct pathogen, which was clearly differentiable in size and form. He also showed that each pathogen always initiated the same disease in a previously healthy host.

Aware that his new discoveries only marked the beginning of a larger redefinition (and consequent reclassification) of known diseases, Koch advised his contemporaries to move cautiously:

The terms pyæmia and septicæmia no longer retain their original signification, for pyæmia does not arise, as was at one time believed, from the entrance of pus into the blood-vessels, and septicæmia is not putrefaction of the living blood. They now remain only as collective names for a number of symptoms which in all probability belong to different diseases. So long, however, as these diseases are not sufficiently separated from each other, it seems best for the present to retain these terms in their ordinary signification, in order to avoid the necessity of constantly adopting new definitions.¹¹¹

While these newly gained insights revealed the actual cause of wound infections, Koch continued his investigations, this time focusing on the measures used in antiseptic surgery. Thus, he turned the treatment outcome of surgical practice into the subject of analysis. His research validated some of the approaches as well as uncovered some wrong assumptions about antiseptic wound healing. One wrong assumption was that the infective agents (pathogens) floated in the air. Koch showed that they instead were spread by the hands of the surgeon and nursing staff, by the bandages and bed sheets, and by surgical instruments that previously were in contact with the pus or the blood of infected wounds (or were not free of dirt). Lister's elaborate method of spraying carbolic acid to create a protective spatial zone within the operating theater turned out to be irrelevant, eventually even causing harm to both surgeon and patient. However, some of the sanitary measures Lister implemented, e.g., the thorough cleaning of hands, bandages, and surgical instruments with carbolic acid (especially the suggested carbolic acid bath for instruments), made sure that fewer germs would reach the wound, Overall, Koch concluded that if carbolic acid were too weak to kill the

¹¹¹ Robert Koch, *Investigations into the Etiology of Traumatic Infective Diseases* (London: The New Sydenham Society, 1880), xiii. First published in German, Robert Koch, *Untersuchungen über die Aetiologie der Wundinfectionskrankheiten* (Leipzig: Verlag von F. C. W. Vogel, 1878), 6–7.

pathogens, one would have to find a better disinfecting substance.

Due to his discoveries in bacteriology, Koch was appointed as councilor and department head of the Imperial German Health Office based in Berlin (1880). Together with his team, he started an extensive experiment on the efficacy of antiseptic agents like carbolic acid. Various chemical substances were analyzed regarding their effectiveness at killing bacteria. A substance called sublimate (*Hydrargyrum bichloratum*) offered the best results. Moreover, compared to carbolic acid, sublimate at even a five thousand-fold dilution was more effective. Yet, it remained true that whatever exterminates bacteria is also extremely harmful to human health, so an equally small amount of sublimate would also kill a human being.

Although Koch published his experiments with carbolic acid in 1881, von Bardeleben (still head of the department of surgery at the Charité) continued for years to spray carbolic acid via Lister's vaporizer inside his operating theater. The fact that Koch's office and von Bardeleben's surgical ward were only 200 meters apart from each other demonstrates how increasingly specialized and divided the medical discipline had become. While von Bardeleben was willing to travel to Scotland to learn from another surgeon, like Lister, he saw no reason to cross the street to learn from a microbiologist, like Koch.

In 1886, however, Ernst von Bergmann (head of the department of surgery at the university clinic at Ziegelstraße) ushered surgery into a new era. Implementing Koch's discoveries on the etiology of wound infections as well as acknowledging the researcher's experiments with carbolic acid, von Bergmann, together with his assistant Curt Schimmelbusch, changed antiseptic surgery into *aseptic surgery*: instead of applying germ-killing (antiseptic) clinical measures, von Bergmann operated within a germ-free (aseptic) environment. What kind of measures an aseptic operating room entails will be explored in detail in one of the following chapters on "Medicated Space."

With the implementation of aseptic surgery, von Bergmann concluded a long process of medical reasoning. If it were not for Virchow's cellular pathological theorem (1858) and Koch's microbiological discoveries (1876), these prophylactic surgical measures would have not been possible. Cellular pathology gave clinical medicine a theorem by which all pathological conditions of the organism could be attributed to morbid changes of the human cell—allowing clinical diagnostics to elicit disease-specific signs. And microbiology, by detecting disease-specific microorganisms, provided a means of identifying the cause of disease. Together they introduced the realm of clinical prevention—eliminating potential risk factors of hospital-acquired infections—and so made the idea of aseptic surgery possible. In 1890, the city of Berlin acted as the host of the Tenth International Medical Congress and the Charité was at its apex, the epicenter of clinical medicine in the late nineteenth century.

¹¹² Jaeckel, *Die Charité*, 523.

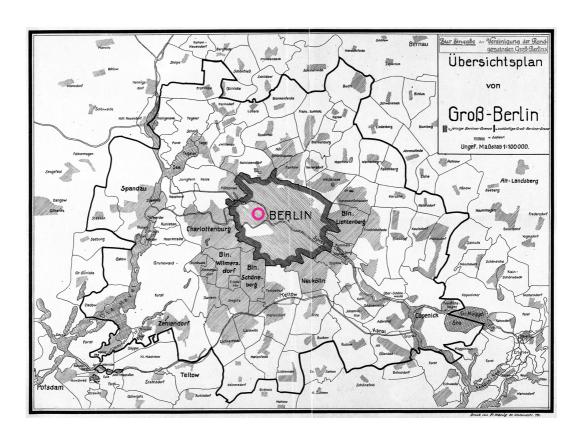


Fig. 1.10. City of Greater Berlin in 1920 (site of the Charité encircled)

The Space of Tuberculosis

Tuberculosis

The year is 1882. After analyzing patients' sputum under the microscope (employing a new staining method by Paul Ehrlich),¹¹³ Robert Koch has discovered the bacillary *Mycobacterium tuberculosis* and thereby identified for the first time the disease-causing agent for tuberculosis. Koch also verifies that the bacillus can spread via the air from person to person, meaning that those who are infected with tuberculosis actually distribute bacilli by coughing, sneezing, or spitting.

By the late nineteenth century, the German Empire had passed the threshold of urbanization, that is, slightly more than half of its population lived in cities. This was the heyday of Social Darwinism. Thus, biological concepts like natural selection and survival of the fittest were being applied to political and economic theory. In particular, maintaining population growth was considered essential to any nation's survival in terms of ensuring military strength as well as furthering economic productivity. Since the majority of those that died from tuberculosis were forty-five years and younger, thus needed as part of the productive workforce, the disease was considered an internal threat to the nation.

Berlin, the imperial capital, has tripled its population since the middle of the nineteenth century. More than one million inhabitants live in the city in 1882. Within the next sixty years, Berlin's population will skyrocket to more than four million. The city will also grow in area until, by 1920, many former suburbs will be incorporated into Greater Berlin (fig. 1.10). In the urbanization of the past

¹¹³ Thomas Brock, *Robert Koch: A Life in Medicine and Bacteriology* (Washington, DC: American Society for Microbiology, 1999), 120.

twenty years, peasant laborers and rural workers have moved into the city in hopes of finding a steady employment. The jobs they find often demand fourteen to sixteen working hours per day. Their work environments are hazardous, including air thick with dust and insufficient ventilation. Despite the new Berlin tenements (Mietskasernen) springing up everywhere, the housing market in the city cannot keep pace with the increasing population. Tenements apartments are being subdivided further, and additional rear tenement housing is being added (fig. 1.11), accessible only through the courtyards. As a result, while the urban perimeter blocks with their six-story buildings appear the same from the street, their inner courtyards have shrunk dramatically. The only regulation the building code prescribes for them is to leave a large enough access for the trolley of the fire department to get in. As the demand for housing continues to exceed the supply, the result is overcrowding: 20 percent of all the Berlin households take in boarders (Kostgänger), who contribute to the payment of the rent. 114 As a census from 1900 and 1905 will later report, many of the tenements were in miserable conditions. 115 Often more than five people shared one room. Kitchens were used as bedrooms at night, and damp and ill-lit basements were rented out as flats.

As it had in the past, tuberculosis in 1882 touches all social classes, but it is primarily the poor who are affected. The mortality rate of tuberculosis is 350 per 100,000 infected people. Known throughout the eighteenth and nineteenth century as consumption (Schwindsucht), it was widely understood as a noncontagious disease until Koch's discovery. The disease was diagnosed primarily through a physical examination that started with observations of the patient's nutritional state, any swellings, and any discoloration of the skin, among other things. The physician would then examine the firmness of the patient's chest (palpation) and use a stethoscope to listen to the breath sounds of the lung, interpreting if moisture were present in the air sacs or if a cavity existed.

René Laennec (the leading authority on consumption at the Paris school of

¹¹⁴ Herbert Landmann, "In Berlin began der Kampf gegen die Tuberkulose," in *Probleme, Projekte, Prozesse* (Berlin: Edition Luisenstadt, 1997), 12–20; http://www.luise-berlin.de (accessed 2013).



Berlin Tenements (1910s)

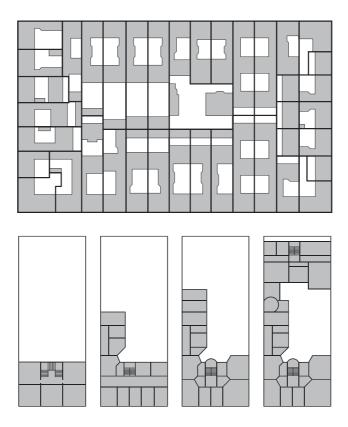


Fig. 1.11. Perimeter Block and Concentration of Berlin Tenements

¹¹⁵ Ibid.

medicine) had described the three stages of the disease early in the nineteenth century. 116 During the first stage, the most obvious symptoms of consumption are a persistent cough, pain in the chest and shoulders, and coinciding weight loss. Physical activity leaves patients sweating and with an elevated pulse. During the second stage, coughing increases in frequency with patients ejecting greenish phlegm (viscid mucus). Common accompanying symptoms are shortness of breath, pain in the body joints, fever, and sweating, as well as a rapid pulse. In the last stage of the disease, the patient has reached the condition that gave the disease its name, that is, the body appears to be consumed by the disease as it slowly wastes away. Patients' faces are pale and appear hollowcheeked. When coughing, patients eject blood. While fever and joint pains continue, shortness of breath increases, the legs swell up, and diarrhea sets in. It is during this stage that death occurs, caused by suffocation from the phlegm in the trachea or by an unstoppable hemorrhage. While diagnosing the disease remains ambiguous throughout the first and second stages of the disease, patients in their last (and mortal) stage of consumption display symptoms that require no further explanation and therefore direct the physician towards a definite conclusion. Finally postmortem examinations of the lungs reveal cavities marking the disease's presence. Because this "consumption" of the lung tissue was referred to as necrosis, i.e., a destruction of a portion of the living lung tissue, Rudolf Virchow (the medical authority in Berlin) categorized consumption as a form of lung cancer. As for the cause of consumption, Laennec believed personal diathesis (melancholy, despair, and sexual excess) as well as hereditary dispositions (inborn and inherited defects) to be responsible for the disease. Because the course of the disease was so slow, consumption was viewed as non-contagious, which meant that contacts with patients were not regulated. Laennec himself died of consumption at the age of forty-five (1826).

That view has changed in 1882. When Koch discovers the *Mycobacterium tuberculosis*, he not only verifies the bacillus as the disease-causing agent but further declares consumption to be a contagious disease. When distributed by

¹¹⁶ René T. H. Laennec, *De l'Auscultation Médiate ou Traité du Diagnostic des Maladies des Poumons et du Coeur* (Paris: Brosson & Chaudé, 1819).

coughing, sneezing, or spitting, the bacilli in the form of airborne droplets enter the body through the nose or the mouth. Consequently, the most commonly affected organ is the lung. Once in the body, however, bacilli can spread via the bloodstream and the lymph system, and a variety of organs can eventually be affected as the disease produces lesions in different parts of the body. To give the nosology greater currency, consumption is renamed tuberculosis (a reference to Johann Lukas Schönlein's observations from 1839, when he assigned the term tuberculum to a distinct disease pattern). This new conception of the disease as contagious requires physicians to reconsider contact with patients. In time, tuberculosis patients will became stigmatized as the contact with them is increasingly regulated. Considering that a fifth of the German population is dying from tuberculosis in 1882, the disease will be viewed more and more as a social disease, i.e., the conditions that allowed the disease to blossom will be associated with urban poverty. In the years that follow, Berlin's unhygienic housing situations, whether tenements, informal barrack housings, ¹¹⁷ orphanages, almshouses, or prisons, as well as various work environments, like the sweatshops, and their accompanied work conditions, like child labor, will be considered preconditions for tuberculosis.

After Koch's discovery, the nosology of the disease expanded. Thus, not only was pulmonary tuberculosis diagnosed in Laennec's three stages, but it was also understood that its symptoms may go in remission, followed in some patients by relapse. Only with the new X-ray diagnostics implemented around the turn of the twentieth century (Röntgen 1895) did physicians begin identifying early stages of the disease. Examining a series of shadows on the X-ray film, interpreted as varied densities of the lung tissue, a radiologist was able to make a disease-specific diagnosis much earlier than before. A diagnosis of early tuberculosis meant patients in most cases would be living with a chronic disease: for about 80 percent of all patients diagnosed with tuberculosis, the overall course of the disease took fifteen to twenty years. The life that they knew was over. If they

¹¹⁷ Kurt Wernicke, "Barackia – Obdachlosigkeit in Berlin" in *Geschichte und Geschichten* (Berlin: Edition Luisenstadt, 1997), 101–105; http://www.luise-berlin.de (accessed 2013).

¹¹⁸ Lester S. King, *Medical Thinking: A Historical Preface* (Princeton, NJ: Princeton University Press, 1982), 84.

were to recover, they most likely would need to find a new occupation, or even a part-time job. Those who could afford it were advised to consider relocating their urban domicile to the countryside or, if possible, to a milder climate. This advice reflected the new understanding that for those diagnosed with first-stage tuberculosis, the urban condition was a correlated risk factor. To remove patients from the city in order to expose them to a different environmental condition, in fact, became the new therapeutic measure medicine began to implement.

The German physician Hermann Brehmer was the founder of what later would become an international sanatoria movement. Supported by Alexander von Humboldt and Johann Lukas Schönlein (chief physician at the Charité), Brehmer nearly thirty years before in 1854 had established the first sanatorium for lung diseases in Görbersdorf, Prussian-Silesia. Brehmer's therapy included extensive exposure to fresh air and an adequate diet of meats, carbohydrates, and milk. 120 Throughout the day, patients had to stay outdoors. Thus, deck chairs or beds were positioned on porches, where patients were instructed to lie down and rest (fig. 3.11). At night, the windows of the patient rooms remained open. In its overall success, Brehmer's therapy surpassed all previous therapeutic measures, relying on a change of climate, exposure to fresh air, and disciplined rest. These three healing factors went on to form the basis of what in the following years became a systematic approach for open-air treatment of tuberculosis patients.

Koch strives to change the focus from sanatoria for treating tuberculosis patients to five basic regulations that, when combined, should act as preventive measures against tuberculosis epidemics. First, he makes a plea for establishing state control so that a physician diagnosing any case of tuberculosis is obliged to notify the local health authorities. Second (and, according to Koch, the most crucial regulation), each patient in the contagious second or third stage of tuberculosis ought to be spatially isolated in especially assigned hospital wards.

¹¹⁹ For example, after being diagnosed with tuberculosis, Anton Chekhov moved from Moscow to Yalta on the Crimean peninsula.

 $^{^{\}rm 120}$ Hermann Brehmer, Die Therapie der chronischen Lungenschwindsucht (Wiesbaden: J. F. Bergmann, 1887), 231–338.

Third, Koch argues for the establishment of public welfare offices throughout the city intended to support not only tubercular patients but also their families. Fourth, he proposes that health literacy measures be taken to inform the public about the risk of contagion that each tubercular patient represents. Fifth, he sees it as being within the power and duty vested in a municipality to improve the unsanitary housing and living conditions of the poorer classes.

Koch will continue to focus on the disease, and in 1890, he introduced what he believed to be a remedy for tuberculosis, so-called tuberculin. This medication, a glycerol peptone broth extracted from tubercle bacilli, was injected into patients. According to Koch, tuberculin killed not the bacilli but the tubercular tissue (the habitat of the bacilli). Hence, when the patient's reactions to the tuberculin injections decreased, the tubercular tissue within the body theoretically had shrunk. Physicians were then advised to increase the doses of injections. The news of the cure spread fast, turning Berlin into a "pilgrimage destination." Up until now, when patients were hospitalized in their last stage of tuberculosis, they were admitted to the isolation ward of the hospital. At the Charité in Berlin, this ward was a subdivision of the area for treating internal sickness. There, patients received morphine as palliative care—clinical medicine had nothing else to offer. But now, the city was crowded with tubercular patients seeking Koch's cure, and various private hospitals sprouted all over the city.

A former student and assistant of Koch's, Dr. Georg Cornet, seemed to have the best access to the limited supply of tuberculin. He worked at three locations within the city. In the mornings, he was available for consultations at the university polyclinic on Ziegelstrasse. In the afternoons, he looked after his patients at his small private hospital on Karlstrasse. And in the evening, he injected tuberculin at the largest temporary private hospital in town, the Central-Hotel on Friedrichstrasse. With its 600 beds, the Central-Hotel was Berlin's largest grand hotel and one of the most modern in the city. The building was

¹²¹ Miller-Keane, *Encyclopedia & Dictionary of Medicine, Nursing, & Allied Health* (Philadelphia: W.B. Saunders Company, 1992), 1535.

 $^{^{122}}$ J. Kastan, Berlin wie es war (Berlin: Rudolph Mosse, 1919), quoted in Jaeckel, Die Charité, 529. 123 Ibid., 552–554.

equipped with central steam heating, running hot and cold water, a large winter garden, and a variety of restaurants, bars, and retail stores on the ground floor. To adapt a hotel for temporary use as a hospital had many advantages. For example, the double bedroom floor plan of the hotel allowed for multiple ways to allocate patients, i.e., dividing them by various stages of the disease and therefore isolating the most contagious cases. Although chambermaids and room service waiters did the nursing, medical students were in charge of keeping up the patient records, which included measuring each patient's temperature twice a day. Each evening Dr. Cornet visited the hotel, injecting tuberculin.

It is perhaps possible to see already that the typology of the hotel was in fact the forerunner of the modern twentieth-century hospital. One can envision inpatient wards structured around a double-loaded corridor, stacked to form a high-rise building, with a variety of different services (diagnostics and therapies) available on the ground and basement floors. While further private hospitals were opened, more and more hotels, such as the Germania at Alexanderplatz, were temporarily turned over to hospital use. At the hotels, the high demand for the cure determined the price. While tuberculin was provided for free to the poor at the university polyclinic, it was sold for 6,000 times its actual value per injection at the hotels. These were times of curative and acquisitive frenzy.

Despite all the commotion, tuberculin proved to be a failure. Patients who had previously improved (and been labeled as cured) returned after a month. Various autopsies conducted by Virchow at the Charité concluded that the bodies of those who had been treated with tuberculin and then died were full of tubercle bacilli in organs that previously did not present them. ¹²⁶ It turned out that Koch had relied on physical examinations only in his animal experiments. The guinea pigs that he had artificially infected with tuberculosis and afterwards treated with tuberculin injections were determined to be cured merely when

¹²⁴ Ibid., 552.

¹²⁵ To stay for one week at the Hotel Germania cost about 1,000 Mark, and for each injection a patient would pay 300 Mark. This was a horrendous price, considering the actual value of tuberculin was 5 Pfenning per injection. Jaeckel, *Die Charité*, 552–554.

¹²⁶ Ibid.

earlier symptoms, like swollen lymph nodes, high temperatures, and tubercle bacilli in the stool, were no longer evident. Koch had never dissected one of his cured guinea pigs, nor did he observe one over the weeks after the cure.

After the tuberculin scandal, the sanatorium came back into vogue since it presented the last hope for a cure. Consequently, by the end of the nineteenth century, the sanatorium was the prime instrument of public health in the fight against tuberculosis. Sanatoria were established in the uplands or outside of the city to isolate those who were infected from the rest of the population. A map issued by the Central Committee for Establishment of Sanatoria in 1904 shows over 100 sanatoria for treatment of pulmonary diseases, evidence of the speed at which a network of sanatoria emerged within the German Empire. Although a third of these sanatoria were private institutions, and therefore were geared towards the upper middle class, overall these institutions were intended to serve various social classes. A stay at a sanatorium in most cases took months (even years) before patients recovered or died. The chances to be cured were fifty-fifty.

Besides relying on the three basic healing factors that Brehmer had established (change of climate, exposure to fresh air, and disciplined rest), physicians added further clinical measures to the treatment at the sanatoria. For example, surgeons developed an artificial "lung rest" (pneumothorax, 1880–1940) that allowed for a temporary collapse of the infected lung. The surgeon inserted a needle into the chest cavity so air from the outside would collapse the lung, allowing the infected lung to rest and demanding the healthy lung to do all the work. It was also during this time that thorax surgery was developed. New surgical methods by Ferdinand Sauerbruch at the Charité allowed surgeons to remove infected lung tissue. Also, inhalation methods with various gas mixtures, like carbolic acid, as well as sun lamp therapies (phototherapy with shortwavelength ultraviolet light) were prescribed to patients. Since all these treatments proved to be beneficial for at least half of the patients, curing tuberculosis became a kind of industry.

Not everyone infected with tuberculosis was or could be committed to a

sanatorium. There were many reasons that the majority of tuberculosis cases relied on home care. For example, if you were not a member of the state insurance institution (LVA), you were ineligible for the sanatorium treatment and instead were compelled to rest at home under some form of medical supervision. In most cases, however, such supervision could only be provided through charitable societies. So-called tuberculosis home sisters cared for the sick and advised their families. While daily home visits tried to insure that contagious patients were isolated, the Berlin tenements did not leave many options for spatially separating the sick from the healthy. Thus, Koch's most crucial regulation, i.e., that each tubercular patient in a contagious state ought to be subject to spatial isolation, turned out to be unenforceable. Most patients who died of tuberculosis died amongst their family members at home. Hospitals were reluctant to admit patients in their final stage of tuberculosis, since they required strict spatial isolation (of which available spaces were limited) and to care for them turned out to be a high-maintenance task.

Since all previous organized measures against tuberculosis turned out to be a drop in the bucket, new approaches needed to be explored. Thus, instead of treating advanced stages of tuberculosis in hospitals and sanatoria, renewed efforts were made to diagnose the disease early on. In 1905, numerous public welfare offices were established in the city of Berlin. Their purpose was to identify early cases of tuberculosis as well as to support tubercular patients and their families. However, the obligation to notify the local health authorities of any new tuberculosis case was not established in Prussia until 1923. Meanwhile, new public health institutions, like dispensaries and social services, came into existence. While the dispensary care aimed to provide hygienic guidance and a variety of health products, the social services agencies acted as intermediaries for cured tuberculosis patients seeking to find a reentry into the labor market.

Up until the 1920s, the unsanitary living conditions among the constantly increasing population of the lower class did not improve. Then a new branch within medical research, so-called social hygiene, emerged. Newly collected research (making use of statistical analysis) provided ample evidence that the

crowded living conditions of the Berlin working class tenements presented essential risk factors for tuberculosis. Over the years various domestic sanitary measures were introduced. For example, the traditional parlor (*Stube*) as a multipurpose space for living, working, cooking, and sleeping started to be subdivided, eventually leading to the separation of individual bedrooms. Also, the bathroom and its plumbing was integrated in stages, from access to running cold water (later hot water) and availability of the water toilet, to the introduction of the bathroom as an additional room with bathroom sink and bathtub.¹²⁷ Thus, sanitary facilities that previously belonged to the public realm found their way into the private home.

It was also social hygiene research that made the child the main target of investigation and care. In the 1920s, the normal condition of a child's physiology became subject to medical observation, e.g., the height and weight growth chart was implemented to monitor closely the early years of child development (the charts showed tubercular children remained backward in development and often were stunted). Overall, more and more medical services were outsourced from the clinical care of the hospital. Exemplary for its time, the city of Berlin implemented communal health departments in each city district, providing various prenatal and infant clinics, consulting services for patients suffering from tuberculosis or venereal disease, and civic institutions for the care of alcoholics, psychopaths, addicts, and cripples for its four million inhabitants. All these changes sprang from repeated attempts to eliminate various social risk factors for tuberculosis.

Some of the healthcare measures introduced in the early part of the twentieth century have been well absorbed into our modern urban folkways. Back then, however, the new behavioral codes had to be communicated in the form of pamphlets and advertisements, instructing the public about the contagious nature of tuberculosis by asking such questions as "how do you protect yourself

¹²⁷ Sifried Giedion, "Die Mechanisierung des Bades," in *Die Herrschaft der Mechanisierung*, Teil 7 (Hamburg: Europäische Verlagsanstalt, 1982), 679–765.

¹²⁸ Jaeckel, Die Charité, 274.

and others from tuberculosis?"¹²⁹ People were told to cover their mouth while coughing, and the no-spitting rule was enforced inside any public building and transportation vehicles, both strictures aimed to eliminate the main transmission route of tuberculosis—human sputum. As obvious as the nospitting rule might appear to us, it is comparable to our contemporary nosmoking rule. A very different healthcare measure targeted another common transmission route of tuberculosis: milk. New regulations were passed to prevent infected milk from reaching the market, which eventually led to the wide consumption of pasteurized milk.

