6. Constructing the Identity of a Late Modern Discipline – Biomedical Science and the Life Sciences in the Post-War United States

In science and technology studies (STS) and adjacent fields, the concept of biomedicine is presented as a new medical paradigm based on the molecular understanding of bodily functions. However, it is also enlisted as an example to argue against the prevailing science policy ideology of the postwar era – the so-called linear model of innovation and the concepts of basic and applied research. In this context, biomedicine epitomizes a distinctly technoscientific understanding that refers to complex transformations of the epistemological, material and institutional configurations of medicine and science in the late-twentieth century (Clarke et al. 2003, see also Keating/Cambrosio 2003). Basic and applied research became prominent during the restructuring of US science policy after World War II and have since determined much of the logic of modern research (Schauz 2014). The corresponding linear model of innovation constitutes a conceptual framework to comprehend the relation of science and technology to the economy, stating that innovation starts with basic research, moving through applied research to development and dissemination (Godin 2006).

The postwar notions of the linear model and of basic/applied research have come under sharp attack in the STS community more generally starting in the 1990s. Authors here have denied the empirical and analytical significance of basic research, relating it to nineteenth-century pure science ideals and placing it against the backdrop of claims that the scientific system has undergone profound changes since the end of the twentieth century (e.g., Gibbons et al. 1992). These changes are taken to signal a paradigm shift, as Schauz recounts, in which "application-oriented research programmes with cooperative and transdisciplinary project teams have replaced the former university-centered basic research" (2014: 274). In this regard, social and cultural studies of biomedicine highlight the category as signifying a new system of interdisciplinary practices, in which the biological and medical laboratory as well as the clinic have moved together due to the molecularization and automation of processes. Peter Keating and Alberto Cambrosio (2003), for instance, use biomedicine as an analytical category that describes scientific practices particularly prevalent in research hospitals of the second half of the twentieth century. They and other authors deny that the category of biomedicine – in the sense of the linear model and basic and applied research – equals the "one-way application of laboratory studies to therapeutics" (Scheffler/Strasser 2015: 664).

I contend, though, that upon closer inspection, this thesis is supported mainly by the employment of sort of a historiographical straw man. I want to explain this with the undifferentiated use of the term "scientific medicine" (which I discussed at the start of chapter 4) to signify virtually all forms of academic medicine preceding the era of biomedicine. This argument abstracts from much of the sematic heritage, which – as I will show here – comes *neither* from postwar clinical medicine and hospital discourses, nor from discussions of the technoscientification of medicine at the end of the twentieth century. Instead, the idea of biomedicine emerged from the research policy debates on basic and applied research after World War II, i.e., from precisely the context from which biomedicine is in the literature taken to be a departure. The assertion is that, in contrast to previous decades, molecular technologies have significantly improved the relationship between the laboratory and the clinic. Therefore, against the linear understanding, "practical" investigations in the hospital are said to contribute no less to the production of "knowledge about the workings of disease and their possible treatment than experiments in laboratories" (Scheffler/Strasser 2015: 664, see also Keating/Cambrosio 2004).[67]

I have illustrated, though, that such supposedly only biomedical conditions were present already in the concept of scientific medicine in Germany and that also the clinical science of the early-twentieth century USA can be regarded as a category that distanced itself from the mechanical ideals of physiological therapeutics, i.e., the almost automatic one-way application of laboratory science to the treatment of disease. Accordingly, in this chapter, I want to show that biomedicine does not necessarily denote a new medical paradigm of the late-twentieth century, but that instead it was devised as a new way of categorizing work in medical and biological research in the postwar era. The concept was prominently employed in the US science policy discourse at a moment in time when it became necessary to reorganize research in biology and medicine due to the changing institutional structures and the vast expansion of the science funding system

67 In a now classic study, Löwy (1996), for instance, shows how it was crucial that also clinicians and patients contributed to the making of interleukin II as a cancer agent in France. She details the processes of research and intervention that took place between the ward and the clinical laboratory.

after the war. The idea of biomedicine was introduced into this context through the shorthand "biomedical", and the label "biomedical science" grouped work on basic biological mechanisms conducted both in university departments and medical schools to distinguish it from other fields in the so-called "life sciences" (US Senate 1959), which had no immediate relevance for public health.

However, as I argue, the distinction was not due to epistemic or practical differences between biomedical science and the rest of the life sciences. Rather, reasons were much more mundane and concerned the administration of research activities in the United States. Nevertheless, through the restructuring of medical and biological sciences in the postwar era the category came to transport specific promises about the relationship between bench research and bedside practice, which I call the "linear legacy" of biomedicine. What is striking is that, in this context, the linear understanding of biomedicine, which sociologists and historians dealing with the topic reject, was engrained into the category as a central feature. Actors in the post-war United States rendered biomedicine – *qua* biomedical science – an autonomous scientific discipline that laid the theoretical basis for future health care improvements. These promises, in turn, need to be understood as deriving from the implications made by actors during the processes of disciplinary reconstruction. The category was used to define a broad scientific culture, which had established itself in academic institutions that were originally distinct, as I demonstrated earlier, namely, in university natural science departments and medical schools.

