Chapter 3

The Physiology of the House: Modern Architecture and the Science of Hygiene

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Physician Max von Pettenkofer (1818-1901) designed a sprawling mechanism in 1862, which he named a "respiratory apparatus." Despite the implication of its name, this unique device was not a medical ventilator. It was composed of mainly two parts: a sheet iron chamber in the form of a cube with sides eight feet in length and a complex piping mechanism attached to the chamber (Figure 3.1). The chamber was austere with a door and a window outside and a single bed, table and chair inside. According to Pettenkofer, it provided the smallest space to comfortably house a human subject for a twenty-four hour period. By analyzing the contents of the air entering and exiting the chamber, Pettenkofer measured the exact amount of carbon dioxide and water vapor discharged by the subject while engaged in daily activities.[1] His ultimate goal was to calculate the optimal air exchange required in a room for a person to remain healthy and comfortable.

[Insert Figure 3.1 here]

Figure 3.1 Respiratory apparatus by Max von Pettenkofer. Theodor Weyl ed. *Handbuch der Hygiene* v.3, (Jena: Gustav Fischer, 1895).

Such experiments brought Pettenkofer international recognition and earned him a place in history as the founder of the science of hygiene. Pettenkofer and his followers proved that all the vague qualities of space could be substantiated by explicit data obtained via experimentation. His scientific method of mapping everyday environments formed the basis of modern hygiene and changed the ways everyday spaces were conceived, designed, and occupied. It was not only everyday spaces that underwent change; hygiene also transformed the way in which bodies were figured in a wide range of social practices and domains of knowledge. Medicine for a long time treated bodies as they were detached from their environment. Hygiene introduced the idea that bodies were inextricably bound up with their environment. By monitoring the exchange between the human body and built space, experimental hygiene rendered the inhabitant's relationship to architecture solely in physiological terms. A number of instruments externalized and expanded the physiological functions of the body in an effort to detail and regulate the body's exchange with its immediate environment whether it was in the form of air, water, food intake or the disposal of carbon dioxide, sweat, urine, and faeces. The young science of hygiene focused on the human dwelling in an effort to improve the sanitary conditions of everyday spaces. This article analyzes the transformation of the dwelling through the science of hygiene in the second half of the nineteenth century.

The emergence of hygiene as an international concern should be understood in relation to the public health movement in Germany. Starting in the 1830s and 1840s, a growing number of middle-class reformers in Germany, as well as in Britain, France, and the United States, raised public awareness of various health crises. Reformers were driven by a desire to eliminate not only recurring epidemics such as cholera, but also any working-class political threat by improving living standards and work efficiency.[2] As the bourgeoisie gained authority and wealth, they employed more and more medical strategies to eliminate threats to their own safety and status, such as crime and social unrest. The health of the nation gradually became a national ideology as the state began to intervene in the issues of hygiene.

Doctors were prominent members of the educated-middle classes due to the growing influence of medicine as a scientifically-based profession. Together with other scientifically educated experts, they gained a significant role in prescribing social policies and individual lifestyles. Pettenkofer along with Rudolf Virschow, Professor of hygiene at the University of

Berlin, became highly influential figures demanding better housing conditions in cities. Doctors involved in the Lower-Rhenish Association for Public Health (Niederrheinischer Verein für öffentliche Gesundheitspflege, founded in Düsseldorf in 1869) and German Association for Public Health (Deutscher Verein für öffentliche Gesundheitspflege, founded in 1873 in Frankfurt) contributed to the large-scale sanitation and planning projects designed to improve public health.[3] Their agenda included all aspects of urban design, from sewers and water supplies, to street layouts and the construction of healthy housing. Together with architects, engineers, and the members of municipal governments, doctors demanded stronger regulations for new urban development. Many doctors lectured and published books on the design of healthy houses and went even further to design model houses.[4] Several societies involved in public health provided education through lectures, meetings, and journals.

Sanitary reform went hand-in-hand with the housing reform. The house was at the heart of the sanitation movement as sanitarians declared "both the physical and moral health of a nation depended on its conditions of housing."[5] Housing reform efforts in Germany date back to 1840 report by Victor Aime Huber, professor of philology, on miserable living conditions among workers. By the early 1870s, a growing segment of the educated-middle class believed in the need for reform.

Physicians involved in domestic sanitation reform established themselves as experts in sanitary design and regarded the architect's task to be confined to aesthetic appearance of a building.[6] Munich based physician Christian Ruepprecht opined, "If the architect is concerned about perfecting the external form of the building, the doctor specifies the health requirements for that building."[7] As the influence of physicians grew on urban policies and building regulations, architects likened themselves to physicians. In 1866, one observer claimed that the architect could rightfully be called the "dwelling doctor," because as the doctor healed the human body, the architect healed the sick dwelling.[8] In the following decades, the idea of the architect as the "dwelling doctor" became more widespread along with the belief that houses were sick; however it was applied more generally to matters of taste. The architect was described in such terms in a 1921 article:

> The true space and dwelling artist must be a physician in some respect. In artistic terms, there are technically and spatially diseased, infectious, toxic things, mentally infectious appliances and art objects that are likely to inhibit the healthy development of a generation. Warding off such pests from our homes, breaking their evil spell, that's the medical side of the high calling to *Wohnungs-Kunst* (the art of dwelling).[9]