Along with Germany's political changesin 1933, the fight against tuberculosis took on a more determined and drastic dimension. The development of the X-ray technology led to nationwide mass screening programs. The timeframe for obligatory notifications to the local health authorities was reduced to twenty-four hours. Those diagnosed with tuberculosis were banned from professions and not allowed to get married (tuberculosis was even accepted as a legitimate ground for divorce). The apartments and homes of tubercular patients were marked. The sanatoria for pulmonary diseases were turned into institutions of control, i.e., the spatial isolation and measures enforced resembled prison-like conditions. What previously had been provided as curative measures against tuberculosis epidemics turned into sanctions. A cure, however, was not yet in sight.

 $^{^{\}rm 129}$ "Wie schützt man sich und andere vor Tuberkulose?" Plate from the 1930s, German Hygiene Museum in Dresden.

Framing the Space of Tuberculosis

To describe the chain of causation that forms the space of tuberculosis, we will start in the present.

Epidemiologists today estimate human tuberculosis to be less than 6,000 years old. ¹³⁰ The disease is, therefore, considered to be endemic to human settlement. Archeological findings in the ancient Egyptian capital of Thebes indicate a wide distribution of tuberculosis there. According to estimates, nearly half of the urban population must have carried the tubercle bacilli. ¹³¹ Compared to other epidemics, like the plague or cholera, tuberculosis emerges slowly without any sudden mass outbreak. Under the right circumstances, however, tuberculosis can take the form of an epidemic. The disease was the primary cause of death for the majority of the population during the nineteenth and early twentieth century throughout industrialized Europe.

Medicine today makes a distinction between active and latent tuberculosis. This means that not everyone inhaling the bacilli actually gets sick. The bacteria enter the body through the nose or the mouth and eventually find their way via the windpipe (trachea) into the lung. Soon after the bacilli arrive, macrophages (agents of the body's immune system) attempt to absorb them since they present as foreign invading bodies. Due to its protective coat, the bacilli subvert the immune system, which forces the macrophages to build a chalk shell around the infection, and a so-called tubercle is formed. Even though the bacteria are still alive, they are trapped, i.e., they are unable to spread through the body and can lay dormant under the tubercle for years. Medicine refers to such a case as latent tuberculosis. Lots of people can live with a latent infection for decades or even for an entire lifetime. Although they cannot infect anyone else, the tubercle inside them is still a time bomb that can explode without any prior warning.

¹³⁰ Carl Zimmer, "Tuberculosis Is Newer Than Thought, Study Says," *New York Times*, August 21, 2014

¹³¹ A. Nerlich und A. Zink, "Leben und Leiden im alten Ägypten," *Münchener Medizinische Wochenschrift* 141, no. 3 (1999): 47–48.

If the immune system of a person with latent tuberculosis is weakened, e.g., due to malnutrition or when other infections are present, the bacilli can break through the chalk shell of the macrophages. After reemerging, the bacteria then can spread via the blood to various body regions and organs. Medicine refers to such a case as active tuberculosis. Through coughing, spitting, or sneezing, the patient releases the bacilli to the outside air. Once in the air, the mycobacterium tuberculosis can spread directly to a nearby person or it can survive in the area—the bacilli prefer dark and unventilated spaces—and remain infectious for days, even weeks. Once someone inhales the bacilli, the cycle restarts, infecting the body with either latent or active tuberculosis. A potential risk factor for any form of tuberculosis is therefore a weakened immune system.

Some epidemiologists argue that during the nineteenth and early twentieth century nearly everyone throughout industrialized Europe must have been infected with the tuberculosis bacteria. However, not everyone's immune system was weak. Some were able to fight off the infection, while others, like people who were malnourished, addicted to alcohol or tobacco, exposed to unhealthy living conditions, etc., were more vulnerable to the disease.

Let us then review how effective some of the medical measures against tuberculosis were. To do so, we will move chronologically. How about the openair treatment and the measures of the sanatorium? The number of patients that recovered enough to leave the sanatoria should not be underestimated. In hindsight, we can see that these treatments strengthened the body's defenses. Such measures, however, might only have been effective in patients suffering from early stages of tuberculosis. So perhaps the most crucial factor that sanatoria contributed to the fight against tuberculosis and its decline is that those patients who could not be cured despite all the therapeutic measures were prevented from infecting others. Spatially isolating those infected turned out to be effective.

We cannot skip the tuberculin treatment. Although the tuberculin therapy turned out to be a failure, it did resurface later in the form of a diagnostic agent.

Koch's concept of how to fight bacteria remains unorthodox even today. As the medical historian Christoph Gradmann describes, Koch did not aim to kill the bacteria but instead targeted the tubercular tissue. By initiating a necrosis, tuberculin aimed to remove the habitat of the bacillus. Using this physiological response to tuberculin, Clemens von Pirquet developed a method for early diagnosis of tuberculosis. The tuberculin sensitivity skin test (later the Mantoux screening test) allows for a semi-accurate diagnosis of latent tuberculosis.

Though Bacille Calmette-Guérin (BCG) developed a vaccination in the 1920s, this did not bring the long-awaited cure. Introduced in the postwar years after 1945, the vaccination was mandatory in Germany until 1998. As a large comparative study from the 1970s in India measuring the effectiveness of BCG vaccination revealed, "the distribution of new cases of bacillary tuberculosis among those not infected at intake did not show any evidence of a protective effect of the BCG vaccines." Hence, the vaccination does not offer protection against tuberculosis.

An actual cure that could eliminate active tuberculosis was first achieved by means of chemotherapeutic agents, so-called *antibiotics*. Similar to our immune system, antibiotics attack specific foreign bodies, like bacteria. Our human cells differ from microorganisms in multiple ways, and these differences open up a variety of ways for drugs to target microbial cells but not human cells. While bactericidal antibiotics kill bacteria (e.g., by attacking its plasma membrane), bacteriostatic antibiotics inhibit bacteria from reproducing (e.g., blocking the multiplying of new proteins). ¹³⁴ In order to defeat different types of bacteria, various antibiotics are needed. Medicine classifies antibiotics according to the range of bacteria they are targeting, i.e., narrow-spectrum versus broadspectrum antibiotics. Targeting a narrow spectrum of bacteria is easier on the body's immune system, since other bacteria that are essential to our body's

¹³² Christoph Gradmann, *Laboratory Disease: Robert Koch's Medical Bacteriology* (Baltimore: Johns Hopkins University Press, 2009), 100.

¹³³ Bulletin of the World Health Organisation 57, no. 5 (1979): 819–827. Also see "BCG: Bad News from India," *Lancet* 315, no. 8159 (December 1, 1980).

¹³⁴ Miller-Keane, Encyclopedia & Dictionary of Medicine, Nursing, & Allied Health, 91.

metabolism are not harmed. However, narrow-spectrum antibiotic treatment requires a specific diagnosis, i.e., it must be clear which microbe needs to be targeted.

The bacillary *Mycobacterium tuberculosis* had been the target of clinical research since Koch's discovery in 1882. Yet it took sixty years for its opponent, the chemotherapeutic agent penicillin, to come into common use against the bacteria. Although Bartolomeo Gosio was able to isolate the first known metabolite with antibiotic characteristics (mycophenolic acid) in 1893, and Ernest Duchesne described the antibiotic properties of penicillin in 1894, both of these groundbreaking discoveries went unnoticed in professional circles. ¹³⁵ Only in 1928 did Alexander Fleming's Nobel Prize-winning discovery of penicillin bring to public notice that some naturally occurring substances had antibiotic characteristics, i.e., certain molds were able to kill bacteria. As a narrowspectrum antibiotic, penicillin is selectively toxic for *Mycobacterium tuberculosis*, which means that penicillin only targets the cell walls of that particular mycobacteria while leaving various other bacteria (including human cells) unharmed. Even with all this knowledge at hand, it took clinical research yet another twenty-five years to synthetically reproduce penicillin. In 1943, the laboratory of Selman Waksman at Rutgers University was able to isolate streptomycin. In the following years, they conducted the first randomized curative trial in the history of medicine (the measures taken to introduce the antibiotic therapy were rigorously scientific, unlike the negligent actions in connection with the tuberculin scandal).¹³⁶ For the first time, tuberculosis could be cured.

Between 1940 and 1980, nowadays considered to be the "antibiotic period," multiple antibiotics effective against a variety of bacteria were developed and extensive treatments were conducted. Yet the antibiotic therapy was fraught with difficulties. For patients to be treated successfully, they had to take

¹³⁵ John Parascandola, "The History of Antibiotics," *American Chemical Society*, Division of the History of Medicine at the American Institute of the History of Pharmacy (1980): 6. ¹³⁶ P. D'Arcy Hart, "A change in scientific approach: from alternation to randomised allocation in clinical trials in the 1940s," *British Medical Journal* 319, no. 7209 (August 28, 1999): 572–573.

antibiotics over the course of six months. To insure patient medication compliance, various initiatives to monitor the intake of antibiotics were introduced, but these turned out to be high-maintenance endeavors. Soon even more serious problems started to emerge. While treating patients with streptomycin, an antibiotic mono-therapy, physicians discovered that certain bacteria had developed a resistance to the antibiotic. What followed were antibiotic combination-treatments, i.e., patients were treated with two or three different antibiotics at the same time. Even though research in the field of antibiotics has grown rapidly in the decades since the 1940s, bacteria resistance today is ahead of research. Multi-drug-resistant tuberculosis (MDR-TB) is resistant to "at least two of the best anti-tuberculosis drugs" that are available today. 137 While antibiotics proved successful for attacking tubercular bacteria in 1940s, MDR-TB developed in direct response to these antibiotics, that is, MDR-TB represents an old disease that has evolved. In 2008, 4,543 tuberculosis cases were recorded in Germany, out of which forty-five cases were MDR-TB (1.5 percent).¹³⁸ Treatment for patients with MDR-TB using second-line drugs and involving six months of daily injections takes two years (four times as long as an average antibiotic course of therapy). The current mortality rate of those treated for MDR-TB is at 40 percent (only slightly better than the mortality rate achieved by sanatoria a hundred years ago). 139 A common environment to get infected with "superbugs" like MDR-TB is a place where lots of antibiotic therapies are conducted—the hospital.

Let us take a long-term perspective on our subject of tuberculosis, focusing on Germany. Figure 1.12 depicts the mortality curve of tuberculosis in Germany from 1750–1950. (Notice that until the middle of the twentieth century, statistics on tuberculosis were primarily viewed by mortality rate, while more recent statistics are concerned with tuberculosis incidences.) Within this 200-year

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¹³⁷ According to the *Center for Disease Control and Prevention, Multidrug-resistant TB (MDR TB)* is: TB that is resistant to at least two of the best anti-TB drugs, isoniazid and rifampin. These drugs are considered first-line drugs and are used to treat all persons with TB disease. http://www.cdc.gov/tb/publications/factsheets/general/tbtravelinfo.htm (accessed 2014). ¹³⁸ S. Castell, B. Hauer, B. Brodhun, and W. Haas, "Epidemiologie der Tuberkulose: Aktuelle Situation in Deutschland und weltweit," *Pneumologe* 8, no. 1 (2011): 9–16. ¹³⁹ Ibid.

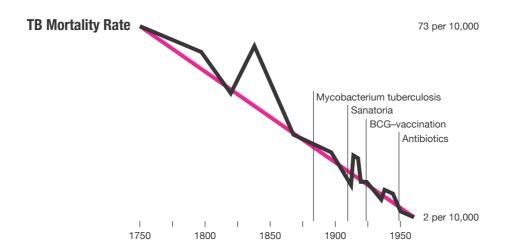


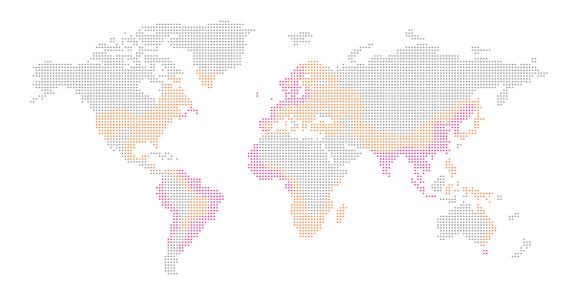
Fig. 1.12. Mortality Rate of Tuberculosis in Germany

timeframe, three larger tuberculosis epidemics stand out. The first (and strongest) epidemic occurred in the early part of the nineteenth century and reached its peak around 1825. This was a time when lots of former weavers were unemployed and depended on the poor law board for assistance, and when lots of ruined peasants from the provinces Brandenburg and Silesia had resettled in the city. The second epidemic struck during the First World War and its aftermath. Preceded by a bad crop and potato harvest, this epidemic coincided with one of the deadliest influenza pandemics in history. The third (and last) epidemic emerged during the Second World War and continued up until the late 1940s. This was a time when most cities were destroyed, emergency shelters were overcrowded, a chronic food shortage was the norm, and tides of refugees were moving in from the former Eastern European territories of German Reich. What appears more striking in this graph, however, is that the overall mortality rate has almost linearly declined since the beginning of record keeping in the year 1750. Thus, while the impacts of all the medical measures developed to fight against tuberculosis (which we just reviewed) are readable, their contribution to the overall decline of mortality in those infected with tuberculosis is extremely slight (or, as Gerhard Buchwald has argued, the impact of "protective" vaccination is literally inconsiderable). 140 Why is that? There are no single factors that may explain this phenomenon, but it is clear that whatever efforts helped to improve the urban living conditions and diets of its citizens genuinely assisted the decline of tuberculosis. Considering that the level of endemic infection continues to be prevalent in the globally connected German society of today, what the graph then represents is an improvement of the collective immune response of its citizens.

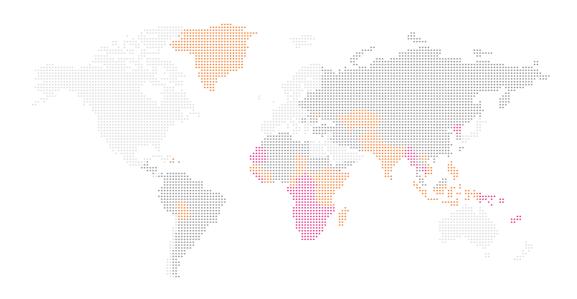
So far, our focus has remained on industrial Europe, and Germany in particular. Figure 1.13 compares the global space of tuberculosis in the early part of the nineteenth century (i.e., during the first tuberculosis epidemic in Europe) with the current space of tuberculosis. Today, it is estimated that a third of the global

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¹⁴⁰ Gerhard Buchwald, *Der Rückgang der Tbc trotz "Schutz"-Impfung: Von der Schwindsucht, Tbc zum Infektionsschutz-Gesetz, IfSG* (Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, 2002).



Global Mortality Rates of Tuberculosis in 1884



 $Global\ Mortality\ Rates\ of\ Tuberculosis\ in\ 2012$

Fig. 1.13. Global Mortality Rates of Tuberculosis

population is infected with the *Mycobacterium tuberculosis*. ¹⁴¹ If a body's immune system is weak, a latent infection can turn into active tuberculosis. In 2012, about 8.7 million people develop an active infection and 1.4 million died. ¹⁴² In places where people are being displaced by war or by natural disasters, tuberculosis infections have risen. Notice how tuberculosis thrives in parts of Africa. For example, Zimbabwe reported a rise in tuberculosis cases of 600 percent. That is because tuberculosis emerges in combination with HIV (human immunodeficiency virus): in Zimbabwe about 68 percent of all newly reported tuberculosis cases are in patients who are already HIV infected, and in South Africa this rate is about 71 percent. For patients with HIV infections, it is not HIV but tuberculosis that kills them. Lots of people that are HIV-positive are unaware of their infection, which operates slowly on the human body, but when HIV is combined with tuberculosis (although tuberculosis is an ancient disease while HIV is only about 100 years old), the immune system can no longer repel them.

Within Europe, conditions vary widely. In parts of the Russian Federation, life expectancy on average for men declined from sixty-four years to fifty-seven years after 1990 due to an increase in tuberculosis. In particular, high rates of incarceration have fed tuberculosis pandemics. In another example, the Republic of Moldova today experiences tuberculosis incidents comparable to the situation in Prussia in the late nineteenth century. Combine an increasing number of tubercular patients with a collapsed medical system and a shortage of medical supplies, and the result is most likely an incomplete antibiotic treatment, which defines the space of disease for multi-drug-resistant tuberculosis. For example, in the northwestern region of the Russian Federation, about 28 percent of all newly reported tuberculosis cases are MDR-TB, and in the Central Asian regions of Tajikistan (part of the former Soviet Union), up to 62 percent of such cases are MDR-TB.¹⁴⁴

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¹⁴¹ World Health Organization, "Tuberculosis Fact Sheet (104)," November 2010.

¹⁴² German Leprosy and Tuberculosis Relief Association; http://www.dahw.de/jahresbericht-2013/tuberkulose-die-toedliche-krankheit (accessed 2014).

¹⁴³ F. C. Notzon, "Causes of declining life expectancy in Russia," *The Journal of the American Medical Association*, 279(March 11, 1998): 793-800.

¹⁴⁴ Castell, Hauer, Brodhun, and Haas, "Epidemiologie der Tuberkulose," 9–16.

Again, to explain the increase in tuberculosis cases requires considering multiple causes, above all poverty, malnutrition, and unsanitary living conditions. People who live in small and overcrowded spaces that are poorly ventilated are especially vulnerable to the disease. Further, the rise of tuberculosis infections is an indicator that more and more people suffer from a compromised immune system.

Four Spaces of Disease

For each of these four epidemics investigated here, various urban conditions can be held responsible for their outbreak, from the living conditions that allowed for close proximity between humans and various animals (in the case of the plague) and overcrowding within the Berlin tenements (in the case of tuberculosis) to the overburdened infrastructure of water supply and wastewater (in the case of cholera) and unsanitary hospital conditions (in the case of hospital gangrene). No matter on what scale we enter these particular spaces of disease—on the scale of a cross-continental trade route, a city, or a building—physical space represents only a potential risk factor, requiring the flow of physical, chemical, and biological components through it to precondition that space for disease. A space of disease exists as a spatio-temporal condition.

The city, as it has been argued elsewhere, is the historical outcome of trade (Jane Jacobs). 145 Thus, the city emerges at the intersection of numerous paths. There is no end to a given city's sphere of activity and flow of innovation, since its paths span great distances, eventually leading to yet other cities. Hence, the city has always operated as a giant transceiver, i.e., transmitting and receiving large concentrations of bodies and vast amounts of materials. The process of receiving can be characterized as one of blending, combining, homogenizing, incorporating, integrating, and merging different entities. As these four investigated spaces of disease have exemplified, the city's output is not always proportional to its input. Incoming and outgoing flows operate on their own timescale. Various processes intensify, hinder, or inhibit other processes in the form of feedback. Thus, not only does the city's economy seem to thrive on these non-linear loops, but diseases have also proliferated under urban conditions. Although these four epidemics are effectively extinct in today's Berlin, each disease is far from extinction in a global perspective. Meanwhile, industrialized countries like Germany are currently facing new but comparable challenges with today's widespread diseases, e.g., chronic asthma, dementia, and numerous cancers. These challenges demand similar investigations.

¹⁴⁵ Jane Jacobs, *The Economy of Cities* (New York: Vintage Books, 1970).

Part 2

Spaces against Disease

Introduction

Space as Confinement

To Cordon Off To Quarantine To Isolate

Space as Treatment

To Cure To Sustain To Protect

Laboratory Space

To Access To Culture

Medicated Space

To Disinfect To Sterilize

Four Spatial Concepts

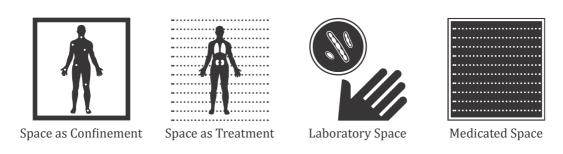


Fig. 2.1. Four Spatial Concepts against Disease

Introduction

Although the majority of the widespread diseases that Berlin has encountered over the last three hundred years are highly treatable by medicine today, the spatial measures that were once essential to countering these epidemics still form the conceptual base upon which numerous spatial devices continue to operate. While various spaces of disease were subject to continuous change, the spatial concepts themselves persisted. Rather than ascribing these spatial concepts to medical requirements alone, the text suggests that their implementations were instead a form of urban defense. In the following, the analysis retains its historical focus on the city of Berlin by reflecting upon specific historical implementations of spatial measures used to control disease within the city. At the same time, these historical examples are occasionally contrasted with contemporary spatial measures nonspecific to a particular city. The intent is not to write the history of the different spatial measures, i.e., the way these spatial measures have been transformed over time, but to demonstrate that the various *spatial concepts* underlying them are indeed continuous.

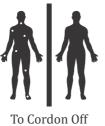
This requires an overview of various spatial concepts that organized medicine has employed against disease. These fall into four comprehensive categories: Space as Confinement, Space as Treatment, Laboratory Space, and Medicated Space. Although categories tend to the constructing of definitions, the reason for introducing these four is merely to illustrate their differences from each other. Each spatial concept operates on a variety of scales, from regional to urban scale as well as from architectural and body scale to microscale. This text explicates the spatial concept identified with each category by exploring an array of related medical measures that attempt to dismantle the space of disease by disengaging the body from the process transmitting the disease. This necessarily requires revisiting some of the measures that were previously discussed. Rather than framing the space of disease, however, our main approach now is to discover how is space used as an agent of therapeutic measures.

Rather than proceeding chronologically in terms of these spatial concepts' implementation or according to scale, the subchapters are arranged to allow for the spatial concepts to be read in the context of the human body. Thus, the text starts with those spatial concepts that are directed towards the body as a whole (space as confinement and space as treatment), then continues with those spatial concepts that are addressed towards particular body parts and specimens (space as treatment and laboratory space), and eventually finishes with those spatial concepts that are targeted at the body's environment (laboratory space and medicated space). The text evolves by moving between opposed spaces, beginning with a space that contains disease (a space full of disease) and ending with a space that is free of disease.

The chapter concludes by looking at spatial measures employed during the most recent outbreak of the Ebola virus in West Africa. Here, in a part of the world that over the last fifty years has undergone an intensive process of urbanization, we find all four spatial concepts combined in the measures taken in an Ebola treatment center. Space has been a vital element of *defense* to compensate for the vulnerability associated with what the city allows to develop, as well as depends upon, that is, its position as a place of openness and trade.

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¹ "West Africa has been experiencing intensive urbanisation for more than fifty years. This urbanisation has affected the region's largest towns and small urban centres alike. The average distance between agglomerations has declined from 111 km to 33 km." Léonidas Hitimana, Philipp Heinrigs, and Marie Trémoliéres, "West African Futures: Settlement, Market and Food Security," *SWAC/OECD WAF*, no. 01 (June 2011).







ff To Quarantine

To Isolate

Fig. 2.2. Space as Confinement

Space as Confinement

To spatially confine someone who is ill is a medical measure, in that it intends to protect everyone else from the one fallen ill. While space is used as a measure to hold up a disease, individual bodies are associated with being carriers, even actual causes, of disease. To hold up a disease means to lock up or restrain the movements of individuals affected by the disease. Hence, a confined space may be as big as a region or as small as a sickbed. In the case of a highly infectious disease, the appearance of disease-related symptoms turns an ordinary citizen into someone subject to imprisonment. In curtailing people's rights by regulating their movements or spatially detaining them, confinement constructs an unequal relation between the individual (the ill person or the one suspected of being ill) and the public at large (those free from suspicion of illness). However cruel such measures may appear at the individual level, the collective behavior demanding them resembles a speeded-up mechanism of natural selection, that is, the fittest survive by sorting out the weakest from their numbers.

The following differentiates between three kinds of confinement measures. First, we explore what it means to *cordon off* someone, i.e., to restrict someone's passage into or out of an area. Second, we look at what it means to *quarantine* someone, i.e., to spatially contain someone and put that person under surveillance for a certain time. Third, we investigate what it means to *isolate* someone, i.e., to spatially segregate a person. While this chapter considers a wide variety of spatial medical measures that regulate the flows of people and goods through urban and architectural space, the main question addressed is how organized medicine utilizes space, i.e., how it gives space a new (medical) use. Although the selected measures are presented as discrete operations, identified while we zoom in from a regional to a citywide to a building to a body scale,

some of these spatial measures most often are applied in coordination with each other and geared to the other's effects.

To Cordon Off

A cordon has military roots: establishing a cordon refers to a particular military strategy of defense. Securing a country's border or a particular town is achieved by distributing military troops evenly in the form of a line. Thus, the word *cordon* (French, *petite corde*) means literally "a cord." To cordon off an area therefore means to stretch a cord (to draw a line) around it and to restrict passage into or out of the area (across the line).

In times when plague and cholera epidemics raged, the military in Prussia was more advanced at strategies of defense than the medical discipline. Applying a military strategy to counter an epidemic was simply to employ the best means then possible. Hence, a state like Prussia literally went to war against disease. The medical physicians in charge at the time were convinced contagionists. They believed that people were responsible for the spread and the outbreak of these epidemics. Both medical nosology and military efforts combined to deal with the disease as though it were an invader or escapee. By enforcing a cordon sanitaire, Prussian authorities attempted to halt the course of the epidemic.

The establishment of a cordon often took advantage of various natural conditions. For example, the Prussian cholera-cordon in 1831 followed the course of the river Oder. Each bridge over the river and each ferryboat was controlled by roadblocks and armed guards; some bridges were destroyed and river ferries were pulled onto dry land. All roads leading into Prussia were similarly controlled, and military posts were positioned along the cordon on ridges or on other strategic observation points across the countryside. As further defense, legitimation cards were issued to healthy citizens, and anyone traveling without such a card who approached Prussia from the east (from Russia or Poland) was denied entry. Depending on the overall length of the cordon and the

number of military posts involved, a cordon varied in its density, i.e., the distance between each post.

