4. An Applied Science Between Laboratory and Clinic – Scientific Medicine in Mid-Nineteenth-Century Germany

When there is mention of "scientific medicine" in the historical literature, it is mostly used as a generic term describing virtually all forms of (modern) science-based medicine before the age of biomedicine. What is thereby obscured, as I will demonstrate in this chapter and the next, is that the German version – *wissenschaftliche Medicin* – as well as the English rendering each indicated very specific and historically bounded programs. I pointed out in the introduction that especially for English-speaking historians, scientific medicine means a variety of different science-based approaches to medicine, ranging from rationalistic systems of pathology and therapeutics in the eighteenth century through application of natural history to the clinic in the early-nineteenth century to medicine grounded in experimental laboratory science (Hagner 2003, Warner 1995). All these programs did indeed make claims to scientificity, but they did not use the moniker of scientific medicine to make these claims. The Anglo-American renderings of the concept of scientific medicine have led to some confusion in the case of nineteenth-century German science and medicine, on which I focus here.[50] How has that occurred?

The analytical use of the term scientific medicine by scholars to describe the German context actually turns out to be somewhat of a false friend. The English-language use differs considerably from the German meaning. While the Anglo-American understanding of scientific medicine comprised a broad category, the German term for scientific medicine (*wissenschaftliche Medicin*) represents a very specific program, which competed with other contemporaneous programs over the dominant description of academic medicine and medical science around the mid-nineteenth century. But social historians of science and medicine in the Anglo-American tradition understand scientific medicine as a general form of German academic medicine, which developed since mid-century centered on the

50 The concept is usually placed into the context of the political and industrial modernization of the German states in the second half of the nineteenth century, in which also the general social and cultural appreciation of natural science is said to have increased (Lenoir 1997: 75–130, Tuchman 1993, see also Hagner 2003: 65ff., Olesko 1988: 323f.).

laboratory and the broadly construed field of experimental physiology (Hagner 2003, Lenoir 1997: 96–130, Tuchman 1993: 54–90). Michael Hagner therefore speaks of a "grand narrative or epic of scientific medicine", which "worked remarkably well in overshadowing the various, sometimes contradictory, meanings of scientific medicine and the sharp conflicts between the bench and the bedside" (Hagner 2003: 85f.). We need to of course consider that Hagner's use of the term scientific medicine here conforms to the analytical understanding in Anglo-American discourses. But what he means is that historians have constructed a (false) coherent image of academic medicine in the second half of the nineteenth century in which practices in the laboratory and the clinic were united by the science of physiology. Next to being a lab science proper, physiology at the time acted as "a model for clinical medicine", lending it "experimental approaches, instruments, and measuring devices", and, even more broadly, as a phenomenon "omnipresent in nineteenth-century discourse and culture" (ibid: 66f.).

The ubiquity of physiology has thus obscured the heterogeneity of the scientific programs for medicine that flourished around the mid-nineteenth century. Historians concerned with German medicine in the nineteenth century acknowledge that the individual programs "differed in their emphasis on key elements" but contend nonetheless that "there was essential agreement on the core of their proposed scientific medicine" (Lenoir 1997: 105, Tuchman 1993: 77, 80). In short, while the science of physiology has dominated historical narratives of science and medicine in the second half of the nineteenth century, for historians the concept of scientific medicine also functions as one of Harris's "supercategories" – integrating the different currents of clinical and laboratory science of the time into a common denominator. This has in no small part complicated the uncovering of medicine's disciplinary identity. Therefore, the task here is to untangle the different competing programs and to trace the conceptual origins of scientific medicine in Germany. This chapter is devoted to discussing the different programs of medical science, which around mid-century constituted a confusing constellation comprising elements like the laboratory, the clinic, competing methodologies, and the sciences of physiology and pathology. What enabled the historical concept of scientific medicine to become the dominant idea of a science-based medicine? And what did it entail if we look behind the grand narratives of experimental physiology?

The programs that were popular around mid-century all relied on physiology in different ways – even the emerging concept of clinical medicine

took recourse to practices coming from the new laboratory science. But these programs were nevertheless divided by their conceptions of scientific knowledge production, and therefore also by their understandings of the relationship between science and medical practice, the lab and the clinic. And whereas scientific medicine has become closely associated with the science of physiology in historiographical epics and narratives, as a historical program, as I will demonstrate, the primary science associated with scientific medicine was in fact *not* physiology, but pathology. Prominent programs at the time that relied heavily on the science of physiology were referred to as *rationelle Medicin* (Henle 1844) or *physiologische Heilkunde* (Roser/Wunderlich 1842). These programs – especially that of physiological medicine by Karl Wunderlich and his Tübingen allies, Wilhelm Roser and Wilhelm Griesinger – stressed the measurement of *normal* physiological processes and introduced laboratory-inspired instruments to the clinic. Volker Hess speaks of "proto-statistical methods" through which clinicians, inspired by the physical sciences, would record clinical phenomena like fever over extended periods and try to evaluate them scientifically (2010b: 91). As he states, it was about "precision and exactitude, reproducibility and independence of place and person" and that clinical measurements "staged a central representational technique" of physiological laboratory experiments: "the kymographic method" (ibid: 94).[51]

As a historical event, the introduction of scientific medicine, or *wissenschaftliche Medicin*, into academic and medical discourses changed the general orientation of the discipline of medical science. Contemporaneous physiological and clinical programs were still indebted to a notion of *Bildung*, which meant the cognitive and moral formation of the individual, as it was devised by Romantic reformers at the start of the century. Even the idea of clinical medicine, which had been spreading since the 1820s, stressed the cognitive and moral formation of the practitioner, although here it was exposure to disease in the clinic rather than to life processes in the lab that acted as the key pedagogical element. Only the clinical teacher or laboratory researcher could achieve a true understanding of medicine, which usually also implied a unidirectional relationship between him (all teachers and researchers were male), his knowledge and medical practice.

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51 The kymograph was a popular physical measuring device invented by the physiologist Carl Ludwig in the 1840s. It measured blood pressure through hydraulic mechanisms and recorded it onto a revolving drum (Bynum 1994: 98f.). Fever measurement imitated this method by recording body temperatures over a period of time onto fever charts (see Hess 1994).

Scientific medicine reconceptualized the relationship between science and medicine in what can be regarded as modern, liberal terms. Its greatest proponent was Rudolf Virchow, the eminent scientist and politician, who popularized the idea in his programmatic writings (Virchow 1847, 1855, 1877). Though Virchow also drew on the idea of exposure to science as a way of instilling the right state of mind into medical professionals, his program deemphasized the Romantic image of the scientist researching in solitude and freedom. He substituted it with an idea of medical science determined by practical procedures and protocols, which were based on the scientific integration of work in the lab and the clinic. He thus removed the elitist idea of science as centered on personal qualities, as with the Romantics. Instead, Virchow reoriented the focus to be more on the methodological and intellectual procedures that enabled arriving at scientific insights for clinical medicine.

Virchow held liberal views and fought on the barricades in the Revolution of 1848/49 (Otis 2007: 148f.). His general concern was with the working-class people of Prussia. He saw "that medicine should be used to reform society, and that it had been created – and should be run – by the practical, hardworking middle class" (ibid: 156). His conception of medical science reflected this attitude. Science was supposed to be employed for finding ways to heal, rather than for only finding natural laws. Additionally, Virchow's program made explicit use of the hospital "working class", i.e., the medical staff. While his contemporaries held on to the Romantic and elitist ideals of the academic professional, for him, just about anybody who knew how research worked could contribute to generating knowledge about disease, without having to be a genuine researcher themselves. Virchow significantly reinvented pathology through his cellular theory and pioneered the field successfully as a modern science. In contrast to his contemporaries, who saw no real use for microscopy in medical science, he emphasized the centrality of a microscopical research culture to study *abnormal* conditions of organic nature. In 1856, the University of Berlin created the first pathological institute in Germany as an epitome to his successful institution-building. He was an astute pathological researcher, studying and naming many important diseases (particularly of the blood), like leukemia and thrombosis (Bynum 1994: 123–127).

Most importantly, however, as a basic concept, scientific medicine was able to maneuver the complicated intellectual and institutional landscape at mid-century between laboratory science and clinical medicine as well as between ideologies of pure and applied science. As Désirée Schauz observes, the fundamental distinction "pure/applied", which organized the scientific

system in the nineteenth century, was not set in stone. Although it provided a classification for sorting the hierarchies between and inside scientific disciplines, the labels were "relative" and depended on the respective disciplinary standpoints (Schauz 2020: 197). "The boundary drawing and claims to taking a superior position in the hierarchy of disciplines and for providing the foundation for the subordinate disciplines was quite contested" (ibid: 198). Medicine was commonly construed as an applied science because it increasingly depended on the insights from existing basic science disciplines like biology and chemistry; because it had the express aim of contributing to the practice of healing; and because it had supposedly no body of knowledge of its own. But others defended it as a pure science on the ground of having "the specific nature of disease" as its own unique object of interest (ibid: 197f.). Virchow regarded medical practice as *applied* scientific medicine, which had to study disease close to where it happened, so to speak, rather than arriving at clinical insights from abstract deliberations generated from instrument measurements. At the same time, he was a strong proponent of academic freedom and of the independence of research from any immediate practical ends – a position that was especially evident in his arguments for pathology as an independent science.[52] This combination was something that distinguished Virchow chiefly from his colleagues, both as a clinician and a laboratory scientist.