Consequently, the dimension of my analysis shifts somewhat with the investigation of biomedicine. While previous chapters explored ideas of local research cultures, or the relationship between academic tribes and territories, biomedicine constitutes sort of a meta-discipline like modern day chemistry or biology, comprising many heterogenous research cultures. What now becomes dominant for making a disciplinary identity is what I described as "global narratives of science" in chapter 2, i.e., the visions and expectations of how a science will contribute to improvements in society. I will therefore demonstrate how biomedicine's underlying linear legacy can be attributed to the ideological power exerted by the concept of basic research in the postwar era. The idea of basic research emerged as part of a larger science policy scheme, in which the notion of a linear relationship between scientific research and its application was dominant. In the context of biomedicine, this led to the idea that the crucial dynamic between research and medical practice was that *from* laboratory bench *to* clinical bedside (Kraft 2013: 29). The linear expectations for innovations associated with biomedicine allowed the community of basic researchers to (re-)establish or maintain a connection to the community of clinical medicine. This connection had largely been dissolved conceptually through the reorganization of medical science in the early decades of the twentieth century and during the war.

To understand the meaning of biomedicine, therefore, it requires taking seriously how the category was employed in the post-war discourse. In this context, as I will show, the term emerged as part of a larger scheme in the reconstruction of US research policy, in which the ideology of a linear relationship between scientific research and its application was indeed prevalent. The focus of actors active in defining key concepts in the period under consideration accordingly changed from institution building to the maintenance of the already established structures. Traditional disciplinary and institutional boundaries in the biological and medical sciences, as we saw, were losing their relevance for science policy at the start of the century, due to a shift to research project-oriented distinctions. However, the war effort had contributed considerably to the general growth of science. To counter the ambiguity of biological and medical activities that was looming since the start of the century, actors saw the need to design a coherent national research policy that would cover both basic laboratory research with and without prospects for medical case.

I want to show how policy makers in the post-war era engaged in a form of boundary work (Gieryn 1999) to legitimize the existence of the broad research culture, which had developed in parallel in medical schools and biology departments. The boundary work approach describes demarcation processes based on the discursive attribution and usurpation of epistemic authority with respect to actors and practices. In my context, to distinguish biomedical from other biological activities, the boundary that was drawn concerned the attribution and usurpation of these research activities with reference to a health care mission. I argue that the young but already existing category of the life sciences – initially synonymous with biomedical science – proved unsuitable as a scientific category. The life sciences comprised a row of biological research activities, experimental and natural-historic, as well as research conducted under roof of medical schools. The reason for the category's unsuitableness, however, was not because it defined the disciplinary culture of those activities inadequately, but because it put them under the purview of the National Science Foundation (NSF) (US Senate 1959). The NSF grew out of the reigning new ideology of basic science as the patron for disinterested and curiosity-driven research

(Kaldewey/Schauz 2018: 124f.). Funding research in medical schools with an interest of health care would have openly betrayed that commitment.

The National Institutes of Health (NIH), however, emerged as the by far largest supporter of basic biological research after the war. As the name states, the institute has an obvious health care-oriented mission. However, it would have been highly inconsistent in keeping with the prevailing basic/applied science distinction to classify all the research under the NIH's patronage as applied vis-à-vis the basic research under the NSF's custody. Consequently, in a 1965 official report on the activities of the NIH, the term "biomedical science" crystalized (NIH Study Committee 1965). It was previously employed as a shorthand for grouping research in biology and medicine in other government agencies and allowed to superimpose the basic/applied distinction with the orientation towards agency mission. The new category thus met both the linguistic requirements of science policy and of the situation of federal research funding after the war. It also defined the scientific cultures that had developed in parallel in various institutions of biology and medicine as a discipline of research activities with a broader health care-mission, in contradistinction to that conducted without the explicit medical relevance.

I. The Birth of the Administrative Shorthand "Biomedical"

To understand how the meaning of biomedicine was made and endowed with a linear legacy, I want to first clear up some issues about when and how the category was introduced and subsequently used in the postwar discourse. Many scholars point to its initial mentioning in the 1923 edition of *Dorland's Illustrated Medical Dictionary*, where it is defined as "clinical medicine based on the principles of physiology and biochemistry". While this seems to be a rather conservative rendering, which could have originated with physiological therapeutics or similar movements, there is need for caution with the use of sources here, especially since most of the scholars in question seem to draw on Keating's and Cambrosio's well-informed etymological elaborations of the term (2003: 51ff., see also Bruchhausen 2011: 499f., Quirke/Gaudillière 2008: 445, Scheffler/Strasser 2015: 663, Strasser 2014: 11). However, Keating and Cambrosio themselves alertly present the entry as tied up in a "case of self-reference", in which "the source of the *Dorland's* definition remains unknown" (ibid: 52). They nonetheless argue for the significance of the early coinage of the term, although "we can find only isolated instances of the word prior to World War II" (ibid.).