The Prussian plague-cordon in previous centuries applied the same strategy of implementing various roadblocks along the roads and river. The aim was to cut off all major trading routes between towns. Gallows were erected as a further deterrent; the death penalty awaited all who attempted to flee out of the areas defined by the plague-cordon.

To sum up, a Prussian cordon sanitaire consisted of a variety of spatial as well as administrative measures. Starting from outside of Berlin and moving inward, we first find roads and bridges blocked and controlled by military posts, followed immediately after by the gallows and quarantine houses; then come the cordon patrols and, finally, the city wall. Establishing this layered protective barrier against the potential spread of disease aimed to create a spatial buffer zone, which was defined as the area between the cordon patrol and the wall of the city. Once an epidemic leaped over the line, the cordon was terminated or, as in the case of the cholera epidemic in 1831, relocated. In that case, the cordon that previously followed the course of the river Oder was shifted westward to patrol the river Elbe.² Roadblocks and quarantine measures for travelers (so-called *Kontumaz*) were suspended, and the associated quarantine houses were converted into lazarettos for the diseased.

As we explored previously in the case of framing the space of plague, it is possible to imagine some of the ameliorating impacts that the new plague regulations in Prussia might have had. In retrospect, a cordon seems most effective as a means of halting the expansion of a pestilence, especially when surrounding an infected town as opposed to defending a line around a much larger area. For example, in times of the bubonic plague, the entire city of Königsberg was cordoned off; after the epizooty of rats had run its course, the resulting epidemic did the same, with the locally devastating result that about a quarter of the Königsberg population died, yet the epidemic did not spread to its

immediate neighboring towns.³ The cordon sanitaire thus had successfully enclosed the city.

However, a cordon was hardly a true prophylactic measure; the bigger the town or the city, the less effective a cordon was at halting the spread of a disease. In the case of Berlin, the city became vastly more open once its fortified wall was displaced by a custom wall, and even that wall by the middle of the nineteenth century had dissolved altogether. The city greatly depended upon trade since the majority of jobs were based on it. The city was also far from self-sustaining, relying as it did on the imports of food from the region. In terms of the survival of the city's economy, the cordon represented perhaps a bigger threat than the epidemic, since the cordon not only prohibited trade with outside towns, but also made it practically impossible. Furthermore, the very military strategy that a cordon is based on (to distribute one's forces in a relatively thin line)4 came under criticism from the Prussian general and influential military theorist Carl von Clausewitz. In military practice, the defense that a cordon provided turned out to be vulnerable and inadequate when the enemy was determined and forceful. The cordon was therefore replaced by a military strategy that relied on a concentration of forces.5

Although in Prussia the cordon sanitaire vanished as a strategic measure against pestilence, it made one final appearance in Europe during a typhus epidemic in 1918, when the border between Poland and Russia was cordoned off.⁶ In the same year, during an influenza pandemic, actions were enforced within the city of Berlin that restricted the movement of its citizens in a slightly different way. In order to prevent the disease from spreading, the city prohibited all public

² Barbara Dettke, *Die Asiatische Hydra* (Berlin: Walter de Gruyter, 1995), 192–193.

³ Wilhelm Sahm, Geschichte der Pest in Ostpreußen (Leipzig: Duncker & Humboldt, 1905), 10–13.

⁴ The military strategy to implement a cordon was common until the French Revolution.

⁵ Von Clausewitz on concentration of forces: "The best strategy is always to *be very strong*; first in general, then at the decisive point. Apart from the effort needed to create military strength, which does not always emanate from the general, there is no higher and simpler law of strategy than that of *keeping one's forces concentrated*. No force should ever be detached from the main body unless the need is definite and *urgent*. We hold fast to this principle, and regard it as a reliable guide." Carl von Clausewitz, *On War*, trans. Michael Howard and Peter Paret (1832; repr., Princeton, NJ: Princeton University Press, 1989), 204.

gatherings, i.e., all major public facilities, like schools, churches, cinemas, theaters, sport stadiums, etc., were cordoned off.⁷ Thus, the cordon reemerged, yet its centralized strategy had been reduced to a decentralized tactic. Multiple urban cordons are an attempt to freeze public life in order to minimize potential risk factors, rather than drawing a line to block the entry of a disease. Today, the old linear concept of the cordon is found at a much smaller scale in the form of the police cordon, a more densely packed line assembled to defend an area against demonstrators or to protect a particular group of persons within a mass of other people.

All this does not mean that the procedure a cordon sanitaire embodies is today "mainly of historical interest," as recent events in West Africa testify. Guinea, Sierra Leone, and Liberia, the three countries worst hit by the Ebola virus epidemic in 2014, jointly enforced a cordon sanitaire in the form of military roadblocks to cut off those areas where the majority of the Ebola cases were detected. Border crossings and airports were also closed. Similar to the choleracordon in Prussia, outgoing and ingoing traffic was restricted, and travelers required legitimation. People attempting to leave the cordoned area had to submit themselves to screening. And as during the influenza pandemic in 1918, public events were prohibited. Thus, in certain crisis situations, to segment space still seems to be the only defense.

⁶ Paul Weindling, ed., *International Health Organisations and Movements 1918–1939* (Cambridge, UK: Cambridge University Press, 1995), 86–88.

⁷ Bernhard Meyer, "Spanische Grippe kam in drei Schüben," *Berlinische Monatsschrift*, Edition Luisenstadt, Heft 4 (2000): 135–138.

⁸ "During the influenza at the end of World War I, many nations attempted to arrest the progress of influenza pandemic by means of a rigorously enforced cordon sanitaire, but all efforts failed. Since then, and especially since the development of modern antibiotics, the cordon sanitaire approach has been little used. The term, and the procedure it embodies, are now mainly of historical interest." John M. Last, "Cordon Sanitaire," *Encyclopedia of Public Health* (2002), Encyclopedia.com; http://www.encyclopedia.com/doc/1G2-3404000227.html (accessed 2015).

⁹ Donald G. McNeil Jr., "Using a Tactic Unseen in a Century, Countries Cordon Off Ebola-Racked Areas," *The New York Times*, August 13, 2014.

¹⁰ "Ebola-Infizierter könnte in Hamburg behandelt werden," *Spiegel Online,* July 28, 2014, http://www.spiegel.de/gesundheit/diagnose/ebola-infizierter-koennte-in-hamburg-behandelt-werden-a-983208.html (accessed 2014).

To Quarantine

One measure that accompanied the cordons was the concept of arranging means to quarantine individuals. While a cordon aimed to establish a nonnegotiable line of defense, quarantine measures introduced a portal in that line for restricted access; although opening the cordon, a quarantine did not subvert its concept, but by regulating passage, functioned essentially as a filter.¹¹

In Prussia, the revised plague regulation of 1709 required that quarantine and lazaretto houses be built outside each town. For Berlin, the king allocated a property that was part of the royal estate northeast of town, along the banks of the river Spree, as the site on which a plague house (the Charité) was built. Every Prussian plague-cordon also had to provide quarantine houses, so-called *Kontumaz* (from the Latin *contumacia*; translated from the German as "inflexibility"). Even when an epidemic leaped over the line and the cordon was relocated (as in 1831 when cholera first reached Berlin), these quarantine facilities, in this case along the roads to Poland, remained; while some were reused as lazarettos, others continued to enforce quarantines. In the case of the cholera-cordon, each foreign traveler was quarantined for ten days. 12

The origin of these plague quarantine measures, according to the historian William McNeil, was the exile/enclosure of lepers, i.e., suspected plague sufferers were spatially confined as though they were "temporary lepers." However, it was not until the late fifteenth century that well-defined quarantine regulations became institutionalized, first at the Mediterranean trading port in Ragusa (1465) and later at the Adriatic trading port in Venice (1485). These

¹¹ Here, Foucault describes such a spatial filter using the example of the naval hospital. "The naval hospital must […] be a filter, a mechanism that pins down and partitions; it must provide a hold over this whole mobile, swarming mass, by dissipating the confusion of illegality and evil. The medical supervision of diseases and contagions is inseparable from a whole series of other controls: the military control over deserters, fiscal control over commodities, administrative control over remedies, rations, disappearances, cures, deaths, simulations. Hence the need to distribute and partition off space in a rigorous manner." Michel Foucault, *Discipline & Punish* (New York: Vintage Books, 1995), 144.

¹² Dettke. Die Asiatische Hydra, 193.

¹³ William H. McNeill, *Plagues and Peoples* (Garden City, NY: Anchor/Doubleday), 151.

¹⁴ Ibid., 151.

regulations required that any ship suspected of carrying the plague be subject to quarantine for forty days (called in Italian *quaranta giorni*). To enforce such quarantines, trading ports had to reserve secluded places where these ships could anchor. No shore leaves or other kinds of direct contact with the port were allowed. The very premise under which quarantine operates is that everyone falls under suspicion, requiring that the suspect, in this case a ship with its crew, be placed under surveillance. No space needed to be constructed at the ports, since the vessel itself presented an ideal place for detainment. If anyone were to fall ill, given the fast course of a disease like plague or cholera, the individual would die within the time frame of the quarantine. If, however, no disease-related symptoms occurred in others on board, they were allowed to enter.

Ports had always been the most vulnerable to disease and were the places that got hit first with epidemics. After the cordon sanitaire as a strategy had been abandoned, Prussia relied on five naval quarantine institutions in the early twentieth century: Memel at the Curonian Lagoon, Neufahrwasser in Danzig at the Vistula estuary, Swinemünde in Stettin at the Oder estuary, Vorbrook in Kiel at the Kiel Fjord and the estuary of the Kiel Canal, and Emden at the Ems estuary. 16 An additional naval quarantine institution in Bremerhaven was jointly established by the states of Oldenburg and Bremen. Quarantine regulations required that ships that arrived from suspected ports had to signal this fact by means of a yellow flag on the foremast. These ships were subject by default to obligatory quarantine. The duration of such a quarantine was five days for cholera and ten days for plague. Crews were confined on board as Prussia had established a legal prohibition forbidding quarantine on land. Those ships that had passed through areas of disease outbreaks were also subject to obligatory health inspections. Medical staff would come aboard to examine crew and order quarantine measures if necessary. In addition to these measures, each quarantine institution included a medical laboratory and various disinfection

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¹⁵ "If isolation could be achieved, forty days was quite enough to allow a chain of infection to burn itself out within any ship's company. The quarantine rules which became general in Christian ports of the Mediterranean in the sixteenth century were therefore well founded." Ibid., 151. ¹⁶ Walther Ewald, *Soziale Medizin: Ein Lehrbuch für Ärzte, Studierende, Medizinal- u. Verwaltungsbeamte, Sozialpolitiker, Behörden und Kommunen,* Band 2 (Berlin: Julius Springer Verlag, 1914), 171–172.

devices, e.g., a rat extermination apparatus. The best-equipped northern port was Hamburg, which in addition to the required naval quarantine institution also ran a naval hospital next to it that employed a full-time staff.¹⁷

In conclusion, the spatial concept of quarantine was to detain and immobilize individuals suspected to be ill; the period of communicability of a particular disease was the gauge of a quarantine's duration, that is, not a physician but time "examined" those suspected. Instead of patients waiting for the results of their lab tests as they do today, port authorities waited for disease-related symptoms to occur or not.

To Isolate

In a medical sense, to isolate means to separate something contagious from other uninfected things. That is, isolation measures are attempts to prevent contagious and clean¹⁸ things from coming into contact, as well as to hinder crosscontamination. This means that both the contagious patient as well as objects in contact with the patient, e.g., laundry and medical waste, require isolation and are therefore subject to spatial segregation. In the following, we explore two spatial means to isolate a contagious patient: isolation by physical distance and isolation by conditioning space.

Isolation by Physical Distance

Originally conceived as a plague house, the Charité was intended to function as an isolation ward. Thus, its early purpose was not to treat, but to segregate contagious citizens. Such isolation was to be achieved by placing physical distance between the sick and the well. It was for that reason that the Prussian king allocated a property that was far outside the city wall. By the early nineteenth century, however, given the city's expansion, the Charité campus was

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¹⁷ Ibid.

just another urban block within Berlin. And while there continued to be a demand for space to isolate patients, it was now met within the institution: a variety of existing spaces had been appropriated and new spaces had been introduced throughout the hospital's history for that purpose. The general impact of clinical isolation measures on the overall hospital typology was considerable. Through the early twentieth century, hospital architecture underwent an immense transformation process of decentralization. In the case of the Charité, an array of different measures emerged over the years to spatially isolate patients. The first ward assigned for isolating contagious patients within the old Charité in 1727 was simply labeled as an infection ward. Later on, we find isolation measures differentiating among various diseases, e.g., a ward for syphilis patients was assigned in 1810, and a smallpox house was built in 1837, etc. By the mid-nineteenth century, due to the increase in hospital gangrene cases, the first major effort was made to provide adequate isolation measures for postsurgical patients. Thus, a summer lazaretto with a total number of 264 sickbeds was constructed. Although unheated, the single-loaded corridor building offered eight wards and therefore provided more leeway to spatially segregate patients according to their contagion risk. Removing patients in their postsurgical phase from the environment of the general hospital wards was believed to decrease the chance to develop hospital gangrene—hence, isolation served as a preventive measure. "Patients with internal diseases should never lie between wounded persons. If these are severe cases of illness, e.g., typhus or cholera ill patients, they endanger the wounded; if they are slight cases of illness, they are endangered by the wounded."19 With time, the overall hospital was divided further into various disease-specific zones.

Robert Koch's institute for infectious diseases was established in 1891 on the western edge of the Charité campus. Its clinical department consisted of seven different wards, all constructed as freestanding hospital pavilions (fig. 2.3 depicts schematically the interior volume of one of these pavilions). Although the

 $^{^{18}}$ The concept of *clean*, i.e., to disinfect as well as to sterilize, is explored at length in the subchapter "Medicated Space."

¹⁹ Herrmann Fischer, *Lehrbuch der allgemeinen Kriegs-Chirurgie* (Erlangen, Germany: Verlag von Ferdinand Enke, 1868), 332. Author's translation.

miasma theory responsible for the implementation of the pavilion typology had been discarded once microbiology entered clinical medicine, the physical distance these pavilions allowed for was seamlessly adapted to the theory of contagion. Compared to the large wards of the summer lazaretto, with up to thirty-three sickbeds, these eighteen-sickbed wards allowed physicians to spatially segregate even smaller numbers of patients, which meant they could differentiate patients by the nature of their disease.

Throughout the hospital, we also find other types of isolation measures. For example, the pediatric hospital of the Charité implemented so-called open isolation partitions (fig. 2.3 depicts schematically this concept of isolation).²⁰ These "boxes" framed single beds by enclosing them from the sides. Chief physician Otto Heubner established the open isolation measures in the cases of diphtheria and measles in order to decrease the spread of these infections among the young patients sharing a ward.²¹ In addition to the spatial segregation, all dishes used by, and instruments applied to, the contagious patients were labeled with the number of the isolation box.²² Each isolation partition had a different white coat waiting for the doctors and nurses, who were compelled to change into it, and wash their hands, before approaching the patient.

As these examples of achieving isolation through physical distance demonstrate, all strict isolation measures attempted to do one thing: they aimed to prevent contagious and clean things from coming into contact, as well as to eliminate cross-contamination.

Isolation by Conditioning Space

Isolation measures that require conditioning a space are employed in clinical medicine today to prevent contamination in the case of highly contagious diseases, e.g., multidrug-resistant tuberculosis, SARS, and Ebola. The associated

²⁰ Volker Hess, ed., *Die Charité in Berlin: Fotografien um 1910* (Berlin: be.ba Verlag, 2010), 36–41.

measures to be taken are referred to as *airborne precautions*, since the infectious agents (i.e., *Mycobacterium tuberculosis* or the Ebola virus) are able to remain infectious within the air over long time. Space allocated for implementing such precautions is called an *airborne infection isolation room* (AIIR). This is a single patient room conditioned and monitored by negative pressure, which means the pressure of the patient room has been conditioned to be relatively different from that of its surrounding areas. The patient (as the "contaminated source") is placed into a preconditioned environment with an airflow that continuously draws the contaminated air out of the room (fig. 2.4) and channels it through a filtration system before it exits the building. The entire air volume of the patient room is exchanged six times per hour. Such an air exchange, which creates the negative pressure mentioned above, is generated by a ventilation system.

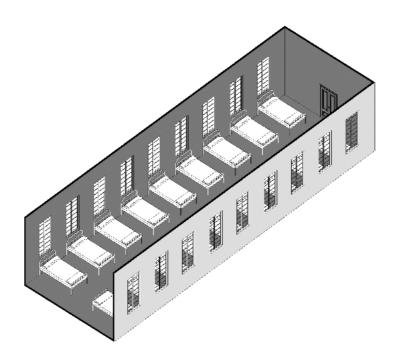
Because air flows naturally from higher to lower pressure, negative pressure environments prevent cross-contamination as the contaminated air cannot reach the corridor or neighboring patient rooms.

In 2010, the Charité opened Germany's largest special isolation ward with a total number of twenty sickbeds. Included in this ward is a quarantine area, which contains its own laboratory and operating room. The special isolation ward consists of four zones that are conditioned at different pressure stages.

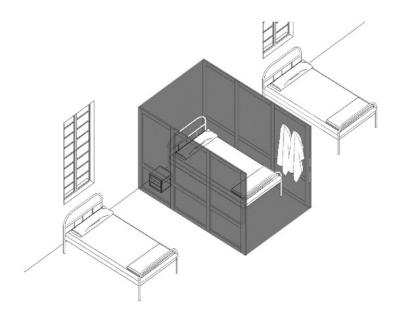
Therefore, a range of isolating conditions is possible using multidirectional airflows.²³ A high-performance filtration system directs the contaminated air through various filters before allowing it to exit the complex. An essential part of such an isolation unit is the transportable high isolation module, or so-called *aeromedical biological containment system* (ABCS), which allow for the movement of highly contagious patients (fig. 2.4). The reason for implementing this new special isolation ward at the Charité is the greater connectivity produced by globalization. The opening of the new Airport Berlin Brandenburg, which will increase the amount of air travel in and out of the city, is expected to

²² Ibid.

²³ "Charité eröffnet größte Isolierstation Deutschlands," Charité press release, December 8, 2010; http://www.charite.de/charite/presse/pressemitteilungen/artikel/detail/charite_eroeffnet_groesste_isolierstation_deutschlands/ (accessed 2014). Dr. Frank Bergmann, medical director of the special isolation ward at the Charité, is quoted.

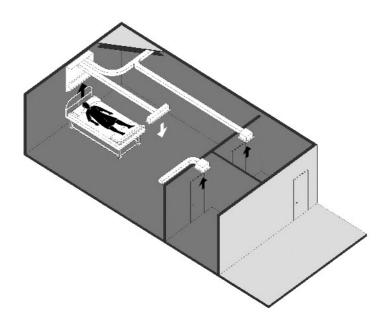


Isolation Ward

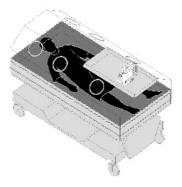


Open Isolation

Fig. 2.3. Isolation by Physical Distance



Airborne Infection Isolation Room (AIIR)



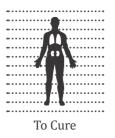
Aeromedical Biological Containment System (ABCS)

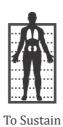
Fig. 2.4. Isolation by Conditioning Space

also increase the risk for importing highly contagious diseases.²⁴ Contrary to the previously reviewed measure that achieved isolation by physically distancing the contagion from uninfected areas, isolation by conditioning space allows for the spatial integration of such isolation zones. That is, instead of depending on spatial segregation, high-level isolation rooms can be integrated into the overall hospital complex (right in the heart of the city). Conditioning the environment around the patient isolates the contagion but does little else. Just as with the cordon sanitaire, the special isolation ward does not present a form of patient treatment (in most cases there is no cure for a patient's condition). Such a high-tech isolation measure primarily protects the public at large.

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²⁴ Ibid. Prof. Ulrich Frei, medical director of the Charité, is quoted.







To Protect

Fig. 2.5. Space as Treatment

Space as Treatment

To treat someone ill by means of spatial measures, rather than simply confine the individual, presupposes that space has the ability to positively influence a body's condition. The following differentiates among three kinds of exerting such an influence on the infected body by using space. First, we explore the spatial concept of *curing* someone, i.e., supporting the bodily process of healing. Second, we investigate the spatial concept of *sustaining* a body's condition, i.e., supporting a body's life. Third, we look at the spatial concept of *protecting* one's own body.

The emergence of the medical conception of space as able to cure patients coincides with people's increasingly ambiguous relation with the rapidly changing urban habitat. The wide and rapid proliferation of disease stands in direct correlation with the accelerating process of urbanization, having the nineteenth-century city as its outcome. It follows that the idealized notion of nature as being in itself cure should rise as a counterforce, triggering the reevaluation of medical therapies. The medical measures brought together here all aim to enable those who are ill to escape the confinements of the hospital walls in particular and the urban space in general. Whether this involved taking postsurgical patients out of the surgical ward and allocating them into barracks and tents, or removing patients from the city altogether and placing them into outlying sanitaria, such measures to bring patients closer with nature are meant to counteract spaces of congestion as much as possible.

The second spatial concept directed toward treatment does not rely on placing a patient in the atmospheric conditions of a natural environment, but instead constructs an artificial space around the patient, one that is able to substitute for faltering body functions. This concept assigns to space an active-assisting role in

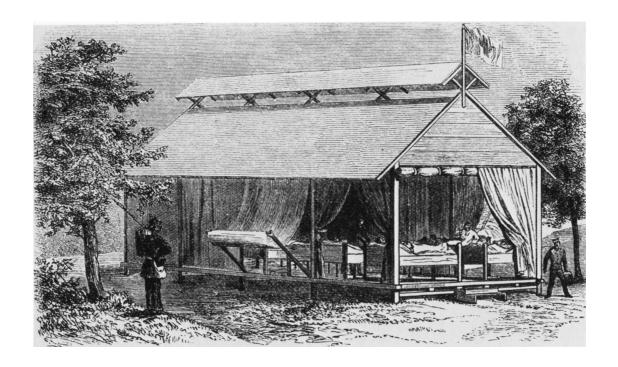
which space functions as a machine. The concept of space as able to perform bodily functions for a disabled patient is a phenomenon of twentieth-century clinical medicine. The medical measures that fit into this category aim to sustain patients until they can resume those bodily functions on their own. These measures therefore are considered life-supporting treatments.

The third spatial concept, focusing on medical measures of protection, is considered as precautionary by medicine, avoiding disease rather than treating it. While some measures provide shelter from contaminants, others detain or restrain patients from their own infection-risking behaviors. Hence, an array of such protective measures can range physically from rooms to objects to clothing.

To Cure

Exposing those who are ill to a natural space is a therapeutic attempt to support the bodily process of healing. Nature in this light is seen as a condition that works on the body. If we begin to unpack the larger subject of body-environment relations in terms of the environment's endangering or healing ability, further complexities emerge. These are most vividly apparent in the case of a body's inherited immunity, but also in the body's "toughening up" response when exposed to a harsh and/or stimulating climate (e.g., in the context of Germany, the climate of the North Sea and the Baltic Sea is considered as being bracing).

As we have recently explored in the chapter on isolation, there is a long tradition in medicine of segregating infectious patients, i.e., to set them spatially apart. During the nineteenth century, when nosocomial infections (hospital gangrene) were raging in all major European hospitals, the general medical theorem said that "all smelly, unclean, purulent wounds, all hospital gangrene, and pyemia cases must be isolated and moved into separated spaces, rooms or tents with fewer sickbeds, in order for them not to contaminate the air or to give cause for



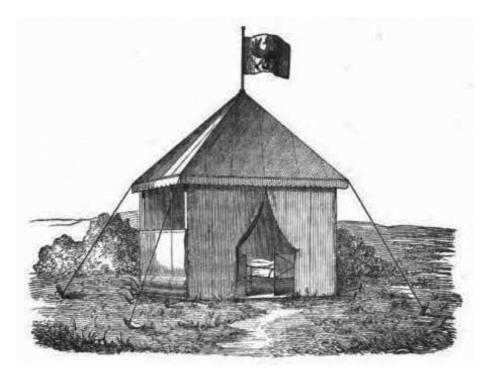


Fig. 2.6. Barrack Tent (1866) and Two-man Tent of the Surgical Ward of the Charité (1868)

transmission."²⁵ Such a theorem was based on physicians' experience in surgery's prime field for experiment and innovation, the battlefields and casualties of war. Often striking with the same intensity of an epidemic, wars produced multiple cases of complex injuries, and the battlefield offered military surgeons an arena for experimentation. Surgery was often conducted under the most difficult circumstances and within a variety of diverse environments, with operating theaters set up in barracks and tent lazarettos, appropriated civilian buildings, or protected areas out in the open, i.e., in nature:

Necessity, the best mentor, has driven the military surgeons to enforced measures of treating their wounded in the open. At the beginning such measures were resorted to only with hesitation and only when spaces were overcrowded with wounded, but later as the successful results of these treatments became evident, they soon were systematized and increasingly were improved. During the summer the wounded were simply placed in shady gardens or protected courtyards.²⁶

Because the military surgeons had to operate under worse conditions than were found in hospitals, the unexpected results they achieved were viewed with astonishment. The hospital therefore investigated these results. Statistics on patients' deaths were no longer collected on the basis of various progressions of wound infections or the consequences of diverse wound treatments, but on the quality and impact of the postsurgical environment. Space was now considered to be a crucial factor during the healing process. Analyzing all the data on impaired processes of healing following surgery produced evidence supporting the military experience. This soon would form the basis for a new theory of hospital design, especially as military surgeons returning from the battlefields implemented their experiments from the war. To provide the proper environment for patients during their postsurgical recovery, the first barrack tents were constructed on the grounds of the Charité adjacent to the summer lazaretto in 1864 (fig. 2.6; also see fig. 1.9 for the site plan). Although these barrack tents were able to hold a maximum of twenty-two patients, ideally, they

²⁵ Fischer, *Lehrbuch der allgemeinen Kriegs-Chirurgie*, 331. Author's translation.