The architect would diagnose and treat the sick dwelling, much like a physician treating a patient. Not only architects, but other experts dealing with the housing question likened their methods to those of physicians reflecting the increasing medicalization of architecture. In his influential book *Handbuch des Wohnungswesens und der Wohnungsfrage* (Handbook of Housing and the Housing Question, 1909), economist Rudolf Eberstadt wrote that the science of the human body had its physiology and pathology and the physician should know about both the state of being healthy and sick. He continued, "The science of housing, just like medicine, had its physiology and pathology." For Eberstadt, the exploration of the normal state was the task of housing experts and the analysis of the sick state was the task of the experts dealing with the housing question.[10]

Mass printing allowed for the expansion of popular scientific literature and the inclusion of striking illustrations. Several books and manuals written by physicians aimed to educate building professionals, state and municipal officials, and general public in the hygiene of the house.[11] Pettenkofer was arguably the most cited physician in such publications. He was born as the fifth child of a small farmer in Lichtenheim in 1818 and brought up in Munich by his childless uncle who was a court pharmacist. He acquired a degree in medicine in Munich in 1843 and served as a chemist at the Mint in 1845.[12] In 1848 when he was just twenty-nine years old, the King recommended him to be appointed Extraordinary Professor of Medical Chemistry at the University of Munich. He later shifted his interest from physiological chemistry to hygiene, then a new field. In 1865, three years after he designed his respiratory apparatus, Pettenkofer became the first university chair of hygiene to be appointed at a German university and, later in 1879, he established the first hygiene institute in Munich. Under his stimulus, the new science of hygiene developed rapidly as his students went on to teach at the newly founded institutes of hygiene at several European universities.

Epidemic diseases such as cholera and typhoid were causes of great concern at the time. In the 1860s and 1870s, Pettenkofer became the undisputed authority on epidemic prevention. He investigated the hygiene of the atmosphere, water, clothing, and housing in clinical studies. He quantified each aspect of everyday spaces via experiments. At which point air in a room becomes vitiated? How much air volume does an individual require to maintain her health in a room? How much window surface is needed in proportion to the room size to receive enough natural light? Pettenkofer's clinical studies contributed to biostatistics, which became the prevalent means of analysing the built environment in hygiene movement.

In broader terms, the emergence of hygiene as a scientific discipline coincides with the rationalization of knowledge and its segmentation into disciplinary divisions from the late eighteenth century onwards. All sciences and arts were increasingly brought under numerological domination.[13] Statistics, which developed as a field in the second half of the eighteenth century, was increasingly used in the interpretation of demographic data as well as in medical sciences. Art historian Barbara Stafford has argued that the misuse of statistics in medical sciences fostered an oversimplification of such concepts as norm, type, ideal, and deviation while promoting a formulaic approach to the body, as if it were a quantifiable entity.[14] Similarly, Georges Teyssot, has analyzed the reduction of the body to a measurable type in nineteenth-century criminology and ethnography. He has argued that such notion of type encouraged the statistical definition of the dwelling. In major cities like London and Paris, sanitation files of houses were created. The analysis of the house was reduced to "measurable data and to a diagrammatic scheme." This new scientific authority culminated in the idea of normalization and "a new semiotics of the house."[15] In broader terms, such views of the house were in line with the production of homogenous abstract space in modern industrial capitalism, which was defined by norms, productivity, and labor power.[16] Experimental hygiene's contribution to this new semiotics has been highly significant. While physicians meticulously measured bodies, sanitarians measured dwellings to determine the optimal height and distance between each apartment, cubic air volume, window area, ceiling height in each room etc. for the body to remain healthy. They converted their findings into statistical data to arrive at universal norms for the healthy house.

Hygiene's abstraction of the house is visible in the 1895 edition of the popular *Handbuch der Hygiene*, where the author explains that the analysis of the dwelling in hygiene is twofold: first, the examination of the dwelling from an experimental, physiological, and pathological viewpoint to show how the poor state of building site and materials, dampness, the lack of light and air, and overcrowding are detrimental to health. Second, the mapping of the state of housing through mass surveillance that is through statistics.[17] Starting from 1861, regular surveys on housing conditions were undertaken in Berlin and other big German cities as part of the general population census. The inhabitants were asked various questions including whether they were owners or tenants, on which floor they lived, the number of total rooms, heated rooms and rooms with windows, whether those faced the street or back, whether there was a kitchen, water supply, bathroom or toilet in their flats.[18] In more detailed surveys, physical descriptions of each dwelling were meticulously recorded. For example, 1889 housing survey of Basel documented descriptions of each room in houses including function, location, width, height, window area, and the manner of ventilation and artificial lighting.[19] Medical archives of existing housing were formed through such ocular inspection and quantitative data. Using them as scientific evidence, sanitarians pointed to an acute housing crisis in big cities caused by overcrowding and insanitary conditions. They demanded for more comprehensive sanitary and public health provisions to regulate new buildings.