But it seems easy to overestimate the importance of the purported early appearance, since the category only entered into general usage around mid-century. Since the start of the twentieth century, and considerably accelerated by the war effort, traditional disciplinary and institutional boundaries in the biological and medical sciences were losing relevance for making science policy. The introduction of the concept of basic science, which became prominent after the war ended, only accelerated the disregard for such differentiations. This situation is reflected in the fact that neither government agencies like the NIH, which was founded on the clear mission of sponsoring research with health-related content, nor the NSF, which understood itself as a patron of basic research, differentiated between whether funds were going to medical schools or to university departments of the natural sciences, nor between disciplines traditionally associated with either biology or medicine.[68] As a consequence, based on questions of what distinguished health-related and non-health-related basic research projects, policy makers and their scientific advisors in the period from the end of the war to the 1960s engaged in attempts to clearly define the different research activities in biology and medicine for the sake of formulating a coherent science policy (Appel 2000, see also Keating/Cambrosio 2003: 56, Schauz 2014: 302f.).[69]

After the war, the notion of biomedicine began to constitute a neat umbrella term for much of basic research in biology and medicine that would yield potential future applications in the clinic. However, it was the adjective "biomedical", not the noun "biomedicine", which was first referred to as a categorization of scientific work in the US research policy discourse of the postwar period (figure 6.2). Not only was the noun not yet widely used at the time, but the fashion in which federal agencies employed the adjective is in accordance with the way in which the term became popularized through the concept of "biomedical science" in later tensions between the NIH and the NSF.

68 They inherited this approach of funding especially from the Rockefeller Foundation's initiative to fund short-term project-oriented instead of disciplinary affiliated research (Schneider 2015).

69 As such, the category biomedicine is part of a more general transition in science and politics denoted by the appearance of new vocabulary to legitimate new forms of doing and organizing research after World War II (Kaldewey 2013: 364, Schauz 2014: 299).

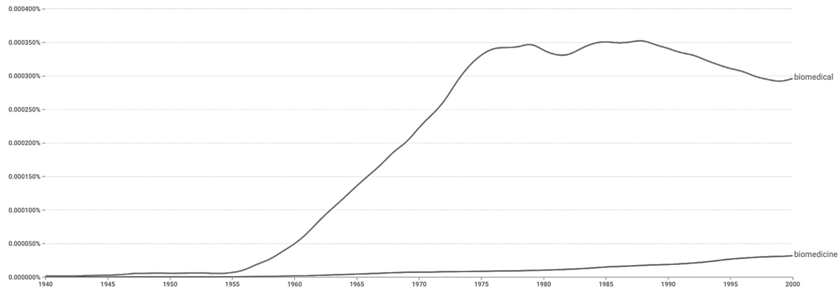


Figure 6.1: Word frequency of "biomedical" and "biomedicine", 1940–2000. (Source: Google Books Ngram Viewer, https://books.google.com/ngrams/graph?content=*biomedicine%2Cbiomedical&year_start=1940&year_end=2000&corpus=26&smoothing=3. [Accessed November 22, 2021]).*

Rather than taking the noun to constitute a new form of scientific and medical practice,[70] the term needs to be understood as originating from a shorthand for describing agency divisions, which were active both in biological and medical research in the early decades after the war. In 1948, for instance, the term was used to describe a health division at the Atomic Energy Commission (AEC), which ran studies on the pathological reactions of living organisms to extreme environments like nuclear fallout. "Although the group was alternatively known as the 'Biological and Medical Research Group,'" Keating and Cambrosio aptly note, "the first annual report (1949) of the Health Division used the term 'Biomedical Research Group' and would routinely do so in subsequent reports" (Keating/Cambrosio 2003: 354, n. 31). The National Aeronautics and Space Administration (NASA) ran similar "biomedical" studies in the late-1950s, but with a focus on how living organisms reacted in outer space, before "the 1960s ushered in the first official reports on biomedicine [sic] and the organization of international meetings" devoted to the subject (Keating/Cambrosio 2003: 56). Subsequently, the term appeared in writings

70 Keating and Cambrosio also acknowledge the peculiarities of the category in an endnote to their book, explaining how usually the noun of a word enters circulation before an adjective is derived from it and becomes used. But "[b]ecause of the prior existence of both 'medicine' and 'biology,' this is probably not the case for 'biomedicine'." They also point out that "in some languages the term 'biomedical' has had a career independent of the substantive 'biomedicine'" (2003: 352, n. 9).

about the medical aspects in engineering, computer science as well as statistics and mathematics (Bruchhausen 2010: 499).

In other words, against the backdrop of the convergence of research work in biological and medical departments since the early twentieth century, AEC and NASA administrators around mid-century thought it convenient to express this convergence in the official documents they drafted – most likely unaware of the far-reaching consequences this would have for the later organization of the natural and medical sciences. Thus, even if *Dorland's* constituted a solid source, we could disregard its definition of biomedicine: the noun developed only after its meaning had already been defined by the shorthand adjective. Furthermore, if the noun was not yet widely used in the 1940s and 1950s, we can only speculate whether agency administrators took notice of it when devising their version. Therefore, their use of the term in government administration must be seen as constituting the semantic origin of biomedicine, rather than the clinical medicine meaning of *Dorland's*.