I. Medicine as an Exact Science – The Physiological Program

When looking back on the publishing history of his journal *Archiv für pathologische Anatomie und Physiologie und klinische Medicin* (which he had been editing since 1847) form his prestigious position as institute head and physician to the German crown in 1877, Virchow recollected that what his generation had above all realized in the past thirty years was that not only physiology but pathology, too, had to be an independent science if medicine was to be genuinely scientific. It did "not suffice to conceive of pathology as applied physiology", he claimed. Instead, it required a "pathological physiology with its proper field of work and independent activity" (Virchow 1958: 149 [1877: 8f.], see also 1849: 18, 1855: 4). As someone who chose his words carefully (Otis 2007: 154), he employed the term "pathological physiology" to at the same time signal his allegiance to the

52 This does not mean, however, that he was not able to frame science in the emerging material interests of state and society (Schauz 2020: 216ff.).

physiological tradition of medical science – after all, he had been reared in the lab of the famous physiologist and anatomist Johannes Müller (who was a direct descendent of Romantic medicine) – and to distinguish his approach from that of his contemporaries, who practiced a physicalist approach to physiological questions.

The ill-defined discipline of physiology, which I discussed in the previous chapter, was taking on more defined form around 1850, differentiating into the physicalist approach, scientific anatomy and the biological science of zoology, amongst others (Nyhart 1995). Physicalists aimed at reducing the study of physiological function to the paradigms of physics and chemistry, i.e., to a common set of experimental methods and mathematical techniques.[53] Virchow foregrounded microscopy, which was employed in anatomy, as the central research culture to study the cellular manifestation of disease. Accordingly, acquiring a *habitus* forged through the science of microscopy was a vital element to cultivate the territory of medical science. In giving his retrospect, Virchow also revealed the double conceptual strategy, which he had pursued in the three previous decades: to establish medicine as an *applied science* it required for pathology to be constituted as a *pure science*, which, in turn, would renew and maintain the disciplinary identity of medicine. What were the reasons for him to venture on this path in the 1840s and 1850s?

What the younger Virchow found in the mid-nineteenth century were contrasting efforts to establish medicine according to the sciences of the day, which were, however, threatening to fragment its disciplinary identity. For Virchow it was unquestionable that physiology laid the groundwork for modern-day medicine. But he also saw how science and medical practice were moving in different directions. I will discuss the physiological program and the ideological role of the scientific method further down. It will then become apparent that, though actors accounted for the scientific constitution of the physician on the one side and for a physiological current that operated independently from medicine on the other, it no longer embraced the idea of medical science as a unified and independent discipline. In the earlier days, Virchow claimed, physiology and medicine

53 Timothy Lenoir (1997) portrays the group of "organic physics". These were physiological physicists, which formed around Emil du Bois-Reymond, Hermann von Helmholtz, Carl Ludwig and other scientists in the early 1840s. They became known for their bold (yet failed) attempts to remove physiology from the medical faculty and place it in an institutional setting among the theoretical sciences, next to other disciplines such as chemistry and physics to make the field "the natural representative of the progressive movement in science" (ibid: 79).

were interrelated, mutually contributing to each other. Now, the idea of *Wissenschaft* had come to dominate for half a decade: "a concept which is nowhere more developed than in Germany and which has nowhere produced more harm than in medicine" (1958: 29 [Virchow 1847: 7], translation modified). The idea of a pure science of physiology had made the field alien to medicine, so "that medical conceptions [*Anschauungen*] have performed without a physiological basis just as physiology has deprived itself of any medical experience" (ibid: 30 [Virchow 1847: 8], translation modified). He accordingly saw the need to renew the relation between science and medicine, which in his case meant making pathology as a pure science the actual basis for clinical practice, while physiology moved to the background as only the general frame in which medical science happened.

Virchow's conceptual innovations were directed at two fronts: on the one side, he was critiquing a medicine based purely on the institution of the clinic, as it had been developing since the early nineteenth century. On the other, he was also opposing the pretensions of the physiological protagonists, who apparently thought they could solve the riddles of the clinic solely from the induction of biological theories through measurement of organic processes. Physiology was now becoming a hugely popular natural science that acted as a conceptual framework for other sciences with its emerging specialties in medicine and in biology (Hagner 2003, Nyhart 1995). For Virchow, physiology in its current state was an impotent medical science, which, by trying to force its paradigm onto practical medicine, as in the category of physiological medicine, did not succeed in "getting to the point of healing" (ibid.). In his 1877 retrospective, he therefore recalled that the elaborations in the early issues of his *Archiv* "were for the most part directed against the so-called 'rational' movement in medicine and the self-designated 'physiological' school, which had been in full bloom at the time." Although he thought it was an unrewarding task "to push back these currents pursued by keen and industrious men" (1877: 9f.).

What did it mean for Virchow that physiology was an impotent medical science? What characterized the competing programs regarding the relationship between science and medicine? A main feature of the new programs was the introduction of the idea that the causes of disease were governed by natural laws. In this, protagonists followed the physicalist paradigm of physiology that was beginning to develop as an independent science. They wanted to create an approach in which the natural sciences provide the overarching theory for the empirical observations of the clinic. In short, these actors took their model from the *natural* sciences like physics or chemistry, instead of from *medical* sciences like pathology. A

look at these natural science programs for medicine will help reveal how they contrasted to Virchow's own idea of scientific medicine.

The programs popular at the time, mentioned by Virchow, were that of "rational medicine" by Jacob Henle and Carl von Pfeufer, who both worked and taught at the University of Heidelberg in the mid-nineteenth century. The other was the program of "physiological medicine" by Wunderlich, Roser and Griesinger, who were initially active in Tübingen. Wunderlich would become professor and director of the university hospital in Leipzig in 1850. What united these different programs in their core was the reduction of the genuine medical science of pathology to versions of physiology, which stressed its natural science features. As Henle programmatically announced in the first volume of his new journal *Zeitschrift für rationelle Medicin* in 1844:

> "The central attribute of rational medicine is that it proceeds from individual facts for which it attempts to find an explanation, and in this physiological and pathological facts have equal values. The final goal is, as far as possible, to trace both back to physical and chemical processes, and in this way to bring these facts under common viewpoints with the phenomena of inorganic nature." (Henle 1844: 31, see also Bleker 1981: 123, Tuchman 1993: 80)

For Henle and Pfeufer, pathology and physiology were merely parts of the same science. They proposed explaining the causal relationships between the pathological phenomena by ultimately making them reducible to an understanding of physics and chemistry. But this also meant degrading the status of disease phenomena, the chief object of pathology, in favor of physiological processes. As Tuchman observes, "for a rational medicine to be successful, [Henle] told his readers over and over again, the notion of disease entities had to be replaced by a definition of disease as nothing more than a deviation from normal physiological processes of life brought about by abnormal conditions" (1993: 78, see also Henle 1844: 15f.). The protagonists of rational medicine had demanded that the names given to illnesses serve merely as "Nomina propria", as labels for a "complex of sensory appearances", and not as concepts for a pathophysiological state itself (Henle 1844: 15, see also Tuchman 1993: 78).

The program of "physiological medicine" by Wunderlich, Roser, and Griesinger saw itself in a similar vein. Protagonists understood their program to stand for medicine as an "empirical and inductive science" that could demand for itself "the same methods as for the exact physical sciences" (Roser/Wunderlich 1842: IIf.). But their pursuit was more rad-

ical. Pathological descriptions had no other legitimacy than as "practical makeshifts", an unscientific starting point for investigation into the physiological *qua* physical causes of a diseased body (ibid: XI). While for Henle and von Pfeufer pathological phenomena were as such legitimate objects to be studied and explained physiologically, the core of Wunderlich and his school was to reduce pathology entirely to the language of physicalist physiology. Pathology resembled merely "a tool to be employed in tracing the pathways of disturbed organ function" (Lenoir 1997: 106, see also Hess 1993: 258f.). A manifestation of the physicalist paradigm can be grasped from Wunderlich's specialization in the study of fevers, for which he developed an extensive method of thermometry. He produced charts that recorded the progression of fever in a patient over an extended period of days (figure 4.1.). Variations in temperatures over time, he contended, would allow the clinician to identify individual patterns of disease (Bynum 1994: 138, Hess 1994).

