5. The Laboratory and the Making of Clinical Science during the Progressive Era – Scientific Medicine in the USA

The idea of scientific medicine took on a very different form in the North American context than it did in Germany. In this chapter I explain that, rather than constituting the program of an individual actor (like in Germany), US scientific medicine was driven by the aim to reshape the academic system. Between the late-nineteenth and the early-twentieth century, medical education in the USA underwent a significant transition. Aspiring doctors were mostly taught in unscientific and unacademic medical schools during the period immediately after the Civil War, from 1861 to 1865. These institutions had hardly any clinical and laboratory facilities; the faculty was part-time and composed of practicing physicians, who ran the schools for extra income. Fields such as physiology were taught as theoretical subjects and not as practical sciences; and the few individuals devoted to research did so privately – without any material or structural support from their institutions.[58] At the start of the twentieth century, in contrast, medical schools became university affiliated and the medical course began to stand up to academic standards. It included laboratory and clinical training and a full-time faculty responsible for teaching and research (in the natural sciences and later also in clinical fields).

The import of German academic culture into the United States played a crucial part in this remarkable transformation. But historians of American science point to how actors adapted the model of the German university to the American context in a highly selective and modified manner (Benson 1991: 60ff., Bonner 1990, 1995b: 292ff., Ludmerer 1996: 93f., see also Mattingly 2017: 255ff.). At any rate, American physicians had flocked to European medical centers throughout the nineteenth century to receive additional training in areas that schools in North America were unable to provide. They travelled across the Atlantic in the early decades, mainly to acquire expertise in clinical techniques and sciences, especially

58 Nevertheless, as John Harley Warner observes, "Medicine was widely acknowledged to be the best occupational choice for a man [sic] who wanted to pursue science in a society that afforded few opportunities to take it up as a profession, and physicians as a group were prominent among the cultivators of science." (1992: 128)

to Paris and Vienna. From the 1860s onward, they increasingly went to German cities to gather practical experiences in the renowned university laboratories (Harvey 1981: 3–30, Warner 1992, Weisz 2006: 72ff.). Some of the physicians who went to the German Empire in the latter part of the century adopted ideals that characterized the science of medicine in the country. They consequently returned as research-minded academics with a "scientific ideology" and views on medical education that "owed much to the example of the German university" (Bonner 1990: 18, see also Maulitz 1979: 92). They now formed the elite of scientists and university administrators that subsequently campaigned to establish features of that research system in US institutions of medical education.

The concept of "scientific medicine" began to emerge as a dominant category in academic and medical discourses in the period in which American physicians were returning from their stays at German universities. It thus is tempting to understand the vocabulary as merely a part of the cultural import. But just as it is too simple to assume that, prior to World War I, US scientists and engineers, for lack of original concepts of science or research, "merely adopted European semantics" (Kaldewey/Schauz 2018: 105), it would also be precipitous to regard the term only as an English-language rendering of the German version. Even though important inspirations were coming from academic medicine in Germany, the cultural understanding of scientific medicine in the United States and its German equivalent varied considerably:

First, in Germany, as I showed, scientific medicine proceeded as a movement within medical academia, whereas in the USA it was a movement to, first, create genuine academic medical institutions. The German term signaled an episode of cultural conflict over the established elite's proper definition of medicine; the American medical elite, in contrast, employed the category with the aim of establishing their scientific interests as an institutional reality in their home country. Therefore, second, while the German term *wissenschaftliche Medicin* connoted the specific program of medicine as an applied science (founded on the independent science of pathology), scientific medicine in the United States functioned more in the sense of Harris's supercategory: It incorporated a broad array of activities and subfields, ranging from pure to applied sciences across to clinical investigation. This more general meaning of "scientific medicine" formed the background to Anglo-American social historians' retroactive portrayals of German academic medicine, although, arguably, it was primarily meant as a program that distinguished itself from the prevailing pure science programs of physiology. They have thereby applied it to include such

opposing programs as Wunderlich's and his allies' physiological medicine and Virchow's program (e.g., Lenoir 1997, Tuchman 1993). Crucially, though, while scientific medicine had one clearly defined meaning in the German university, its counterpart in the Unites States, as I demonstrate below, harbored two largely distinct notions, namely, (1) that of the "basic" medical laboratory sciences and (2) that of clinical science.

The American medical profession saw two separate disciplines emerge under the name of scientific medicine at the end of the nineteenth and the start of the twentieth century. Scholars have thoroughly investigated how the American medical elite inspired by the German university and its medical training campaigned to have their ideals of science and laboratory investigation installed into the domestic system (Bonner 1990, 1995b, Fye 1987, Ludmerer 1996, see also Kohler 1982: 121–157). Hence, I here concentrate on how, in comparison, the idea of *clinical science* was defined, and on how its disciplinary identity was institutionalized in the USA. From a diachronic perspective, this model is still visible as the clinical culture in much of the Western hemisphere, i.e., in the large research hospitals that harbor facilities for treating patients and performing medical research (Keating/Cambrosio 2003).

Semantic evidence for this disciplinary differentiation can be drawn from the appearance of the term "preclinical" with the prefix "pre" in the 1910s, used to designate the laboratory sciences in contradistinction to clinical science. The label indicated, in the words of Lewellys Barker, physician-in-chief at Johns Hopkins, that "the time has passed when the work of the clinics could be regarded as something that is not scientific – as something merely practical or technical to be sharply distinguished from the 'theoretical' or 'scientific' work of the preclinical sciences" (1916: 632). The notions of preclinical and clinical science nevertheless overlapped in their core scientific values, as I will show. With the words of Becher and Trowler, I claim that they were of the same tribe, but that they settled on different territories, that is, they differed in their conception and orientation. Preclinical and clinical sciences shared the ideal of the scientific method, although in the American academic discourse this meant something different than in the vocabulary employed in Germany. The aim in the United States was to create a new clinical science that adhered to the experimental ideals of the laboratory. Ultimately, this new science was founded on a new institution. As such, clinical science could now be performed through inputs from their own clinical laboratories, which had acquired important administrative and service functions in large hospitals by 1920. "The main function of these laboratories", as Kohler notes,

"was to provide routine laboratory tests for diagnosis or therapy, but the professional staffs were also expected to cooperate with the clinical staffs, to instruct interns and medical students in advanced analytical procedures and to do research" (1982: 231).