II. From "Allied" to "Underlying" Sciences

Having sorted out the etymology of the prevalent basic concept, I can now turn to the specifics of how actors came to employ the category, following a period of far-reaching reconceptualization in science policy. It is known that the idea of basic science effectively replaced the older ideal of pure science as the dominant category after the end of World War II, although this did not mean that it simply adopted the meaning of the former category (Kaldewey 2013: 360–371, Schauz 2014: 298–313). In his famous report to US President Harry S. Truman in 1945, titled "Science – The Endless Frontier", Vannevar Bush (1995) used the concept to legitimize new forms of doing and organizing research, particularly the continuation in peacetime of the large-scale public support for scientific research begun during the war. While the pure science ideal meant that the pursuit of science was imbued with moral qualities, Bush's "basic research", in contrast, received its importance through helping to achieve the larger goal of social progress (Kaldewey/Schauz 2018: 110–116, 122–129). The report justified government expenditure for basic research on the grounds of arguing that advancing medical research would enhance public health; that more research would lead to prosperity, due to economic growth, job security and the availability of new technologies; and that it would guarantee a technological advantage of the USA's armaments over its enemies (particularly the Soviet Union). "Only then", according to Désirée Schauz, "did basic research become a real keyword in research funding. And the metaphor of 'basic' did the trick; by laying the basics for all kinds of future benefits, the federal government financed basic research as for the common good" (2014: 299).

However, the new category solidified by Bush's report conflicted with the cultural and institutional distinctions that existed in biology and medicine, and therefore, in the long run, warranted a new category to classify basic research activities directed toward the larger goal of public health. The conceptual conflicts become apparent through comparison of the vocabulary of Bush's report with the older terminology used to characterize medical science since the turn from the nineteenth to the twentieth century. The dominant framing until about the end of the war was "medicine and allied sciences".[71] This use of terminology can be explained with the institutional rearrangements that characterised scientific medicine in the early decades of the twentieth century. Allied sciences were those natural sciences supporting the furthering of medical knowledge, like biochemistry or microbiology. Since medical science as an institution had become removed from clinical medicine through the establishment of its own clinical science discipline, the scientific basis of medicine began to be defined more by its allegiance to the other experimental sciences rather than to medical practice. It therefore seems to be no coincidence that Samuel Meltzer, for example, one of the chief inventors of the pure science of clinical medicine, already employed the phrase at an early point. That the concept was also still popular in the science policy discourses immediately after the war can be drawn from a document published in 1947, "Science and Public Policy" (the so-called Steelman-Report), designed to assess for the US President the situation in science and research.

Volume five of the report, "The Nation's Medical Research", refers to the concept throughout in different variations (Steelman 1947: iii, 3, 4, 6, 10, 13, 15, 17, 18, 19, 20, 24, 27, 30, 73, 93, 96, 101, 108, 113, 114).[72] The concept clearly implied an equal footing of medicine and other biological laboratory disciplines in the context of the pure science ideal, but

71 The Department of the History of Medicine at Yale University, for example, still referenced the old terminology, when launching the *Journal of the History of Medicine and Allied Sciences*, which published its first issue in January 1946, https://academic.oup.com/jhmas (accessed November 22, 2021).

72 Next to "medicine and allied sciences", the report uses mainly the words "medical and allied research", "research in medical and allied fields", or "medical and allied sciences", thereby underscoring their commonalities as sciences.

it referred to them as housed under the roof of the medical school – it included fields like physiology, pathology, bacteriology, biochemistry or pharmacology. Accordingly, the “allied sciences” meant only a limited number of “biological” fields in total. And I illustrated in the previous chapter that physiology was a broad and ambiguous field appropriated also by biologists.

Before the 1940s, biology was still divided into three major and institutionally largely separate groups. Botany and zoology formed the major disciplines that were, for the most part, organized in separate departments at American universities (see also figure 5.3). The other group of important “‘biological’ disciplines – anatomy, physiology, biochemistry” – had their home almost exclusively in the medical schools. “They had their own departments, doctoral programs, societies, and journals; they scarcely interacted with botany and zoology” (Appel 2000: 14). For the time being, the institutional separation held. The notion of “medicine and the allied sciences” was still able to circumscribe fields housed in the medical school as opposed to university departments of biology (i.e., botany and zoology). However, as I indicated earlier, with the reform of medical schools, turning them into genuinely academic institutions at the start of the twentieth century, ambiguities were looming with respect to the description of medical and biological research.

Additionally, the general format of research funding changed after the Great Crash of 1923, since private philanthropies were hit hard by the following economic depression. Until World War II, private philanthropies shouldered the major burden of promoting research. The Rockefeller Foundation, founded in 1913, was the largest private philanthropy to sponsor medicine and science in the early decades of the twentieth century. Initially, the program of the foundation was directed towards broad areas like education and public health. But the economic situation compelled a reorganization of the institution. The reorganization meant, among other things, that the “broad goal of ‘welfare of mankind’” changed into the “narrower focus of ‘the advancement of knowledge’” (Schneider 2015: 286, see also Kohler 1991: 239ff.). Accordingly, the foundation’s Division of Medical Education turned into that of Medical Science and was situated next to the divisions for the natural sciences, the social science and the humanities. The Rockefeller Foundation’s subsequent emphasis was now on supporting research (admittedly, the creation of academic medical institutions had from the start also implied giving money for laboratory investigations). In the process, the institution adopted a new practice of patronage and turned “from institution building to aiding individual projects in specific research fields", as Kohler notes (1991: 260, see also Schneider 2015: 287).