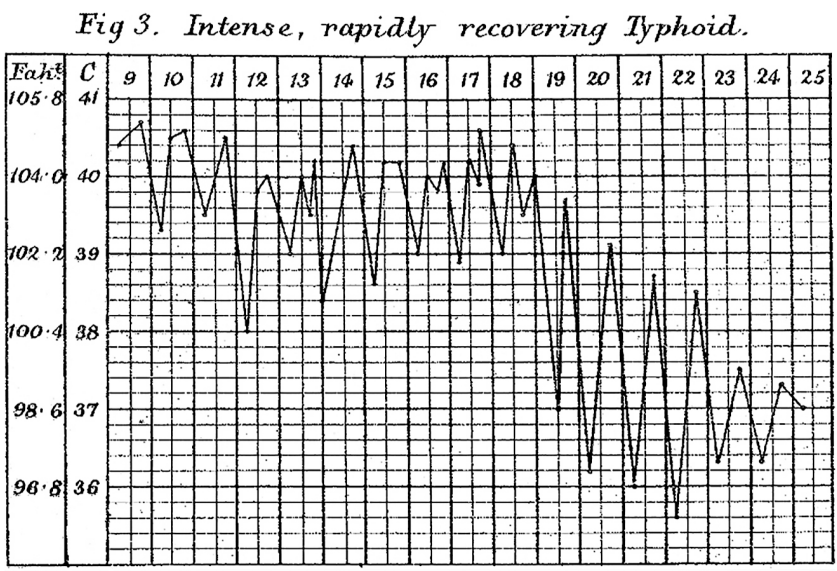

Figure 4.1: Fever chart (typhoid) from the English edition of Karl August Wunderlich's On the Temperature in Disease. A Manual of Medical Thermometry. *London 1871. (Source: Wellcome Collection, https://wellcomecollection.org/works/tk2hrp99, [accessed August 1, 2022]).*

The aim of "physiological medicine" was to oppose the thriving idea of clinical medicine by socializing the medical student in the special physicalist culture of physiology. They wanted to tune his (again, no women in academic medicine at the time) senses to only those phenomena which were measurable with laboratory methods. Roser and Wunderlich had accordingly introduced their new journal, the *Archiv für physiologische Heilkunde*, to readers in 1842 with the assertion that "this one word" – "physiological medicine" – "contains everything that the science [of medicine] possesses, what it demands, and what is essential to it" (1842: I). In the introduction to the second volume in 1843, however, clarifying the assertion made in the prelude, they revealed the radical extent of their program:

> "That physiology control and inform the doctor's entire reasoning, that it purifies his concepts, and forces him, for every pathological fact, to seek the motives for his judgement in the utmost knowledge of the anatomical and functional [=physiological] circumstances of the affected parts – this is the direction in which medicine must strive, and by virtue of which it deserves the name physiological [medicine]." (Roser/Wunderlich 1843: 2)

The proponents of the physiological program wanted to instill a professional *habitus* into the student that comprised schemes of perception, thought and action, which made him see illness inside the patient with the eyes of the "organic physicist", as measurable disturbances of organic function.

Volker Hess has argued that by basing medicine on the model of the natural sciences, and on physicalist physiology in particular, "Wunderlich was fighting for the scientific recognition of the medical clinic" (Hess 1994: 300). Particularly Wunderlich's practice of thermometry was aimed at mimicking the constellation of the experimental natural sciences. Hess shows how the thermometer was framed by Wunderlich to formally embody all criteria, "which at this time could be posed to a measuring experimental setup: it isolated a variable, but measurable physiological function" (Hess 1994: 308). Wunderlich furthermore used the setup to transfer the sort of research questions inherent to physiological experimental methodology to the approach of clinical thermometry, however, replacing scientific values with values for clinical practice (ibid: 309). In other words, rather than consulting an adjacent experimental laboratory, he envisioned the clinic itself to become sort of a lab to study disease in the fashion of the natural sciences (Hess 2010b: 91ff.). This already indicated a move in

which the disciplinary identity of medicine would become displaced from the institution of the experimental laboratory. His physicalist approach to measuring fevers already provided the necessary natural science language and an image of objectivity to make the case. As Hess concludes, the rhetoric of objectivity and of methodological autonomy for clinical investigation allowed a broad circle of practicing physicians and readers of the *Archiv für physiologische Heilkunde* "to identify the scientific as well as disciplinary autonomy of the medical clinic with the thermometer and the fever curve" (Hess 1994: 318).

With this framing of clinical medicine as part of the natural sciences, Wunderlich and his allies were opposing a different framing of medicine as scientific, which gained popularity in the 1820s. We do not know very much about the history of university clinics (see Bleker 1995, Hess 2010a,b). But as universities were setting up clinical teaching facilities and receiving access to patients in general hospitals, clinical medicine as a scientific program began to emerge in Germany with the figure of Johann Lucas Schönlein. He was professor of medicine at the University of Würzburg, became director of the medical clinic at the Juliusspital in 1824 and received a chair in Berlin in 1840. Schönlein is founder of what has been called the the Natural Historical School in medicine, which applied classificatory and taxonomical approaches to historical accounts of sickness and the observation of disease in the clinic. He is credited with having systematically integrated the teaching clinic into the concept of academic medicine (Bleker 1981).

In contrast to Wunderlich's natural science approach, Schönlein's idea of clinical medicine was based on an empiricism that combined astute bedside observation with the historical study of disease. Schönlein deemed clinical medicine "scientific" because of its natural-historical methodology. Using a comparative method, doctors' past accounts of sicknesses and symptoms were to be combined with meticulous records of individual patient histories, marking how diseases unfolded temporally and spatially in the individual and in society (Schönlein 1929: 7f., see also Bleker 1981: 71–80, Hess 1993: 238–242). His systematization and classification of disease was furthermore aided by physical and chemical practices. Clinical medicine had been helping itself with the newest scientific and clinical technologies, which complemented the natural historical descriptions with indications of organ damage by adding "a 'physiological' viewpoint" (Hess 1993: 249, see also Hess 1995: 106ff., Bynum 1994: 30–46). Percussion, auscultation, microscopic and chemical analysis had become popular techniques to study disease in the hospital and clinic since the early decades of

the century.[54] Clinical teachers like Schönlein therefore maintained small laboratories to run routine diagnostic tests and to perform auxiliary research (Hess 2010b: 97f.). The empirical description of the Natural Historical School resulted in combining symptoms into specific disease patterns, with their disease progression and transformation. Thereby Schönlein's and his school's clinical method gave the rather abstract phenomenon of sickness of former ages a concrete clinical definition in the modern sense.

Schönlein was convinced that previous generations of medical thinkers, especially the Romantics, had distorted the study of disease through their rational speculations. Thereby they created a distinction between theory and practice that harmed the idea of practical medicine. In his inaugural address as professor in Würzburg in 1819, he claimed:

> "All of natural science [*Naturkunde*] was a strong tree when its golden fruit, medicine, appeared. An unfortunate methodology has teared this golden fruit from the living stem in newer times and, through the absolute contrast of theory and practice, twisted nature into un-nature. To compensate for this unnatural [and] mindless opposition [between theory and practice], to show and to prove that theory and practice are one and the same, that they are identical, is the one and only task of the clinic" (Schönlein 1929: 5).

To the speculative and rationalistic approach of the Romantics, Schönlein opposed the clinical method. He was questioning how practical advantages could come from abstract speculations, from philosophical models and representations of biological processes generated away from the actual place where disease happened – in the patient's body. To identify medical theory with practice meant that both had to be founded on the same institution. As Schönlein contended, the clinical method was supposed to account for both the practical and theoretical side of medicine (Bleker 1981: 53). It meant that the treatment of patients and the study of the specific and universal features of disease went hand in hand.

A true experience of disease was therefore only possible in the clinic, which allowed for systematic and controlled observation. Quoting one of Schönlein's students, Hess accordingly remarks that the central idea of the clinical method was that "the clinic 'takes the sickbed as the standpoint from which it scrutinizes all other branches of science for what they can offer it for the ultimate end of healing. All beams of science result in this

54 The "breakthrough" event in this respect was the invention of the stethoscope and of the technique of auscultation by Laennec in 1819 (Reiser 1979: 23–44).

center'" (1995: 108f.). Students were accordingly taught to make careful bedside observations of individual patients, to record these observations and use them for making prognosis and therapy. Additionally, however, they were encouraged to use these meticulous reports to ponder on the general causes of specific diseases in humankind, next to the individual causes in a certain patient (Bleker 1981: 55f.).