How can it be explained that, unlike in Germany, where the category *scientific medicine* entailed the integration of the clinic and lab, scientific medicine in the US context meant the formation of an independent discipline of clinical science next to the medical laboratory sciences? The general answer is that the ideals of science had to be accommodated to the dominant orientation on practice that characterized medicine and society in the nineteenth-century United States. American physicians "agreed that practice, not the possession of or access to special knowledge, was in the final analysis the source of the medical practitioner's authority and identity" (Warner 1992: 125, see also Warner 1986). Consequently, arguments for founding medicine on science needed a legitimation that pointed to its usefulness for practical medicine, while in Germany, in contrast, medicine was defined in terms of knowledge basis and academic credentials. Though the German medical elite was split internally over questions of whether the proper scientific basis for medicine should derive from laws of organic nature explored in laboratories or from the practical experience physicians collected through empirical observation in the clinics, they did not call into question the academic status of medicine. University affiliation provided German medicine with authority, whereas the situation in the US proved to be more complicated.

Historians of American medicine warn their readers about the need to be careful not to understand the profession as too monolithic when looking at scientific medicine in the US (Ludmerer 1996: 118f., Warner 1995: 178f., see also Weisz 2006: 74f.). Different to Germany, the academic physician and the ordinary practitioner here belonged to different communities. "The clinical professor in Germany was primarily an academic man," Bonner observes, "whereas the American teacher-practitioner was firmly rooted among the patients in the home soil of the city where he lived" (Bonner 1995b: 284, see also Harvey 1981: 133). Consequently, the academic doctor and the routine practitioner had different reasons for adopting the ideals of scientific medicine: first-row advocates "saw the greater infusion of experimental science into American medicine as a vehicle for scientific career making" and progressive medical practitioners viewed science "as a vehicle for augmenting cultural authority and income" (Warner 1995: 179).

The strategy of academic actors in the US to institutionalize the medical laboratory sciences as a primary form of occupation superficially resem-

bled that of their German counterparts. It involved advocating for the methods of the natural sciences as a requirement for medical training. But whereas German actors claimed that training in the scientific method enabled doctors to behave like a scientist at the bedside, the reasoning in the Progressive Era differed slightly but significantly. The argument was that training in the methods of the natural sciences was appropriate for both the scientist *and* physician, because essentially the practice of science and clinical medicine were the same, just applied to different objects (Flexner 1910). In the last decade of the nineteenth century, it was accepted that the concept of scientific medicine entailed the idea of practical medicine as an applied science based on the laboratory sciences (this, in a sense, resembles the false friend understanding, which I mentioned in the previous chapter [Davis 1891, see also Warner 1991, 1986: 235–283]). Not even two decades later, however, actors called for a "pure science" of clinical medicine, that is, for basing clinical medicine on an independent institution of clinical science, distinguished from the pure laboratory sciences on the one side and the obligations of medical practice on the other (Meltzer 1909, see also Harvey 1981: 112–126). Clinical scientists shared the values of pure science. But instead of aiming at furthering the theoretical (biological) knowledge of medicine, like their counterparts in Germany, they strove to improve medical practice with the aid of modern science. As a result, while scientific medicine in Germany was just one name among several, the American equivalent was more encompassing since it entailed the institutionalization of science for the equal furthering of both medical theory and clinical practice.

In the following, I will reconstruct how the category of scientific medicine in the US absorbed the medical profession's existing structural preferences for practice and together with the ideals imported from Germany transformed them into two distinct disciplinary identities of academic medicine. I want to argue that the separation into different institutions, due to their different orientations to practice and science, also prepared the later transformation of medical science into biomedicine. Adopting central concepts of German laboratory science to the medical discourse of the Progressive Era made them lose most of their restrictive and elitist German undertones. Consequently, these concepts provided more of a general framework of values in which the laboratory sciences and the clinical science of American scientific medicine were able to develop their individual cultural characteristics and identities. At the same time, however, the two scientific cultures arrived at somewhat crossed relations with each other. Different from Germany, where scientific medicine

meant an applied science that maintained connections to the clinic, the establishment of independent clinical laboratories as auxiliaries to clinical science paradoxically caused the conceptual separation of the institution of the clinic from that of the medical laboratory sciences.[59] As a consequence, this left the latter sciences with merely a rhetorical link to clinical medicine. From this point, these sciences have been devoted to research issues that became increasingly indistinguishable in their biological and/or medical trajectories. As I demonstrate in the next chapter, institutions nominally "medical", such as university medical schools or the National Institutes of Health, became entrusted with furthering research that factually belonged to the basic biological sciences. By the end of World War II, this led to an ambiguous situation of research jurisdiction and of funding in biology and medicine, necessitating a new categorization (Appel 2000). The basis for this unclear situation, which is addressed later in this chapter, derived from the inability to define academic biology in the US before the twentieth century and the resulting imbrication of biological and medical cultures.

I. German Ideals of Academic Medicine in the American Discourse

To understand how the disciplinary structures of biomedicine were prearranged in the making of academic medicine, I unfurl the emergence of the idea of scientific medicine in the US. How did it come to comprise two independent medical disciplines – that of clinical science and the preclinical sciences? These two evolved in succession, not in parallel, which is owed to the fact that the scientific ideals of the medical laboratory, in a sense, subsequently began to rub off onto practically oriented actors through their education in the new methods. To make sense of this development, I trace how medical actors inspired by German science introduced academic ideals, like the "commitment to the full-time system, the experimental method, and the research ethic" (Fye 1987: 207), into the American discourse. Nevertheless, I will highlight how they were transformed into having a specifically North American meaning.

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59 Such a separation was, of course, not absolute since clinical science continued to draw on laboratory practices and knowledge. But the emergence of clinical laboratories was also accompanied by the development of a culture specific to these places and distinct from that of the medical research laboratory (Kohler 1981: 237–243, Reiser 1979: 139ff.).

Bonner analyzed how the didactic ideals that American physicians brought back from their visits to Germany differed from the original, although they tirelessly "proselytized the strengths of the German system" – high overall standards, the pursuit of original research work, academic freedom, the "unity of research and teaching", highly specialized fields and the appropriate research facilities headed by prestigious scientists (1990: 19, see also Bonner 1995a: 292ff.). At the same time, however, American reformers withheld important aspects that defined medical education at German universities. They regarded them as undesirable or unsuitable for the American context, "notably the research-oriented institute, the private teacher or *dozent*, the great power of the professor, and the freedom of students to select their own courses" (Bonner 1995a: 292). Academic medicine in Germany was characterized by a two-tier system. The great mass of undergraduates was only minimally exposed to the workings of the laboratory or the clinic, while advanced students received personal laboratory experience and facetime with professors.[60] "Lectures", therefore, as Bonner notes, "remained a principal and dominant medium of teaching medicine [in Germany]" (1990: 20). Accordingly, a clear separation of laboratory research and advanced training "from undergraduate teaching in crowded lecture halls, clinics, and laboratories" existed (ibid: 30). The medical education that was established in the US, in contrast, was infused with democratic or egalitarian values, making "a good medical education" the standard for all students, "in contrast to Europe, where the best training was reserved for the elite" (Ludmerer 1996: 94, see also Bonner 1990: 31). Clinical experience, for example, played a greater role in the education of physicians in the US after 1870 than it did in Germany. More importantly, though, in the medical institutions that the American elite intended for their home country, undergraduate students also received the kind of extensive laboratory training reserved only for advanced students in nineteenth-century Germany. According to Bonner, the "fragile university medical schools of the late nineteenth century" in the US did not allow to distinguish between "normal teaching and advanced work" (1990: 26).