More importantly, however, this added to the ambiguity between biological and medical research because grants for biological projects were also going to researchers in medical schools (Kohler 1991: 313–321). The new concept of the project grant conflicted with common practices of distinguishing between biology and medicine institutionally. Research projects were now being supported based on their specific problem formulation and not on the grounds of their institutional location. The introduction of the project grant mechanism into science policy signals the emerging importance of research as a central quality of disciplinary cultures (Kaldewey/Schauz 2018: 116f.). For medicine, this meant a shift from methods and practices to making original discoveries. Scientists, in both university departments of the natural sciences and in medical schools, were beginning to pursue research work in "general physiology", which could be associated with medicine as well as with animal morphology. They began to communicate professionally with each other over problems of their research and began forming a community that was undertaking their work neither strictly for clinical nor zoological interests.

The institutional separation of medical and biological research practices was further undermined by the rhetoric in Bush's own account to the President and the post-war situation of federal research expenditure. As Appel (2000) shows in her insightful book about the NSF and the constitution of biology in the post-war United States, the US government contributed only a limited amount to the support of biological research or to medical research and education before World War II. During the war, the US Office of Scientific Research and Development's (OSRD) Committee on Medical Research became the chief resource for funding projects in medical science, while the patronage of private foundations receded dramatically in comparison. "The federal government provided lavish support not only for physicians' clinical investigations but also for research in such medically related fields as physiology, biochemistry, and pharmacology" (ibid: 14). Purely biological studies, in contrast, were left virtually unsupported by the Office at the time. After the war, however, the NIH, which was formally established in 1930, had taken over a stock of project contracts from the OSRD. These contracts did not adhere to the institutional distinction between medical schools and university departments, thereby effectively establishing the NIH as a key player in patronage of research in both medical and biological disciplines (Appel 2000: 32, see also Swain 1962: 1235).

This change is also reflected in the introduction of a uniform ideology of basic science equally to all fields. Therefore, where there used to be institutional distinctions regarding disciplinary cultures, Bush no longer differentiated between the university and the medical school:

> "The primary place for medical research is in the medical schools *and* universities. […] Apart from teaching, however, the primary obligation of the medical schools *and* universities is to continue the traditional function of such institutions, namely, to provide the individual worker with an opportunity for free, untrammeled study of nature, in the directions and by the methods suggested by his interests, curiosity, and imagination. The history of medical science teaches clearly the supreme importance of affording the prepared mind complete freedom for the exercise of initiative. It is the special province of the medical schools *and* universities to foster medical research in this way – a duty which cannot be shifted to Government agencies, industrial organizations, or to any other institutions" (1995: 15, my emphasis).

With institutional differences becoming irrelevant for categorizing research, the relationship between medicine and its allied sciences shifted significantly. While they were once convened within the walls of the medical schools, they were now categorically joined with other biological fields across institutional divides. The direct responsibility for clinical medicine had become the task of the clinical science discipline. Consequently, the basic biological and medical sciences, in concordance with the basic science ideology, became subordinate to the larger goal of public health. Their task was not with clinical practice but has been ever since with laying the knowledge foundations for future improvements in health care. Hence, Bush no longer spoke of medicine and its "allied sciences" in his report,[73] as if they were equal fields in the same institution. Instead, in keeping with the "basic" metaphor also here, he substituted the concept for the term "underlying sciences":

> "It is wholly probable that progress in the treatment of cardiovascular disease, renal disease, cancer, and similar refractory diseases will be made as the result of fundamental discoveries in subjects unrelated to those diseases, and perhaps entirely unexpected by the investigator.

73 The phrase "medicine and allied sciences" appears only in the letter of transmittal of the Chairman of the Medical Advisory Board to Bush, included in the 1960-edition of "Science – The Endless Frontier" (Bush 1995: 47).

> […] Progress in the war against disease results from discoveries in remote and unexpected fields of medicine and the *underlying sciences*. Further progress requires that the entire front of medicine and the *underlying sciences* of chemistry, physics, anatomy, biochemistry, physiology, pharmacology, bacteriology, pathology, parasitology, etc., be broadly developed" (ibid: 14, my emphasis).

Bush's conceptualization of the relationship between medicine and science greatly expanded the spectrum of sciences that would be seen as able to contribute to the improvement of public health well beyond the confines of the original scientific discipline of medicine. But it also defined them as remote to, or even detached from, the actual concerns of clinical practice. This contributed to the removal of an inherited responsibility for practical medicine, which seemed to rest now more with clinical science, and it also lowered the stakes for those who wished to frame their work as a contribution to the nation's health. I will discuss later that this ambiguity about the responsibilities for clinical matters becomes especially pressing, when biomedicine is used not as the name for a basic science discipline, but as an overarching supercategory to designate all of the academic health care system, including clinical science and practice.[74]

At the same time, while the new terminology left the integrity of such mentioned disciplines as physics or chemistry intact, it had a noticeable effect on the social identity of biology, which was aiming to establish itself as a unified and autonomous field after World War II. If neither institutional nor disciplinary boundaries could any longer guarantee a differentiation between research pursued for the end of improving public health and research conducted for the sake of expanding the knowledge of biological forms and functions, it required the invention of new research policy categories, which could draw a clear boundary to prevent that biology's disciplinary identity would be appropriated by a dependence on medical ends.