> "This being next and after each other [*Neben- und Aufeinandersein*] of disease, researching how they have grown apart, affords the physician, who does not locate the highest of his art in the technical and in writing prescriptions, a high, [and] not only scientific interest. Because in this way he finds types of disease [*Krankheitsformen*] in nature next to each other, which are far apart in our textbooks; he sees a common bond between things, which were presented to him as highly heterogeneous and different" (Schönlein 1929: 9).

Schönlein was convinced that "just as in the other teachings of the natural sciences" – with which he meant natural history – also in medicine, "a natural systematization [of disease] is possible" (ibid.).

II. The Ideology of Methodology in Mid-Nineteenth-Century Germany

Schönlein had the same aim as Wunderlich – to argue for the scientific status and disciplinary autonomy of the medical clinic. But both programs did so under vastly different ideologies. These differences were revealed in the role and the status of the natural sciences for medicine, the image of the truly scientific physician and the right methodology to apply to research and teaching. The natural sciences for Schönlein were moulded after the comparative and taxonomic practices of the natural historian, while for Wunderlich the experimental and quantifying approaches of physics acted as a model. For the image of the physician, this resulted in conflicting ideals about the appropriate cognitive and moral qualities. Schönlein's doctors had to be meticulous observers, attentive to the development of disease, its history and the improvement or deterioration of the patient under treatment. Wunderlich's doctors were also meticulous observers, but of the variables and swings in his measuring devices, and of the significance this had for understanding biological processes. The practices and virtues being taught in a clinic-based medical education were those that Hess has aptly described as forming the "clinical doctor", and

not so much the natural science-minded physician or the future medical scientist (Hess 1993: 18, 1995: 108, s. also Tuchman 1993: 66).

Historian Johanna Bleker has suggested that the structural differences between Schönlein's clinical and Wunderlich's physiological program was not as great as the polemics they exchanged might imply. In fact, she argues, "the manner in which the physiological current wants to investigate the essence of disease has a remarkable similarity with Schönlein's approach" (1981: 117). We can take this observation as an indication of the playing field on which both schools fought over primacy in academic medicine, namely, that of ideology. More generally, competing ideologies surfaced especially in debates over methodology in the context of education around the mid-nineteenth century. I want to include this to also mean debates over scientific and clinical methods. As Phillips shows, controversies over methods in Germany pertained to questions of professional and anthropological characteristics. "*Methodologie* dealt extensively with personal qualities," she notes, "the concrete competencies and character traits necessary to practice a given science or profession" (Phillips 2012: 238). As she demonstrates, though, rhetoric of the scientific method was foremost used by actors to discursively distinguish the human and the natural sciences. Nevertheless, we can gain some insight for academic medicine more specifically and how the clinical method and the scientific method were opposed here.

Advocates of the scientific method aimed at presenting a refined concept of *Bildung* in the mid-nineteenth century (Phillips 2012: 239ff., Schauz 2020: 224f.). They stressed the epistemological particularity of the natural sciences in contrast to that of the humanities. As we saw earlier, whereas neo-humanists advocated that "the classical curriculum was the best preparation for boys whose lives would be devoted to *Wissenschaft*", the "German *Naturfoscher*" was keen on showing that "the natural sciences had their own distinct epistemological contribution to make" and that they "provided skills different from those that could be gained studying books" (ibid: 230). They used qualities such as a refined sensory perception, critical observation and hands-on experience as markers for a pedagogical ideal that stressed practical-intellectual purposes, but nevertheless understood the natural sciences to constitute a unified body of knowledge (ibid: 245, see also Bonner 1995a: 236ff.). Stated differently, for these actors, the scientific method represented a reformed notion of the moral and intellectual source that would now mold the elite researcher, just as *Bildung* formed its equivalent in previous decades. As Phillips furthermore notes, "the idea that refined sensory perception was the hallmark of the *Naturforscher*

(and by extension the medical doctor) was a commonplace in introductory textbooks, both in the natural sciences proper and in medicine" (ibid: 249). Thus, by stressing the superiority of the skills acquired through training in the method, it worked rhetorically to defend the natural sciences curriculum against the humanist curriculum.

In the case of academic medicine, actors also stressed the epistemological particularity of the scientific and clinical method. Reference to either the clinical or the scientific method worked for protagonists to emphasize different cognitive and moral qualities in the academic physician. Moreover, it functioned to map different relationships between the institutions of the clinic and experimental science. Wunderlich wanted students to be trained to see medicine through the eyes of physiology as an exact physical science, while Schönlein's students were to see it through the rich history and system of disease. For Schönlein, the natural sciences employed in the clinical context merely constituted aids, because of their reduced role to diagnostics and analysis. Wunderlich's program was built on the skills and qualities students received in laboratory training, although it depended on other laboratories to provide such training. In the eyes of physiological contemporaries, therefore, clinical medicine deprived the medical discipline of its exact science identity, by delegating the laboratory to the status of a handmaiden. In reaction, Wunderlich and his allies tried to very publicly make a central place for physiology and the method of the natural sciences (see figure 4.2). For this purpose, they debased the epistemological peculiarities of clinical medicine and its method. The dirty manner of the debates again suggests that the playing field was that of ideology and not of scientific facts or proofs.

The central critique levelled against Schönlein's Natural Historical School was the supposed reliance on an ontological understanding of disease. Wunderlich and his conspirators very publicly accused Schönlein and his followers of an irresponsible adherence to the outdated idea of disease entities (Bleker 1981: 114–126). In effect, this was meant to suggest that Schönlein and his allies were still adhering to premodern and antiquated medical philosophies. The *Archiv für physiologische Heilkunde* turned into a collection of polemics against the Natural Historical School in the half decade after its inauguration. Protagonists wondered "how one could tolerate the fact that its inventor [Schönlein] claims [to have a] monopoly on an exclusive-natural scientific medicine" (Roser/Wunderlich 1841: X, see also Bleker 1981: 116). As Bleker argues, though, Wunderlich and his followers only feinted the radical opposition between their own and Schönlein's program. Schönlein had made it unmistakable that the

idea of disease entities acted merely as a methodological device for the empirical study of sickness (Schönlein 1929: 7). He simply demanded of his students that every disease ought to be treated as *if it were* a concrete object. "Thereby it becomes very clear that he is not at all asserting that disease are concrete objects, but only that one needs to study them as if they were entities sui generis. This demand has nothing to do with his general definition of illness [sic]" (Bleker 1981: 55, see also Hess 1993: 250).

But instead of philosophical, actors rather had institutional axes to grind. By implying that Schönlein's clinical method conveyed thinking in an antiquated fashion, proponents were emphasizing the role of training in the experimental laboratory sciences. Their main worry was to legitimize a natural sciences-based education, so that future doctors approach problems in the clinic with the appropriate mindset and skills (Bleker 1981: 124f.). At the University of Heidelberg, the proponents of "rational medicine", Henle and von Pfeufer, introduced extensive practical training in various scientific methods into the curriculum in the 1840s that would expose medical students to a natural sciences environment (Tuchman 1993: 72–77). And Wunderlich, too, made practical clinical training in Leipzig mandatory that required physiological reasoning and scientific methodology (Lenoir 1997: 123–127). Rhetorical emphasis on scientific methodology was a way to articulate the essential features that training in the scientific laboratory provided to the medical student over their training in the clinic.

The effects of degrading clinical medicine in favor of the physiological approach, however, had far-reaching structural implications for medical science as a discipline. Wunderlich's program split the originally unitary idea of a discipline as composed of research and teaching into two, where the teaching remained in the institution of the laboratory, since it required the skills of experimental sciences, while the research part was moved to the clinic. This separation plaid more into the hands of those medical scientists who were beginning to remove themselves from medical practice, like the "organic physicists", rather than for those seeking to make the clinic a sort of a natural sciences laboratory. Historian Timothy Lenoir argues that the famous physiologist Carl Ludwig capitalized on the ideological understanding of the scientific method. The establishment of Ludwig's institute at the University of Leipzig in 1869 (the first of the major physiological institutes to be founded in Germany in the late-nineteenth century), according to Lenoir, needs to be seen as the result of his strategic bargaining for material gain for his enterprise. Employing the rhetoric of the

scientific method, Ludwig rendered the science of physiology "serviceable to the practical needs of clinical medicine", to secure funding for his cause of strengthening the discipline of physiology. "This did not imply giving up the disinterested pursuit of knowledge. Rather, it meant coordinating scientific research with the material interests of the state" (Lenoir 1997: 129, see also Kremer 2009: 355f.). We can now better understand what this entailed – namely, framing the pure science laboratory as a training ground for clinicians.