This difference in national style can be explained with the high regard for praxis that prevailed in the medical world of the US (Warner 1986). While German professors could allow themselves to introduce scientific ideals into medical training to further the academic quality of medical students, their American peers needed to dress these ideals up as improve-

60 I noted in the previous chapter that eminent scientists like Hermann von Helmholtz refrained from their duties in medical education.

ments of graduates' practical proficiencies. Consequently, one key concept of medical education in Germany – the scientific method – acquired a meaning mostly devoid of its more restrictive and elitist connotations in the New World. In Germany, as argued above, ideology drew a clear line between the laboratory and the clinic. Apart from protagonists like Virchow, who employed the idea of scientific methodology with a practical aim in mind, German scientists introduced the scientific method as a pedagogical ideal primarily to foster recruitment into medical research.

No such ideological distinction between clinical and preclinical sciences existed in the US Here, more generally, rationales to justify the pure science ideal "gradually shifted […] towards utilitarian arguments" (Kaldewey/Schauz 2018: 115). In medicine specifically, it required adapting the idea of the scientific method to a practically oriented climate and framing it straightforwardly as a means to improve medical care. The employed strategy accordingly dropped the categorical distinction between work done in the laboratory and in the clinic. To illustrate in detail how the strategy of equating the mental capacities of the researcher and those of the medical practitioner worked, I refer to the single most important document associated with medical reform in the US – the Carnegie Foundation's Bulletin Number Four, *Medical Education in the United States and Canada*, compiled by the educational reformer Abraham Flexner and published in 1910.

The so-called Flexner Report is a scathing critique of the system of American medical education at the turn of the century. The report is reminiscent of the muckraking literature that was popular during the Progressive Era, in which authors exposed the corruption inherent in established institutions of American society. Abraham Flexner visited all medical schools in the US and Canada to examine their entrance requirements, training of the faculty and quality teaching facilities, financial resources and access to hospitals. The inquiry had damning results (Flexner 1910: 27–51). Of the over one hundred and fifty existing schools, he recommended that the vast majority ought to be shut down due to their poor quality. He saw that that they were graduating a too large number of doctors of a far too disparate quality. Only a few schools could in his opinion boast the appropriate academic standards – for which the Johns Hopkins Medical School, opened in 1893, stood as the shining example (Flexner 1910: 12). Flexner was an advocate of removing medical education from the control of practitioners and placing it under the surveillance of the university system. He designed a four-year medical curriculum as a model for this purpose, divided equally between training in the preclinical and clinical

sciences, complete with the requirement of full-time faculty in both fields, which illustrated his educational ideal.

The history, context and implications of the Flexner Report for medicine haven been thoroughly researched and it is beyond the scope of my book to recite these works here (see e.g., Berliner 1985, Ludmerer 1996: 166–190, Mattingly 2017: 218f. McClelland 2013, Wheatley 1989). Generally, the text can be said to be a public document that is rare in having "had such a deep impact on any cultural activity" in the US and around the globe (McClelland 2013). It is interesting for my argument precisely because of what historian of medicine Kenneth Ludmerer called its "galvanizing effect on public sentiment" (1996: 167). It acts as an example of the accepted language and concepts to talk and write about science and medicine, propagated by the elite of academic physicians since the 1870s. The report uses the term "scientific medicine" only sporadically but definingly (Flexner 1910: 9, 53, 157, 158, 162). This may indicate that the term had become a common category in the academic discourse at the time of the report's publication and had little need for explication.[61] According to Ludmerer, the term scientific medicine meant two things for Flexner: first of all, it meant the acceptance of physics, chemistry and biology as "the intellectual foundation of modern medicine" (1996: 174). Secondly, it was the realization of the "scientific method applied to practice as well as research" (ibid.).

Flexner gives a lengthy elaboration of why the method underlying sciences like physics, chemistry or biology is "just as applicable to practice as to research" (1910: 53). According to Ludmerer, "Flexner abhorred the 'rule-of-thumb' practitioner", who oriented his/her[62] actions according to protocol and not by his/her own critical thought (1996: 175). Like proponents of the pure science ideal, who viewed the products of science as a foundation for the practical application of knowledge in engineering and other areas (Kaldewey/Schauz 2018: 117), Flexner thus saw that science would help structure the practical aspects of medicine. He accordingly explained that, at the basis, the professional actions of the researcher and

61 The report, furthermore, refers to "pre-medical" instead of 'preclinical' "sciences", "work", or "courses" (Flexner 1910: 30, 33, 43, 47, 71, 77, 78, 83, 210, 211, 212).

62 Although women were not formally restricted from medical education, and medical schools specifically for women were established in the nineteenth century, the existing cultural climate in many places of the United States nevertheless still prohibited that women receive academic medical training.

the medical practitioner were essentially the same and could be structured using the scientific method:

> "And just as it makes no difference to science whether usable data be obtained from a slide beneath a microscope or from a sick man stretched out on a cot, so the precise nature of the act or experiment is immaterial: it matters not in the slightest, from the standpoint of scientific logic, whether the step take the form of administering a dose of calomel, operating for appendicitis, or stimulating a particular convolution of a frog's brain with an electric current. The logical position is in all three cases identical" (Flexner 1910: 92).