74 Today, the term biomedicine is largely used as a supercategory to describe the academic health care system globally. It defines the bridging of laboratory research and clinical practice. But in the science policy discourses after World War II, biomedical science was understood as a basic research discipline that only laid the foundations for the possibilities of future improvements in public health. In the conclusion to my book, I will reflect on some of the implications this ambiguity in meaning has for our society's understanding of science and medicine.

III. The Political Boundary Between Biomedical Science and the Life Sciences

There existed a term – "life sciences" – with the potential to define the different cultures of basic experimental research as a disciplinary community, as a report commissioned by the US Senate and published in 1959, titled "The National Science Foundation and the Life Sciences", reveals (US Senate 1959). The plural form of the word "science", however, indicates that it was still only a loose bracket around a larger multidisciplinary field, which included work being done in medical school laboratories (figure 6.2). The NSF established a joint Division of Biological and Medical Sciences in 1952. Appel reports that Alan Waterman, the NSF's first appointed director, proclaimed that the agency did not make any distinction "programwise between basic research in the medical sciences and basic research in the biological sciences" (Appel 2000: 52, see also US Senate 1959: 1, 15). Instead, research in these areas was supported based on distinguishing biological functions.

Field	1st year	Intermediate	Terminal year	Total by field
Life sciences:				
Agriculture	1	2	2	5
Anthropology	2	7	5	14
Biochemistry	8	20	8	36
Biophysics	4	6	1	11
Botany	8	5	7	20
General biology	2	4	1	7
Genetics	1	12	4	17
Medical sciences	4	9	2	15
Microbiology	5	2	4	11
Psychology	8	18	4	30
Zoology	22	37	25	84
Total, life sciences	65	122	63	250

Figure 6.2: Example of the grouping of research fields under the rubric 'life sciences' in the Senate report on the NSF. Botany, zoology as well as medical sciences feature as part of the category. The table refers to the distribution of predoctoral awards of the NSF offered by scientific field and year, 1958–59. (Source: United States Senate. 1959. The National Science Foundation and the Life Sciences. *Washington, D.C.: The US Government. p. 35; https://books.google.de/books?id=rZVUAAAAMAAJ&printsec=frontcover&hl=de&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false [accessed November 22, 2021]).*

The Foundation accordingly had programs for the support of basic research organized around eight categories: "(1) developmental biology; (2) environmental biology; (3) genetic biology; (4) metabolic biology; (5) molecular biology; (6) psychobiology; (7) regulatory biology; and (8) systematic biology" (US Senate 1959: 2, 13ff., see also Appel 2000: 64ff.). Conceiving of basic research in this fashion was the result of new ways of approaching biological problems that had developed since the 1930s. Warren Weaver of the Rockefeller Foundation, for example, introduced the idea of grouping biological research according to the overarching idea of "vital processes" instead of disciplinary demarcations, whereby he fostered a field of biological science that also harboured physicists and chemists (Kohler 1991: 275–283).

While a focus on biological function helped establish new areas of research, by the 1940s it also caused the traditional barriers, which separated botanists and zoologists, and biological researchers in university departments and in medical schools, to crumble (Appel 2000: 16). As Appel attentively notes, the distinction into the functional categories allowed for the NSF to support their own version of basic research in medicine, "since biomedical [sic] categories were effectively hidden under biological rubrics" (ibid: 64). As decreed by its founding document, the NSF understood itself as a federal patron for sciences that contributed to the general expansion of knowledge – the "endless frontier" – as a foundation for social progress. Regarding medicine and biology, the term "life" aptly reflects this broad comprehension. Supported programs encompassed the areas of biological, medical and agricultural sciences and "conceived basic research in the life sciences so that biological processes, whether in plant, animal, or man," were "seen in their basic contexts" (US Senate 1959: 13).

However, the two major federal agencies – the NIH and the NSF – were competing over funding these activities at the start of the post-war era. It appeared incongruous that the NSF, as the patron of the prestigious category of basic science, was factually being dwarfed by the NIH, which despite its clear mission, was providing funding to basic research in biological fields. Therefore, drawing a clear distinction between jurisdictions of both agencies became a matter of utmost political importance. Actors used the method of emphasizing the differences in mission that was attached to the NSF and the NIH for this purpose.[75] The criterion that was being used to distinguish the NSF's program in the life sciences from other federal agencies was that it was not "subject to the limitations, however broad, of a specific program commitment or assigned mission" (ibid: viii). The NSF was seeking a hegemony over basic research-patronage, while at the

75 Next to the NIH, other agencies that competed for financing research in the life sciences in the period, which included the Office of Naval research and the AEC (Appel 2000: 24–30).

same time trying to avoid duplication with other funding agencies (Appel 2000: 101–129). The only viable strategy regarding the NIH – which was the most serious competitor in the business of federally funding research in the life sciences – was for NSF protagonists to try and draw a clear line between the sort of activities conducted under the support of the NSF and the NIH.