Lenoir also shows how Wunderlich structurally prepared the advent of Ludwig and his research institute: "A more harmonious fit than that between Ludwig's perspective on physiology and Wunderlich's program for physiological medicine", he argues, "could scarcely be imagined" (ibid: 127). Ludwig pursued a physiological research program that had little to do with clinical practice (ibid: 107ff.). Training in the scientific method, however, which he provided in his laboratory, was for students that went on to become practicing physicians. In sociological terms, he was rearing a tribe for settlement on a foreign territory, namely, the clinic. They were not being prepared for medical research (ibid: 115). In a way, Ludwig and Wunderlich thus represented two separated disciplinary programs in which one depended unilaterally on the other. However, judging from the degree of institutionalization that followed, we need to consider that Ludwig's scientific program superseded that of Wunderlich.

III. Rudolf Virchow's Program of Scientific Medicine

Virchow emphasized medicine as an *applied science* in part to distinguish his idea from the likes of Wunderlich (and Ludwig), who were more interested in the methods of physiology as a pure science. For him, the fact that medicine had to be an applied science did not reduce its status among the other sciences, though. On a general level, the designation placed his concept of scientific medicine in the realm of pursuits dedicated to the common good, just as technology was beginning to be framed as the result of a knowledge transfer from science, which led to general improvements (Schauz/Lax 2018: 67). Furthermore, in medical discourses concretely, the label worked to elevate his concept of pathology as a full-blown academic science within the context of the medical discipline. If medical practice was applied scientific medicine, then pathology laid the theoretical foundations for this purpose and therefore constituted the chief science of scientific medicine and the medical discipline (Benaroyo 1998).

Virchow argued that this constellation would restore the central objective of medical science, which was to be able to heal sick patients. "Virchow wanted a renewal of medicine from the inside out – from the morgue and the microscope to the wards – and he focused on clinical practice. To him, the bottom line of any epistemological strategy was its value to the suffering patient" (Otis 2007: 146). His contemporaries seemed to have exchanged this objective for purely scientific pursuits (through the Romantic influence). Whether it was investigating life processes in the physiological laboratory or studying disease in the clinic using physical measuring techniques – in both cases protagonists seemed to follow the primacy of scientific research rather than that of healing patients. But there is need for qualification.

Virchow was just as much a proponent of scientific freedom and research autonomy as his contemporaries in physiology were. As already mentioned, he was a liberal and concerned with Prussia's working-class. But it needs to be recognized how this fact reflected in his ideas about medical science specifically. Although Virchow held simultaneous appointments in the University of Berlin and the Charité hospital throughout his career, he had little interest in medical practice beyond the routine inspections he was obliged to. As Cay-Rüdiger Prüll notes, in fact, Virchow "was not very successful in therapy"; and when making his ward rounds, he examined patients like a clinician should, but appeared to be more interested in the manifestations of disease that would only become visible during autopsy (2000: 97f.). This attitude was not unusual. Hermann von Helmholtz became professor of physiology at the University of Heidelberg in 1858. As Tuchman notes, he showed scant interest in practical medicine. In the decades following his appointment, he "remained aloof from routine drill conducted in his laboratory. […] Helmholtz distanced himself even further from his 'medical' duties by requiring his assistant to teach his courses in microscopical anatomy, justifying this by his lack of histological knowledge and his tendency to get headaches" (Tuchman 1993: 161). What distinguished Virchow's program from that of his contemporaries, however, was not the general orientation towards medicine, but only the research orientation of medical science. Wunderlich and the physicalists (like Ludwig and Helmholtz later in the century) were seeking to understand the natural laws of biological processes. Virchow, in contrast, was aiming to arrive at scientific principles for clinical practice by directly studying disease according to the paradigm of the natural sciences (I will explain this shortly).

Clearly, Virchow saw some confusion over what a science-based medicine meant to his contemporaries. There was obviously no "core agreement" on the idea of scientific medicine among him and his rivals, as historians of German medicine tend to believe. Virchow introduced readers to his new *Archiv* in 1847 with an important plea to end the confusion: "When speaking of scientific medicine, at the present time," he claimed, "it is highly necessary to come to agreement concerning the meaning of the words" (1958: 26 [Virchow 1847: 3]). He programmatically differentiated between "practical medicine" and "scientific medicine" in the text to signal that his program meant more than the relationship between physiology and clinical practice:

> "Ever since we recognized that diseases are neither self-subsistent, circumscribed, autonomous organisms, nor entities which have forced their way into the body, nor parasites rooted on it, but that they represent only the course of physiological phenomena under altered conditions – ever since this time the goal of therapy has to be the maintenance or the reestablishment of normal physiological conditions.
>
> The actual accomplishment or, put more precisely, the striving for an actual accomplishment, of this aim comprises the task of practical medicine.
>
> Scientific medicine, for its part, has as its object the investigation of those altered conditions which characterize the diseased body or various ailing organs, the identification of abnormalities in the phenomena of life as they occur under specifically altered conditions, and finally, the discovery of means for abolishing these abnormal conditions" (ibid: 26f. [1847: 3f.]).

While practical medicine was thus defined as restoring or maintaining the normal life functions in the patient, the actual province of scientific medicine was pathology and therapy, and not physiology. The point of scientific medicine is the acquisition of knowledge about altered life conditions, and of the means to neutralize these conditions. Of course, maintaining the normal state necessarily also presupposed a knowledge of normal functions. Virchow was implying those keen and industrious men, who tried appropriating pathology with the concepts of physicalist physiology. Committed principally to the pure science ideal, however, "the most recent developments in medicine" made it "appear as if this had hardly anything to do" at all with the matter of healing (ibid.). He programmatically proclaimed that the sciences of pathology and therapy

could only be constructed from inside of the institution of practical medicine, "and we dispute the right of any discipline not itself rooted in the observation of diseased life to share in the interpretation of its phenomena" (ibid: 31f. [Virchow 1847: 10], translation modified). The possibility to observe disease, as he saw it, rested equally within the pathological laboratory, where diseased bodies were dissected, and the clinic, where sick patients were treated. As will become clear in the following, in a crucial sense, his program offered a sort of middle ground between the competing factions of clinical and physiological medicine: by integrating the institutions of the laboratory and the clinic equally, instead of only relating them hierarchically. "Poised between the university and hospital, between *Wissenschaft* and the clinical bustle of the Berlin Charité, Virchow through his [pathological] institute stood ready to investigate the productions of each in the terms of the other" (Maulitz 1978: 170).

a. The Science of Pathology

One central part of Virchow's strategy was to renew the scientific basis of medicine. As I showed above, he regarded physiology as no longer appropriate for the task of founding medical practice. It was not enough to instruct doctors as physiologists and send them out into the clinic in the hopes that they, upon contact with the sick patient, would deduce the right methods of action from the laws of organic nature they had observed in the lab and/or the clinic. For this reason, he claimed that pathology was a pure and full-blown science laying the foundations for any knowledge of practical medicine to be constructed. In his 1877 retrospective, he proclaimed:

> "Now that the work is done, we need to remain aware [of the fact] that the emancipation of pathology, the ennoblement of pathology to the rank of a natural science, requires that pathologists keep their independence, that they do not allow any external science [*fremde Wissenschaft*] to introduce their hypotheses readily into pathology; and that they do not let the latter be forced back into the position of merely an applied science" (Virchow 1877: 9).

The founding of scientific medicine on the science of pathology was not simply intended to displace physiology; the intention was rather to mend the purported impotency of the discipline, which physiology had caused in relation to medical matters. Virchow recalled Bacon's famous dictum

"*scientia est potentia*" in his programmatic introduction to the *Archiv* in 1847. He honored his physiological contemporaries for their advancement of scientific knowledge, but in a scathing critique that was unmistakably directed at Wunderlich and the other physicalist physiologists, he claimed that "this is no real knowledge, which is not also able [to perform] what it knows; and what sort of precarious ability it is, not knowing what it does!" (Virchow 1847: 5).

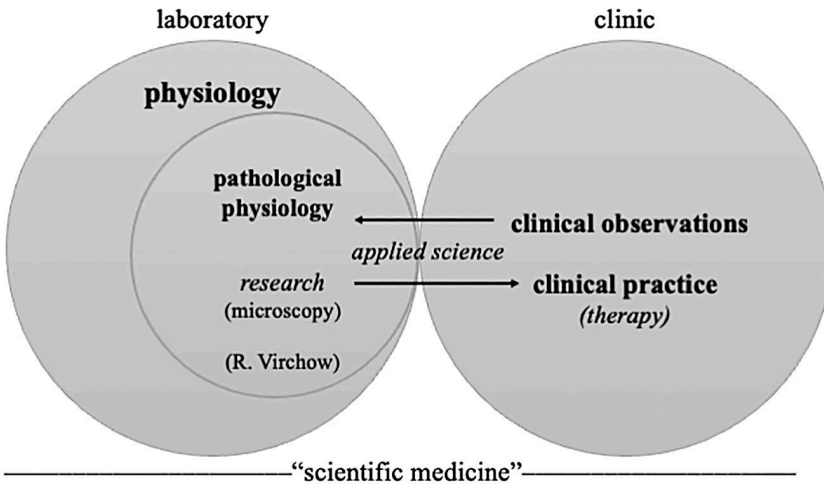

Figure 4.2: Schema of the structural relationship between laboratory and clinic as well as research and clinical practice in Virchow's idea of "scientific medicine" (my depiction).