Flexner argued at length that both scientist and doctor work with theories or hypotheses, which is in the case of medical practice "called a diagnosis"; that both are "confronted with a definite situation", which the scientist observes for "taking all the facts", whereas for the physician the "patient's history, conditions, symptoms, form his data"; for both, this "suggests a line of action" (Flexner ibid: 55). And just in the way that the researcher's mind "flies like a shuttle" between theory and fact, allowing him to "understand, relate, and control phenomena", so the competency of the medical practitioner is determined by the "ability to heed the response which nature thus makes to his ministrations" (ibid.). Flexner is tireless to repeat that the "practicing physician and the 'theoretical' scientist are thus engaged in doing the same sort of thing" (ibid: 92); "They employ the same method, the same sort of intelligence" (ibid: 56); "Investigation and practice are thus one in spirit, method, and object" (ibid.); "The progress of science and the scientific or intelligent practice of medicine employ, therefore, exactly the same technique" (ibid: 55, see also Weisz 2006: 128).[63]

The dogmatic insistence on the sameness of the intellectual properties grounding the scientist's and physician's actions is, of course, an exaggeration. Experiment serves as a pedagogical tool in medical training through which the physician's "powers of observation" are fostered to allow a perception of disease in adequate detail (ibid.). "In each a supposition, – whether expressed or implied, whether called theory or diagnosis, – based on supposedly adequate observation, submits itself to the test of an

63 Flexner does, however, concede that if "we differentiate investigator and practitioner, it is because in the former case action is leisurely and indirect, in the latter case, immediate and anxious." Nevertheless, "the mental qualities involved are the same." (1910: 56)

experiment" (ibid: 92). But it is questionable whether it is really flattering to the practicing physician to have his/her actions compared to that of an experiment. From a sociological perspective, important structural differences underlie the actions of modern scientists and physicians. While the one, for example, downright embraces uncertainty, the other risks losing his/her professional authority over its disclosure in the interaction with a patient. In other words, while the open communication of still uncertain knowledge is a central feature of scientific practice and progress, the medical practitioner must necessarily conceal the uncertainty underlying his/her actions, and compensate it with subjective factors, to maintain the trust of his/her patient (Stichweh 1994a: 296f.). The fact downplayed by Flexner is that in the "twilight region" between knowledge and uncertainty about the nature of disease "the physician may indeed only surmise", although he is fully aware of the fact of only surmising (ibid: 55). This is, however, one of the crucial factors constituting the difference between science and a practical profession – one that differentiates experiment and the operations of diagnosis and therapy.

Be that as it may, in the American context, "with its emphasis on the clinical branches at the expense of the scientific subjects" (Fye 1987: 107), eliminating the conceptual boundary between the actions of the scientific and practical professions in medicine was required in order to justify the large-scale establishment of facilities for research and training in science. These were foundational for institutional arrangements that would ensure recruitment of students endowed with the proper cultural repertoire into the new occupation of medical science. The removal of the conceptual difference between scientific and medical practice has also contributed to the bias evident in sociological and historical literature today. Conflating the idea of both practices resulted in the creation of an identity for medicine as a professional practice, which is at the same time scientific, instead of viewing it as a profession next to that of a scientific discipline.

The underlying rationale employed by medical actors in the US towards the end of the nineteenth century was similar to that used by their German counterparts more than two generations earlier: only a direct exposure to the phenomena of nature, rather than relaying them through lectures or textbooks, would allow the student to develop the mental qualities necessary to pursue either a scientific or practical profession in medicine (Bonner 1995a: 236ff.). "What helps" the student of medicine, according to Barker, "is less the facts which he learns, or the memory of the experiments he makes, than the establishment in him of the conception that in order really to understand it is necessary to come into direct personal contact

with the object to be understood" (1908: 607, see also Flexner 1910: 53). Like the German reformers, they stressed that working with the methods of scientific investigation in the laboratory would provide a training of the senses unmatched by mere recitation (Harvey 1981: 34, Ludmerer 1996: 65).

There was a slight but crucial difference between the two national cultures, however. The German argument read that such a training would primarily foster intellectual and moral capabilities from which appropriate instructions for action could then derive naturally. It was directed at the academic who, as a well and comprehensively educated person, would automatically know how to act. The American idea, in turn, was more pragmatic in the literal sense; in that the priority for action was the reason for acquiring the theoretical equipment since it taught one how to approach a problem practically. Ludmerer accordingly argues that the concept of "progressive education" of the early elite of medical scientists in the US was identical to that popularized by the philosopher John Dewey at the start of the twentieth century and interlaced into Flexner's report (1996: 63–71, 176, see also Flexner 1910: 68 n.2).

The egalitarian understanding at the heart of the scientific method in the US did not only eliminate the strict boundary between the scientific and practical occupations of medicine, but it also linked the concept of scientific medicine to the idea of social progress characteristic of pragmatism. For Dewey, just as for the actors in medical science, the prevailing ideology was that the same "scientific habit of mind" or "scientific habit of thought" applied to not only the activity of research, but to virtually all circumstances of modern everyday life – including patient care (Dewey 1910: 126, Barker 1908: 607, Flexner 1910: 157, see also Ludmerer 1996: 67). In a lecture given to the American Association for the Advancement of Science at the start of the twentieth century, Dewey explained that science was not defined by its subject matter, but that it rather constituted "a mode of intelligent practice, an [sic] habitual disposition of mind" (ibid: 125). Its value lay therefore less in its content but in its procedures, in "the knowledge of the ways by which anything is entitled to be called knowledge" (ibid.). Knowledge of the methods of scientific inquiry were accordingly more than just the benchmark of a small scientific elite:

> "Scientific method is not just a method which it has been found profitable to pursue in this or that abstruse subject for purely technical reasons. It represents the only method of thinking that has proved fruitful in any subject – that is what we mean when we call it scientific. It is not a peculiar development of thinking for highly specialized ends; it

> is thinking so far as thought has become conscious of its proper ends and of the equipment indispensable for success in their pursuit" (ibid: 127).

The crucial aspect of scientific thinking, which a training in the method enabled, was for Dewey therefore the cultivation of a critical disposition in the mind of the modern individual. Science and its method were not only for "highly specialized ends" – this also meant that it represented a way of thinking equally applicable to medical matters. In his book *How We Think*, published in 1910, he contrasts the scientific method with what he calls the empirical method. The latter is characterized by the construction of general facts from the indiscriminate association of observations with each other. It thus enforces established customs and beliefs through the perception of ostensibly similar cases (Dewey 1997: 145–149). Thinking scientifically with the aid of the scientific method, in contrast, allows for innovation in knowledge and behavior to occur, because of its change in attitude from the simple dependence on "routine and custom" to the "intelligent regulation of existing conditions". While the empirical method is characterized by passivity, since it must rely on cases being presented to the individual to be realized, science employs the experimental method, which is characterized by the ability to actively vary the conditions of observation (ibid: 151). "The empirical method inevitably magnifies the influences of the past; the experimental method throws into relief the possibilities of the future" (ibid: 154). The use of the scientific method as an ideal for medical training in the US, therefore, did not only imply a more democratic understanding of academic medicine compared to Germany, but it also infused ideals of science into the institutions of laboratory and clinical research, amongst which progressing the scientific knowledge of medicine was a central goal.