²⁶ Ibid., 306. Author's translation.

were furnished with only up to fourteen beds.²⁷ Thus, the number of patients in each ward had been cut in half.

These barrack tents with their wooden decks and roofs, and their canvas walls primarily aimed to improve the air quality. Citing the benefits of bodily exposure to what was considered to be a bracing climate, these measures attempted to stimulate the bodily process of healing:

Like the sea air for the city dweller, the tent appeals to the house patients. [...] The medical treatment in tents—despite the rigor of the weather and our climate—has led to none of the dreaded disadvantages and has indeed positively affected the general state of health. [...] Giving the sick more room has advantages not only for those sick in the tents, but also for the entire house. [...] The periodical evacuation of the male ward was able to improve the health of those who stayed behind, and the improved air quality had its effect even on detached wards.²⁸

When all preventive measures to forestall hospital gangrene had failed, patients fallen ill with the nosocomial infection were allocated to small two-man tents (fig. 2.6). These canvas tents, which were subject to strict isolation, were placed a specified distance from the barrack tents (their positions were rotated). For those allocated there, this treatment in as much open air possible, short of placing the sickbed outside on the ground, presented the last-ditch attempt at a cure before amputation. The changes that came with the concept of space as an agent of therapeutic measures had started with the implementation of the single-loaded corridor building and here has culminated in the tent, a place where the wall of the building, its delineation between inside and outside, has been reduced to the bare minimum of clothing (Semper).

The popularity of open-air treatment reached its peak at the end of the nineteenth century with the arrival of sanatoria treating tuberculosis patients. One of the largest sanatoria, just outside of the city of Berlin, was Beelitz-Heilstätten (1898–1930). Almost 200 hectares of woodlands surrounded a

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²⁷ Ibid., 310.

²⁸ Charité, *Annalen des Charité-Krankenhauses*, Band 12, 1 Heft (Berlin: Th. Chr. Fr. Enslin, 1864), 48 and 51. Author's translation.

facility of 1,338 beds.²⁹ A stay at a sanatorium in most cases took months (even years) before patients either recovered or died; the chance to be cured was fiftyfifty. While the exposure to fresh air was essential, a sanatorium relied on a variety of additional isolation measures. On the regional scale, a sanatorium became the prime instrument of public health in the fight against tuberculosis, i.e., it spatially segregated contagious citizens by removing them from the city, reducing the potential risk to the public at large. On the local town scale, a sanatorium functioned more as an asylum-like institution. Spatially, the grounds of a sanatorium were often fenced in, so patients essentially lived inside a gated community where strict rules governed their lives. On the architectural scale, each sanatorium complex provided a range of isolation spaces inside to spatially segregate patients according to their stage of disease in an effort to prevent cross-contamination. On the scale of the individual, a sanatorium educated patients about "self-isolating" behaviors so as to avoid spreading the contagium in public—for example, covering one's mouth while coughing and collecting one's sputum in especially designed sputum cups.

Therapy at a sanatorium relied on removing patients to a different climate, exposing them to fresh air, and enforcing disciplined rest. These three healing factors, which were established by Hermann Brehmer in 1887,³⁰ went on to form the basis of what became a systematic approach to the open-air treatment of tuberculosis patients.³¹ Such treatment was constructed around a strict daily schedule. Throughout the day, patients had to stay outdoors. Deck chairs or beds were positioned on porches, where patients were instructed to lie down and rest. At night, the windows of the patient rooms remained open, allowing for continuous air circulation. The idea was that the more fresh air one received, the more support in the process of healing one's body would receive and the greater likelihood of a cure.

²⁹ Sonja Brandt, Marie-Luise Buchinger, and Marcus Cante, *Die Beelitzer Heilstätten* (Potsdam, Germany: Landesdenkmalamt Brandenburg, 1997), introduction.

³⁰ Hermann Brehmer, *Die Therapie der chronischen Lungenschwindsucht* (Wiesbaden, Germany: J. F. Bergmann, 1887), 231–338.

³¹ Also see author's chapter on tuberculosis.

To Sustain

Sustaining ill bodies here means substituting mechanical means for impaired or missing bodily functions. This concept puts space in an active-assisting role where it functions as a life-supporting machine. Although certain supporting measures in the past required an actual physical space, over time machines or medication has replaced them. The physical space involved can be quite small: similar to all those other processes that are intertwined with technological advancement, sustaining measures have been continuously subject to ever more miniaturization.

The first two examples of space as a measure that sustains the sick body are two forms of a positive pressure environment. Medicine refers to these measures as reverse isolation, and they are for patients in critical situations, like premature newborns, surgical patients, and immunodeficient patients, who are in need of shelter from the normal germ-rich environment and need of support to live. Although medicine also labels these spaces as protective environments (PE), they do much more than simply protect, i.e., they actively assist in body functions, whether that is to help with breathing, blood circulation, nourishment intake, etc. Spaces that most commonly fall into this category are operating rooms and neonatal incubators. Also, up until recently, a positive pressure environment was required during stem cell transplantations for immunodeficient patients, as in the case of leukemia treatments. Patients undergoing the procedure were subject to reverse isolation, which meant that even a normal patient room (allowing contact with a variety of people, exposure to unfiltered air, etc.) presented an extremely hazardous environment; contracting a common cold not only would interrupt the therapy but also potentially could kill the patient. Due to improved treatment therapy, this spatial support is no longer necessary.

Perhaps the most all-encompassing example of a sustaining environment is the neonatal incubator for premature newborns (a space increasingly more in use



Fig. 2.7. Couveuse Room at the Pediatric Hospital of the Charité (1910s)

today)³². The incubator includes an apparatus that supports a newborn's insufficient bodily functions. The precursor of the neonatal incubator was the so-called *Couveuse* room (fig. 2.7). This partitioned room, which included four beds, was able to keep the room's heated temperature constant.³³ The incubator represents a total conditioned environment. It monitors and regulates the ambient temperature, usually by means of an overhead warmer (bilirubin lights).³⁴ An oxygenation ventilator provides for positive airway pressure (CPAP), while an oxygen saturation monitor continuously checks the newborn.³⁵ Nutrition is provided by means of a feeding tube and intravenous catheter.³⁶ An umbilical artery catheter accesses the central circulation of the infant, connecting to the arteries or vein of the umbilical cord.³⁷ The activities of the heart and blood pressure readings are closely measured by the heart monitor and electrocardiography readings.³⁸ Overall, the sustaining environment of the incubator attempts to mimic the space of the womb.

The historical implementation of the concept of space used for sustaining body functions includes the hypobaric chamber and the hypobaric ventilator. They work to sustain the body by assisting the usual functions of the same organ, the lung, by regulating the pressure around the body. While the hypobaric chamber conditions a space around the patient, the hypobaric ventilator activates chest muscles to support respiration. The hypobaric chamber, developed for use in early thoracic surgery, is a small, pressurized operating room. By lowering the relatively higher pressure of the space outside the body to the lower pressure ratio of the thorax, the hypobaric chamber for the first time made it possible to operate on an open thorax. The surgical chamber marked the beginning of thoracic surgery, where surgeons are able to access the lung and, in

³² Hospitals across Western Europe are expanding their neonatal care units due to the fact that the average age for women having their first child has gone up, while the length of their pregnancy is shortening, resulting in more cases of premature birth.

³³ Hess, Die Charité in Berlin: Fotografien um 1910, 36-41.

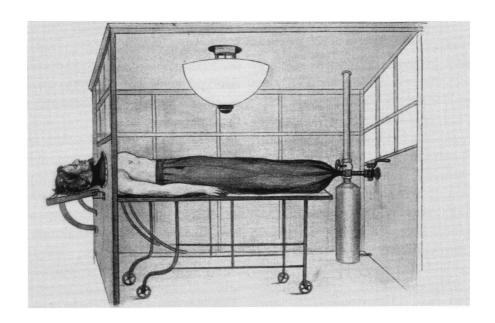
³⁴ "Intensive Care for Your Premature Baby," Mayo Clinic website; http://www.mayoclinic.org/diseases-conditions/premature-birth/multimedia/intensive-carefor-your-premature-baby/img-20008553 (accessed 2014)

³⁵ Ibid.

³⁶ Ibid.

³⁷ Ibid.

³⁸ Ibid.



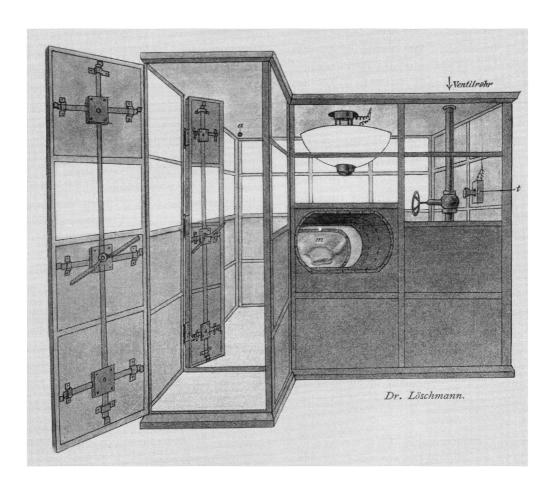


Fig. 2.8. Hypobaric Chamber by Johann von Mikulicz-Radecki and Ferdinand Sauerbruch

the case of tuberculosis, remove infected lung tissue. This surgical method was developed in 1903 by Johann von Mikulicz-Radecki and Ferdinand Sauerbruch (fig. 2.8), the latter serving as the head of the surgical department at the Charité from 1928 to 1949. The hypobaric chamber effectively enlarges the thorax condition (in terms of air pressure) from a body scale to a room scale. Conceptually speaking, a surgeon operating within a hypobaric chamber now occupies an extended thorax space.

The method that eventually displaced this negative-pressure (or depressurized) chamber is based on the opposite concept. Rather than depressurizing the operating room, the new method conditions the body space by pressurizing the patient's lungs with compressed air using an endotracheal ventilator (intubation). The lung is prevented from collapsing while the thorax is surgically opened.³⁹ The hypobaric ventilator, the so-called iron lung, also functioned for many years as a life-supporting machine. The device, a tube-like metal container, was employed in cases of respiratory paralysis (viral infection poliomyelitis).⁴⁰ By alternating between negative and positive pressure, the hypobaric ventilator moved air in and out of the lungs, affecting the body's chest movement. Its active-assisting role substituted for the paralyzed respiratory muscles. Today, since an effective vaccination against poliomyelitis has been implemented (since 1954), only rare cases occur, and the iron lung has phased out of use. Much smaller and more portable ventilators are now available.

To Protect

The following measures could easily be included in the category of *space as confinement*; however, since these measures not only confine but also, and more importantly, *protect* a patient in a form of treatment, they require their own category.

³⁹ Wolfgang Eckart, *Geshichte der Medizin*, 6th ed. (Berlin: Springer-Verlag, 2009), 302.

⁴⁰ Miller-Keane, *Encyclopedia & Dictionary of Medicine, Nursing, & Allied Health*, 5th ed. (Philadelphia: W.B. Saunders Company, 1992), 796 and 1184.

The first protecting measures reviewed here are precautionary measures. Both spaces serve as shelters for patients suffering from a neurological disease. Although it could be a historical example as well, the padded cell is employed in psychiatric treatment for patients who experience mental disorders causing them to become violent and display homicidal or suicidal behaviors. The padded cell is therefore a conditioned space that aims to protect patients against their own aggressive behavior. All objects within the room, including walls, chairs, edges, etc., are padded with a foam material and covered with a rubber-like surface (hence the colloquial expression "rubber room"). While protective, the padded cell also presents a form of involuntary detainment, since no door handles are provided inside the room. Ever since the introduction of neuroleptic drugs, ⁴¹ the padded cell is no longer part of the standard treatment. However, we can still find these kinds of protective environments employed in various healthcare facilities in Germany, as so-called crisis intervention rooms.

As one space falls out of use, another new type emerges. Rather recently, the city district Berlin-Pankow opened eight urban shelters for people suffering from dementia. To put this number somehow in proportion, currently about 14,000 people live in Berlin-Pankow who are age eighty and over, and the number of the elderly is soon expected to double. It has been estimated that within the city district about 4,000 people are currently suffering from dementia, and which about a third require permanent care. The police have reported more and more cases of people with dementia lost in the city. So these shelters were opened to both protect as well as provide care, i.e., people's identities are checked and their living circumstances are investigated (some of the elderly live alone and might not be receiving the needed care). The urban shelters, just like the padded cells in the past, present a form of precautionary detainment. Dementia today represents one of those diseases that lack effective remedies or treatment therapies. Therefore, we find spatial measures to treat dementia everywhere, especially for patients that require permanent care, who are subject to

⁴¹ Borwin Bandelow, *Kurzlehrbuch Psychiatrie* (Heidelberg, Germany: Steinkopff, 2008), 204.

⁴² Berliner Woche, Ausgabe Prenzlauer Berg, July 16, 2014, 4.

⁴³ Ibid.

⁴⁴ Ibid.

detainment measures. Although these measures continuously change (some facilities keep their locked nature more hidden, like using rooms or wards that require code access for entry or exit), they primarily detain people in order to protect them.

The next two measures discussed undeniably incorporate objects (and not simply spaces) in their protective function, but they are still spatial measures and therefore need to be included in the analysis. Patients in hospital beds who are psychotic or suffer from confusion and mental disorders are often protected from hurting themselves by means of patient restraints. Physical restraints vary, yet they most commonly include bindings for the restraint of legs, arms, and waist.⁴⁵ Such measures to detain and immobilize a patient in bed require close monitoring by medical staff. Although these measures have vanished from the hospital psychiatrist's repertoire, restraint measures have resurfaced for protecting bedridden patients suffering from dementia. Again, when no medical remedy is in sight, space is the last-resort measure. In a similar way but for other reasons, people at the scene of an accident with suspected spinal or limb injuries are stabilized by a mobile emergency device, the so-called spinal board. Straps immobilize them to protect them from further injuries while in transport. Various other devices can be employed as well, e.g., vacuum mattresses, but the board basically substitutes for an injured body's spine. Similar to a body cast (or a bandage), this device supports and stabilizes the body's condition.

The final measure considered in this category brings us back to Semper's clothing principle, i.e., that built enclosures have their origins in clothing. Protective clothing is perhaps the most essential means of sustaining a healthy body within an otherwise contaminated environment. For example, in the case of airborne infections, full-body protective clothing shields the wearer from the diseased environment. An array of protective equipment (e.g., gloves, masks, caps, goggles, shoes, etc.) has been around from the times of the plague (Dr.

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⁴⁵ Ibid., 1300.



Fig. 2.9. Protective Clothing

Schnabel; translated from the German as "Dr. Beak"),⁴⁶ and all has been updated for use today (fig. 2.9). In medicine, protective clothing has always been necessary if doctors or nurses are to interact with infected patients. Other industries need it to conduct various disinfection measures.

⁴⁶ Dr. Beak wore a beak-like mask, which was a device used for burning strong odorous herbs, e.g., lavender, thereby fumigating and filtering the inhaled air. The wooden cane was employed to examine infected patients as well as to keep the contagion at a physical distance. "Plague Doctor in 1721," *The Journal of the American Medical Association*, Volume 34 (1900): 639.





Fig. 2.10. Laboratory Space

Laboratory Space

One of the essential preconditions for clinical chemists working to test bodily fluids and tissues is the space in which an analysis takes place. That is, for numerous medically significant signs to be elicited, particular kinds of spaces are needed. Under the concept of laboratory space, we therefore find two spaces with accessibility in terms of allowing the entry and interaction of matter at microscopic scale, as well as with controllability in terms of energy exchange.

By making visible the otherwise invisible microscopic world, the laboratory acts as a portal that allows humans to enter an otherwise inaccessible space. Thus, the laboratory space extends our natural sensory range. Within the laboratory, various controlled conditions also can be constructed. This means that the condition of an analysis is shaped and adjusted by its determination as either an open, closed, or isolated system. While an open system is able to exchange both matter and energy with its environment, and a closed system solely allows for energy exchange, an isolated system prevents the exchange of either matter or energy. Constructing a controlled condition determines if, how much, and when the exchange of matter and energy takes place.

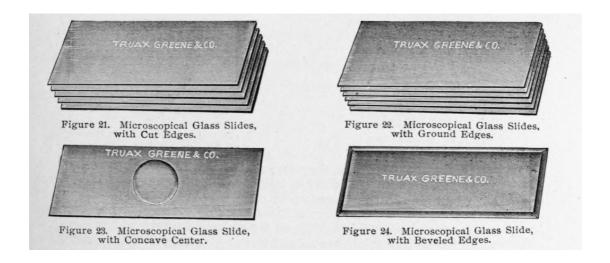
The practice of clinical medicine relies on these laboratory spaces. Their accessibility and controllability allow clinical researchers and diagnosticians to conduct tests and measure reactions. Because laboratory spaces allow clinicians to access and culture physiological and pathological processes, these spaces are essential elements in the process of diagnosing disease-specific signs, framing the space of disease, and constructing medicinal remedies. Clinical laboratory spaces guide and evaluate clinical therapies.

To Access

Humans are toolmakers. Our physical capabilities in comparison to those of the rest of the animal kingdom are limited. As the previous chapter on body signs outlined, without the invention of the proper tools, medicine's understanding of pathological processes would have been impossible. For example, we needed to extend our visual capacity, which in turn required the development of microscopy and a variety of staining methods. In this regard, the medical laboratory represents first of all an environment that contains a variety of tools that allow us to access the space of disease beyond our natural visual range. This accessibility means that we are able to observe, interfere with, or initiate various physiological as well as pathological processes at microscopic scale.

Perhaps the essential laboratory space is the microscope slide. It mounts the specimen and enables it to be analyzed under the microscope. What appears as a two-dimensional space (a flat image sandwiched between the microscope slide and the cover slip) is in fact a sampling collected from our living environment, a fragmented inventory at microscopic scale. It is within this space that the cell, the structural primary unit of the living organism, becomes visible and thereby becomes the object of analysis.

The microscope slide holding specimens was essential for pathologist Rudolf Virchow at the Charité, who studied, collected, and compared morbid morphologies by examining them under the microscope. Thus, the microscope slide functions as a data storage device that allows for a comparative analysis of various pathological-morphological changes of the human cell. Virchow focused on the origination process of cells, studying both the cell's physiological as well as its pathological conditions. As a consequence of these investigations, he was able to define the theory of cellular pathology; with it, clinical medicine had a theorem by which all pathological conditions of the organism could be attributed to morbid changes of the human cell.



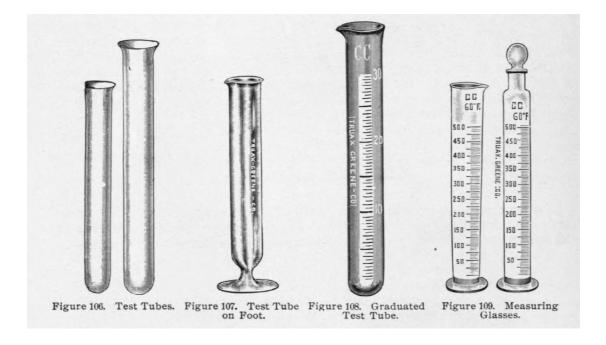


Fig. 2.11. Microscope Slides and Test Tubes in the 1890s

For Robert Koch, his main research tool was also the microscope. After acquiring new lighting equipment developed by Ernst Abbé at the University of Jena, Koch was able to probe even further into the world of microbiology. Within the space of the microscope slide, small bodies appeared to Koch at the size of 0.0008 to 0.0001 millimeters.⁴⁷ It was by looking into this newly accessible space within the microscope slide that Koch could make his numerous bacteriological discoveries, which included, among others, *Bacillus anthracis* (1876), *Mycobacterium tuberculosis* (1882), and *Vibrio cholerae* (1884).⁴⁸

Hence, the microscope slide in the hands of either the pathologist or the microbiologist became a piece of *circumstantial evidence*. Only by means of such evidence were these discoveries validated and eventually allowed to scientifically support the germ theory (the foundation of bacteriology). Hence, it was the laboratory space that disproved the old and robust theory of miasma, which argued that the foul air of unsanitary spaces was the cause of disease, as well as the old theory of spontaneous generation, which assumed that living organisms could emanate spontaneously from inanimate matter.

These advancements in clinical research and medical etiology allowed for the greater accessibility enabled by laboratory space to become more and more applicable for the assessment of the body's specimen and fluids. Consequently, this rationalized scientific space, which previously belonged entirely to the research pathologist, found its way into clinical diagnostics. Between 1840 and 1860, methods were developed to analyze the body's physiological processes of ingestion and digestion, and between 1880 and the early 1930s, clinical-chemical methods were systematically implemented. ⁴⁹ The space that allowed for tests such as a urinalysis and hemanalysis to take place could be best generalized by the test tube. While the content of such a tube, e.g., urine and blood samples, as well as bodily fluids and specimens, was subject to analysis for making an evaluation of a body's condition, the tube itself represented the patient.

⁴⁷ Gerhard Jaeckel, *Die Charité* (Berlin: Ullstein, 2010), 518.

⁴⁸ Although previously discovered by Filippo Pacini in 1854.

To Culture

By means of laboratory spaces (the microscope slide, the test tube), medicine was for the first time able to verifiably identify the actual cause of disease, i.e., frame the space of disease and thereby determine potential risk factors. In order to define the disease-causing agents of an infectious disease, Robert Koch together with Friedrich Loeffler established a framework that derived from earlier concepts by Jakob Henle. This so-called Henle-Koch-Postulate (1884) argues that four factors need to be proven before assigning a particular pathogen as the cause of a disease. First, a distinct pathogenic bacterium has to remain the same, however often the disease is transmitted from one organism to another.⁵⁰ Also, these pathogenic bacteria should not be present within a healthy organism. Second, the pathogenic microorganism must be extracted from the diseased organism and cultured as a pure microbiological culture.⁵¹ Third, the pure culture of the suspected pathogen must initiate the disease within a healthy host.⁵² Fourth and last, to prove that the pathogenic microorganism is identical to the one first extracted, the bacterium must be isolated once again.⁵³

⁴⁹ Wolfgang Eckart, *Geschichte der Medizin*, 1st ed. (Berlin: Springer-Verlag, 1990), 291.

⁵⁰ "But even in the small series of experiments which I was able to carry out, one fact was so prominent that I must regard it as constant, and as it helps to remove most of the obstacles to the admission of the existence of a contagium vivum for traumatic infective diseases, I look on it as the most important result of my work. I refer to the differences which exist between pathogenic bacteria and to the constancy of their characters. A distinct bacteria form corresponds, as we have seen, to each disease, and this form always remains the same, however often the disease is transmitted from one animal to another. [...] With regard to these differences, I refer not only to the size and form of the bacteria, but also to the conditions of their growth, which can be best recognised by observing their situation and grouping." Robert Koch, *Investigations into the Etiology of Traumatic Infective Diseases*, trans. W. Watson Cheyne (London: The New Sydenham Society, 1880), 65.

⁵¹ "The greatest stress, in investigations on bacteria, is justly laid on the so-called pure cultivations, in which only one definition form of bacterium is present. This evidently arises from the view that if, in a series of cultivations, the same form of bacterium is always obtained, a special significance must attach to his form: it must indeed be accepted as a constant form, or, in a word, as a species." Ibid., 68.

⁵² "[...] a pure cultivation is possible, even in the case of the bacteria which are smallest and most difficult to recognize. This, however, is not conducted in cultivation apparatus, but in the animal body." Ibid., 68.

⁵³ "When, therefore, several species of bacteria occur together in any morbid process, before definite conclusions are drawn as to the relations of the disease in question to the organisms, either proof must be furnished that they are all concerned in the morbid process, or an attempt must be made to isolate them and to obtain a true pure cultivation. Otherwise we cannot avoid the objection that the cultivation was not pure, and therefore not conclusive." Ibid., 70.

Such a framework relied on two kinds of spaces: a living animal organism (a body) and a "cultivation apparatus" (a laboratory space). While Koch produced wound infections in animals (e.g., he induced blood poisoning and gangrene in mice, and he reproduced abscess formation, purulent sepsis, non-purulent sepsis, and erysipelas in bunnies), he needed to construct a laboratory space that allowed him to trace each disease back to a distinct pathogen. Isolating a pure microbiological culture allowed Koch to control the growth of these microorganisms outside of their natural environment, i.e., without other organisms or contaminants being present. To construct such a habitat, a growth medium (in the form of a liquid or gel) was required. A growth medium is a nourishing substance that holds a culture.⁵⁴ A petri dish provides the space in which the growth medium is placed, a constructed space where the growth of a cell culture (plants or animals) or a microbiological culture (microorganisms) can be initiated under controlled conditions. Once it is inoculated with the pathogenic microorganism, the growth medium functions as the ground upon which the suspected pathogen stands out as fig., i.e., becomes visible. The microorganism growing in the form of a pure culture thereby allowed Koch to assess its metabolic and physiological characteristics.⁵⁵ Being able to observe and control this growth process further made it possible to determine the range of the microorganism's habitat. While the petri dish represents the condition of a potential host, the determined range of the host's habitat defines the area of future clinical intervention.