Advice books and manuals on hygiene usually devoted a chapter to the dwelling.[20] In their analysis of the dwelling, physicians utilized data that ranged from statistical and empirical data to technical drawings and house diagrams. The house was systematically dissected from its foundations to the roof. Starting with the building site, all elements of the house including materials, walls, floors, individual rooms, and roof were examined. Each spatial and structural component was discussed in terms of proper construction methods and materials.

When hygiene first emerged as a new science in the early nineteenth century, it was closely associated with physiology. The nineteenth-century scientific thought was dominated by physiology, which provided conceptual models for the laws of life and mind.[21] This pervasiveness of physiology originated in the Enlightenment, when, in Stafford's words, "the human body represented the ultimate visual compendium, the comprehensive method of methods, the organizing structure of structures."[22] Pettenkofer dubbed hygiene "applied physiology."[23] He wrote:

> It is not only a matter of the physiology of the body; we now need—insofar as the extent of its health is influenced by it—a physiology of its environment. We need knowledge of the air, of the soil, of nourishment, of the house, of clothes, of the bed; we need a physiology which continues beyond the organism.[24]

In other words, hygiene became the physiology of the everyday spaces the body occupied. Elsewhere, Pettenkofer described hygiene as a young science that emerged from physiology and pathology.[25] Physiology studied the reactions of the healthy organism to normal stimuli whereby the organism could adapt itself. When the stimuli exceeded the organism's adaptability, it displayed signs of disease, which then became the subject of pathology. Using the knowledge produced in both disciplines, the science of hygiene aimed to determine the optimal stimuli in an environment in exact figures for the organism to remain healthy. It quantified and rationalized the relationship between the body and everyday spaces according to health criteria.

It was not a coincidence then, at its inception in 1865, Pettenkofer's hygiene department was located in the Physiological Institute where he collaborated with a group of physiologists.[26] This close alliance between hygiene and physiology can also be seen in the journal Pettenkofer co-edited from 1865 to 1882, *Zeitschrift für Biologie*, which was partly devoted to hygiene and partly to physiology. By 1883, all German universities had hygiene departments. As hygiene gained more independent existence, Pettenkofer co-founded the *Archiv für Hygiene* in 1883 and co-edited it until 1894.[27]

As architectural historian Annmarie Adams has shown, domestic sanitation movement regarded "the house as an extension of the body and the body as a reduction of the house."[28] Physicians applied the language and visual techniques of physiology to examine dwellings. Houses and bodies were represented in section diagrams in popular press to show the overlapping circulatory systems.[29] Physiology succeeded in the division of the body into increasingly distinct and specific systems and networks. Similarly, house diagrams mimicking the body diagrams in physiology mapped the complex network of systems of ventilation, water circulation, heating, and drainage (Figure 3.2). The physiological systems of respiration, circulation, and digestion became models for the healthy circulation of air, water, heat, and expulsion of sewage in the dwelling. The house was increasingly mechanized as the circulation systems became more intricate. Jonathan Crary has observed that mechanical invention is not an independent dynamic that imposes itself onto a social field from the outside, on the contrary, it is always subordinate part of other forces.[30] Many technological developments in the nineteenth century were modeled on the body.[31] By the end of the nineteenth century, scientific work attempted to increase the performance of the body by various mechanical devices. According to Tim Armstrong, modernity regards the body as lack and offers technological compensation. Gradually, that compensation has been integrated into capitalism's fantasy of the complete body. Instruments of advertising, cosmetics, cosmetic surgery, and cinema are all prosthetic in the sense that they promise the perfection of the body.[32]

[Insert Figure 3.2 here]

Figure 3.2 Drainage system in an apartment. Christian Nussbaum, "Das Wohnhaus" in Theodor Weyl ed. *Handbuch der Hygiene* v.4, (Jena: Gustav Fischer, 1896).

As early as 1877, German philosopher Ernst Kapp (1808-1896) presented a philosophy of technology that examined a two-way analogous relationship between the body and mechanical instruments whereby tools became prosthetic mechanical extensions. Kapp remarked, "man unconsciously transfers the form, function, and normal proportions of his body to the works of his hands."[33] He dubbed this unconscious act as "organ-projection."

While all technological artifacts imitated the form of human organs, Kapp claimed, at the same time the human body was increasingly understood in terms of mechanical instruments. To prove his point, he compared various inorganic artifacts with human parts and systems of the body. Tools such as hook, bowl, plow, or shovel imitated the finger, hand and arm, telegraph cables imitated the nervous system, and railroads imitated the vascular system.

Practitioners of the discipline of hygiene viewed the body and the house through such a two-way analogous relationship. Physicians came to understand the anatomical body as a mechanized house or a factory. They used the machine metaphor to describe the functioning of the body and purposeful interdependence of parts within the organism.[34] For example, in his 1887 book, *The Physiology and Hygiene of the House in Which We Live*, American physician Marcus Patten Hatfield likened the body's metabolism to the heating system, plumbing, water supply and communication network in a house.[35] In Germany, such an analogy was still visible in the popular 1920s anatomy book *Das Leben der Menschen* (The Life of Humans 1926-31). The author Fritz Kahn represented the functions of the human body as a factory. The mechanisms of breathing were illustrated through a transport system in a modern factory composed of a complex network of pipes, with elevators carrying oxygen to the lungs, the blood, and organs.[36] Another illustration depicted the process of smelling as a mechanical process in a factory.