II. From Applied Science to the Pure Science of Clinical Medicine

The conceptual shift from medical practice as an applied science of the laboratory to being founded on the independent discipline of clinical science is an example of the institutional ramifications of the Progressive Era understanding of medical education in the United States. The idea of medicine as an applied science, as pointed out, developed in Germany as the result of basing medicine on the method of the natural sciences laboratory as opposed to the rigorous empiricism of clinical medicine. According to historian of medicine John Harley Warner, the development

of a program of "applied medical science" in the US also resulted from efforts to oppose the empirical approach to clinical practice (1991: 461, see also Warner 1986: 247ff.). The crucial difference, however, was that in Germany the conflict between the scientific ideals of the laboratory and the empiricism of the clinic was about defining the proper basis of academic medicine. In the US, in contrast, it revolved around establishing the basis for professional practice, namely, a "science of therapeutics" for medical practitioners (Warner 1986: 247). The "science" of empiricism ruled in American medicine from the early decades of the nineteenth century to the end of the Civil War. Physicians trained in Europe had imported it especially from the Clinical School tradition of the Paris hospitals. After the 1860s, the approach was deemed unable to support a truly scientific basis for therapeutics.[64] At this point, instead, "making therapeutics more rational by basing it on laboratory experimentation meant making it more scientific" (ibid: 248).

In 1891, the eminent physician and charter member of the American Medical Association, Nathan Smith Davis, gave a lecture in Chicago titled "The Basis of Scientific Medicine and the Proper Methods of Investigation". The talk was an indication of the successful introduction of the laboratory sciences into medicine in the US. However, it still referred to the dominance of the medical laboratory for practice and did not yet imply the idea of a separate clinical science. Although his conception of scientific medicine differs somewhat from the movement of "physiological therapeutics", which Warner describes as part of American medicine in the second half of the nineteenth century (1984: 235–257, see also Warner 1991), the core rationale of both was very similar. Davis remarked only the need to substitute "the word *pathology* for physiology", arguing that "Therapeutics relates to the application of remedies for the control, not of healthy or physiological processes, but of morbid or pathological condi-

64 The Paris Clinical School at the end of the eighteenth century has entered the annals of medicine for relating empirical observations in the clinic with insights from dissections at the end of the eighteenth century. Michel Foucault (1976) has famously suggested that this resulted in a general change in medical epistemology. The main argument is that the systematic use of clinical observation, including physical methods of diagnosis, and the practice of pathological anatomy henceforth enabled physicians to "see" disease and how it was located inside the patient's body. This moved the idea of sickness from premodern understandings and abstract ideas to a concept of disease that centered on disturbances in the human body itself, like anatomical lesions.

tions, and is consequently applied pathology" (1891: 115).[65] He conceded, however, that physiology was the basis for a science of pathology. Thus, according to Davis' categorization of scientific medicine,

> "the great fields of natural and physical sciences known as anatomy, histology, physiology, pathology, medical chemistry and materia medica, constitute the acknowledged basis of modern medicine; while therapeutics or practical medicine, surgery, and sanitation or preventive medicine, are strictly applied sciences developed by the same methods of observation, experimentation and induction that have brought into existence all other inductive sciences" (ibid.).

It is worth noting that Davis calls medical disciplines "great fields of natural and physical sciences" to make their common heritage and conception unmistakable. However, the "same method" in Davis' remarks did not so much refer to the same education of the scientific and clinical practitioner – this was only slowly starting to become an established fact among the academic medical elite at the time of Davis' lecture (Fye 1987: 206ff.). Instead, it referred to the use of the same procedures and techniques – and implied even the same facilities – to investigate both the basis of modern medicine and ways to improve clinical practice. Davis was very much in line with the physiological protagonists of mid-nineteenth-century Germany. The practitioner was to receive an exact orientation on how to treat a patient via study of normal and abnormal phenomena and of the effects of drugs in the laboratory (Warner 1986: 250f.). "Therapeutics was to be advanced", Warner notes, "by reasoning from the laboratory to the bedside" (ibid: 246). A common comparison used to emphasize the relation between laboratory science and clinical action, therefore, was that between mathematics and engineering, "implying that the reasoning called for in the treatment of disease was mechanical and almost automatic" (Warner 1991: 458, see also Davis 1891: 115). It was meant to emphasize an ideal of exactness and precision that would supposedly characterize therapeutics based on the ideals and finding of the laboratory sciences.

From the early twentieth century onward, it no longer sufficed for clinicians in the US to apply the knowledge of the medical science departments to practical medicine. In 1909, at the first meeting of the new Association

65 The semblance with Virchow's program seems striking. But it needs to be remembered that his program entailed the integration of clinic and laboratory as equals. Davis, as will become obvious, was implying more the sort of reasoning characteristic of the program of physiological medicine in Germany.

for Clinical Research, for example, physician and physiologist Samuel Meltzer advocated for establishing clinical medicine as a genuine and autonomous science. Four years later, in 1913, the physician-in-chief at Johns Hopkins was calling for establishing the according facilities for such a science – namely, research laboratories adjacent to clinics in hospitals. Germany witnessed similar ambitions toward the end of the nineteenth century. But here clinical medicine was construed in demarcation from the laboratory sciences. With the takeover of the medical curriculum by the natural sciences, clinicians had (again) begun to react with criticism toward the close of the nineteenth century (Bonner 1995a: 269–274, see also Bleker 1987/88). The techniques of the laboratory (especially in the wake of bacteriology) increasingly allowed a sole reliance on animal experiment for studying disease, causing a separation of medical science from the clinical object of study, i.e., the human subject. Clinical researchers-teachers, in turn, felt threatened in their professional identity and reemphasized the importance of practical clinical experience for medical students. According to historian Russell Maulitz, in this context, "German physicians seized on two basic tools": on the one hand, they revived the nosographical tradition of their predecessors, "the classification and description of disease in the older, natural-historical mode"; on the other, clinicians reacted with "their own technological innovations", with bed-side methods "to permit observation of previously unexplored body orifices" (1979: 95). Similar to developments earlier in the century, German clinical medicine thus defined itself methodologically in contradistinction to the method of the laboratory sciences. The establishment of laboratories in clinical institutes therefore merely meant that the natural sciences were serving as auxiliaries (Bleker 1987/88: 43).