Koch's and others' proof that small (single-cell) microorganisms exist not only within the environment but also within the human body, and that they are responsible for spreading diseases, placed the human body into an extremely

⁵⁴ A growth medium, so-called food-gelatin, as it was used in Koch's laboratory has been described by George W. Lewis: "Take 250 grams of fresh beef as free from fat as possible, and, after cutting it up into fine particles, add 500 grams of distilled water. Allow this to stand over night in an ice-chest and then strain it through a towel of ordinarily fine texture. The resulting mass will amount about to 400 ccm. [...] the whole mass is to be thoroughly cooked until it has the appearance of the white of an egg. [...] the whole solution is to be strained through a double thickness of filter-paper arranged in the form of a funnel. [...] The filtered substance is perfectly clear and transparent, and while still warm should be poured into re-agent glasses." George W. Lewis, Ten Days in the Laboratory with Dr. Robert Koch (Buffalo, NY: Times Print, 1885), 7-8. ⁵⁵ Eckhard Bast, Mikrobiologische Methoden: Eine Einführung in grundlegende Arbeitstechniken, 2nd ed. (Heidelberg/Berlin: Spektrum Akademischer Verlag GmbH, 2001), 94-97.

complex context, where it became only one out of numerous hosts in the world. Today, using current means, microbiologists have been only able to isolate less than one percent of the common microorganisms of the environment. Clearly, the microorganic world in and around us is far more complex than the founding fathers of microbiology envisioned it to be. Today, the Henle-Koch-Postulate is no longer considered to be valid or complete, since it assumes that scientists ought to be able to isolate all microorganisms in pure culture, ⁵⁶ an assumption that undermines further complexity. Besides, Koch already knew from investigating different cases of cholera that the pathogen *Vibrio cholera* appeared in both infected and healthy people, therefore negating his first postulate. ⁵⁷ However, no matter how limited or inaccurate these early microbiological means were, they managed to identify all four disease-causing agents ⁵⁸ of the previously examined epidemics.

We are not going to explore the other large field of laboratory activity, that is, the development of disease therapy. If we did, we would encounter the same basic laboratory spaces that allow clinicians to *access* and to *culture* life at a microbiological as well as cellular level.

⁵⁶ Alfred S. Evans, "Causation and disease: the Henle-Koch postulates revisited," *Yale Journal of Biology and Medicine* 49, no. 2 (May 1976): 175–195.

⁵⁷ Ibid.

⁵⁸ As previously examined in the chapter "Framing Urban Disease," these disease-causing agents were *Yersinia pestis* (discovered by Alexandre Émile Jean Yersin in 1894), *Virbio cholerae* (discovered by Filippo Pacini in 1854 and rediscovered by Robert Koch in 1883), a variety of pathogens of wound infections (discovered by Robert Koch in 1878), and *Mycobacterium tuberculosis* (discovered by Robert Koch in 1882).

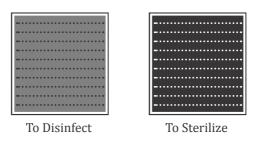


Fig. 2.12. Medicated Space

Medicated Space

The concept of medicated space includes those interventions that identify space as subject to medical measures. In a sense, space has become the patient. Most of the therapeutic measures that fit into this category are preventive interventions. By decontaminating objects, environmental surfaces, or people, they aim to eliminate spatial risk factors for humans. Thus, decontamination serves as an umbrella term for this category, which incorporates a range of measures, like cleaning, disinfecting, or sterilizing. Although numerous ancient folkways had already operated as spatial measures directed to disease prevention, the increasing susceptibility to disease among the urban population in the nineteenth century pressed for new measures. In that regard, to medicate space has become a kind of urban folkway of defense against disease risks.

This chapter differentiates between two kinds of spatial measures that fit into the category of medicated space. First, we explore the spatial concept of *disinfecting*, which includes any intervention that reduces the present amount or inhibits the growth of microbial flora. Second, we investigate the spatial concept of *sterilizing*, which underlies various clinical processes that aim to destroy all microorganisms within a defined area, including bacillus endospores on inanimate surfaces.⁵⁹ Disinfection is differentiated from sterilization in that the former presents a range of germ-killing measures while the latter describes a particular state of being entirely germ-free.

Medicated spaces are ephemeral spaces, that is, they require recurring maintenance if they are to remain free from disease-causing contaminants, such as bacteria, viruses, fungi, and parasites. Thus, processes organize these spaces.

Although spatially defined, medicated spaces are primarily described by their spatial practices, i.e., the recurring inflows of contamination and the defending medical measures to disinfect or sterilize them anew.

Before we consider these two categories, let us briefly review some of the ancient folkways that incorporated a variety of spatial measures as disease prevention. This requires looking back at a time period when pathogenic microorganisms belonged to the world of the imaginary. To simplify the various measures, we can group them within three types of decontamination agents: biological, physical, and chemical.⁶⁰

Perhaps the oldest measure of all is the burial of cadavers. As previously described, in times of epidemics, old burial rituals were abandoned and new burial sites were often established outside the city. Due to the larger number and greater frequencies of deaths, mass burial sites were common. Folkways required that these sites lie fallow for at least fifty years. Although a burial represents a physical measure of decontamination, the decontamination agent at work is biological, i.e., various microorganisms are responsible for the decomposition of cadavers. Another (although very different) example of a biological disinfectant is ivy, known to produce high amounts of oxygen. Ivy was planted at the loggias of the surgical ward of the Charité in order to improve the air quality.

Perhaps the best preventive measures against contagion were heat and fumigation. Older folkways used fire to purify spaces, objects, clothing, and cadavers by either burning or fumigating them directly. Fumigation measures involved burning herbs to produce a disinfecting smoke, while the incineration

⁵⁹ Bacteria form endospores by which they are able to lie dormant for extended periods under unfavorable environmental conditions. Miller-Keane, *Encyclopedia & Dictionary of Medicine, Nursing, & Allied Health,* 1405.

⁶⁰ These three categories are based on Jean Blancou's article. Jean Blancou, "History of disinfection from early times until the end of the 18th century," *Scientific and Technical Review of the Office International des Epizooties* 14, no. 1 (1995): 31–39.

of cadavers has been the most effective and fastest measure to eliminate sources of contaminations.

Common in times of plagues, sulfur derivatives and concentrated soda lime were used as chemical disinfectants.⁶² They were dusted around sickroom spaces and sometimes directly onto contaminated objects. Mercury derivatives served as a form of protective paint and were adapted into medicine compounds.⁶³ The most common chemical disinfectant and one still widely used today is the application of organic vinegar for disinfecting objects.⁶⁴

To Disinfect

The first public attempt to enforce disinfection measures within the cities of Berlin and Cölln was perhaps the well and alley ordinance of 1660. The regulation specified that the contamination of the urban alleys was hazardous to human safety and that certain wells presented a dangerous source of infectious diseases. The well and alley ordinance thereby defined those aspects of city life as potential urban risk factors. At the time, drinking water was drawn from the groundwater, pumped from 379 wells (238 in Berlin and 141 in Cölln)⁶⁵ and carried in buckets to the houses. Wastewater, including feces, was dumped directly into the unpaved alleys or open gutters that lined the roads. The disinfection measures enforced by the ordinance ordered that feces were to be transported for disposal into the river Spree. Back then, moving the contaminants from the alley to the river solved the problem.

Prior to the implementation of a sewer network in the late nineteenth century, a large portion of the contents from the cesspools of houses in Berlin landed either in the city's open canals or the drainage channels, which washed the

⁶² Ibid.

⁶³ Ibid.

⁶⁴ Vinegar water was once used for medical disinfection of abdominal wounds. Ibid.

⁶⁵ "Brunnen- und Gassen-Ordnung (1660)," *Berlin Von A-Z* website; http://www.luiseberlin.de/stadtentwicklung/index.html (accessed 2014).

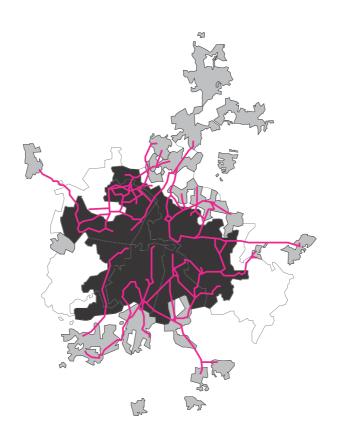
contaminants into the river Spree. It might seem far-fetched to argue that such a system can be thought of as a form of disinfectant, but I would argue that it did. When Berlin was smaller (with a population somewhere between 50,000 and 100,000), the natural infrastructure in place was the river Spree, which functioned well as a disinfectant. The natural current of the river took the contaminants away as well as diluted them. So, up until a certain time in the city's history, this infrastructure was sufficient, i.e., the amount of people generating waste was proportioned to the capacity of what the river could "treat."

Multiple circumstances led to the building of sewer networks in Berlin. Physically, waste disposal in time literally turned the river into a large cesspool, and the odor from this natural infrastructure was noxious and unbearable. Furthermore, in theory, this smell meant disease to the scientific hygienist. So the city authorities saw the need to disinfect it. Berlin's building of sewers could also be read as a reaction to what other cities, like London, had started to construct. Rudolf Virchow, who acted as the medical advisor for the project, encouraged the authorities to undertake such a large project, arguing that a sewer network would improve the sanitary condition of the city by reducing the atmospheric pollution (miasmatic air), water, and soil conditions that were in his opinion responsible for cholera. Cholera at that time was not considered to be a waterborne disease nor was it known that it spread through contaminated drinking water. Even so, by removing waste from the water infrastructure, one of the most ambitious engineering projects of the city's history did in fact function as a preventive measure against cholera. Why it successfully defeated cholera was completely misunderstood.

Over the course of twenty years (1873-1893), twelve separate radial systems for sewage collection were installed (fig. 2.14). Each consisted of various underground channels. While the larger collecting channels were oriented to maximize the natural slope of the terrain, the remaining connecting channels required pump stations. Their purpose was to pump waste and surface water through pressurized lines from the inner districts to irrigation fields far outside



River



Sewer Network and Sewage Farms

Fig. 2.13. Wastewater Infrastructures in the City of Berlin

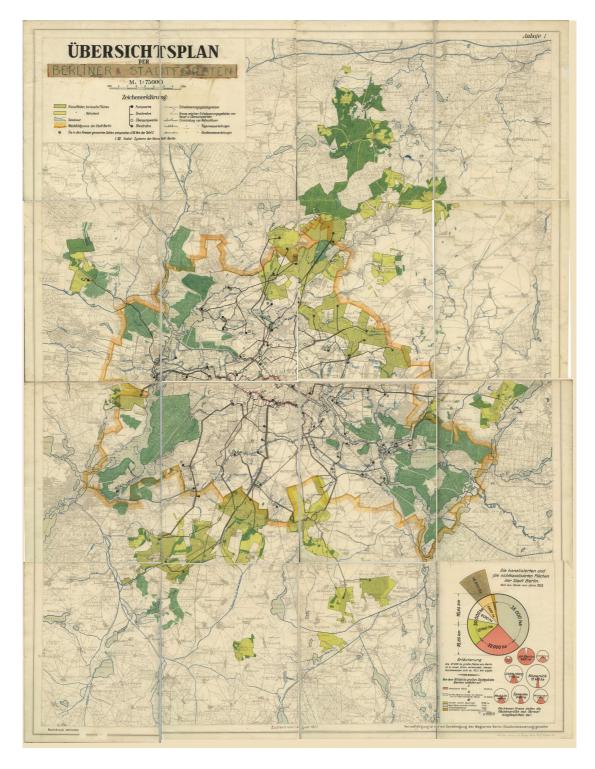


Fig. 2.14. Sewer Network and Sewage Farms in the City of Berlin (1927) $\,$

of the city. For example, the first sewage farms were constructed approximately ten kilometers outside of the city's boundary. The use of multiple radial systems ensured that further connections, e.g., due to future city expansions, could be added without readjusting the existing sewage networks.

Channeling of sewage, however, risked stirring up sickening and harmful fumes. The sewage system therefore needed to include ventilator shafts, which protruded through the roof in each house. So, while the sewage was pumped far outside of the city, its harmful fumes were channeled into the air above the rooftops (fig. 2.15). In order for the sewer contents to reach the sewage farms before the process of bacterial decomposition set in, the wider streets of Berlin had two sewer canals, running on either side of the street, to speed up the flow. Further, the sewer lines need to be at least one and a quarter meters below ground to be protected from frost. Overall, the aim of this sewage system was to decontaminate the river. That is, the river that previously served as a disinfection measure was now itself subject to disinfection. The *biological infrastructure* was simply displaced by a *physical infrastructure* of twelve artificial rivers (the radial sewage system).

The last element of this urban disinfection infrastructure is the sewage farm. Although man-made constructions, the sewage farms functioned as a biological measure (like the river before them). Sewage was filtered through a large area of pebbly grounds, which made parts of the drained water reusable. Also, large portions of the sewage were used to fertilize the soil directly. A sizeable land area was involved: approximately one hectare of sewage farmland was required for 330 inhabitants. By the late 1920s, the area of the sewage farms consumed about 10,000 hectares. Farts of the sewage farms served as farmland. Since the fields were well fertilized, being flooded eight times a year with sewage, they turned out to be highly productive. It has been estimated that these fields provided about a quarter of the city's milk and fresh vegetables. The sewage farms were therefore not only of hygienic but also of economic importance to the

⁶⁶ Hermann Hahn and Fritz Langbein, *Fünfzig Jahre Berliner Stadtentwässerung*, 1878–1928 (Berlin: Verlag A. Metzner, 1928), 160.

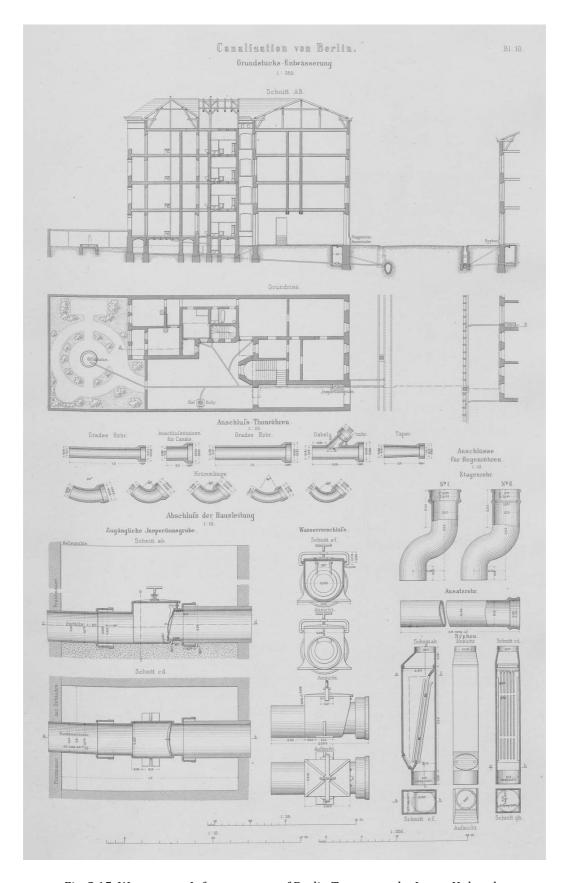


Fig. 2.15. Wastewater Infrastructures of Berlin Tenements by James Hobrecht

⁶⁷ Karl Nasch, *Die Berliner Rieselfelder* (Berlin: Karl Heymanns Verlag, 1916), 102–117.

city.

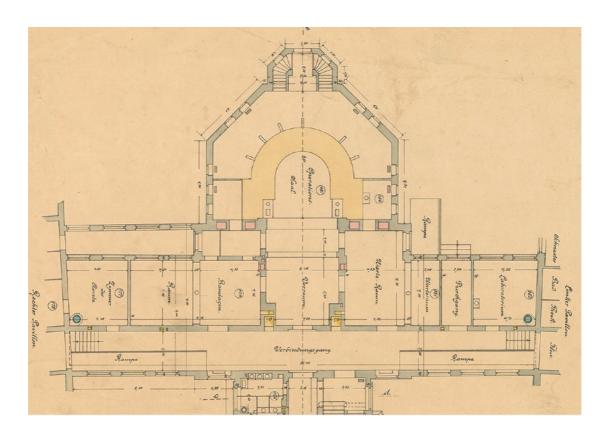
The stench from these sewage farms led to yet another disinfecting measure. The previous discussion of hospital gangrene mentioned Thomas Anderson, a professor of chemistry at the University of Glasgow, who explored the efficacy of carbolic acid in disinfecting sewage observed from its use by the town of Carlisle.⁶⁸ As early as 1863, the town of Carlisle had already been equipped with modern sewage canalization, but the adjacent rural parishes that were situated near the irrigation fields protested the offensive odor of the sewage farms. A local pharmacist then discovered that even small amounts of carbolic acid were sufficient to stop the smell. Reviewing this astonishing discovery from Carlisle, Anderson began with the idea that the smell of the sewage was the result of fermentation caused by microbes, similar to what Louis Pasteur had described in his publication "Recherches sur la putrefaction." ⁶⁹ Therefore, Anderson concluded that the carbolic acid must have killed these microbes. As we already noted, the discovery of the disinfecting efficacy of carbolic acid had found almost immediate use in clinical medicine as well as in a variety of hygienic measures. Joseph Lister had postulated that the fermentation observed in the sewage process was identical to the process of wound sepsis.⁷⁰ Consequently, Anderson and Lister speculated that if carbolic acid also worked against the microbes attacking the surgical wounds, they would have found a disinfectant applicable in cases of hospital gangrene. As a result, Lister introduced antiseptic surgery by using carbolic acid in 1867. This disinfecting measure thus led to the process of sterilization in clinical medicine.

⁶⁸ Wolfgang Genschorek, Wegbereiter der Chirurgie (Leipzig: Teubner Verlag, 1984), 57. ⁶⁹ Louis Pasteur, "Recherches sur la putrefaction," Comptes Rendus de l'Académie des Sciences 56 (1863), 1189.

⁷⁰Dennis Pitt and Jean-Michel Aubin, "Joseph Lister: Father of Modern Surgery," Canadian Journal of Surgery, 55 (Oct. 2012): 5.

To Sterilize

While disinfection measures found their origins in public works that grew from scientific hygiene, sterilization measures are rooted in the laboratory space. Again, it was Robert Koch who directed his laboratory investigations to include the measures used in antiseptic surgery and their associated treatment outcomes. While his research validated some of the approaches, it also, more importantly, uncovered some wrong assumptions about antiseptic wound healing. Figure 2.16 (the diagram above) depicts the operating theater of the department of surgery at the university clinic at Ziegelstraße as it was originally designed in 1882. The generalized schematic of the workflow (see fig. 2.17 the diagram above) illustrates the procedure of antiseptic surgery introduced by Joseph Lister (which was a common surgical practice at the time). While the patient awaits surgery in an adjoining room, the surgeon and the staff follow the mandatory measures of washing their hands. The patient is then moved into the operating theater, which is an auditorium that holds 158 seats with additional standing room. By now various hygienic measures and regulations governed clinical practice with the aim to minimize the spread of disease, in particular the postsurgical nosocomial infections, or hospital gangrene. We therefore have to assume that the floors, walls, and ceilings of the operating theater were subject to strict cleaning routines. The assumption was that this would counteract the operating room's potential to produce miasmatic atmospheres, i.e., the room was primarily viewed as volumetric air container whose stagnant air posed a potential risk factor. These antiseptic measures begin inside the operating theater with an elaborate method of spraying carbolic acid to create a protective spatial zone within the operating field, into which the patient is then moved. Although visible, the patient is shielded inside a fog of carbolic acid. This is the assumption—that the infectious agents float in the air—that Koch proved was wrong. He demonstrated that these pathogens instead were spread by the hands of the surgeon and nursing staff, by the bandages and bed sheets, and by surgical instruments that came in contact with the pus or the blood of infected wounds or with other contaminants. The elaborate method of spraying carbolic acid to create a protective spatial zone within the operating theater turned out to be



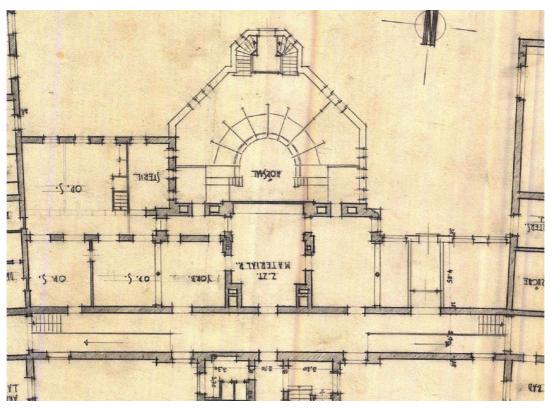


Fig. 2.16. Original Plan (1879) and Redesign (1890s) of Operating Theater at the University Clinic

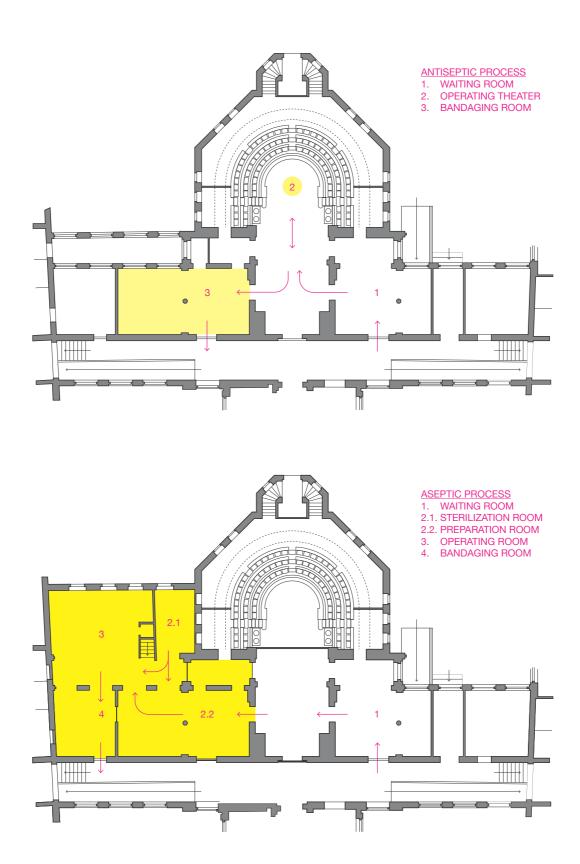


Fig. 2.17. Operating Theater vs. Operating Room at the University Clinic

irrelevant; in fact, it eventually proved to cause harm to the surgeon, nursing staff, and patient.

However, Koch did acknowledge that some of the sanitary measures Lister implemented, e.g., the thorough cleaning of hands, bandages, and surgical instruments with carbolic acid (especially the suggested carbolic acid bath for surgical instruments), ensured that fewer germs would reach the wound. Which brings us to the next step of the antiseptic procedure, the postsurgical cleaning of the wound and the immediate application of bandages. The procedure established by Lister required medical staff to rinse the wound directly with diluted carbolic acid and to cover it with eight layers of gauze that had been previously soaked in carbolic acid. The outer bandage consisted of taffeta impregnated with liquid wax to isolate the wound from the surrounding air. As the diagram depicts, the most crucial step of the antiseptic surgical method is the bandaging room, which consumes a large portion of the surgical space. In concluding his analysis, though, Koch stated that microbiological examination indicated that the diluted carbolic acid was in fact too weak to kill the pathogens, and that one would have to find a better disinfecting substance. Ernst von Bergmann (head of the department of surgery at the university clinic) had plenty of experience with carbolic acid, having continuously experimented with, and encountered the limits of, the chemical disinfectant. Together with his assistant Curt Schimmelbusch, von Bergmann used Koch's discoveries in the etiology of wound infections to transform antiseptic surgery into aseptic surgery. Instead of employing germ-killing (antiseptic) clinical measures, the department of surgery at the university clinic began in 1886 to operate within a germ-free (aseptic) environment.

Figure 2.16 (in the diagram below) depicts the operating room of the same department of surgery at the university clinic as it was eventually redesigned, in phases throughout the early 1890s, under von Bergmann's leadership. The most obvious difference is that the large auditorium has been closed off. Although still in use, the former operating theater now serves as a lecture hall since surgery is no longer performed in front of a large audience. Due to the need for more space,

the previous loggia has been expanded into a larger room for operating. Here we find the origin of the linguistic change from *operating theater* to *operating room* (fig. 2.17), the latter a more familiar term today, which is commonly abbreviated as OR.

To better reconstruct the changes brought on by the implementation of aseptic surgery, it is useful to review what von Bergmann (together with Schimmelbusch) presented at the tenth International Medical Congress in Berlin (1890) to an audience of 5,000 international physicians.⁷¹ In his presentation, von Bergmann did not perform surgery (as was usually the case), since the implementation of aseptic surgery did not bring fundamental changes in terms of surgical methods. Focusing instead entirely on the operating procedure, he began with an extended description of the preparatory measures to be taken. To prepare instruments and laundered materials, aseptic surgery requires sterilization measures. Based on Koch's findings, all surgical instruments are to be boiled in a 1 percent concentration soda solution.⁷² All bandaging materials, surgical drapes, and bed sheets are required to go through a steam sterilizer,⁷³ i.e., they are exposed to hot water vapor in order to sterilize them. As the floor plan of the aseptic operating room indicates, these newly added sterilization measures require space, with a room specially set aside for all sterilization apparatuses. The sterilization room is part of the larger operating room to reduce the distance between preparation and surgery. Further, the sterilization room is embedded into a high-level disinfection zone, which consists of the preoperating, operating, and post-operating rooms.