Conversely, the more the house was mechanised to facilitate healthy circulation, the more it resembled the anatomical body. German architect Heinrich Muthesius depicted the modern house in 1904: "Houses now become veritable networks of pipes, supply-pipes and waste pipes, pipes of every kind, for hot water, heating, electric light, for the news service, so that they resemble complex organisms with arteries, veins and nerves like the human body."[37] The view of the building as a network of mechanical systems replaced the concept of architecture as an autonomous aesthetic practice with one that highlights infrastructure and performance.

Such a house taken over by mechanical equipment is visible in an advertisement titled "A Modern Country House" published in *Gartenstadt* in 1912 (Figure 3.3). A seemingly traditional rustic villa in a wooded area is sliced open in a detailed section perspective, allowing the reader to see how it is infiltrated by cables, pipes, ducts, and various machines. The equipment advertised include electrical-automatic compressed-air waterworks, sanitary systems (bathroom, water closet, washstand, water heater, kitchen), central heating, central vacuum unit, laundry, natural ice maker, and water filter. The exposed cables, pipes, and machines dominate the house as the manifestations the new domestic health regime.[38]

[Insert Figure 3.3 here]

Figure 3.3 Advertisement titled "Modern Country House." *Gartenstadt,* 1912. Staatsbibliothek zu Berlin – Preußischer Kulturbesitz, shelf mark: 4" Fd 3494/26

Physicians' perception of the dwelling highlighted its spatial envelope that facilitated exchange with its environment. The majority of the circulation that involved air, water, heat and sewage was integrated into the envelope of the domestic spaces composed of foundations, floors, walls, ceilings, and roof. This concept of the house suggested the house was essentially a type of skin. The idea that the house was a form of skin in hygiene was first developed by Pettenkofer who viewed the functions of clothing and the house in a similar manner to the skin.[39] He argued that clothing and dwelling partially took over "the functions of the natural surface of the body." Hence their main purpose was physiological, "namely the regulation of heat flow from the body."[40]

The dwelling and clothing protected the body against atmospheric effects including wind, rain, solar rays, and temperature changes. Heating and ventilation were regarded as the essential means of freeing the body from external environmental conditions.[41] They also regulated the indoor air quality, which emerged as an important health criterion in nineteenth-century theories of disease, such as the miasmatic theory.[42] Overcrowded rental blocks came under a sustained attack by sanitarians and physicians.[43] They warned against breathing vitiated air in badly ventilated, overcrowded rooms as it caused drowsiness and headache. One of the earliest theories on the impact of indoor air quality on health was Lavoisier's 1777 study, which claimed that an excess of carbon dioxide from respiration in overcrowded rooms caused discomfort.[44] In the mid-1850s, Pettenkofer proposed a major shift in Lavoisier's theory. He argued:

> What makes the air in a room filled with people unpleasant and oppressive, what affects our nerves and gives rise to symptoms such as fainting is not simply the heat or the humidity or the carbon dioxide or the depletion of oxygen… It seems to us obnoxious due to its having been breathed several times or as it has come into contact with the skin numerous times, as it is thus laden with organic exhalations, even in minute quantities.[45]

While carbon dioxide did not directly cause specific diseases, it indicated other impurities that diminished the body's resistance against disease-producing agencies. Pettenkofer established the rule taught by physicians and sanitarians till the turn of the twentieth century that the proportion of carbon dioxide in inhabited places affords a safe indication as to the amount of other impurities resulting from respiration and other exhalations from the bodies of the occupants.[46]

At the time, heat or cold could be reasonably measured with simple instruments, whereas the freshness or stuffiness of air could not be easily measured.[47] The challenge Pettenkofer faced was to assess the air quality in enclosed areas in numerical terms. His respiratory apparatus was an attempt to accurately measure the amount of carbon dioxide and water vapor discharged by a human being in the course of a day. Based on his study, Pettenkofer came up with a standard amount of ventilation required for an occupant to remain healthy in a room, which was sixty cubic meters in an hour.[48]

The requirement of consistent exchange with the atmosphere involved a rethinking of the spatial boundaries of the house. Hygiene manuals discussed natural and artificial methods of ventilation. Pettenkofer described natural ventilation as slow air exchange in an enclosed room without a draft. It occurred through walls, doors, and windows because of wind pressure and temperature difference between outside and inside. External walls presented a challenge in terms of natural ventilation; while they had to protect against heat and cold, they also had to provide constant access to fresh air. According to Pettenkofer, those two conflicting requirements were the greatest influence the house exerted on health.[49]

Pettenkofer advocated that external walls should be porous to facilitate fresh air access and to prevent humidity in the house. He did several experiments to test the porosity of various building materials. His ideas on porosity of walls were cited by many sanitarians till they were scientifically discredited in the 1920s. Construction materials, such as stone, brick, concrete, granite were tested to compare their permeability rate.[50] Physicians argued that porous walls purified air to a certain degree by absorbing odors and humidity.[51] The *Verein für öffentliche Gesundheitspflege* in the mid-1880s identified dampness in walls not only as an agent capable of fostering disease, but also as an impediment to ventilation by clogging the pores of brickwork or plaster with vapour.[52] Referring to a clothing metaphor, Pettenkofer warned that impermeable walls would create a climate, in which one would experience discomfort similar to the experience of wearing a rubber suit all day long. Badly ventilated, overheated rooms caused the skin to be damp. Once outside the heated room, the skin immediately cooled down preparing the bodily conditions for serious diseases.[53] In other words, the skin could breathe only if walls did.