The category of clinical medicine as a pure science, which Meltzer introduced and Barker indirectly adopted, did not necessarily oppose the idea of practical medicine as an applied science. Instead, it argued for placing clinical practice on an autonomous scientific basis separate from the department of the medical laboratory sciences. In a sense, this move was a direct reference to the idea of scientific medicine introduced by Virchow after the mid-nineteenth century in Germany. It was designed to provide a new institutional basis for practical medicine, just as Virchow had designed a new basis with the science of pathology. "I am of the opinion", Meltzer stated, "that clinical medicine as it exists now is made up of two constituents: one part has all the elements of a pure science and ought to be coordinate to the other pure sciences of medicine, and the other part is the real practice of medicine, an applied science which

has many elements of an art" (1909: 508). The concept of "pure science", as it was floated at the turn of the century, employed two contradictory meanings that actors could appropriate. It served as "a distinct activity separate from technology and commerce" or as foundational to the realms of applied science and technology (Kaldewey/Schauz 2018: 115). The main reason to employ the category of pure science here was to argue for the academic status of clinical science and for its institutional independence from practical medicine, since currently the subject was still taught mostly by active physicians "who devote most of their time and energies to their practice and to the golden fruit it bears" (Meltzer 1909: 510).

Barker's reasoning led to the same result, although it pursued a different route. To him, "all the sciences, with the possible exception of mathematics, are largely 'applied sciences'" (1913: 732). Internal medicine, the main province of clinical medicine, "is, of all the biological sciences, the one to which the largest number of other sciences contribute facts for application" (ibid.). Accordingly, he endowed the science of clinical medicine with qualities of a pure science, arguing that even as an applied science it had to grow in its own way and required its own professional actors to do so: "each science is creative and has to devise methods of its own; even when a new fact in a science basal to it is applicable, the application actually has to be made" (ibid.). The point of both Barker and Meltzer was to underline that the growth of medical knowledge coming from the laboratories did not automatically equal a growth in knowledge for practical medicine. Thus, only if clinical medicine was treated as an independent science, equipped with the according features (and not simply as the endpoint of laboratory research), would it advance in a similar fashion to the other medical sciences. "Clinical science will not thrive through chance investigations by friendly neighbors from the adjoining practical and scientific domains", Meltzer argued (1909: 509); and for Barker it was a still common misunderstanding "that the laboratories of the non-clinical sciences can be called upon to do the laboratory work of clinical science" (1913: 735).

Working from a background in which a new generation of physicians had just been extensively trained in the new methods and techniques of the laboratory sciences, the advocates of clinical science in the US did not want to oppose this foundation of medicine. In Germany, scientific medicine and clinical medicine were distinguished methodologically. But in the US the demarcation was drawn less based on the methods applied than on the subjects they were applied to. Physiology and anatomy provided knowledge of normal structures and processes, pathology that of

abnormal changes in the body. "To clinical medicine is left", Meltzer accordingly concluded, "the study of the phenomena and their sequence as they occur in a living body during the entire course of a disease" (1909: 508). Observational methods played a key role in defining the practice and research of clinical medicine in Germany, but American clinicians embraced the methods of the experimental laboratory sciences for promoting their cause. Although Meltzer defines "the domain of clinical research" as "the study of the natural history of disease, their physiology and their pharmacology", he brings it in proximity not to the methods characteristic of German clinical medicine but to the "experimental methods" of the "pure sciences" (ibid: 509). It was widely accepted in the American academic discourse at the start of the twentieth century that the methods of the experiment were applicable to the study of disease and therapeutics. Leading research in the fields of internal medicine, paediatrics, surgery and gynaecology was no longer simply understood in terms of describing disease manifestations in the clinic. "Rather, research in these fields, like research in the basic sciences, had become laboratory-based" (Ludmerer 1996: 208f., see also Flexner 1910: 101f.).

The professional qualities and *habitus* of the individuals pursuing research in clinical science, at first sight, thus differed little from those pursuing "pure" lab research. According to Meltzer, they should not simply be trained in "other sciences of medicine" but should in fact have done "investigations in one or more of these pure sciences" to be acquainted with "careful scientific method and imbued with a scientific spirit"; they should "acquire the habitus and the taste of the investigator, the scientist, which may stick with them for life" (1909: 509). They were thus clearly of the same academic tribe as the preclinical scientists. For Barker, the objects of clinical research needed to be "intellectualized partly by accurate training in the most recent clinical technique, partly by the previous education in the methods, facts and hypothesis of the non-clinical sciences" (1913: 734). Most importantly, though, the new clinical scientists, using Becher's and Trowler's terms, occupied a different territory than the preclinical scientists. They had to "select clinical research as the main field of their scientific activity", applying the scientific spirit acquired through medical education to the furthering and cultivation of knowledge specific to the field of clinical science (Meltzer 1909: 509).

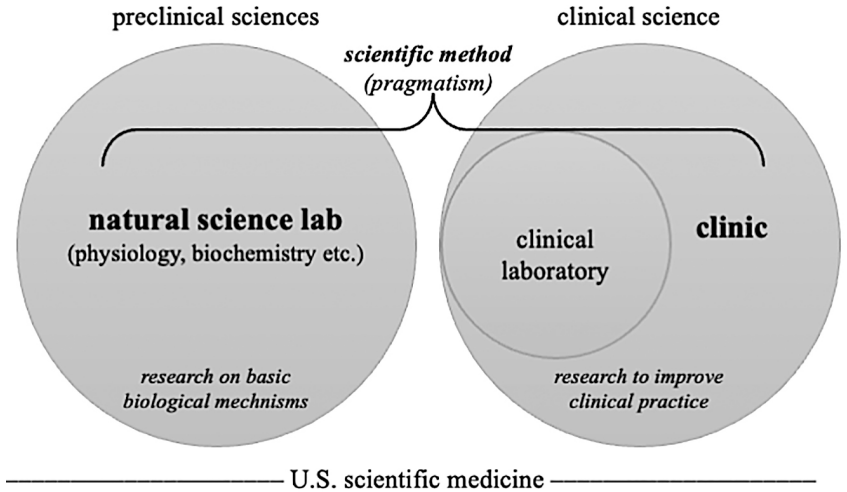

Figure 5.1: Schema of the structural relationship between preclinical sciences and clinical science in the US idea of scientific medicine (my depiction).

It is interesting to note that in the hands of the clinicians the scientific method, which constituted an emblem of democracy and progress, turned into a central element of a larger scheme to constitute their own scientific elite. It became applied to genuinely clinical problems outside the reach of the lab researcher. Whereas laboratory scientists in medical departments could study disease *in vitro* or in animals, only clinical scientists could study disease in humans. Physician and medical historian A. McGehee Harvey identified this as the emergence of "a new type of medical worker", stylized as a hybrid actor based on the convictions that clinical science was a genuine science, which devoted itself legitimately to the study of disease, thus bridging "the work of clinic and laboratory, physician and basic scientist" (1981: 116, see also Barker 1913: 735).[66] The idea of the new clinical scientist was, therefore, not simply distinct from that of the German clinical professor, but also from the American medical scientist. It combined the scientific virtues of the laboratory scientist with the general orientation of the practitioner (figure 5.1), so that the new breed of clini-

66 I referred to the prototypical creation of this figure in the previous chapter, in Virchow's reframing of the clinic and consequently also of the clinician as a practitioner and researcher. It will become relevant again when we discuss the concept of translational research in chapter 7.

cians "adopted some of the values of the biomedical scientists but not their professional goals" (Kohler 1982: 221). Unlike the laboratory researcher of medical science, and similar to the practitioners who embraced science in the later part of the nineteenth century, they justified their program not with reference to science itself, but with the prospect of science to improve clinical practice (Warner 1991: 461).