As Virchow reflected in 1877, his efforts in the past thirty years had been "to introduce a scientific language into medicine" that would prevent newly found insights from becoming tarnished "by sudden ideas, by improper generalizations, [or] by the tendency to figuratively translate concepts" (1877: 4). In other words, medical scientists and practitioners had to desist speaking in the language of abstract laws and physiological theories and start employing a language with which to comprehend the concrete phenomena clinicians encountered in their everyday routine. "Pathology, which had once consisted of speculations about humors and solids in general, and then moved to the organs and tissues, seemed now to come to a final basis on the ultimate cellular components of organic structure" (Benaroyo 1998: 115). As part of the natural sciences, it would introduce a common conceptual ground for medical research and practice into the

medical discipline that would allow the orientation of both upon each other, instead of the one-way direction from physiology to practical medicine engrained in the competing programs. It therefore entailed setting up a cultural foundation that would speak equally to the pathologist as a researcher and the clinician as a practitioner. Initially, Virchow named it "pathological physiology" in 1847, but later in the 1850s refined it famously to constitute his "cellular pathology" (Virchow 1855). A central feature of pathological physiology was therefore to know what practical medicine was void of and what had to be investigated in order to improve its scientific foundation: "Pathological physiology receives its questions in part from pathological anatomy, and from practical medicine; it generates answers in part from observation at the sickbed, and therefore is part of the clinic, and in part from animal experiment" (Virchow 1958: 37 [1847: 16f.], translation modified). Medical knowledge, in other words, relied on the combination of close clinical observation, animal experiment and systematic autopsy aided by histology and chemical analysis (Prüll 2000: 91, Otis 2007: 146).

I will illustrate the functioning of the conceptual space using the example of Virchow's cellular pathology. The development and institutional consequences of Virchow's pathological theory are well known (e.g., Maulitz 1978, Schmiedebach 1992). My purpose here is only to provide a general outline regarding the production of a scientific culture for the shared orientation of scientific and medical action. First, I need to clarify some names, though. From current standpoints, Virchow's cellular pathology would be considered as pathological anatomy and histology (see figure 4.3), that is, a subfield of anatomy, although when Virchow published his famous piece on the theory as an editorial in his *Archiv* in 1855, he saw it as a first culmination in his intention of "founding a *pathological physiology*" and not anatomy (Virchow 1855: 6). However, the combined approaches of anatomy and physiology were only starting to become institutionally separated in the 1850s (Nyhart 1995: 84ff.). Thus, Virchow's ideas drew on the shared anatomical-physiological tradition that emerged at the start of the century, and became exemplified in Johannes Müller, though his emphasis on anatomical methods was clearly intended to separate his approach from that of physicalist physiology. However, his employment of the term physiology made it clear that he still saw himself indebted to the scientific tradition of physiology, which emerged with Reil and matured with Müller and his pupils. His article on cellular pathology was followed by a book in 1858, with the same name: *Cellular Pathology*, comprising lectures he held at his pathological institute in Berlin.

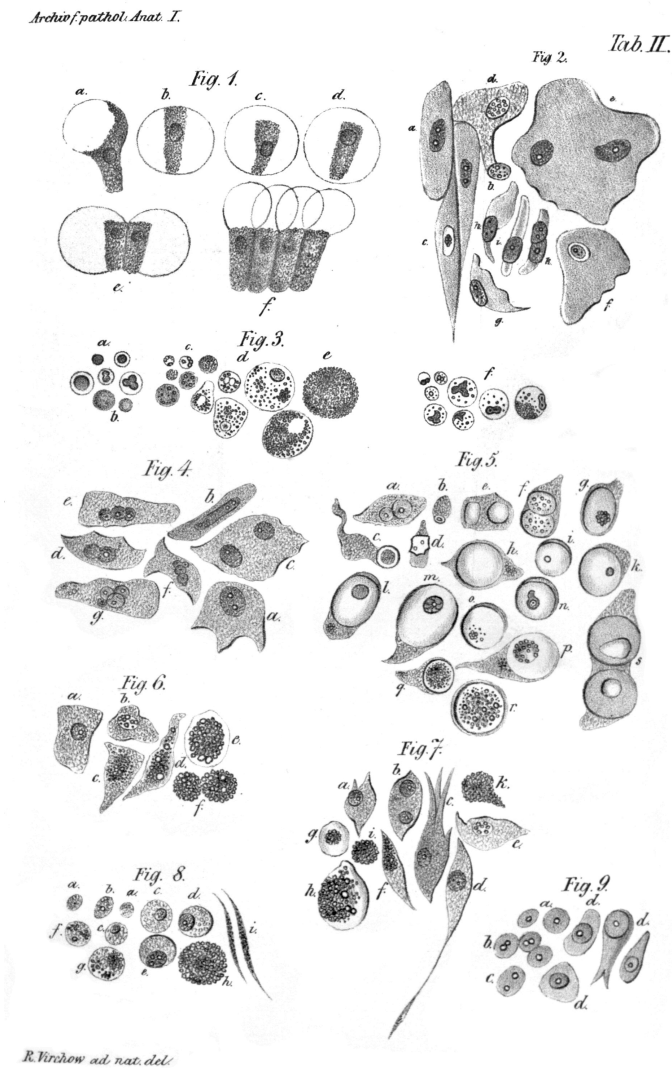

Figure 4.3: Different cancerous cells illustrated by Virchow from microscopic investigations and printed in the first issue of his Archiv. (Source: Rudolf Virchow. 1847. Zur Entwicklungsgeschichte des Krebs nebst Bemerkungen über Fettbildung im thierischen Körper und pathologische Resorption. Archiv für pathologische Anatomie und Physiologie und für klinische Medizin *1(1), p. 206 https://commons.wikimedia.org/wiki/File:Virchow-cell.jpg [accessed August 1, 2022]).*

Second, the development of the achromatic compound microscope in the 1830s allowed investigators for the first time to observe living tissue at high resolutions over comparatively long periods without straining their eyes. As a result, Müller's student Theodor Schwann revealed that animal organisms are composed of cells or of structures produced by cells, after Matthias Schleiden had previously proven the case for plants (Harris 1999: 94–105). Virchow applied a modified version of this theory to pathology, which stated that all tissue – diseased and normal – originate within the cell from physical and chemical mechanisms (Virchow 1855: 15).[55] Virchow constructed his idea of pathology on a "conception of the human body as an organized cell state, a social system of continuous development, in which each microscopic cellular unit performed its parts" (Benaroyo 1998: 115). Accordingly, the theory holds that every illness can be traced back to disturbances of living cells, causing large parts of the "cell state" to deteriorate, and it required that "the physiology of pathological developments be pursued hand in hand with the history of normal developments" (Virchow 1855: 14). In short, Virchow's theory replaced the idea of organic lesions as the cause for functional impairments with that of disturbed cell growth, that is, as anatomical aberrations causing organic functions to fail.

The advantage of this concept over those of his medical competition was that it allowed to center scientific medicine on the science of microscopy, which could – literally – provide a common focal point tangible for both science and medicine, compared to the rather abstract biological processes only inferred to from work with physiological measuring devices. "Disease processes," according to Virchow, "were to be studied by medical microscopists with pathological training" (Maulitz 1978: 169). Thus, for him, the microscope constituted an agent of true reform in medicine in an age when anatomy was only starting to become part of the natural sciences in its own right (Virchow 1855: 8, see also Nyhart 1995: 80–90). While the instrument was increasingly being used as a diagnostic aid, only few had actually learned to *think* microscopically in medicine, Virchow asserted; and he demanded that not the use of the instrument as a practical tool, but the epistemic virtues of the science become the foundation for pathology and therapy, that is, "scientific medicine" (ibid: 7, 38).[56] As the pathologist

55 The famous dictum connected with Virchow's theory is the "*Omnis cellula e cellula*" (1855: 23). Historian Henry Harris provides a portray of Virchow's controversial role in the formation and spread of cell theory (1999: 132–137).

56 Henle had both used the instrument for scientific study while working with Müller in Berlin, and later in Heidelberg taught the technique to his medical

would thus become accustomed to "the finer construction of the body by his own perception [*Anschauung*]", and subsequently interpret experiences "in accordance with this conception [*Anschauung*]", it would ultimately enable the practitioner to "thinking microscopically" (ibid: 100 [1855: 38f.], translation modified). Bynum aptly notes that instead of recording the progression of symptoms or measuring biological processes, "microscopy encouraged doctors to think about the dynamics of disease, about the genesis of lesions rather than their gross, end-stage structures" (1994: 123).