Artificial methods of ventilation included ventilating fireplaces and diverse ventilation systems with ducts. One such system was the central heat-extraction system, which involved letting fresh air into each room through inlets and extracting foul air via ducts leading to a large central exhaust flue with a furnace at its base. Like ventilating fireplaces, it used suction fire to draw the foul interior air.[54] Other systems used extraction fans.

The spatial boundaries of the house remained under scrutiny in the 1880s and 1890s, as bacteriologist and physician Robert Koch's germ theory of disease came to dominate the sanitary discussion. Koch's theory regarded the presence of germs as a necessary condition for sickness.[55] With the new focus on germs, the germ killing effects of sunlight came to the fore. "Light and air" became the motto of the sanitary reform. The house and its surroundings came to be seen as the locus of germs.[56] In an 1892 article titled "Breeding places of bacteria in houses," the author views the house in this new light:

> From the time man learnt that bacteria played an important role in nature and can turn into an endless, small but scary enemy of man, man has striven to trace the obscure life and activities of these uncanny, invisible guests. Until now, there is not much success in discovering the places germs live outside the human body. But we know that a contagion does not only occur from one person to another and that the germs survive outside the human body and sometimes breed. Where do they find haven from which they pose a constant threat to human beings? First, we must turn to the dwelling and its surroundings.[57]

The surfaces of domestic spaces were brought under microscopic inspection to detect germs. House dust and infill materials found between floor slabs were seen as potential medium where germs thrived. Bacteriologists analysed samples of each to warn against the dangers lurking in them. Physicians claimed the infill materials could germinate pathogens leading to diseases as varied as typhus, cholera, and pneumonia. Purification processes and machines that sterilize the infill materials were developed (Figure 3.4). The standards of cleanliness in the house were altered to eliminate house dust. The vacuum cleaner emerged as an indispensable household item in removal of dust (Figure 3.5).

[Insert Figure 3.4 here]

Figure 3.4 Rudolf Emmerich "Die Wohnung" in *Handbuch der Hygiene und der Gewerbekrankheiten.* (Leipzig: F.C.W. Vogel, 1894). Staatsbibliothek zu Berlin – Preußischer Kulturbesitz, shelf mark 4" J 6347.

[Insert Figure 3.5 here]

Figure 3.5 Advertisement for vacuum cleaner. *Hygiene* 6:3, 1913.

Bacteriologists inspecting spatial surfaces identified house diseases such as dry rot. They argued that dry rot was toxic and hence detrimental to health.[58] Wooden surfaces in humid houses were more susceptible to dry rot infection. Like contagious diseases, dry rot could spread either through workers moving from house to house or through reuse of infected wooden elements from older buildings.[59] Microscopic images of dry rot on domestic surfaces testified to the clinical inspection of the house (Figure 3.6). Although later experiments indicated that humans inhaling or consuming its spores were not infected, physicians continued to warn against it as a symptom of humidity in houses.[60]

[Insert Figure 3.6 here]

Figure 3.6 Microscopic images of dry rot. "Ueber den Hausschwamm (merulius lacrimans)" in *Deutsche Bauzeitung,* 22:14, 1888. Staatsbibliothek zu Berlin – Preußischer Kulturbesitz, shelf mark: 4" Ny 2724.

Physicians stressed the importance of spatial segregation to prevent the spread of germs through air. Hence, they advocated ceilings and floors that did not transmit air and heat to abolish the danger of infection. “The worst evils of the floor decks in relation to the health of the house stem from their leakiness and the wrong selection of filling materials,” wrote architect Hans Christian Nussbaum.[61] He had wooden floors in mind. In choosing filling materials, one had to take into account cleanliness, dryness, lightness, and fireproofing qualities. Washed and dried gravel and sand were regarded as good filling materials. The roof had to be insulated against rain and heat. An air gap between the roof and the attic apartment was recommended as a way of insulation. Similarly, foundations and basement floors had to be technically better insulated against water and air as they were the most exposed to miasmas in the ground soil.[62] Well-insulated materials such as asphalt and cement were recommended for the basement floor so that poisonous air could not infiltrate the house.

Porous walls presented a dilemma in terms of the requirement for spatial segregation. In the 1880s and 1890s, several physicians undertook tests on whether walls could be infected with bacteria present in the room dust. Some warned that porous walls were prone to infection with pathogen microorganisms. In suitable conditions, they could permeate deeper layers of walls and reach the air inside the room. Thus impermeable walls were recommended for hospital wards.[63] This argument was rejected in 1894 by bacteriologist Rudolf Emmerich who claimed that porous walls were less prone to infection than impermeable walls. He argued the latter was more likely to have water condensation, which resolved the nutrient in dust and made it easy for bacteria to grow.[64]

The idea that residential spaces could be infected culminated in the development of disinfection devices for residential use. At the 1911 International Hygiene Exhibition in Dresden, a special section was reserved to exhibit those new equipment. Such chemicals as ammoniac, formaldehyde, steam were sprayed into the enclosed room. The spraying equipment could be deployed inside a room or through a keyhole from the outside (Figure 3.7). The air and surfaces of the room were purified.