With the acceptance of central elements of laboratory culture and the ideals of the progressive scientific method as their professional marks, clinicians cultivated their own disciplinary identity within the university. Albeit the logic defining the relationship between science and action in medicine did not change, the scientific discipline that formed the basis of this relationship changed radically. Physiological therapeutics entailed the application of knowledge from the medical science laboratory to the bedside. In clinical science, it meant applying knowledge from the laboratory of the clinical department or hospital. Consequently, the new clinicians employed similar comparisons with engineering or technology. For engineers, physics provides the methods and ideas from which conceptions for materials and layout are constructed; for clinicians, physiology and pathology provide the basis for conceiving of states of disease and therapies. "It was not simply a matter of applying basic science", Robert Kohler attentively notes, "but of creating new basic applied-science disciplines. Clinical scientists' ultimate purpose was to cure the sick, just as the aim of engineering was to build dams or machines" (1982: 221).

Consequently, with a new discipline wedged between the laboratory sciences and clinical practice, the former became more removed from clinical reality. "Without the development of such a department of clinical science the efficiency of the practice of internal medicine will lag behind, no matter how progressive the allied sciences of medicine are and how great their efforts to be useful to medicine might be" (Meltzer 1909: 510, see also Barker 1913: 736f.). The reference to medicine's "allied sciences", which Meltzer used, as I show in the next chapter, manifests a significant semantic development: with a new knowledge foundation for practical medicine, "pure" medical science began to transition closer to biology and further away from the problems of clinical medicine.

III. Institutional Ambiguities of Medical and Biological Research

The Relation of biology and medicine in the USA at the turn to the twentieth century was ambiguous. It was affected by the conceptual migration

of medical science away from the clinic and this development impact the institutional structures of academic medicine and science. To get a better picture of how American academic structures prearranged the idea of biomedicine at the end of the nineteenth and the start of the twentieth century, I want to briefly sketch the development of academic biology at the time. My focus is only on very general institutional developments, not on the different biological schools nor on the contexts of application of biology, which there were many. Academic biology was still an ill-defined entity in the US at the end of the nineteenth century and mainly split between the specialties of zoology and botany (figure 5.2). Historians of science furthermore reveal the "clearly discernible cleavages between the biomedical [sic] sciences, based in medical schools, and those biological sciences primarily based in universities" (Appel 1991: 89, see also Appel 1987, Kohler 1982, Pauly 1984). The reference to location is crucial, as will become obvious, since effectively it was the only factor demarcating the disciplinary cultures of experimental biology and medical science.

Characteristic of biology's development in the late-nineteenth century US, in comparison to medicine, was its fragmentation. While the Flexner report was the manifestation of an interest for centralized standards of academic medicine, biology developed at several centers with different emphases and orientations (Pauly 1984). It was unable to organize itself as a discipline even after the start of the twentieth century (Appel 1991). Kohler notes that American biology at the time still lacked the characteristics of a "homogenous community" and the "unusually authoritative core elite" of other fields. Instead, biology constituted "a congeries of competing and contentious subspecialties or subcultures," which were connected to various fields like medicine, agriculture, psychology or the management of natural resources, "all of which offered attractive but competing opportunities for discipline building" (Kohler 1991: 108, see also Appel 1991).

The reforming medical schools and their programs in the late-nineteenth century in a sense helped shape modern experimental biology negatively. In general, and like other academic sciences, biology was fundamentally reconstructed after the Civil War. In the process, it became infused with the American version of institutional concepts and scientific techniques coming from Europe. The field then gradually transitioned from a popularly and religiously oriented museum science of natural history to an academic discipline largely defined by laboratory research on animal form and function (Benson 1991). At Johns Hopkins University, for instance, "laboratory investigation, advanced instruction, and research in biology" "offered a new direction to the former natural history tradi-

tion" (ibid: 63). Philip Pauly argues that, apart from Johns Hopkins, where both medicine and biology were able to thrive next to each other, biology "prospered precisely" in regions where there was a "lack of sufficiently broad support for scientific medicine prior to 1900" (1984: 370). In other words, biology was able to maintain a strong position in those institutions (Harvard, Chicago, Columbia, or Pennsylvania, for example) in which the laboratory programs were not limited to or unable to provide for the practical preparation of medical students. Accordingly, protagonists in the biological field increasingly began to try and define the culture of experimental biology as the core of a general academic discipline that would organize and categorize the various specialties and subdisciplines that treated issues of organic nature. But their attempts to distinguish themselves culturally from their predecessors in the now outdated fields of natural history also had the effect of bringing the discipline of biology closer to that of medical science, where experimental practices had been propagated since the start of the nineteenth century in Europe and since the end of the Civil War in the USA.

Like the medical schools, biological departments in the last three decades of the nineteenth century also adopted the concept of the scientific method as a call "for a new approach to the teaching of science" (Benson 1991: 60). Just like their medical colleagues, they argued that students had to be exposed to nature directly through experiment, instead of being educated through the relay of natural phenomena in textbooks and lectures. They furthermore adopted the progressive understanding of the method described above. However, due to the lack of a professional recipient, such as sick patients for medicine, the ideology was reoriented toward the general goal of higher education and civic formation – something that hardly distinguished biology from general college education earlier in the century (Stichweh 1994a: 282f.). Biologists, like the medical scientific elite, therefore operated within the idea that the role of college training was to liberate the student from dogma and "discipline the mind" (Pauly 1984: 381). Biology would teach the methods and techniques of science "that students could use to deal 'scientifically' with problems of business, society, and politics" (ibid.). The shared cultural basis, however, led to attempts to distinguish the scientific sides of biology and medicine.