To illustrate, Virchow drew an analogy between the role of the microscope for biology – and by extension pathology – and the meaning of the telescope in astronomy (ibid: 16f.). Naturally, it was indispensable that an astronomer knew how to handle a telescope, Virchow argued. But his objects of interest – the sun, moon, stars, the milky way and nebulas – are also visible with the unaided eye. However, compared to the simple observer, the astronomer has a different perception of these objects. Even without the direct aid of his instrument, he resolves the same moon, stars and nebulas visible in the night sky into a large number of telescopic images every time he *thinks* astronomically. Equally, under the microscope, "everything that lives is dissolved into tiny elements, not all too small that their presence cannot be recognized with the naked eye, to be sure, but possessing a structure so fine that a clear understanding of it is completely impossible without a microscopic conception [*Anschauung*]" (Virchow 1958: 82 [1855: 17], trans. mod.). In short, the pathologist – and by extension the clinician – needs to acquire a professional *habitus* premised on the science of microscopy.

Virchow wanted to give science and medicine an idea of disease as an empirical and tangible object. The different visual representations of the same disease in the pathological laboratory and in the clinic allowed his concepts to transgress disciplinary and institutional boundaries. Thrombosis and cancerous tissues now occupied a shared space, rather than being sicknesses, which derived from abstract physiological deliberations; they functioned as what in STS discourse has become known as "boundary objects" (Star/Griesmer 1989). This point is important, since in the debates around biomedicine, the aligning of the cultures of science and medicine is regarded as a unique feature of medicine in the post-war era. Keating and Cambrosio (2003), for instance, have influentially called biomedicine

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students (Nyhart 1995: 84, Tuchman 1993: 57f., 76f.). But his approach was nonetheless physicalist, that is, not requiring students to 'think' microscopically, but rather in physical laws.

a "hybrid practice" of biology and medicine. Informed by "new entities and events", which have emerged with post-war molecular biology, biomedicine allows to coordinate knowledge and action of normal biology and pathology, without reducing the one to the other (Keating/Cambrosio 2004: 368, s. also 2003: 76). However, the objects identified by Virchow's pathologists were already simultaneously plastic enough to orient actions individually, both in medical science and practice, but also stable enough to suggest a common identity across the boundary of both institutions. As a result, pathological physiology presented the discipline of medicine as better oriented towards practical medicine and thereby justified its medical identity.

b. A Science of Therapy

As I illustrated above, the programs of Virchow's contemporaries still adhered to the Romantic image of the scientist as someone who is part of an elite and labors in solitude. Accordingly, their concern was with instilling the right cognitive and moral constitution in the student, which, by extension, would also qualify him as a physician (there were generally no woman doctors until the end of the nineteenth century). The protagonists of physiological medicine thought it sufficient, to infer the instructions for clinical actions from the natural laws governing organic life. In their ideological understanding of the scientific method, they believed clinical problems could be solved by sending practitioners into the clinic, who were scientifically educated, but ultimately had no way to assess the theories for their actions other than the crude means of trial and error.

Wunderlich published an article in 1845 titled "The relation of pathological medicine to medical practice" (*Das Verhältniss der physiologischen Medicin zur ärztlichen Praxis*), which made clear how his program still depended on the traditional image of the physician. It shows how he had no formalized concept for therapy other than the quasi-religious beliefs in the capabilities of a doctor and his natural sciences *Bildung*. After lengthy expositions about the different traditions and methods for diagnosis and medical theory-building, chemical analysis and physical examination, Wunderlich draws a preliminary conclusion: "Only after a thorough examination [*Erforschung*] of the objective facts [*Thatbestand*] has occurred, can we speak of considering the individual case theoretically, combining the elements found through analysis into a whole of inner relationships and connecting it to the causes" (Wunderlich 1845: 11). Immediately after,

he makes the strange remark that in many cases "this happens by itself". What does he mean? The answer follows in a climatic praise of the physiological physician, which could not have been phrased more emphatically by a true Romantic: "Only the physiological physician knows his task, only the physiological physician, endowed with the necessary knowledge and skills, is able to meet it: only he can know what his patient lacks, only he can judge a clinical case [*Krankheitsfall*], only he will be able to prescribe a rational therapy plan [*vernunftgemäß Heilplan*]" (ibid: 11f.).

Clearly, for Wunderlich everything in academic medicine centered on the scientific doctor and his enlightened spirit. From a scientific standpoint, however, this approach left therapy far behind. True, Virchow was similarly stressing personal and professional qualities with his insistence on the research culture of microscopy and cellular pathology. Later in his career, he would more emphatically emphasize the role of the natural sciences for moral education to counter the overwhelmingly material connotations associated with scientific progress (Schauz 2020: 223). But unlike his contemporaries, Virchow saw the scientific method not primarily as ideological. For him it meant more than sending people with the right cognitive and moral qualities to practice medicine. The method rather provided a practical rigor that could be extended beyond the laboratory to integrate it with the clinic (Benaroyo 1998). In this sense, it enabled a conceptualization of medical practice that was uniquely modern and adapted to the young aspiring industrial state (compared to Wunderlich's Romantic connotations) because it centered the idea of science on actual research practices.

After mid-century, reforms of higher education made science available to a broad spectrum of students and the general orientation of scientific training had shifted. While science was still an elitist pursuit during the Romantic Era, students in the second half of the nineteenth century underwent scientific training to acquire a mindset and skills that would enable them to actively partake in the industrial and economic growth of society. In the early century, only students who seemed promising for pursuing a career in the natural sciences received thorough laboratory training; now scientific methodology was presented as essential equipment for all professionals pursuing careers in the vastly expanding industrial society. As a result, an education in laboratory techniques became to be available equally to all the students enrolled into the course of medicine (Lenoir 1997: 98–104, see also Coleman 1988: 39f.). "Like computers today," Arleen Tuchman argues, "the scientific method in the nineteenth century provided an instrument for teaching school children and college students

not only specific skills but also a particular way of approaching, defining, tackling, and solving problems" (1993: 7). She, like others, considers the emergence of training in the methodology of the natural sciences on a broad scale around 1850 as "a tool for the democratization of medicine", since it allowed to replace "talent and intuition" with "routine methods" (ibid: 83, see also Hess 1993: 264).

Virchow adhered to this liberal idea of the scientific method as characterized by routine and instrumental aspects. In his essay on cellular pathology, he accordingly argued for a pragmatic understanding of science in medicine:

> "It does not matter at all whether someone is a professor of clinical medicine or of theoretical pathology, whether he is a practitioner or a hospital physician, if only he possesses material for observation. In addition, it is not of decisive significance whether he confronts an overwhelming or a modest amount of material, if only he understands how to exploit it" (Virchow 1958: 77 [1855: 11]).

This meant that the practitioner "must be in a position to put the right questions and to find the right methods for answering them", making practical use of scientific methodology wherever the questions demanded it (ibid.). This was already a clear rejection of the elitist Romantic ideal of the solitary and free scientist. The actions of practical medicine had to be assessed scientifically in the institution of the clinic and by whomever was practically capable to perform such a task.

Virchow's pragmatic understanding of the scientific method was connected to his liberal political views and it reflected in how he conceptualized the institution of the clinic. A more pragmatic understanding of scientific methodology will also come to play a significant part in early-twentieth-century discourses of scientific medicine in the United States, as I discuss in the next chapter. There, however, it was framed within a general ideology of social progress. The clear aim of Virchow's concept of scientific medicine, in contrast, was to heal patients, who in a large part derived from the working middle class. But again, there is need for qualification: the chief way Virchow saw that he could help patients was through *science*. To come to scientific pronouncements on therapy, it required to study disease in patients. Therefore, similar to Wunderlich, patients constituted a crucial research object. "Virchow's writing demonstrates why, for him, clinical findings and theories of disease were inseparable. In his view, patients were the source of knowledge just as they were the reason for its creation" (Otis 2007: 155).

The liberal political understanding extended also to the realm of academic professions and to the divisions of scientific work as such, which separates Virchow's pragmatism from his contemporaries' Romanticism-infused values. The scientific method was not confined to the natural sciences laboratory, nor was it the sole province of the natural scientist. Instead, it could be encountered just about everywhere where scientific issues were being pursued. For Virchow it was evident that "the practicing physician and the clinician", who in a sense constituted the hospital "working class", had unique access to the experience of diseases and their treatment. This fact had to be acknowledged by integrating these roles into the process of scientific study. As the clinical tradition of Schönlein had shown: "all the others, who do not stand by the sickbed, can at best annunciate points of view, perhaps direct the investigation, and keep a critical eye on the principles of therapy […]" (ibid: 56 [Virchow 1849: 22]). The institution of the clinic was crucial, in other words, because it allowed to scientifically observe the practice of medicine in action; how specific therapies worked in the case of certain pathological conditions, how the state of patients improved or worsened. "Only from this time on will therapy begin to develop like a natural science," Virchow claimed, "for all of the natural sciences begin with empirical observation" (ibid: 57 [Virchow 1849: 23]). In correspondence, the role of the clinician was stressed as that of a practitioner and researcher. Stated differently, the task of the clinician was to gather therapeutic data and evidence of medical treatments. This could be achieved by employing scientific methodology, using it, just as in the laboratory, to control the observations made in the clinic. Hence, Virchow saw that "appointment to a clinic is in our time such an immensely important task because the clinician of our days has to be not only a scientific practitioner," as the physiological proponents asserted, "but also a researcher, an observer" of clinical phenomena (Virchow 1847: 5).