The aseptic preparation requirements also extend to the surgeon and surgical nurses working in the operating room. First everyone is required to thoroughly scrub their hands with glycerin soap and dry them only with sterilized cloths.⁷⁴ Hands are then further disinfected with absolute alcohol (0.5 percent

⁷¹ Moritz Pistor, *Deutsches Gesundheitswesen: Festschrift zum X. Internationalen Medizinischen Kongress Berlin* (Berlin: Springer, 1890), 316–320.

⁷² Ibid.

⁷³ Ibid.

⁷⁴ Ibid.

concentration corrosive sublimate).⁷⁵ Since these measures, if regularly applied, often led to eczema, surgical gloves made out of seamless rubber were developed and soon implemented everywhere.⁷⁶ As the final step of their preparation, surgeons and nurses are helped into sterilized scrubs. Over the years, further protective clothing was added, e.g., surgical caps and facial masks.

Regarding the aseptic preparation of the patient, von Bergmann advised that the operating area of the patient's body be first soaped and then shaved, removing even small hairs.⁷⁷ Afterwards, the area is thoroughly washed and scrubbed with distilled water and glycerin soap until the outer layer of the skin has been being removed.⁷⁸ This layer of the skin was thought to contain most of the contaminants and microbes. After the cleaning is complete, the operating area of the skin is dried with only a sterilized cloth.⁷⁹ The final step is to rinse the area with absolute alcohol (0.5 percent concentration corrosive sublimate).⁸⁰

In his presentation, von Bergmann skipped the actual operating part of surgery, only noting that the patient is then brought into the room to be operated on. He instead moved on to the aseptic postsurgical measures, that is, the wound treatment. Contrary to practices followed in the former antiseptic surgery, von Bergmann recommended leaving some space between the stitches closing the surgical incisions to allow for the wound fluid to drain.⁸¹ The bandages covering the incisions consist of sterilized lint (mull) and absorbent cotton, which are stored in isolated nickel containers invented by Schimmelbusch. Unlike the previous application of chemical disinfectant (carbolic acid), aseptic surgery allows no chemical to reach the wound. Only sterilized bandaging material is used for physical disinfecting. Von Bergmann recommended that these bandages stay for eight to ten days before being removed.

⁷⁵ Ibid.

⁷⁶ Wolfgang Eckhart, *Geschichte der Medizin*, 6th ed., 221.

⁷⁷ Ibid.

⁷⁸ Ibid.

⁷⁹ Ibid.

⁸⁰ Ibid.

⁸¹ Pistor, Deutsches Gesundheitswesen, 316–320.

While antiseptic surgery focused primary on the elaborate application of bandages during the postsurgical wound healing process, aseptic surgery shifted to focus to preparation. In other words, antiseptic surgery relied on the implementation of postsurgical treatment, while aseptic surgery enforced preventive medical measures before surgery. That is likely why the bandaging room, the most important room within the antiseptic procedure, is transformed by the redesign of the operating room into the preparation room, making it the essential room within the aseptic procedure. Architecturally, this room has remained unchanged, but its clinical workflows and decontamination measures are substantially different.

The changes enumerated in von Bergmann's presentation represent perhaps the greatest triumph of modern surgery. This success came not from surgical innovation, but from microbiological discoveries in the laboratory space, which enabled the detection of disease-specific microorganisms and identification of the cause of disease. Thus, the laboratory space guided the revision of existing surgical workflows, which eventually led to spatial change within the hospital. The transformation of the operating room serves as an example of how space can be medicated and thus act as a preventive agent within a clinical context by eliminating potential risk factors of hospital-acquired infections. A medicated operating room can only be described by recounting its clinical workflows, and it is through these workflows that aseptic surgery was made possible.

As with any medicated space, all sterilization measures have their shelf life, that is, they are effective only for a specific period of time between activation and disposal. An operating room is therefore subject to a repetitive cleaning routine, which involves thorough daily cleaning and disinfecting of floors, walls, ceiling, furniture, and appliances. The aim is to prevent "smear infections," i.e., the communication of an infection by direct contact with surfaces or objects. These hygienic concerns were accompanied over time by material changes within the building itself, e.g., terrazzo floors were preferred throughout hospitals in the early part of the twentieth century since they allowed for easy cleaning with

products like Lysol,⁸² and a century later a photocatalytic coating (a burnt-in titanium dioxide nano coating) began to be applied to ceramic wall and floor tiles since, in combination with direct lighting, it uses photocatalysis to form an antiseptic ozone (O_3) that corrodes disease-causing contaminants, such as bacteria, viruses, fungi, and parasites.⁸³

Medicated space includes all disinfecting or sterilizing measures applied to space and to inanimate objects to precondition the environment and thereby act as preventive measures against infection or disease transmission. The only disadvantage is that most disinfectants are hazardous when in direct contact with the body and therefore can present a risk to human health. Indeed, the increase in hypersensitive disorders leading to a multitude of new allergies demonstrates the unintentional negative side effect of medicating space.⁸⁴

⁸² Hess, Die Charité in Berlin: Fotografien um 1910, 36-41.

⁸³ Birgit Hansen, *Praxis-Handbuch Badmodernisierung* (Köln: Rudolf Müller Verlag, 2011), 50–51.

⁸⁴ Miller-Keane, Encyclopedia & Dictionary of Medicine, Nursing, & Allied Health, 724.

Four Spatial Concepts

Our examination of a typical Ebola treatment center⁸⁵ is a useful conclusion as such a center combines all four spatial concepts proposed in this chapter. While the introduction at the beginning described how patients are assigned a place and moved inside the treatment center, this subchapter identifies all spatial measures adopted in the center to further therapeutic ends.

Again, various spatial measures are used during an Ebola epidemic for defense against further spreading infection (fig. 0.1). At the scale of the region and the town, space *cordons off* areas of peak contagion, thereby defending the public at large. At the scale of the treatment center, space *quarantines* those showing a probability of infection and *isolates* those with the disease, as well as being subject to *decontamination* itself, thereby preventing cross-contamination among patients. At the scale of the body, space gives *access* to specimens for examination at microscopic scale to detect disease signs. Further, space in the form of barrier clothing *protects* health workers against the contagion, thereby allowing the medical staff to execute all these measures.

The spatial concept of *confinement* is thus applied fully, since all three measures (to cordon off, to quarantine, and to isolate) are taken in the Ebola treatment center (fig. 2.18).

Of particular significance here is the material used to build the double fence⁸⁶ that *cordons off* the entire compound. It is of a quality and flexibility that one associates not necessarily with a treatment center but more with a road or construction site. The fence thus functions as a signifier rather than as a fortification. Constituting the minimum means of segmenting space, these double fences are like erected lines drawn in space. Like a queue barrier, they suggest

⁸⁵ The reproduced schematic is from Doctors Without Borders, the Center for Disease Control and Prevention, and the World Health Organization. Clark Patterson, "An Ebola treatment center," *Washington Post*, Health & Science section, September 22, 2014; http://apps.washingtonpost.com/g/page/national/an-ebola-treatment-center/1333/ (accessed, 2014)

⁸⁶ Patterson, "An Ebola treatment center," Washington Post.

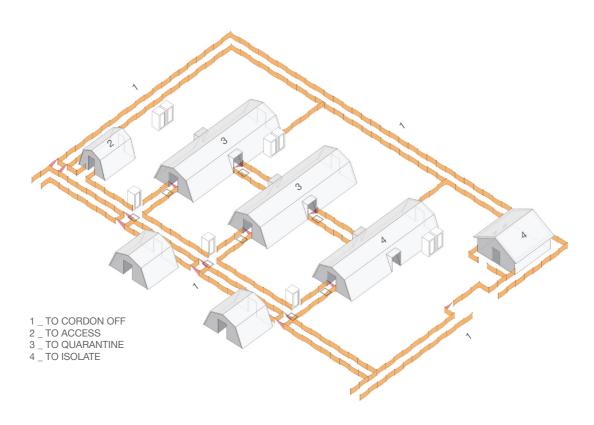


Fig. 2.18. Ebola Treatment Center – Space as Confinement

walls and imitate corridors, and serve to channel patient as well as medical workflows.

The triage process depends upon *laboratory space*. Here, the spatial concept of *access* is of relevance. Within the space of the microscope slide, suspicions of Ebola infection are either confirmed or denied. That space is the focus, whether specimens are examined on-site or shipped in vacutainers (vacuumed-sealed test tubes, another space) to nearby clinical laboratories.

Because the low-probability and high-probability wards are implemented *to quarantine* the contagion, quarantine measures take up two-thirds of the treatment center (at least in our example considered). Here, the spatial concept of quarantine detains and immobilizes patients, differentiating between low and high suspected cases.

The Ebola ward aims *to isolate* confirmed cases of infection. Isolation measures, by establishing physical distance of different degrees between infected patients (who are very contagious) and others, prevent not just the sick individuals but any items in contact with them from crossing that distance, thereby hindering cross-contamination. That means protective clothing, like disposable gloves, as well as corpses and medical waste require isolation and are therefore subject to further spatial segregation.

The protective suit (perhaps the iconic image of the Ebola crisis from the perspective of a European observer) further represents the concept of *space as treatment*. The special clothing of the medical staff is intended *to protect* their healthy bodies as they move within an otherwise contaminated environment. In the case of long-lived, airborne Ebola infection, a large amount of protective clothing is needed to shield the medical workers, with the full suit incorporating a dressing gown, apron, respirator, surgical cap, goggles, boots, and two pairs of gloves.⁸⁷ The protective clothing must be worn properly and, after it is contaminated, must be removed with care to avoid touching the outer layers.

Accordingly, strict routines on how to dress and undress require medical staff to work in twos. The procedure to undress especially is a very slow and careful process that requires the fullest attention of the medical staff. Consequently, the treatment center provides two spatially separated rooms, one for the dressing in, and the other for the undressing from, protective clothing.

The concept of *medicated space* is omnipresent (fig. 2.19). The treatment center relies on a range of decontamination measures, evident in the medical workflows and daily routines of the medical staff. Before entering the treatment center for their shift, the medical workers spend a good amount of time examining each other's protective suits, e.g., making sure that the dressing gowns and aprons are tightly sealed, the goggles and respirators are applied correctly, or there aren't any damages like small holes or tears.88 Before entering their assigned ward, they pass through a variety of decontamination foot basins⁸⁹; every corridor and every crossroad, any possible entry or exit, all are equipped with these basins. To eliminate cross-contamination, after putting on their protective boots, medical workers literally step into a bath of disinfectant each time they enter or exit. After their shift, medical staff is required to decontaminate their protective clothing before exiting the ward. Again, they work in twos in order to assist each other in a thorough decontamination process. Afterwards, workers reach the undressing room and remove the protective suits. They are able to reuse some protective equipment after further disinfection is applied. Other clothing items are subject to high-level decontamination measures, like disinfecting with a 0.5 percent chlorine solution.⁹⁰ Still other items are subject to incineration, nearby but outside the treatment center compound. Before they exit the undressing room, medical staff is required to take an antiseptic shower.

Patients are also provided with a variety of decontamination measures, e.g., each ward has its own patient showers and toilets, which are themselves subject to thorough disinfection measures. As mentioned earlier, those patients that

⁸⁷ Ibid.

⁸⁸ Ibid.

⁸⁹ Ibid.

⁹⁰ Ibid.

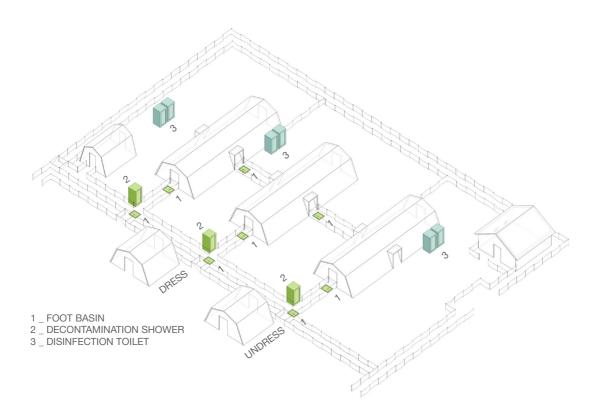


Fig. 2.19. Ebola Treatment Center – Medicated Space

recover are required to take an antiseptic shower prior to leaving the treatment center. ⁹¹ The bodies of those patients who have died of Ebola also undergo physical decontamination, then are stored temporarily in a morgue until the necessary burial arrangements are made. Their cadavers eventually leave the compound to a nearby (and assigned) cemetery, where they are buried with equally stringent measures to avoid direct contact with mourners. The cycle ends with a biological decontamination measure.

The Ebola treatment center thus embodies each of the four concepts in which space acts as an agent of medical intervention, in this case functioning to defend the uninfected from an especially contagious disease.

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⁹¹ Ibid.

Part 3

Space in Clinical Practice

Introduction

Specialization in Clinical PracticeDiversification and Division of Labor
The Logic of Departmentalization

Departmentalization of Clinical Practice Spatial Claims Clinical Workflows

The Chase of the Charité

Clinical Research
Clinical Treatment
Departmental Structure
Infrastructure

Fig. 3.1. Pace Layers of Clinical Specialization

Introduction

As one of the most innovative places within the nineteenth-century city, the hospital of clinical medicine provided an environment for the development of a complex array of technological tools and a variety of specialized clinical techniques. Thus, medical practitioners needed the hospital if they were to navigate through the body's complexity. To reach today's high level of innovation, the practice of clinical medicine relied on both diversification and division of labor. Only by means of clinical specialization was medical innovation possible, which in turn enabled physicians to scientifically diagnose and treat ever more diseases. Incorporating the medical laboratory into the hospital was especially key to giving physicians the means to apprehend the larger cause and space of disease.

What drives the engine of specialization? According to George Rosen, it is urbanization. The movement of people and the resulting exchange of ideas historically have made specialization possible. Rosen based his observations on Émile Durkheim's idea that the division of labor resulted from the greater density of urban populations.¹ But if specialization was, in fact, a phenomenon of the nineteenth-century city, how does one narrow the analysis to grasp the phenomenon of *medical* specialization? Hans-Heinz Eulner traced the output of medical literature produced at universities within the German-speaking area of the nineteenth century,² and George Weisz observed the rise of specialties as recorded in medical directories.³ Thus, Eulner's analysis focused on the output of medical specialization, and Weisz analyzed its context.⁴ In seeking to answer how medical specialties evolved, this chapter focuses on the hospital of clinical medicine.

¹ George Weisz, *Divide and Conquer: A Comparative History of Medical Specialization* (Oxford: Oxford University Press, 2006), xiii.

² Hans-Heinz Eulner, *Die Entwicklung der medizinischen Spezialfächer an den Universitäten des deutschen Sprachgebietes* (Stuttgart: F. Enke Verlag, 1970).

³ Weisz, *Divide and Conquer*.

⁴ Hans-Heinz Eulner categorized the available literature by research emphases, thereby providing an overview of the emerging medical specialties. George Weisz, on the other hand, conducted a comparative study on medical specialties by looking at medical directories and the

The phenomenon of specialization in clinical practice can be viewed as a bundle of interrelated processes. Sorting different processes according to their pace of specialization allows one to draw a cross section through medicine's general process of specialization (fig. 3.1).⁵ Processes that specialize at a fast pace, like clinical research and treatment, propose and integrate ideas, while processes that specialize at a slower pace, like departmental structuring and clinical infrastructure formation, establish regulations and affirm persistence.⁶ While the fast changing processes are prominently reflected within the medical discourse, the slower changing processes dominate clinical practice. Rather than contextualizing the phenomenon of specialization solely within the fast-paced processes of clinical research and treatment or within the slow-paced processes of clinical infrastructure formation, this analysis describes the hospital's departmental structuring, which specialized at an intermediate pace.

In the following, we are going to analyze in depth the historical transformation of the departmental structure at the Charité. One advantage of focusing on departmental structuring is that departments occupy a double zone, i.e., they are, for the most part, physically defined, yet at the same time they present an administrated space (fig. 3.2). For example, use of an office room can be divided between departments without the construction of a wall. Analyzing the departmental structuring process therefore allows one to trace the process of specialization as it overlaps both spatial practice (clinical research and treatment) and spatial form (clinical infrastructure). One disadvantage of focusing on changes in the departmental structure is that a specialty department can host multiple specialties at once. Hence, an analysis that uses alteration in the departmental structure as a prime indicator for clinical specialization will undoubtedly miss some of the fast-changing specialties. We therefore need to view a specialty department as a spatial organization that brings together a group of relevant specialized activities by separating them from other less relevant specialties.

associated regulations on standardizing specialist practice in France, Britain, the German-speaking world, and America.

⁵ The diagram is based on Stewart Brand's diagram "The Order of Civilization" in Stewart Brand, *The Clock of the Long Now* (New York: Basic Books, 1999), 34–39.



Fig. 3.2. Departmental Structure as Indicator of Clinical Specialization

⁶ Ibid.

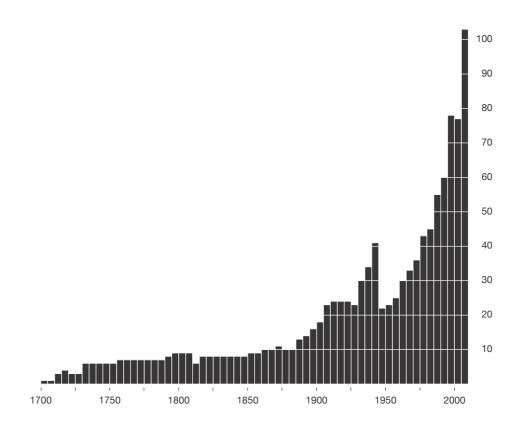


Fig. 3.3. Number of Specialty Departments at the Charité

Specialization in Clinical Practice

By tracking the number of specialty departments in existence at the Charité every five years over its three hundred-year history, figure 3.3 gives visual shape to the phenomenon of clinical specialization. Notice that the graph does not list multiple departments of the same specialty. No hierarchy is given to signal larger or smaller departments, nor is a distinction drawn between departments that were meticulously planned and those that have been slowly altered and redesigned over time. By depicting the process as one of simple accumulation, the graph makes the phenomenon of clinical departmentalization quantifiable.

At first glance, the graph reveals a striking consistency. That is, since the late nineteenth century, the increase in specialty departments is similar overall in its cumulative characteristic. Some historical periods thus stand out for their stagnant accumulation of specialty departments: the period of post-1919 reparations, the time of hyperinflation during the Weimar Republic (1921–24), and the following Great Depression (1929–32). Most visible is the big wound opened in the departmental structure by the Second World War and its aftermath.

The Charité started out with four general departments in 1727 and comprises today 103 specialty departments. In total, 166 specialty departments were added over time since the Charité was established (not all of them exist anymore). While the addition of new departments happened occasionally throughout the eighteenth and into the nineteenth century, it was only in the late nineteenth century that the accumulation of new departments increased rapidly—in this

case, threefold.⁷ Combining the number of new specialty departments added in the nineteenth century with the number added in the twentieth century, the accumulation increased eightfold. Furthermore, the "doubling time" of specialty departments substantially narrowed, i.e., while it took seventy-five years to double the six specialty departments that the Charité had in 1810, it took only about twenty years to double the forty-five specialties at the hospital in the mid-1980s. These numbers demonstrate that since the late nineteenth century, the departmental structure of the Charité has added specialty departments at an exponential rate. In fact, three periods of super-linear growth,⁸ during which the accelerating cycles of growth are prolonged, are discernible. If we disregard the interruption of the Second World War, the Charité has been adding specialty departments exponentially since the 1930s.

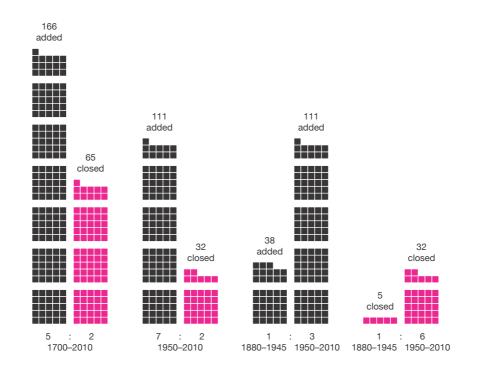
Despite the overall accumulations of specialties, figure 3.4 brings to light a correlation that otherwise would have remained invisible, namely, the ratio of added and subtracted specialty departments. The graph depicts the turnover of specialization during the Charité's existence, including all those departments that became obsolete as time passed. When viewed in its entirety, the total number of added and subtracted specialty departments produces a ratio of five to two, i.e., for every five specialty departments added, two existing departments eventually closed. However, zooming in on the two main growth periods, from 1880 until 1945 and from 1950 until 2010, makes apparent a striking change in the accumulation rate. Although they are almost equal in timespan, the later period generated about three times more specialty departments than the previous period. Further, during the second growth period, about six times more specialty departments were closed than during the period until 1945.9 That is to

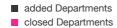
-

⁷ That is, while eleven specialty departments were added up to 1800 and thirteen departments were added from 1800 until 1900, forty specialties were added in a period of only sixty years between 1880 and 1940.

⁸ When the exponent of an exponential function scales above 1, with $y = x^n$ (n > 1), the growth is described as super-linear. Two periods of super-linear growth occurred, the first from 1930 until 1945 (eighteen specialties were added within a period of fifteen years, i.e., $\log_{15}(18) = 1.067$) and the second from 1950 until 2005 (eighty-one specialties were added within a period of fifty-five years, i.e., $\log_{55}(81) = 1.097$).

⁹ These numbers exclude the impact of the Second World War, which in its aftermath led to the closure of twenty-one specialty departments. However, this number is still lower than the number of closures caused by the two recent mergers.





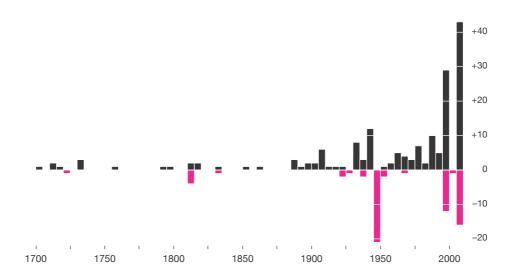


Fig. 3.4. Turnover of Specialty Departments at the Charité

say, for every three specialty departments that opened after the 1950s, one department closed. Thus, these two periods of growth represent two very different responses on the part of the hospital's departmental structure to the overall process of specialization. While specialty departments have been added exponentially over the long term, as more time passed a proportionally higher number of departments became obsolete and were closed over the short term. Therefore, not only is the pace of accumulation for specialty departments within the hospital increasing, but its existing specialties are being rendered obsolete at an ever-accelerating pace.

It is important to note that the exponential accumulation of specialty departments at the Charité represents only a fraction of the rapidly changing environment of clinical specialization. Although we are most definitely missing the short-lived specialties (i.e., those that adapt and change extremely fast within the departmental boundaries), a historical analysis of the transformation within the departmental structure allows us to trace the most influential of the specialties that clinical medicine incorporated.

Diversification and Division of Labor

A common misconception about specialization partially results from the fact that its process does not involve merely the simple division of labor. Medical specialization instead is an advancement that occurs after labor first diversifies. George Weisz, who scrutinized the context of specialization, outlines the logic of specialization in the following way:

First, [specialization] expresses a fundamental intellectual strategy: dividing problems into smaller and more manageable units in order to solve them more easily. [...] Second, [specialization] represents a way of dividing people into smaller and more manageable groups based on common attributes in order to facilitate their management in every sense of the term. [...] Third, [specialization] describes what has happened to medical institutions and the medical profession that in the space of a century were literally divided and conquered by new forms of organization based on a novel kind of expertise. [...] Finally, [specialization] portrays what we now

experience as patients: we are allocated to special wards or hospitals so that specific parts of our bodies can be treated.¹⁰

Although I do not disagree with Weisz's general observations, the first and second stages of his outline represent an oversimplification of the subject of specialization. In her book *The Economy of Cities*, Jane Jacobs criticizes the unwarranted appreciation of the concept of division of labor:

Adam Smith [...] seems not to have recognized that new work arises upon older divisions of labor. [...] Smith gave to division of labor unwarranted credit for advances in economic life, a mistake still much with us. Division of labor, in itself, creates nothing. It is only a way of organizing work that has already been created. [...] Division of labor is a device for achieving operating efficiency, nothing more. [...] Seen as a source of new work, division of labor becomes something infinitely more useful than Adam Smith suggested.¹¹

According to Jacobs, to specialize means first and foremost to add *new kinds* of work. Such an understanding demystifies Weisz's third (unexplained) stage of specialization showing "the medical profession [...]conquered by new forms of organization based on a novel kind of expertise." That is, the process of clinical specialization entails adding a significant amount of new clinical work. Innovative hospitals, like the Charité, not only develop in complexity, but also constantly expand their scope of work, as Jacobs describes:

When new goods or services are added to older work, they are not added to the whole of the older work. Rather, the new work is added directly onto only a fragment of the older work. [...] The following generalization can be stated: Existing divisions of labor multiply into more divisions of labor by grace of intervening added activities that yield up new sums of work to be divided. [...] In an economy where many new goods and services are being added, new divisions of labor multiply more rapidly than old divisions of labor become obsolete.¹²

Accordingly, in the context of clinical medicine, the general process of specialization should be viewed as three different types of developments: specialization, subspecialization, and multidisciplinarity (figure 3.5).

¹⁰ Weisz, *Divide and Conquer*, xxiv-xxx.

¹¹ Jane Jacobs, *The Economy of Cities* (New York: Vintage Books, 1970), 81–84.

¹² Ibid., 58.