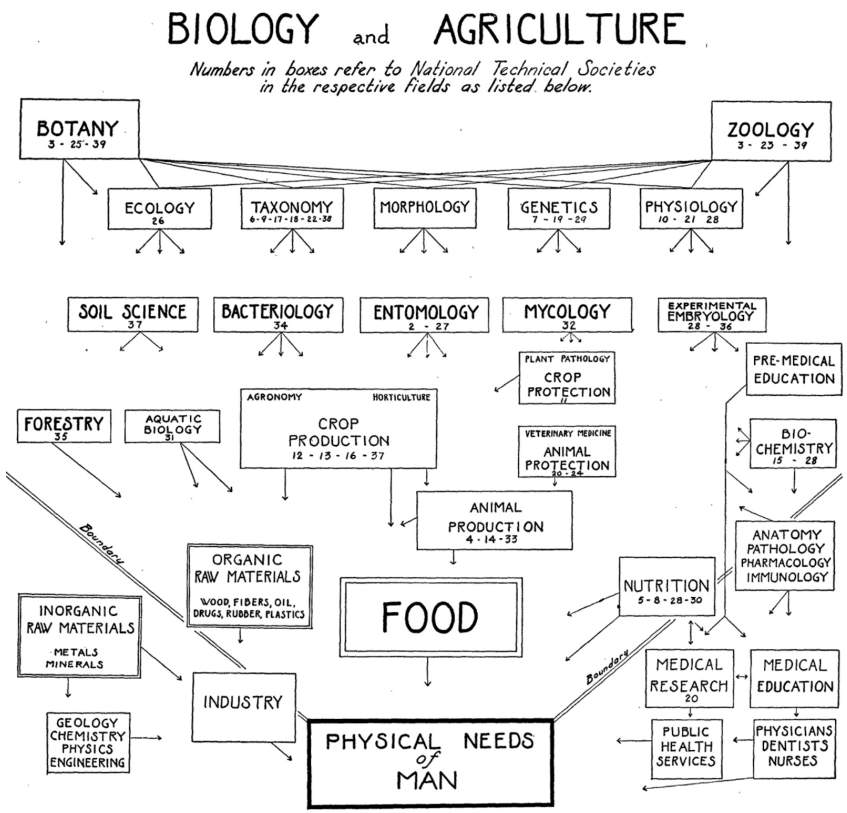

Figure 5.2: Organizational structure of biological and agricultural sciences in the USA in the 1940s, with botany and zoology as major cornerstones. Note that physiology is subsumed under zoology and other medical fields are separated by a boundary or situated at the fringes. I have omitted the list of societies that comes with the original image. (Source: Robert F. Griggs. 1942. The Organization of Biology and Agriculture. Science *96(2503). p. 546.)*

Charles Whitman, for instance, founding director of the Marine Biological Laboratory in Woods Hole and professor in Chicago, promoted the idea of differentiating between morphology and physiology, and attacked the latter for being "limited too exclusively to the practical ends of medicine" (ibid: 384, see also Pauly 1987: 197). He was thus calling for the establishment of a "nonmedical 'biological physiology'", which was undistorted by medical concerns in concentrating on the organic functions of invertebrates (ibid.). Toward the end of the century, Jacques Loeb was beginning

to define an experimental area of "general physiology", which would later constitute a main element of academic biology in the US. He conceived of it as a comparative field of study, removed from any medical concerns, and with the explicit aim of solving "problems that would lead to scientific control over organisms" (Pauly 1987: 197).

The wording, however, already indicates that, despite the attempts to differentiate it from medicine, the institutional boundary between biological and medical work was becoming ambiguous. At some institutions the categorization "zoology" was preferred, instead of "biology", in order to verbally exclude the biological parts of medicine. But medical professors were nevertheless becoming "accustomed to university surroundings and began to encroach upon areas claimed by the biologists" (Pauly 1984: 388f.). At the same time, it was recognized that medicine's physiology was annexing turf in the "Pure Science and Philosophical faculties" and that it "should be placed and will be placed by the side of chemistry, physics, and the morphological division of biology" (ibid.).

Historian of science Toby Appel additionally shows that the founders of the American Physiological Society (APS), which was established in 1887, "were in effect appropriating the term 'physiology' for themselves" (Appel 1987: 166). Originally, physiology had a broad meaning, which was not restricted to the understanding of an experimental science as it emerged at the start of the nineteenth century in Europe. But the idea of an experimental physiology became representative of virtually all the "basic" medical sciences pursued in medical schools; and the physiological approaches to experimental investigations were also increasingly seen as relevant to morphological studies, which belonged, strictly speaking, to zoology (Fye 1987: 188f.). The science was framed as being experimental by the founding members of the association (all of them physicians by training, but with some of them having one foot also in natural history). Both the naturalists and the progressive medical community readily accepted this framing as the proper representation of physiology. "The new society by its membership policy, programs, and journal", Appel notes, "helped to define the discipline, at least in the early years, as experimental, medically-oriented animal physiology, neither too zoological nor too clinical" (1987: 166).

It requires no further explanation that the idea of a "medically-oriented" science left ample room for interpreting that orientation, so that the link to the actual institution of practical medicine was becoming weak. But as a scientific association, the interest of the APS was to make it as inclusive as possible for all who devoted themselves professionally to questions that

fell within the purview of the ill-construed science of physiology. In short, people in both medical schools and natural sciences departments had to be included if they engaged in questions relevant for the APS and its community. Consequently, a shared research culture began to define work both in medical schools and biological departments.

After 1900, the situation became even more conflicting, as the culture of doing experimental work in biological and medical fields was no longer confined to the corresponding institutions but spread equally to medical schools and university departments. Zoologists assimilated the experimental techniques characteristic of physiological and biochemical research in the medical schools. But out of fear of incorporating "the alien culture of medical schools", they were reluctant to employ physiologists and biochemists (Kohler 1991: 313). Instead, at this point, medical schools were also harbouring scientists whose research interests were very remote from medicine, since "general physiologists found their best career chances in medical school departments of physiology and biochemistry" (ibid.).

Despite their colonization of medical school departments, biologists were nonetheless able to create a very narrowly defined disciplinary identity for their enterprise, with which they then began to settle on the fields of heredity and genetics to expand their constituencies into agriculture and industry (Pauly 1984: 394f.). But having been removed institutionally from the requirements of medical practice, the biological-medical culture of research began to establish itself in medical schools, without, however, the need of pursuing specifically medical interests. As I explain later in chapter 7, the molecular revolution in biology, for instance, took shape out of the biochemistry department at Stanford University's medical school. As a result, neither the territories nor the cultures of research devoted to these issues could be delineated neatly as biological or medical in the first decades of the twentieth century. Thus, while the new caste of clinical scientists began to distinguish themselves through their object of study, their academic territory, which was for them the phenomenon of disease as it appeared in the patient, scientists in the medical schools were left to devote themselves to more general questions about organic processes as they could be studied in animals – and later – other model organisms. However, at the same time, their relative freedom from clinical concerns and the early formative stage of modern academic biology in the US led to ambiguities between medical science and the communities of experimental biological researchers. On the level of research policy, this was paving the way for later conflicts over the funding of research fields (Appel 2000).