[Insert Figure 3.7 here]

Figure 3.7 Room disinfection devices. G. Sobernheim ed. *Sonderkatalog der Gruppe Desinfektion der International Hygiene-Ausstellung*, Dresden 1911. Staatsbibliothek zu Berlin – Preußischer Kulturbesitz, shelf mark: Kr 1960/104-2.

In the upcoming decades, the obsession with light, air, and cleanliness became the defining features of modernist architecture. The science of hygiene played a significant role in the medicalization of architecture. Physicians blurred the boundaries between the body and dwelling turning the latter into a corporeal extension that enhanced the physiological functions of the body. This reduction of architecture to the basic metabolic functions of the body persisted throughout twentieth-century. The twentieth-century avant-garde continued to pursue the concept of architecture as a permeable membrane and well-tempered space.[65] As the house became more open and more mechanized, architectural critic Reyner Banham declared in the title of his 1965 article "A Home is not a House," as it has become "little more than a service core set in infinite space."[66] Ultimately, the performance of the house in terms of physical comfort and health came to be its overriding function.

NOTES

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[1] Max von Pettenkofer, "Über einen neuen Respirations-Apparat," *Abhandlungen der Mathemat-Physikalischen Classe der Königlich Bayerischen Akdamie der Wissenschaften* 9, no. 2 (1862).

[2] Eike Reichardt, *Health, 'Race' and Empire: Popular-Scientific Spectacles and National Identity in Imperial Germany, 1871-1914* (lulu.com, 2008), 55.

[3] Brian Ladd, *Urban Planning and Civic Order in Germany, 1860-1914* (Cambridge, Mass.: Harvard University Press, 1990), 38-76.

[4] See for example David Sarason, *Das Freilufthaus: Ein neues Bausystem für Krankenanstaltenund Wohngebäude* (München: J. F. Lehmann's Verlag, 1913).

[5] Prof Dr C Franeken, "Vorwort" in *Weyl's Handbuch der Hygiene: Bau und Wohnungshygiene*, (Leipzig: Verlag von Johann Ambrosius Barth, 1914), III.

[6] Annmarie Adams has examined the similar role Victorian physicians played in domestic sanitation movement. As physicians gained authority during the final decades of the nineteenth century as designers of a healthy domestic environment, the public became increasingly wary of building professionals. Physicians promoted a systematic and scientific view of the house whereas the role of architects was perceived to be limited to form and decoration of houses. Annmarie Adams, *Architecture in the Family Way: Doctors, Houses and Women, 1870-1900* (Montreal: McGill-Quenns University Press, 1996), 36-72.

[7] Dr. Christian Ruepprecht, *Mensch und seine Wohnung in ihrer Wechselbeziehung* (München: Theodor Ackermann, 1885), 3-4.

[8] A. v. Cohausen, "Kasernen-Abtritte," *Archiv für die Offiziere der Königlich Preußischen Artillerie und Ingenieur-Korps* 60 (1866): 245.

[9] Kuno Graf von Hardenberg, "Wohnungs-und Raumkünstler," *Architektur und Wohnform* 32 (1921).

[10] Rudolf Eberstadt, *Handbuch des Wohnungswesens und der Wohnungsfrage* (Jena: G. Fischer, 1910), 1.

[11] Those include Jozsef von Fodor's *Das gesunde Haus und die gesunde Wohnung* (1878), relevant sections in Max von Pettenkofer and Hugo Wilhelm von Ziemssen's *Handbuch der Hygiene* (1882-1910), Carl Flügge's *Grundriss der* Hygiene (1889), Theodor Weyl's *Handbuch der Hygiene* (1882-1910), and later Rudolf Abel's *Handbuch der praktischen Hygiene* (1913).

[12]During his time at the Mint, he came into the lime light through a series of discoveries. He developed a method to separate gold and silver, which was seen as an important discovery. King Ludwig I commissioned him to rediscover the production process of the mysterious haematinum of ancient times. Pettenkofer provided the experimental proof that it was in fact a copper-colored glass. On Pettenkofer's life see Alfred Beyer, *Max von Pettenkofer* (Verlag Volk und Gesundheit, 1956); H. Breyer, *Max von Pettenkofer: Arzt im Vorfeld der Krankheit* (S. Hirzel, 1981); Martin Weyer-von Schoultz, *Max von Pettenkofer (1818-1901): die Entstehung der modernen Hygiene aus den empirischen Studien menschlicher Lebensgrundlagen* (Frankfurt a.M.: Lang, 2006); Karl Wieninger, *Max von Pettenkofer: Das Leben eines Wohltäters* (München: Hugendubel, 1987).

[13] Barbara M. Stafford, *Body Criticism: Imaging the Unseen in Enlightenment Art and Medicine* (MIT Press, 1991), 107.

[14] Ibid.

[15] Georges Teyssot, "Norm and Type: Variations on a Theme," in *Architecture and the Sciences: Exchanging Metaphors*, ed. Alessandra Ponte and Antoine Picon (New York: Princeton Architectural Press 2003), 156.