What exactly did Virchow's pragmatic understanding of the scientific method entail? And how was it different from the ideological usage? Virchow chose his words carefully to avoid being grouped too closely with his main physiological opponents. He titled the programmatic essays that appeared thirty years apart, assessing the state of affairs in academic medicine from his respective viewpoints, "Standpoints in Scientific Medicine" (*Ueber die Standpunkte in der wissenschaftlichen Medicin*) (1847, 1877, see also Virchow 1958: 26–39, 142–150). But he also used the unabbreviated adjective *naturwissenschaftlich*, which signifies the modern English "scientific", throughout the running text of his essays (Virchow 1847: 6, 9, 15, 1849: 5,

7, 9, 23, 1855: 3, 11, 1877: 3, 6). Only the extensive methodological paper on therapy he called Scientific Method and Therapeutic Standpoints" (*Die naturwissenschaftliche Methode und die Standpunkte in der Therapie*), which had a different programmatic relevance (Virchow 1849, see also 1958: 40–66).

As Phillips shows, the use of "*naturwissenschaftlich*" was innocuous until about the 1830s, simply designating "something that had to do with knowledge about nature" (2012: 231). Accordingly, "*wissenschaftlich*" or "scientific" had the broader meaning of designating sound reasoning. But by mid-century, "*naturwissenschaftlich*" began to signify the particularity of the epistemology and method of the natural sciences, as opposed to the human sciences, and was used in a political fashion to separate the two camps ideologically. In other words, the designation "*naturwissenschaftlich*" pointed to the programs by Henle, Wunderlich and others from which Virchow distinguished his concept of scientific medicine in the 1840s and 1850s (they defined their programs as "exact sciences", as can be recalled). That Virchow did not call his program "*naturwissenschaftliche Medicin*", although he was making clear references to the method of the natural sciences in more than ten occasions of the small sample of texts, which I am discussing here, was because he was drawing a polemical demarcation between his and the physiological programs. He was referring to an idea of scientific methodology as sound and rigorous reasoning, which he had inherited from his teacher Johannes Müller.

My thesis is that Virchow employed the title "*wissenschaftliche Medicin*" (instead of "*naturwissenschaftliche Medicin*") as a nod to Müller to emphasize this point. Müller had used the term "scientific" still in its broader, harmless meaning, when he, after his appointment to the University of Berlin, began editing a journal in 1834, calling it the *Archiv für Anatomie, Physiologie und wissenschaftliche Medicin*.[57] Müller's position in the history of science and medicine is ambiguous, because as a representative of the first generation of beneficiaries of the new scientific discipline of medicine he is regarded as still a strong proponent of its Romantic inaugurators and of their philosophical interests (Lenoir 1997: 103f.). Despite differences in epistemologies (Virchow was highly critical of Romantic ideals, as I have demonstrated), I want to suggest, however, that Müller and Virchow were connected by sharing a similar institutional or disciplinary condition. Müller was simultaneously appointed to the medical and the philosophi-

57 Müller's journal stands in a tradition of scientific publishing that reaches back to Reil's *Archiv für Physiologie* established in 1796 (Lohff 1981: 33).

cal faculty as professor of physiology and anatomy (Lenoir 1997: 104). Virchow, as I already mentioned, was appointed to both the university and the Charité hospital. Müller oversaw an ill-defined academic discipline of "physiology". Though he saw himself primarily as an anatomist, his work spanned studies in human anatomy, animal physiology as well as medical science. The ambiguous constitution of his home discipline required that he create an overarching element around which his heterogeneous work could coalesce and be identified as belonging to a unified scientific discipline – for Müller this was the sound reasoning associated with the methodology of the natural sciences. Virchow's situation was similar in that he needed a way to overarchingly integrate the institution of the laboratory and the clinic as elements of the discipline of medical science. For this purpose, he took inspiration from Müller's strategy.

Müller was known for offering readers of his journal annual critical reviews of the published research conducted in his heterogeneous field. But he did not use it to expound a clear ideological program. Instead, these reviews contain Müller's practical understanding of scientific research. It was mostly contained within his critiques of how others in the field have pursued their work (Lohff 1981: 40–45). Nevertheless, in the first of his annual reviews, Müller was clear that applying "the exact method in empirical analysis of facts is the indispensable task of the natural researcher [*Naturforscher*]." Furthermore, the devising of hypotheses "should only have worth as an incentive for new empirical investigation; and one has to always remember that not the mere erecting of a theory but only the decision about its validity is the actual field of the empirical natural researcher" (Müller 1834: 2f.). In Virchow's words, it sounds like this: "Hypothesis is thus an essential part of scientific investigation, for it represents the thinking that must precede every rational action. […] The hypotheses and analogies in themselves have no value in scientific investigation except to the extent that they function as entering wedges for further investigation" (Virchow 1958: 33 [Virchow 1847: 12]).

Virchow adopted Müller's idea of scientific rigor and methodology and made it the overarching principle to integrate the different laboratory and clinical approaches into his concept of scientific medicine. Emphasizing its practical instead of its ideological side, Virchow saw that the method of the natural sciences would enable the introduction of what he called an "empirical standpoint" into scientific medicine. Applying it to medical practice allowed to scientifically assess the actions of clinical medicine, instead of, as the "so-called 'physiological school' of therapists" presupposed, only giving theoretical explanations of their therapies (Virchow 1958: 52

[Virchow 1849: 17]). In his text on the natural scientific method and therapy, Virchow therefore made a programmatic statement about what was actually required to work scientifically:

> "The scientific method [*naturwissenschaftliche Methode*] […] enables posing *scientific questions* [*naturwissenschaftliche Fragestellung*]. Everyone capable of properly posing such a question is a natural researcher [*Naturforscher*]. A scientific question is a logical hypothesis based on a known law, which moves forward with the aid of induction and analogy. *Experiment*, itself implicit in the question, gives the answer. […] Anyone who knows the facts and is capable of logical thought can compel Nature to answer an experimental question, provided that he [sic] has the *materials* necessary for performing the experiment. Natural research [*Naturforschung*] thus presupposes knowledge of the facts, logical thinking, and the appropriate materials" (Virchow 1958: 43f. [1849: 7f.], translation modified).

Consequently, the presupposition for actors of scientific medicine was not their allegiance to the physiological laboratory, but the mere ability to understand and employ the cornerstones of scientific research. Though his emphasis was on microscopy and cellular pathology, Virchow's concept nevertheless depended on a combination of practical and scientific approaches, held together by sound reasoning and pragmatic methodology. For the academic discipline of medicine this meant that medical science became open to research questions and subjects that transcended questions posed in experimental physiology or through physiological measurements. At the same time, making therapy the proper domain of scientific inquiry also altered the expectations associated with medical science: Just as scientific discoveries generally were seen to lay "the ultimate cornerstones for technical progress" (Schauuz/Lax 2018: 68), the promise in medicine now was that more and improved medical research would lead to progress in medical care, i.e., a foundation to tackle all forms and manifestations of sickness in the future with the right clinical means. This is why he believed that progress in science would lead to improvements in public health.

In 1877, Virchow remarked that it was no longer required "to write that scientific medicine is also the best foundation for medical practice" (1958: 149 [Virchow 1877: 9]). Its influence had become self-evident in a variety of practices in the system of academic medicine throughout the German Empire. The program of scientific medicine, as Virchow proposed it, adapted to the ideals of the emerging industrial state of Prussia. It took its bearings from the needs of the working class and also introduced a mod-

ern theory of scientific labor into medical science and clinical medicine. His concept furthermore recategorized the relationships within the academic discipline of medicine: as an applied science, medicine hinged on the theoretical foundations and empirical qualifications laid out by pathological physiology. As the name indicated, this science remained indebted to the physiological tradition of Müller, but it no longer functioned to ground medical practice in the way the physiologists proposed (via the epistemic and moral qualities of the scientific doctor trained in measuring bodily processes). As the foundational science for clinical medicine, scientific medicine prescribed a new – and decidedly modern – organization of practical medical knowledge, which outstripped that of its physiological peers, by providing a program to scientifically test and validate medical interventions in a combination of laboratory and clinical observation.