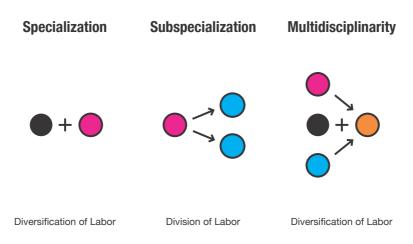


Fig. 3.5. Specialization, Subspecialization, and Multidisciplinarity

Specialization in clinical practice is either generated by innovative ideas or derived directly from the response to a problem, i.e., an action taken in response to a particular disease. Innovative ideas might have their origin in new or imported skills, technological advancements, or novel material properties. To specialize resembles more or less a process of diversification. That is, the process of specialization does not start with dividing labor, but starts with adding new work. For new work to be added, a rather open environment is needed, one that allows for focused activities to unfold.

Subspecialization in clinical practice encompasses those divisions and departments that emerged out of a particular specialty. The process of subspecialization mirrors the division of labor. That is, already established specialty departments start to divide their specialized practice by subspecializing, whether focusing on a particular body region, body part, or body chemical, or limiting patients to a particular age or gender. The division of labor implies in general a striving for efficiency. In the context of clinical practice, however, this also means perfecting a specialty's craft.

Multidisciplinarity in clinical practice occurs when either innovative ideas or actions taken in response to a particular disease require the involvement of more than one specialty. Hence, the process that generates multidisciplinary practices repeats, in a way, the cycle of specialization, i.e., multidisciplinarity in medicine represents a form of clinical specialization where two or more previously separated specialties merge. Multidisciplinary departments tend to favor problem-oriented approaches that focus on particular diseases or treatments and require the combined expertise and practices of previously separated specialties. In the context of the Charité, where many new approaches and experiments are added continually, new divisions of clinical practice emerge

¹³ Historically, as George Weisz points out, there have been cases of mergers all along. "One way of keeping the number of specialty categories under control was to unite specialties with visible

of keeping the number of specialty categories under control was to unite specialties with visible and defensible links into a single category. Wherever national medical associations addressed the issue seriously, they preferred to treat gynecology and obstetrics as a single unit. For similar reasons, associations usually encouraged the combination of diseases of the ear with those of the throat and nose and, in some countries, of psychiatry with neurology." Weisz, *Divide and Conquer*, 206.

at a faster pace than does the obsolescence of old divisions of clinical practice. It follows that new multidisciplinary practices do not replace existing specialties, but simply get added on alongside them.

In the context of clinical specialization (figure 3.1), clinical research offers ideas, and clinical practice attempts to integrate those ideas. For that reason, clinical research specializes at a faster pace. Hence, we will find proportionally more specialties in clinical research (e.g., task-based specialties) than in clinical practice. As mentioned previously, this analysis does not reveal those specialties that change and disappear at a rapid pace or that stay confined within a department, but instead traces the most influential specialties that have impacted the departmental structure of the hospital.

For purposes of this analysis, the medical specialty of surgery serves as a case study. Tracing its chronology within the departmental structure of the Charité allows an exemplary longitudinal section to be drawn through the perplexing process of specialization. First, contextualizing surgery in the early years of the Charité requires an understanding of the centuries-long separation of medical doctors (internists) and military surgeons. Rather than reading these parallel worlds of internal medicine and practical surgery as a form of specialization in itself, a look at the chronology of the departmental structure indicates that both medical cultures must have operated more or less within the realm of general medicine throughout the eighteenth century, is given that the clinical specialty of surgery was added in the nineteenth century by both sides. While spatially separated and governed by different regulations (civil and military), the Charité's clinical specialty of surgery up until 1932 should be viewed not as two distinct specialties, but as a specialty that simply took place within two distinct

¹⁴ "In most nations, official healing in the eighteenth century was divided into two branches, medicine and surgery, the former focusing on medications or diet taken internally, and the other, on the external parts of the body or those few internal parts directly accessible to the surgeon's knife. [...] By the early nineteenth century, obstetrics was considered by many as a third major branch of medicine. This status was explicitly recognized when medicine was united with surgery in Prussia in 1852; henceforth, medical graduates received a single diploma identifying

them as Arzt, Wundarzt und Geburtshelfer." Weisz, *Divide and Conquer*, 196–209.
¹⁵ Annette Drees (Hrsg), *Blutiges Handwerk – klinische Chirurgie* (Münster: Westfälisches Museumsamt Münster, 1989).

hospital operations.

Figure 3.6 depicts the chronology of the formation of all specialty departments at the Charité that are directly related to surgery. The table juxtaposes the three processes of diversification and division of labor as they unfolded over time within the hospital's surgical practice: specialization, subspecialization, and multidisciplinarity.

Specialization began as a poor precondition of surgical practice appeared for the first time within the departmental structure as a "division of surgery" (1810), directly subordinate to the department of general medicine. That is, surgical tasks needed to be managed within the existing general medical departments of the hospital. Until the mid-nineteenth century, the Charité was not equipped with operation rooms. Instead, operations were carried out on operating chairs or tables that were brought into the hospital rooms. The first "department of surgery" was established within the university hospital in 1882. Meanwhile, a division of surgery had also emerged for military surgeons and received department status in 1898. The department of surgery became the department of general surgery in 1945 (just before the process of subspecialization set in) and remains as such today.

Subspecialization began when the division of cardiac surgery and the division of vascular surgery, i.e., forms of division of labor, emerged in 1982 within the department of general surgery. The two subspecialty divisions then merged nine years later, establishing the department of cardiovascular surgery. The general process of subspecialization can penetrate multiple levels, dividing subspecialized labor even further. For example, pediatric surgery first emerged within the departmental structure in 1982 as a division, subordinate to the department of general surgery. Pediatric surgery became a subspecialty since it focused its efforts on a particular age group. In 1994, the subspecialty pediatric surgery was established as an autonomous department. In 2000, when the department established its own division of pediatric neurosurgery, focusing on a

particular body part (the brain), the process of subspecialization continued.

Multidisciplinarity began as the first multidisciplinary care unit emerged at the Charité in 1981, linking the department of anesthesiology together with the department of operative intensive care medicine. This echoes the action taken eighty-three years earlier by the surgeon August Bier, who served as chief surgeon at the university hospital at the Charité from 1907 until 1932, when he was the first to perform an operation by injecting cocaine for intrathecal anesthesia, thus adding a new activity within the specialty of surgery.¹⁷

¹⁶ Ibid.

¹⁷ August Bier, "Versuche über Cocainisierung des Rückenmarkes" (Experiments on the cocainization of the spinal cord), in *Deutsche Zeitschrift für Chirurgie* (1899).



- Clinical Practice
 - Surgical Practice within the Dept. for General Medicine (1727–1810)
- Specialization
 - Division of Surgery within the Dept. for General Medicine (1810–98)
 - Department of Surgery (1898–1945)
 - · Department of General Surgery (1945-)
- Subspecialization
 - Department of Cervical and Maxillofacial Surgery (1958–82)
 - Department of Oral and Maxillofacial Surgery (1982–)
 - Division of Cardiac Surgery within the Dept. of General Surgery (1982-)
 - Division of Neurosurgery within the Dept. of General Surgery (1982-)
 - Division of Pediatric Surgery within the Dept. of General Surgery (1982-)
 - Division of Vascular Surgery within the Dept. of General Surgery (1982–)
 Department of Cardiovascular Surgery (1991–)

 - Department of Neurosurgery (1991–)
 - Division of Thoracic Surgery within the Dept. of General Surgery (1991-)
 - Division of Visceral Surgery within the Dept. of General Surgery (1991–)
 - Department of Pediatric Surgery (1994-)
 - Division of Pediatric Neurosurgery within the Dept. of Pediatric Surgery (2000–)
- Multidisciplinarity
 - Department of Operative Intensive Care (1981–)
 - Department of Trauma And Reconstructive Surgery (1991–)
 - Department of Surgical Oncology (1991–2000)

Fig. 3.6. Specialty Departments of Surgery at the Charité

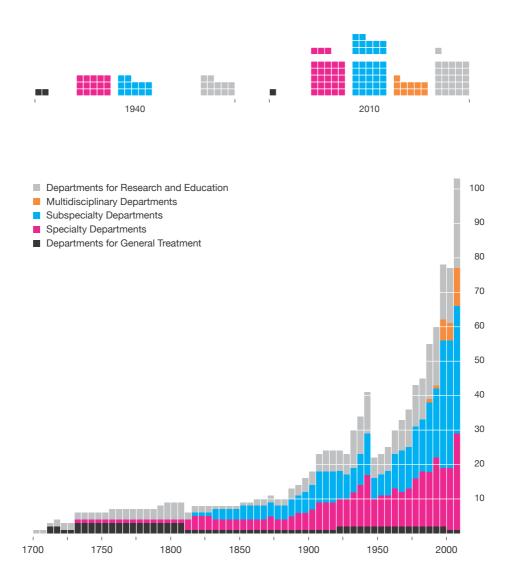


Fig. 3.7. Spectrum of Specialty Departments at the Charité

The Logic of Departmentalization

As the case of surgery vividly illustrates, the logic of departmentalization in clinical practice is far from arbitrary and, in fact, can be classified according to three interrelated strands, namely, the processes of specialization, subspecialization, and multidisciplinarity. Taking this view, figure 3.7 redraws the 310-year history of specialty departments at the Charité according to the three categories, outlining their proportional impact on the overall process of departmentalization. Besides the obvious accumulation of specialties and subspecialties as departments, the departments of general medicine—at the core of clinical practice throughout the eighteenth century—have been diminishing within hospitals to the point that the only general medical department left at the Charité today is an outpatient department. With the exception of the departments for research and education, every clinical department today is assigned to a particular specialty. That is, departmentalization now governs all aspects of clinical practice.

By comparing the total numbers of different kinds of specialty departments in 1940 and in 2010 (the high points of the previously examined growth periods), the graph further highlights some striking differences. Within the timespan of seventy years, the number of specialty departments doubled, while the number of subspecialties tripled. Further, within the timespan of thirty years, the number of emerging multidisciplinary departments by 2010 came to roughly the same number of subspecialties in the 1940s. This was quite a fast transformation, considering that in the 1940s it took more than a hundred years for these subspecialties to accumulate.

These facts obviously confirm the overall pattern of exponential growth; however, figure 3.8 also offers insights into what has stimulated this accumulation. The graph compares two processes, namely, the processes of specialization and multidisciplinarity viewed in combination as one, and the

 $^{^{18}}$ The graph includes two further categories for the remaining departments, i.e., departments based on general treatment as well as departments assigned to research and education.

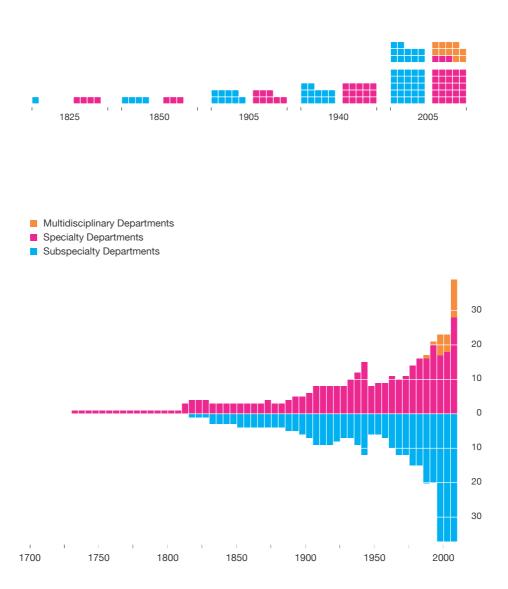


Fig. 3.8. Diversification and Division of Labor at the Charité

separate process of subspecialization. Remarkably, both accumulations mirror one another: These two essential processes are the main contributors to the overall accumulation of specialty departments. While specialization and multidisciplinarity both lead to greater diversification by adding new specialties, subspecialization powers a greater division of labor by branching into subunits within existing specialties. New specialty and multidisciplinary departments are derived from added work, while subspecialty departments result from dividing the work within existing specialties. For a new specialty or multidisciplinary department to emerge, the added work must expand from a previously side activity to a principal specialty. Further, the rise of multidisciplinary departments represents a paradigm shift within the greater process of specialization, whereby new specialty departments emerge not as before, by establishing an entirely new practice from what began as an ancillary activity, but through merging existing practices, i.e., by working in a problem-oriented way. Such a paradigm shift has taken place not only due to changes in clinical practice, but also due to changes in medical education. Over the course of the last ten years, the university hospital of the Charité has implemented a new problemoriented curriculum, thus preparing students to work within multidisciplinary environments.

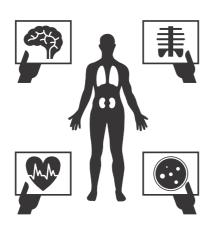
The emergence of subspecialty departments, on the other hand, highlights another factor, that is, the way in which subspecialty departments and clinics are like "focused factories" (Gawande):

Western medicine is dominated by a single imperative—the quest for machinelike perfection in the delivery of care. [...] Twenty-five years ago, general surgeons performed hysterectomies, removed lung cancers, and bypassed hardened leg arteries. Today, each condition has its specialist, who performs one narrow set of procedures over and over again. [...] all the repetition changes the way [physicians] think.¹⁹

Each subspecialty thus represents a different set of highly specialized skills that a given practitioner of clinical medicine possesses. Specialists are trained to read

¹⁹ Atul Gawande, *Complications: A Surgeon's Notes on an Imperfect Science* (New York: Picador, 2002), 37–38.

otherwise encrypted (technologically generated) images or to perform specific techniques in order to make sense of disease-related symptoms (transforming them into signs). Therefore, not only does the rise of subspecialization reflect today's technical possibilities or the capacity for a clinical specialty to infinitely divide its labor in order to gain further honed expertise, but it also represents a response to the ever greater demand of disease and ever greater complexity of human biology. After all, clinical medicine is a practice that gets activated first and foremost in cases of illness.



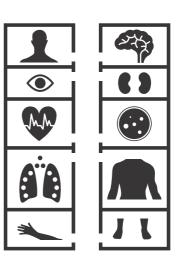


Fig. 3.9. Topographic-anatomical vs. Architectural Space

Departmentalization of Clinical Practice

Spatial Claims

As specialists limit their scope of operation, this narrowed focus requires greater concentration. That is, clinical specialties seek a space that allows both for focus and for the unfolding of specialized skills. Those clinical specialties that do not depend on proximity to the patient have the advantage of appropriating various spaces far from the sickbed.

[...] by the middle of the 19th century there was already evident a significant change—the medical sciences were separating from the actual care of the patient. Physiology, chemistry, and pathology, as emerging disciplines, claimed more and more allegiance of their devotees. Each of these subjects became a science in its own right and demanded highly specialized training. Professional pathologists, physiologists, and chemists no longer practiced clinical medicine to any extent, but attended to their laboratory disciplines.²⁰

These claims on space distant from the patient often appear gradually. But before a spatial form (e.g., the plan of a building) is changed, spatial practices go through a process of adaptation in response to new conditions and requirements (fig. 3.2). Let us consider a few examples. Perhaps one of the least disruptive adaptations of a spatial practice is the reuse of an already existing space. Thus, an existing work desk inside a clinical laboratory might be reserved for a newly emerging diagnostic technique, or a certain number of sickbeds might be assigned for a newly developed clinical therapy. The newly established work desk as well as each newly designated sickbed requires the assigning of particular clinical staff to it. If the added work produces relevant results, the reserved work desk might soon demand a work area, and the rooms with the

²⁰ Lester S. King, *Medical Thinking: A Historical Preface* (Princeton, NJ: Princeton University Press, 1982), 135.

assigned sickbeds gradually will turn into a specialized subdivision or ward. It is only then that actual alterations to the existing space plan would be observed. That is, partitions with doors might be erected to allow for partial visual or acoustical seclusion of the work area, or in the case of the specialty ward, the same doors might intersect corridors. Such doors might be changed to allow uncensored unidirectional access (by providing a door handle only on one side) or fully controlled access (by requiring a key or magnetic card). The example of the partition door demonstrates how what was once a simple passage can be turned into a control element, administrating access and consequently regulating workflows. In a larger perspective, these partitions (walls and doors) mark the territorial claims of clinical specialties. By redesigning the existing space plan of the clinical infrastructure, these seemingly ephemeral partition devices in fact reorganize the clinical workflows and therefore affect (invisibly) the existing spatial relations within the hospital. Therefore, we can view the process of clinical specialization as a constant adaptation of movement. Such a reconfiguration of workflows gradually reorganizes the hospital and eventually bears a large share of responsibility for the rapidly diversifying clinical culture, whose daily routines digress, clinical practices deviate, and medical terminology differs widely.

What eventually results from clinical specialization is spatial change, as the hospital's infrastructure spatially transforms and expands over time. Figure 3.10 depicts the spatial change on the scale of the urban block, focusing on the historical campus of the Charité in Berlin-Mitte. By applying to the process of spatial change the same perspective that was previously used to study the phenomenon of specialization in clinical practice, we can view the transformation of the clinical infrastructure as a bundle of interrelated processes. Different spatial elements similarly can be sorted according to their pace of change, which allows one to draw a cross section through the hospital's general process of spatial change (fig. 3.11).²¹ Some spatial elements change at a faster pace (like adding partitions and walls to define hospital rooms), while

 $^{^{21}}$ The diagram is based on Stewart Brand's diagram "The Order of Civilization" in Brand, *The* Clock of the Long Now, 34-39.



Fig. 3.10. Charité Campus in Berlin-Mitte

Oliviaal Dagaganak	- - (
Clinical Research		Partition
Clinical Treatment	.	Wall
Departmental Structure Infrastructure		Room
		Ward
		Building
	(Urban Block

Fig. 3.11. Pace Layers of Spatial Change

other transformations occur at a much slower pace (like the hospital building itself and the urban block). We should emphasize, however, that even the fastest changing spatial elements are extremely slow compared to the pace of clinical specialization. For example, a room absorbs and integrates spatial partitions over time, i.e., a partition wall might be seen as the precursor for a solid wall that will replace it. And adding new work or dividing existing labor within a department is in itself a spatial claim and leads more or less to spatial densification. But the fact remains that a room cannot be divided ad infinitum. Therefore, whereas the process of clinical specialization both is paralleled by departmentalization and also resembles a process of spatialization, the creation of new spaces is the outcome of a process of divergence and division within clinical practice.

Clinical Workflows

Without a doubt, specialization in medicine has raised clinical standards and therefore improved treatment outcomes. These benefits of specialization often outweigh its drawbacks, i.e., the radical impact that departmentalization has on the hospital as a whole. Although merely a by-product of clinical specialization, space has reemerged as decisive factor of that impact. Thus, as space establishes an ever greater physical distance between clinical specialties, those specialties operate within an increasingly isolated and individualized environment. Isolation allows and even encourages each clinical specialty to pursue its interests as well as to establish particular regulations. The increasing distance that accompanies clinical departmentalization means that the patient experience in the hospital has gained complexity. By stretching various diagnostics and therapies across numerous specialty departments, the workflows of patient treatments have expanded substantially in both space and organization. Thus, the process of specialization has led slowly to a new spatial condition, where the patient is scattered physically, histologically, and virtually (e.g., in the form of patient records) within a labyrinth of simultaneous programs and juxtaposed specialists (fig. 3.12). Consequently, patients as well as the clinical staff have to cover great distance.



Fig. 3.12. The Scattered Patient

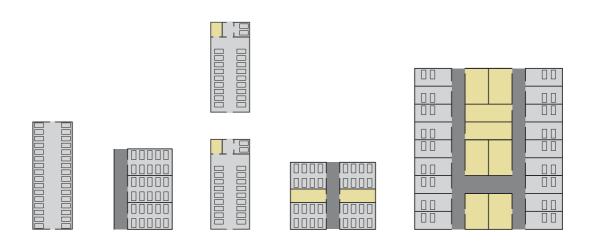
To overcome this new spatial distance, hospitals have adopted various means over the years. As shown in figure 3.13, which depicts diagrammatically the typological transformation of the in-patient ward at the Charité, the floor plan of the hospital was transformed primarily to accommodate departmentalization. Yet, as is evident in the 1980s high-rise tower with its double-corridor layout, changes were also made to decrease the distance between the nursing staff, the technological tools of care and treatment, and patients' sickbeds.

Communications also underwent improvements, so what started as an in-house mail and later telephone system has been expanded since the early 1990s into an in-house computer network. For the last seven years, physicians at the Charité view X-rays, not on film, but on computer screens, which means that X-ray diagnostics are spatially distributable at a much faster rate. Then in 2010 the Charité introduced the so-called tumor conference, employing videoconferencing:

Each tumor conference brings together experienced physicians from various disciplines, to come to an interdisciplinary decision on the best strategy for treatment for individual patients. The conferences will be held at the various Charité Comprehensive Cancer Center sites and will be linked via videoconferencing. If the conference is centered at one location, other physicians will be able to join in the videoconference and present their own patients. Currently private physicians and other regional clinics are being linked to the system.²²

All of these communication devices diminish distance and therefore allow for cross-departmental consultation on various treatment plans. Yet for an X-ray to be taken, a gallbladder to be removed, or chemotherapy to be induced, a patient still needs to be physically in the specific department at a particular time. This is where the Balkanizing spatial effect of specialization has created problems.

The CCCC offers coordinative support to collaborations between the various faculties and will provide the technical support for the videoconferencing system. The recommendations for therapy proposed by the tumor conference will be documented and tracked. Long-term tracking will permit regular evaluations as a measure of quality control of the effectiveness of the conferences. The responsible physician will discuss the recommendations in conference reports in detail with each patient. If the conference recommends participation in a clinical study, the physician is required to study all the requirements for participation—as well as criteria for disqualification—before any recommendation is shared with the patient." Online description of the Charité Comprehensive Cancer Center on the Charité Portal, http://cccc.charite.de/en/services/interdisciplinary_tumor_conferences/ (accessed in 2014).



different inpatient wards based on approx. 30 sickbeds (moving chronologically)

Fig. 3.13. Transformation of the Inpatient Ward

Indeed, the inefficiency of the hospital's multiple workflows has become one of the biggest economical burdens on clinical medicine. It is paradoxical that the same environment that depends on multiplicity in order to generate greater knowledge should find that exact same complexity responsible for reducing its operational efficacy. To minimize operating costs, attempts have been made to maximize the efficiency of these ever more highly specialized clinical services. Yet such optimization addresses departmental flows rather than treatment flows, e.g., treatment facilities or patient beds are still developed separately from the diagnostic area of a given specialty, however more streamlined those diagnostics have become, which means these attempts are often far from acknowledging that a hospital actually resembles a complex adaptive system (Jensen) that derives little benefit from such improvements. Within a hospital instead are "a number of people who are making day-by-day, even minute-byminute, decisions that impact hospital-wide patient flow, and they are making these decisions without access to information about what is going on in the rest of the hospital. So they may be optimizing flow within their microsystem, just within their own individual field of play."23 That is, space has turned into a problem of mobility. It is the manageability of clinical practice that is in question here:

Evaluations must be multidisciplinary, and they must address themselves to comprehensive and fully completed processes or outcomes. What difference does it make to a patient, for example, that the test has been completed if the physician has not yet been able to use that information in making a recommendation for action to resolve the patient's health issue? Patients' perception of "value" comes with the belief that they were treated for their problem, that their problem was effectively addressed. The test itself is not the value. From this perspective, services should be coordinated and pulled to the patients to produce the value outcome they expect to receive. This pull concept requires us to challenge every departmental boundary and to look at patient movement as a rationalization of service efficacy, as the value stream, and as the key to mending our currently broken commitment processes.24

To overcome silo-like departmental thinking requires shifting the focus onto the

²³ Kirk B. Jensen, MD, MBA, FACEP, Chief Medical Officer for BestPractices, Inc., quoted in David Chambers, Efficient Healthcare: Overcoming Broken Paradigms (Houston: Rice University Building Institute, 2009), 21.

workflows of patient treatments. From this perspective, each treatment represents a distributed workflow incorporating various departmental activities. These workflows move patients, doctors, staff, and materials through, in, and out of various departments. Each actor is operating on its individual clock, but their workflows nevertheless overlap in multiple mutual zones of cross-departmental circulation, e.g., waiting rooms, lobbies, corridors, vestibules, staircases, elevators, walkways, and service roads. These spatial zones are the connecting tissue that allows a distributed space to form. We just need to see these mutual paths as an opportunity. For example, one could easily imagine them paired with a virtual navigational space that adapts quickly, leads the way, steers around congestions, tracks positions, reminds and updates time schedules, and simulates choices. Fed by data from multiple handheld devices, this virtual space allows for communication among all actors and for the physical space to learn and eventually adapt faster.

Why the hurry? Because the adoption of multidisciplinary specialties will soon restructure the entire system of today's clinical medicine. This upcoming phase of diversification into ever more clinical specialties of overlapping interests is likely to be far more explosive than the specialization started by the implementation of clinical microbiology at the turn of the previous century (think of the genetic discoveries ahead). The resulting expansion of the hospital will reach far beyond the hospital campus and into the neighborhoods and homes of the city.

²⁴ Ibid., 17-18.