[16] See "The Production of Abstract Space" in Mary Poovey, *Making a Social Body: British Cultural formation, 1830-1864* (Chicago &London: The University of Chicago, 1995), 25-54.

[17] A. Oldendorff, "Einfluss der Wohnung auf die Gesundheit," in *Handbuch der Hygiene*, ed. Theodor Weyl (Jena: Gustav Fischer, 1895).

[18] H. Albrecht, "Wohnungsstatistik und Wohnungsenquete," in *Handbuch der Hygiene: Allgemeine Bau und Wohnungshygiene*, ed. Theodor Weyl (Jena: Gustav Fischer, 1895), 13-16.

[19] Ibid., 17-19.

[20] Carl Flügge's chapter on the dwelling in *Grundriss der Hygiene* (1889) is symptomatic of the physicians' approach to the topic. He was a German bacteriologist and sanitarian who was a prolific contributor to publications on hygiene. The book's first section deals with urban design policy recommendations on reserving open spaces for each housing site, pulling buildings back from the street, regulating minimum distances between each building, limiting the height of buildings, and orientation of streets to allow balanced sun exposure for each side of a building. He then zooms in on the individual house.

[21] Bruce Haley, *The Healthy Body and Victorian Culture* (Cambridge, MA; London: Harvard University Press, 1978), 69.

[22] Stafford, *Body Criticism*, 12.

[23] Max von Pettenkofer, "Über die Mittel zur Förderung der Theorie und Praxis der öffentlichen Gesundheitspflege," *Zeitschrift für Biologie* 7 (1871): 503.

[24] Pettenkofer cited in Klaus Bergdolt, *Wellbeing: A Cultural History of Healthy Living* (Cambridge: Polity Press, 2008), 280.

[25] Max von Pettenkofer, "Was ist und was will „Gesundheitslehre"?," *Die Gartenlaube* 20 (1878): 328.

[26] Pettenkofer had been working in the laboratories in the Physiological Institute since 1855, when he became a full professor. Henry E. Sigerist, "Introduction to the Value of Health to a City," *Bulletin of the History of Medicine* 10 (1941): 478.

[27] Ibid., 479.

[28] Adams, *Architecture in the Family Way*, 3.

[29] Victorian Thomas Teale's illustrated book, *Dangers to Public Health: a Pictorial Guide* (1879) is the most well-known example of this genre. Ibid., 64-65.

[30] Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (Cambridge MA, London: MIT Press, 1990).

[31] For an excellent account of the body's relationship to technology see Tim Armstrong, *Modernism, Technology, and the Body : A Cultural Study* (Cambridge, UK ; New York: Cambridge University Press, 1998), 81.

[32] Ibid., 3.

[33] Ernst Kapp, *Grundlinien einer Philosophie der Technik: zur Entstehungsgeschichte der Cultur aus neuen Gesichtspunkten.* (Braunschweig: George Westermann, 1877), V-VI.

[34] At the first international hygiene exhibition in Dresden in 1911, the core of the exhibition was the popular division titled *Der Mensch* (The Human), which showed functions of human organs to foster an understanding of man as "both a work of art and a complex machine." *Katalog der Internationalen Hygieneausstellung Dresden* (Berlin 1911), 375-400. Quoted in Hau, *The Cult of Health and Beauty in Germany*, 108. In his study of the human sciences, *The Order of Things* (1970), Foucault argued that the body under the clinical gaze of doctors becomes an anatomical machine, an object of knowledge. Michel Foucault, *The Order of Things: an Archaeology of the Human Sciences* (London: Tavistock, 1970).

[35] Hatfield wrote: “The body in this book has been likened, in its various parts, to a house, and it may be truthfully claimed that no other of man's dwellings has as many "modern conveniences" as his body. There is nothing that his ingenuity has yet devised for the safety and comfort of his home that he may not find foreshadowed, and usually bettered in the body. Where, for instance, can you find an automatic steam of hot-water heater that will perform its work as well as the thermogenetic system of the body? Where can the block or building be found that is as well sewered and ventilated? ” Furthermore, he finds in this house of ours elevators, telegraphs and telephones innumerable, also pictures, photographs, library and music-rooms, and a dining room from twenty to thirty feet long.” Marcus Patten Hatfield, *The Physiology and Hygiene of the House in Which We Live* (New York: Chautauqua Press, 1887), 3.

[36] Fritz Kahn, *Das Leben des Menschen: Eine volkstümliche Anatomie, Biologie, Physiologie und Entwicklungsgeschichte des Menschen,* vol. 3 (Stuttgart: Franckhsche Verlagshandlung, 1927), plate 12.

[37] Hermann Muthesius, *The English House*, ed. Dennis Sharp, trans. Janet Seligman (New York: Rizzoli, 1979), 163.

[38] Didem Ekici, "From Rikli's Light-and-air Hut to Tessenow's Patenthaus: Körperkultur and the Modern Dwelling in Germany, 1890-1914," *Journal of Architecture* 13, no. 4 (2008): 388-90.

[39] Max von Pettenkofer, *Beziehungen der Luft zu Kleidung, Wohnung und Boden* (Braunschweig: Friedrich Vieweg und Sohn, 1873).