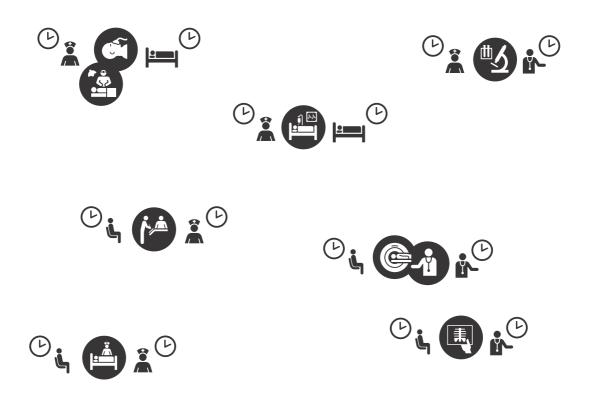


Fig. 3.14. Juxtaposed Specialists

The Case of the Charité

Considering all the innovations clinical medicine has generated over the years, i.e., various diagnostic means to examine, open, test, and image the corporal space of the body, we can see that they all relied upon clinical specialization. In other words, what the eliciting of ever more accurate disease-related signs required was innovation. The hospital provided an environment that generated innovation as well as made such innovation applicable to both diagnosis and treatment.

This conception of the hospital as a place of innovation, however, came later in its evolution. Historically, the Charité evolved through three larger stages before becoming the university hospital, which is currently its fourth stage. When the Charité was established (1710), it was intended as place of isolation for infectious patients. The hospital was therefore evacuated from the city and placed outside of the city wall (fig. 1.2). Its first specifically assigned responsibility, however, was to take care of the poor (1727). Through this second period, the hospital's reputation slowly improved until it could claim its role as a place capable of healing. To address the early high rates of mortality linked to surgical care, the hospital's building typology was transformed. New extensions in the form of loggias or single-corridor building wings were added to existing building stock. A new typology in the form of the hospital pavilion was also introduced and eventually led to the larger distribution of various detached buildings on the university hospital campus (fig. 1.7). By the end of the nineteenth century, the Charité was a focal point for global clinical research and treatment of modern medicine. In its third period, as a hospital of clinical medicine, it represented one of the most essential components of the healthcare infrastructure of the welfare state. At the same time, as this chapter investigated, the Charité underwent a process of intensive specialization in clinical practice. Throughout the twentieth century, the hospital began to assume an omnipresent place in our lives (most of us were born in hospitals). The spatial transformation that accompanied this change, while lacking homogeneity, can be characterized overall as a process of concentration, departmentalization, and spatial expansion (fig. 3.10). In the course of this transformation, from adapting, extending, or demolishing existing buildings to constructing temporary or new ones, the hospital resembled a continuous construction site. As for the nature of the current (fourth) stage of the hospital's transformation, we can only speculate by comparison on how the Charité will be able to manage the internal complexity that has followed from that intense specialization, which continues today.

As the Santa Fe Institute studies in the science of complexity have shown, companies that grow exponentially are destined to collapse. ²⁵ That is, the ever more rapid growth increases the inefficiency of the overall system of the company. This explains why many companies start to monitor their value streams in order to detect signs of inefficiency in their workflows.²⁶ Beyond that, most fast-growing companies eventually are forced to import innovative ideas through mergers, since they are unable to sustain the accelerating cycles of innovation needed. Something similar occurred during the process of greater specialization at the Charité. Rather recently, the Charité underwent two major mergers. First, in 1998, the Charité and the medical faculty at Humboldt-University merged with the Virchow University Hospital and its associated faculty of the Free University of Berlin. And second, in 2003, the Charité merged with the Benjamin Franklin University Hospital, which had previously also been part of the faculty of the Free University of Berlin. As a result of these mergers, the Charité became the largest hospital in Europe and Germany's leading university hospital.²⁷ The benefits of such mergers were twofold: importing innovation as well as eliminating obsolescence (fig. 3.4).

Yet, a basic spatial problem remains. A university hospital like the Charité needs to balance its clinical environment between two diverse spatial demands. While

²⁵ Geoffrey B. West, "Why Cities Keep on Growing, Corporations Always Die, and Life Gets Faster" (lecture, Long Now Foundation, San Francisco). See also: Geoffrey B. West and James H. Brown, *Scaling in Biology: Santa Fe Institute Studies in the Science of Complexity* (New York: Oxford Press, 2000).

²⁶ Value stream mapping was development by Taiichi Ohno and first implemented by Toyota. Taiichi Ohno, *Toyota Production System* (New York: Productivity Press, 1988).

 $^{^{27}}$ According to information provided by the hospital, the Charité employs 13,100 people (3,700 scientists and physicians, 4,100 nurses and care givers, 730 administrators, and 230 professors) and educates 7,000 students.

clinical diagnostics and treatments require an environment governed by efficient workflows, clinical research demands one that allows innovative ideas to emerge. Because efficiency is best managed by a hierarchical (vertical) organization that is based on the division of labor, and creativity is best managed by a nonhierarchical (horizontal) organization, ²⁸ an environment allowing for efficient workflows might not automatically turn out to be the right environment for fostering innovative ideas. Hence, an efficient hospital might not be an innovative one or vice versa. Since it serves as the engine of specialized clinical practice within the welfare state, the university hospital is at the forefront of these challenges in delivering healthcare in the near future. At this time, the hospital represents an environment open enough for exploration, yet focused enough for precision. Yet it seems most likely that the university hospital will eventually become part of a distributed network of clinics, even more so than it is today. The range of these specialty clinics will be broad, from specialized ambulatory centers to acute care hospitals. In this time of "the Internet of Things," the Charité will distribute its innovative capacities into other places of education, research, treatment, and care.

The hospital of clinical medicine merely serves as one example of the many drivers of a city's innovation. It is as one of those machines that the hospital produces, by means of diversification and division of labor, great multitudes of medical applications. What the hospital's innovative capacity creates on a small scale, the city generates on a much larger scale through its numerous engines of change. However, the hospital and the city are interdependent. While the

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²⁸ "In the old days, bosses were people who knew their business better than the subordinates did, so both the typical organizational structure and the typical career path were vertical. As you stuck around and presumably learned more about the business, you moved up. But today, with growing specialization, this no longer holds: '[T]hose in authority,' Barley writes, 'no longer comprehend the work of their subordinates.' Even the eminent research scientist can't boss the lab technicians around: They have knowledge and skills that he doesn't. Thus what we used to think of as jobs or occupations, Barley argues, devolve into 'clusters of domain-specific knowledge.' For things to go well in any organization, these clusters must interact on equal footing. This is why the vertical hierarchy and traditional career ladder have been replaced by horizontal division of labor, sideways career move between companies and a horizontal labor market." Richard Florida, *The Rise of the Creative Class* (New York: Basic Books, 2002), 113–114. In this excerpt, Florida is quoting Stephen Barley from his book *The New World of Work* (Toronto: C.D. Howe Institute, 1996).

hospital may be but one of those machines whose emergence was tied to the demands of the urban condition, the city relied upon clinical innovation for its very survival.



Trade (Cölln and Berlin in 1250)



Defense (Berlin in 1688)

Fig. 4.1. Market and Wall

Outlook

The city, it has been argued, is the historical outcome of defense (Lewis Mumford). Thus, the city emerged from the human instinct to gather in a well-fortified place. The wall is the primary spatial element of the city's fortification; it spatially protects the urban dweller from any agent approaching from the rural areas. Another argument understands the city as the historical outcome of *trade*, based on consumption patterns that make the city the central source of skills and innovation (Jane Jacobs).² The *market* is the primary space of trade within the city.³ Although open and ephemeral, the market is also grounded in the larger infrastructural space, consisting of trade routes, bridges, canals, and ports, etc., that allows the market to access distant crafts and specialties. A trade city therefore sees no end to its sphere of activity and flow of innovation, since its paths span great distances, eventually leading to yet other cities (e.g., see the Eurasian trading routes of the fourteenth century, fig. 1.4, or the steamboat shipping routes of the nineteenth century, fig. 1.6). A fortified city, on the other hand, spatially defines the city's limit with its walls, which helps to concentrate its population. If we compare the two (fig. 4.1), a trade city could be characterized as an open network, while a fortified city could be defined as a concentrated place. Despite their

¹ "The need for a common fortified spot for shelter against predatory attack draws the inhabitants of the indigenous village into a hillside fortification: through the compulsive mingling for defense, the possibilities for more regular intercourse and wider co-operation arise." Lewis Mumford, *The Culture of Cities* (New York: Harcourt, Brace, Jovanovich, A Harvest Book, 1970), 5. ² "The people of the city are wonderfully skilled at crafts and will become still more so because of the opportunity to specialize. [...] The system of trade that prevails runs this way: The initiative is taken by the people who want to buy something. [...] Rural production is literally the creation of city consumption. That is to say, city economies invent the things that are to become city imports from the rural world, and then they reinvent the rural world so it can supply those imports." Jane Jacobs, *The Economy of Cities* (New York: Vintage Books, 1970), 20, 40.

³ "But every town, wherever it may be, is first and foremost a market. If there is no market, a town is inconceivable. But a market can be situated near a village, even at a point in the open road or at an ordinary crossroads, without giving rise to a town." Fernand Braudel, *Capitalism and Material Life:* 1400-1800, trans. Miriam Kochan (London: Fontana/Collins, 1974), 389.

oppositional nature, the city eventually employed both spatial concepts.⁴ Over time, each concept was subject to transformation and multiple applications.

The spatial concept of defense, for example, went beyond a response to the threat of war to include defense against the threat of disease. The result was a variety of therapeutic measures, from the military strategy of the cordon sanitaire (which expanded the concept of the wall from the scale of the city to the region) to the protection of the body by means of protective clothing (which finds its origin most likely in the armor that reduced the concept of the wall to the scale of the body). The concept of the city as a concentrated place also underlies various forms of urban typologies. For example, even though a custom wall displaced the fortified city wall of the seventeenth century.⁵ the basic concept of limiting spatial expansion can be found in the Berlin tenements of the nineteenth century, where the urban perimeter block (like the city wall) spatially defines the outer limit, leaving the inner block (due to less regulation and high demand) to an ever increasing spatial concentration over time, thereby diminishing its courtyards. The resulting urban conditions in turn can be held responsible for the outbreak of various diseases requiring still other therapeutic spaces of defense (think of the overcrowded Berlin tenements in the case of tuberculosis and the overburdened infrastructure of water supply and wastewater of these tenements in the case of cholera).6

The spatial concept of trade, on the other hand, developed an ever-expanding conveyer belt, providing new mobility to a variety of agents of the space of disease (think of the spread of the plague and cholera to Europe). This open network continuously expanded in size, capacity, and frequency (growing from the railroad, to the autobahn, to air travel) and, like the city wall, found complementary application in the form of spatial therapeutic measures against disease. For

⁴ Regarding the earlier argument about the city's origin, in the case of Berlin and its twin Cölln, both cities clearly originated from trade. However, the fortification of the united city did occur, four hundred years later in the seventeenth century.

 $^{^{\}rm 5}$ Such a strategy was resurrected from 1961 to 1989 in the Berlin Wall, a reverse isolation measure.

example, the construction of the sewer network and sewage farms at the end of the nineteenth century was based on the idea of trade. While sewage (as a contaminant) was exported from the city, milk and fresh vegetables (as nourishment), grown on fertilized soil, were imported in return. In a tradeoff between the urban and the rural, the sewer network with its sewage farms, the roads back into the city, and the market formed a continuous loop. All this would have been mutually beneficial but for the unforeseen environmental problems. In the context of Berlin, the irrigation of farms with sewage led to an acidification of the soil, followed by heavy metal poisoning of the lower soil layers, ending any future agricultural use of these areas. Complications multiply once we start to wonder just how polluted the supply of vegetables and milk products was that came from the sewage farms all these years. How much did this engineered infrastructure (celebrated as a successful disinfection measure) impact the population's health at large? Yet any answers must be weighed against the clear evidence that the implementation of the sewage system lessened the overall risk factor that the contaminated water presented within the dense urban context.

Infrastructures, whether natural or man-made, most often function invisibly until they fail.⁷ But unlike the collapse of a powerline during an icestorm or the explosion of a house due to a gas leak, the contaminated river and the acidified farmland both represent failures that unfolded over a long period of time. With each infrastructure operating on its own timescale, its outputs are not always proportional to its inputs. Only when such an infrastructure has swung out of balance do we realize that the extreme complexity of these systems lies within various nonlinear feedback loops.

Organisms, it has also been argued, coevolve with their environment (James Lovelock). *Homo sapiens* have influenced their abiotic environment and that environment in return has influenced them (and other organisms).⁸ Such

⁶ Also, think of the times when the city wall defined the limit of expansion and the living conditions were such that the close proximity between humans and animals allowed for the spread of plague.

⁷ Bruce Mau, *Massive Change* (London: Phaidon Press Limited, 2004), 1–15.

⁸ This argument is based on James Lovelock's *Gaia Hypothesis*, which argues that organisms

[&]quot;influence their abiotic environment, and that environment in turn influences the biota by

coevolution occurred as humans acted to protect themselves against the environment as well as trade with it through a series of calculated tradeoffs. Over the last two hundred years, Germany has been transformed from an agricultural to an industrial society in a process generally referred to as urbanization. By 1880, slightly more than half of the German population was living in urban areas, and since the mid-twentieth century, over 80 percent of the population has been urbanized. This general process of urbanization bundles two different causes. What is often referred to as the *rural push* basically means that certain people had no choice but to move to the city. Often dire living conditions or cultural constraints forced people to seek a new start in the city. At the same time, the city has always been a generator of wealth and culture. Moving to the city promised, besides a greater variety of job opportunities, access to education, healthcare, and culture. These motives are often to be referred to as the *urban pull*.

While cities may have once imported or cultured disease, urbanization has improved population health: there seems to be a strong correlation between the increase of urban population and average life expectancy (fig. 4.2). Over the course of 150 years, Germans have added forty-two life-years on average, i.e., life expectancy on average has gone up from thirty-eight to eighty years. Biologically speaking, *Homo sapiens* have left their biological position, which originally placed their life expectancy somewhere between that of a bear and a hippopotamus. By means of urbanization, *Homo sapiens* has surpassed the rhinoceros, the elephant, and the previously oldest-living mammal, the whale. The city has turned out to be quite a tradeoff for *Homo sapiens* in its coevolution into *Homo urbanus*.

Darwinian process." James Lovelock, *The Ages of Gaia: A Biography of Our Living Earth* (Oxford/New York: Oxford University Press, 1995), 38.

⁹ The same applies to the global population today. While at the beginning of the nineteenth century about 3 percent of the global population lived in urban areas, at the beginning of the twentieth century about 14 percent did, and at the beginning of the twenty-first century about 50 percent were urbanized.

¹⁰ In general, the measurement of life expectancy serves as an objective parameter for the health status of a nation. That is, *Homo sapiens* have evolved collectively, so while there have always been people of advanced age, the ratio of people of advanced age within the population has never been as high as today.

¹¹ Jürgen Bähr, Bevölkerungsgeographie (Stuttgart: UTB für Wissenschaft, 1992).

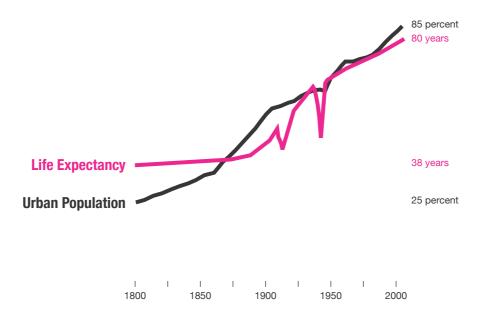


Fig. 4.2. Urban Population and Average Life Expectancy in Germany

One could further argue that urbanization seems to have allowed for the socio-economic development of the overall population. This is significant since socio-economic development seems to be the number one determinant in the fight against diseases like tuberculosis (fig. 1.12). Responsibility for such development, however, has multiple factors. Above all, the general diets of people have improved with the greater availability of essential nutrients¹² throughout all seasons. The introduction of public hygiene,¹³ the implementation of the welfare state,¹⁴ and the rise of preventive medical research have all contributed to this improvement.

However, what are the tradeoffs for this socio-economic development? The same process of urbanization that led to the increase of life spans has also initiated a general decline in birth rates (fig. 4.3). The city, in effect, acts as population sink. This is apparently not a new phenomenon, but indeed is a distinguishing characteristic of the city.

The city is almost the defining characteristic of that most complex of societies, 'civilization.' Cities are demographically unique. For most of human history, cities were demographic sinks—they lost population. This was true in the Old World and New and for many different countries. Urban residents had few children, and lack of sanitation and crowding encouraged the spread of disease on an unprecedented scale.¹⁵

¹² Braudel, Capitalism and Material Life: 1400-1800, 66-191.

^{13 &}quot;Hygiene and sanitation were not unknown in other civilizations: what community could have survived the ordeal of close permanent quarters without a certain respect for their laws? But in our new biotechnic economy, hygiene occupies a commanding place: not merely does it mean public defense against disease: it means taking positive steps to make the whole environment favorable to health, animal joy, and length of days." Mumford, The Culture of Cities, 423. ¹⁴ Early healthcare legislation in Germany included a vaccination law (1874), food safety legislation (1879), the implementation of the first health insurance (1884) and disability insurance (1889), and further insurance legislation (1911). These social reforms (besides being initiated in reaction to social unrest and dissatisfaction among the working class) were primarily conceived as preventive measures aiming to eliminate various social risk factors. However, to fully establish healthcare for about 90 percent of the population took Germany almost one hundred years, first covering industrial workers (1883), then transport and office workers (1901), agriculture workers and domestic servants (1911), civil servants (1914), all dependants (1930), retired people (1941), and students and disabled people (1975). 15 Steven A. LeBlanc, Constant Battles: Why We Fight (New York: St. Martin's Griffin, August 2004), 177.

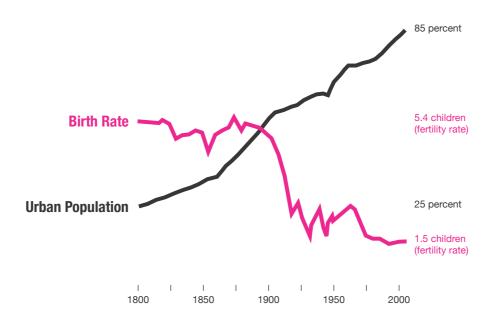


Fig. 4.3. Urban Population and Birth Rate in Germany

Yet what is striking is that this demographic loss of population continued even after the city was able to fight off most of the deadliest epidemics.¹⁶ That is, the population sink describes what currently is referred to as *demographic change*.

One of its results, ever more evident today, is an increasingly aging society. Because such a demographic change was not conceived at the time the welfare state was implemented, this largely successful democratic tool has turned out to be quite vulnerable, since it demands a larger and younger generation to support the elder generation, and that younger cohort is shrinking. A further underestimated tradeoff is that an increasingly aging society means large numbers are now vulnerable to a radical new spectrum of diseases, i.e., age-associated diseases.¹⁷

Cancer is an age-related disease—sometimes exponentially so. [...] In most ancient societies, people didn't live long enough to get cancer. Men and women were long consumed by tuberculosis, dropsy, cholera, smallpox, leprosy, plague, or pneumonia. If cancer existed, it remained submerged under the sea of other illnesses. Indeed, cancer's emergence in the world is the product of a double negative: it becomes common only when all other killers themselves have been killed. Nineteenth-century doctors often linked cancer to civilization: cancer, they imagined, was caused by the rush and whirl of modern life, which somehow incited pathological growth in the body. The link was correct, but the causality was not: civilization did not cause cancer, but by extending human life spans—civilization unveiled it. 18

Thus, our biggest tradeoff as a civilization—after being urbanized, improving socio-economically, establishing healthcare for all, adding years to life—is that we unveiled a *waiting disease*. Cancer (according to medicine's growing awareness) waits inside our bodies.

¹⁶ "For every woman you know (or are) who has no children, some other woman has to have 4.2 just to keep the population even, and they don't. Geneticist William Haseltine put it harshly: "There's a very odd phenomenon which seems to be cultural invariant: once women gain economic independence, they do not reproduce our species.' In most cases, just the prospect of economic independence does the trick, and that's what moving to cities provides." Stewart Brand, *Whole Earth Discipline* (New York: Viking, 2009), 60.

¹⁷ This further means that other kinds of diseases need to be examined. Industrialized countries like Germany are currently facing new challenges and different widespread diseases, e.g., chronic asthma, dementia, and numerous cancers.

 $^{^{\}rm 18}$ Siddhartha Mukherjee, The Emperor of All Maladies: A Biography of Cancer (London: Fourth Estate, 2011), 44.

One last tradeoff bears mentioning. Although it represents only a fragment of medicine's cancer treatments, the example may demonstrate how even the most innovative medical research derives from the basic concept of defense.¹⁹ Robert Koch's laboratories at the Charité worked with staining methods developed by Paul Ehrlich. Thus, the clinical laboratory depended upon specific dyes that were produced by factories, like those run by Hoechst and Bayer. These factories, among others, later started to manufacture chemicals that turned out to be precursors for war gases, like mustard gas.²⁰ A product of the laboratory space, mustard gas virulently attacks the human body by causing respiratory difficulty, burning the skin, and leading to blindness.²¹ Like Lister's carbolic acid cloud in the operating theater, mustard gas hung over the World War I battlefields for days, killing thousands of soldiers. The military responded by developing protective clothing in the form of a gas mask (early models consisted of impregnated cloth without any filter). This cultivated poison was subsequently outlawed as a chemical weapon, with United Nations prohibitions against its development, production, stockpiling, and use.²² Then mustard gas returned (a medical tradeoff) in the form of an innovative cancer treatment in the 1960s,²³ used for chemotherapy treatments of leukemia. Nitrogen mustard (mustard gas) destroys cells that are newly formed by division, and since cancer cells divide faster than normal cells, the treatment primarily affects malignant tissue in its early stage of development.²⁴ As Paracelsus, the Swiss German Renaissance physician, once famously remarked: "Poison is in everything, and no thing is without poison. The dosage makes it either a poison or a remedy."

¹⁹ "The design of defensive and offensive technologies, a practice centered on raw efficiency, has generated the twentieth century's dominant cultural mode. Innovations developed by the military have migrated to almost every design practice—from material development to command and control, to robotics and communication—providing exponential impact in the civilian sector. We are living in a 'war machine,' as renowned urbanist and military theorist Paul Virilio sees it." Mau, *Massive Change*, 159.

²⁰ Mukherjee, *The Emperor of All Maladies: A Biography of Cancer*, 87–88.

²¹ Ibid.

²² "Chemical Weapons," United Nations website;

http://www.un.org/disarmament/WMD/Chemical/ (accessed 2015).

²³ Such innovative cancer treatment was conducted, among others, by Tom Frei and Gordon Zubrod at National Cancer Institute in Boston. Mukherjee, *The Emperor of All Maladies: A Biography of Cancer*, 162–163.

 $^{^{24}}$ Miller-Keane, Encyclopedia & Dictionary of Medicine, Nursing, & Allied Health, $5^{\rm th}$ ed. (Philadelphia: W.B. Saunders Company, 1992), 1030.

The same theorem (poison or remedy) could be applied to our body. Although two-thirds of various cancer types are "due to 'bad luck,' that is, random mutations arising during DNA replication in normal, non-cancerous stem cells,"25 one-third of all cancerous diseases can be traced back to lifestyle-related risk factors, i.e., colon cancer from poor diets, skin cancer from too much UV exposure, and lung cancer from tobacco smoking. Thus, one's own body presents perhaps the greatest risk factor to oneself. Given cancer's ties to both genetic predispositions (we are, after all, the tradeoff of reproduction) and the outcomes of how the body gets used, we will likely see significantly more research on genetics and on prevention. In the case of cancer medicine, for example, a patient-centered model in medicine ought to emerge from patient-oriented research that focuses on the individualization of results.²⁶

As for the hospital, the Charité will most likely continue its long process of transformation from the *concentrated place* it once was to something that resembles an *open network*. Hence, the hospital will soon be unable to treat patients in line with its own research demands for studies of individual genes and behavior in addressing cancer-related risk factors, rather than focusing on cancer eradication by surgery, radiology, or chemotherapy. The hospital will therefore act as innovative hub, establishing various spin-off clinics and centers throughout the city and the region. Thus, various subspecialties that can operate more cost-efficiently in the private sector as well as those diagnostic departments that focus on early detection will be outsourced. At the same time, the Charité's remaining nursing wards will close, due to an overcapacity of such services within the city. As for its internal departmental structure, the hospital will grow more flexible to meet the demands of research needs at an ever-faster pace, and thereby will find itself subject to a continuous redesign processes.

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²⁵ Cristian Tomasetti and Bert Vogelstein, "Variation in cancer risk among tissues can be explained by the number of stem cell divisions," *Science* 347, no. 6217 (January 2, 2015): 78–81. Also see chapter on "Body Risk Factors."

²⁶ "A patient-centered model in medicine leads to patient-oriented research, which focuses on the individualization of results. Thus, treatment effectiveness is assessed by comparing subgroups of patients to individual patients. The goal is to identify which treatment options are more effective

While the healthcare system will follow the same logic of decentralization, its actions will pluralize. Just like ancient Greek medicine once did, we have to develop a new corpus of knowledge that will guide a way of living that includes avoiding various risk factors.²⁷ The city will become the *new market* of prevention and care.

for which patient." Dr. med. Harun Badakhshi, "Patient-oriented medicine, an urge?" talk presented at the Symposium for Health & Design, Villa Vigoni, Italy, 2013.

²⁷ This is something that ancient Greek medicine somehow internalized. As Foucault describes: "[...] medicine was not conceived simply as a technique of intervention, relying, in cases of illness, on remedies and operations. It was also supposed to define, in the form of a corpus of knowledge and rules, a way of living, a reflective mode of relation to oneself, to one's body, to food, to wakefulness and sleep, to the various activities, and to the environment. Medicine was expected to propose, in the form of regimen, a voluntary and rational structure of conduct." Michel Foucault, *The Care of the Self: The History of Sexuality*, vol. 3 (London: Penguin Books, 1990), 99–100.

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