[40] "Über die Funktion der Kleider " *Zeitschrift für Biologie* 1 (1865): 180.

[41] Hermann Fischer, "Heizung und Lüftung der Räume," in *Handbuch der Architektur*, ed. Josef Durm, et al. (Darmstadt: Arnold Bergstraesser, 1890), 91.

[42] The miasmatic theory, which Pettenkofer called the ground-water theory, was the most dominant theory of disease at the time. He advocated that the germs of disease were spread through vapors in air coming out of contaminated soil. Depending on its moisture content, the contaminated soil could germinate epidemic diseases such as cholera and typhus. The disease, then, was transmitted through polluted air.

[43] The common belief was that urban masses became uprooted in rental blocks which led to their physical as well as moral degeneration. Building one's own house rather than living in rental apartments were promoted in popular literature in hygiene. For example in 1903, under a heading "Is it advisable to build one's own house?" architect Georg Uster discussed the benefits of living in one's own house, "One builds for himself, for his family and frees himself from miseries and tutelage of others." See Louise Holle, ed. *Im deutschen Hause* (Hanau: Fr. König's Verlagsbuchhandlung, 1903), 5.

[44] On Lavoisier's theory see David Hansen, *Indoor Air Quality Issues* (New York: Taylor & Francis, 1999), 4-5.

[45] Pettenkofer, "Über einen neuen Respirations-Apparat," 234.

[46] John S. Billings, David H. Bergey, and Silas W. Mitchell, *The Composition of Expired Air and its Effects upon Animal Life* (City of Washington: The Smithsonian Institution, 1895), 3-4; Hermann Schülke, *Gesunde Wohnungen* (Berlin: J. Springer, 1880), 99.

[47] Reyner Banham, *The Architecture of the Well-tempered Environment*, 2 ed. (Chicago: The University of Chicago Press, 1984), 40-41.

[48] Pettenkofer, "Über einen neuen Respirations-Apparat," 236.

[49] *Über den Werth der Gesundheit für eine Stadt* (Braunschweig: Friedrich Vieweg und Sohn, 1973).

[50] See for example Adolf Wolpert, *Theorie und Praxis der Ventilation und Heizung* (Leipzig: Baumgaertner's Buchhandlung, 1887), 331.

[51] Rudolf Emmerich, "Die Wohnung," in *Handbuch der Hygiene und der Gewerbekrankheiten*, ed. Max von Pettenkofer and H. v. Ziemssen (Leipzig: F. C. W. Vogel, 1894), 127.

[52] Nicholas Bullock and James Read, *The Movement for Housing Reform in Germany and France, 1840-1914* (Cambridge Cambridgeshire; New York: Cambridge University Press, 1985), 97.

[53] Maximilian Bresgen, *Klima, Witterung und Wohnung, Kleidung und Körperpflege in ihren Beziehungen zu den Entzündungen der Luftwege* (Halle a. S.: Carl Marhold, 1900), 25, 30.

[54] August Gärtner, 1892. 162-67.

[55] Koch built his work largely on research by Louis Pasteur. Koch's research on bacterium that causes anthrax was so successful; he became one of the founding fathers of the new science of microbiology. On Koch and germ theory see Thomas D. Brock, *Robert Koch: A Life in Medicine and Bacteriology* (New York: Springer Verlag, 1988); Ruth E. Simpson, "The Germ Culture: Metaphor, Modernity, and Epidemic" (PhD, The State University of New Jersey, 2006).

[56] The belief that the house being potentially dangerous was also shared by Victorians. Adams has shown that contrary to the common belief that the home symbolized a safe haven to Victorians, middle-class houses were actually considered poisonous, hence in need of intense medical scrutiny. See Adams, *Architecture in the Family Way*, 36-72.

[57] "Brutstättender Bakterien im Haus" in *Wiener Illustrierter Zeitung* Nr 2564, 20 August 1892.

Wiener Illustrierter Zeitung Nr 2564, 20 August 1892

[58] See for example Emmerich, "Die Wohnung," 122.

[59] F. Hueppe, "Bakteriologie und Biologie der Wohnung," in *Handbuch der Hygiene: Allgemeine Bau- und Wohnungshygiene*, ed. Theodor Weyl (Jena: Gustav Fischer, 1895), 928.

[60] Emil Dr. Gotschlich, "Die hygienische Bedeuting des Hausschwammes," *Zeitschrift fuer Hygiene und Infektionskrankheiten* 20 (1895): 509-11.

[61] Hans Christian Nussbaum, "Hygienische Forderungen an die Zwischendecken der Wohnhauser," *Archiv für Hygiene* 5 (1886): 265.

[62] Moritz Alsberg, *Die gesunde Wohnung* (Berlin: C. Habel, 1882), 9. The ideal building site should have soil that was porous, dry, and not polluted. Removing waste from urban areas by sewerage system became a priority in sanitary reform.

[63] Emmerich, "Die Wohnung," 122.

[64] Ibid., 126.

[65] Laurent Stalder, "Air, Light, and Air-Conditioning," *Grey Room*, no. 40 (2010).

[66] Reyner Banham, "A Home is Not a House," *Architectural Design*, no. 1 (1969): 47.