Accordingly, Waterman explained in the preface to the 1960-edition of "Science – The Endless Frontier" what distinguished the two agencies:

> "The National Institutes of Health stresses research aimed at the care and cure of diseases, including basic research related to its mission, as defined by Executive Order 10512. The National Science Foundation, on the other hand, supports basic research in this area primarily for the purpose of advancing our knowledge and understanding of biological and medical fields" (Waterman 1995: xii).

But how precisely was basic research "related to the cure and care of disease" different from basic research "for the purpose of advancing our knowledge and understanding of biological and medical fields"? In both cases, the concept of basic research defines "research performed without thought of practical ends" (Bush 1995: 18)? To put it crudely, if concrete practical outcomes for the clinic were not the measure by which to distinguish the missions of both agencies, adherence to either of them appeared to amount to not much more than paying lip service. It depended on the communicative framing of how research work would potentially pay-off in either one or the other direction – a communication that could be adapted strategically and in accordance with where funds were coming from. I will explain in the next chapter how molecular biologists jumped the biomedical bandwagon by employing the appropriate communicative framing to their research projects.

Like the sciences supported by the NSF, the NIH's purview in the post-war period also encompassed a broad range of activities that could not inherently be reduced to their health care implications. But to make its health-related mission more visible, the organization was restructured after the war from being based on medical disciplines to overseeing disease categories (Park 2008). Actors campaigning in support of the NSF took advantage of the NIH's new categorization in attempts to frame the agency as better suited to support research conducted on the "applied" side of science rather than in genuinely basic areas. Their hope was that this framing would reflect on how the federal government allocated its budget to the agencies. Maintaining that applied research was already receiving its full share, it was therefore not more applied, but basic research that was needed to ensure medical progress. This argument implied nothing else than that the government should stock up the budget of the NSF for basic research in the according fields and not that of the NIH (Appel 2000: 106, see also 116f.).

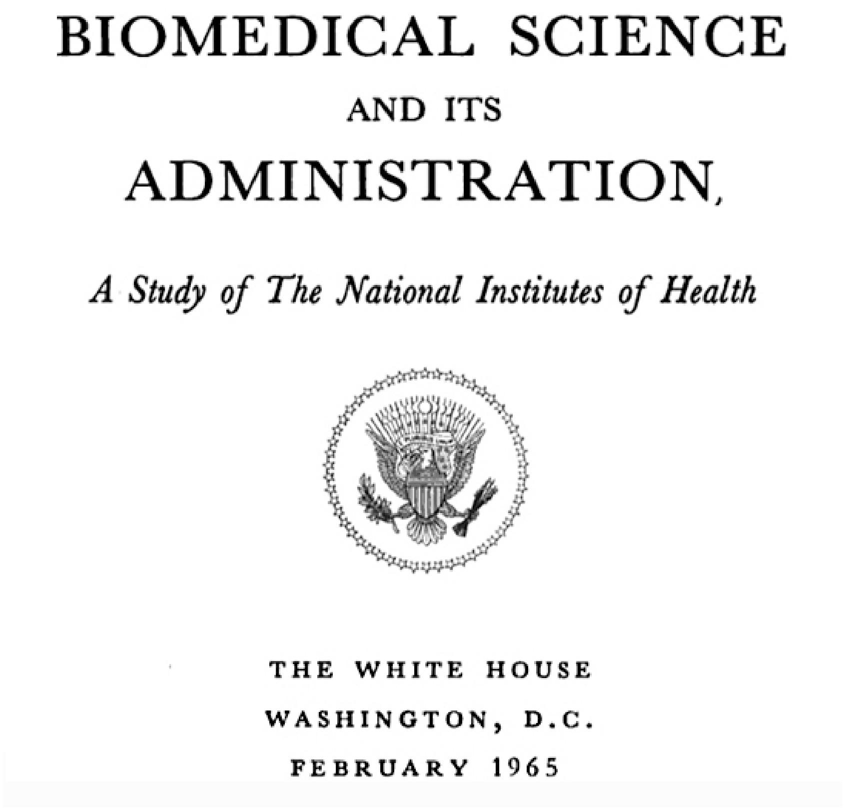
According to the Senate-commissioned report on the NSF and the life sciences, unbound scientific curiosity and creativity was viewed as the main quality sought for through basic research in biological and medical sciences, as opposed to "immediate and practical results" (US Senate 1959: ix, see also Bush 1995: 12). "The subcommittee [of the Senate] has welcomed the many affirmations of this sound concept of encouraging creativity on the part of the Federal organization most directly concerned with research against disease – the National Institutes of Health" (ibid.). Therefore, while not directly denying the NIH its legitimacy of receiving a budget for supporting basic research, the disease category-structure of the NIH was nevertheless used to indirectly create a hierarchy between the two agencies, to assign them separate jurisdictions in the realm of biological and medical sciences:

> "But, sometimes, rigidity of procedure creates a paradox: (*a*) we increase resources for applied, i.e. *categorical*, medical research (and very justifiably so, in my personal judgment). But, simultaneously, (*b*) we deny desperately needed and urgently requested resources to expand *pure* [sic] research proportionately.
> The result is that pure research is still a stepchild, receiving what constitutes but a small fraction of the total. The culprit responsible for this paradox is the 'either-or' way of thinking. Surely, we should have learned by now that *both* pure and applied research are essential." (ibid: x)

However, despite arguments that disease categories downgraded the NIH to an agency that was better suited to foster applied research, they were a factor that did not only play into the hands of those seeking to establish the NSF as the main patron for basic research in all biological and medical fields. Historian Buhm Soon Park has looked closely at the development of the NIH's intramural and extramural funding programs in the post-war period. He notes that disease categories constituted a concept ambiguous enough to rhetorically serve the promotion of a variety of research activities – basic and applied, medical and biological – under the heading of benefitting the future health care of society. He argues in fact "that there was a common goal among the categorical institutes at the NIH to establish a strong *basic research* program covering several scientific fields, even if their links to categorical missions might be neither direct nor transparent" (Park 2008: 28, my emphasis). At any rate, next to research grants awarded according to the categorical division of the NIH's institutes, the agency also reserved money for support of non-categorical research. This practice was manifested by the creation of, first, in 1958, a Division, and later, in 1962, an Institute of General Medical Sciences. Accordingly, the mandate of the NIH expanded beyond research oriented towards specific diseases and also encompassed activities that fell inside the NSF's jurisdiction over the life sciences. As a result, by the 1960s, the NIH was funding research in virtually all life science areas and responsible for the largest share in federal support of professional biologists (Appel 2000: 138ff.).

Subsuming the work not only of biologically oriented medical researchers but also of biologists under federal health research policy meant that the term "life sciences" was unable to adequately capture the differences that constituted the activities of the NSF and the NIH. It therefore required an additional category, a similar umbrella term coming from the side of medicine. This term needed to draw the boundary between forms of research under purview of agencies with a mandate to support science for the broader societal outlook and those that had a more narrowly defined health-related goal – albeit these pursuits were hardly distinguishable when looking at their research cultures. A study committee, chaired by Dean Wooldridge and appointed by the White House to examine the activities of the NIH was to deliver the necessary semantic specification. Published in 1965, the report to President Lyndon B. Johnson by the Woolridge-Committee was titled "Biomedical Science and Its Administration", employing the administrative shorthand, which agencies like the AEC and NASA had previously used for categorizing their inhouse research (NIH Study Committee 1965, see also figure 6.3). The report is generally credited with having relayed the category to a larger audience and with defining the modern enterprise publicly (Bruchhausen 2010: 499f., see also Keating/Cambrosio 2004: 364f.).

To be sure, the report does not set out to explicitly define "biomedical science". Instead, the language of the report reveals how the adjective "biomedical" was already an accepted vocabulary in US science policy discourses by the time it was written, because of the AEC and NASA. Originally, it implied something very similar to the term life sciences, namely, the convenient grouping of basic research in biological and medical fields under one heading. The above-mentioned report by the Senate Subcommittee (published six years prior to the Woolridge-Report), for instance, had also employed the adjective. In the Letter of Transmittal by the chairman – and only here – the term biomedical research is used. It acts as a synonym for basic research in the life sciences, in order to state the purpose of the report as to summarize the activities of the NSF that bear on the fields of biology and medicine (US Senate 1959: iii).


BIOMEDICAL SCIENCE

AND ITS

ADMINISTRATION,

A Study of The National Institutes of Health

THE WHITE HOUSE

WASHINGTON, D.C.

FEBRUARY 1965

Figure 6.3: Title page to the Wooldridge Report "Biomedical Science and its Administration. A Study of the National Institutes of Health", The White House, Washington D.C., released February 1965, which made "biomedical science" an official concept in science policy discourses (Source: Google Books, https://books.google.de/books?id=cK0wAAAAIAAJ&printsec=frontcover&hl=de&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false [accessed November 22, 2021).

The Woolridge-Report describes the NIH's conception of science as implying the same basic science-ideology that was at the heart of the NSF:

> "In general terms, the public funds that support NIH activities are intended to 'buy' for the American people a commensurate degree of relief from suffering and improvement of health. To achieve this goal, NIH devotes its principal effort to a broad program of investigation of life processes, rather than to a search for direct cure or prevention of specific diseases. It employs this approach for a simple and valid reason: life science is so complex, and what is known about fundamental biological processes is so little, that the 'head-on' attack is today frequently the slowest and most expensive path to the cure and prevention of disease" (NIH Study Committee 1965: 2).

That the Woolridge-Report refers to biomedical science in the singular, however, indicates that it was not meant to be a synonym for the life sciences.[76] Furthermore, while life sciences was a concept for scientific research in the biological and medical sciences defined by a broad experimental culture, biomedical science was intended to delineate an area within this larger group that corresponded to a clear mission objective. Most importantly, therefore, the 1965 document makes clear that the NIH and the NSF were effectively responsible for funding the *same* sort of research, since the basic distinction was no longer between biology and medicine or between basic and applied sciences, but between missions. For the committee, the term acted as a means of boundary work, drawing a subtle distinction between the research sponsored under the aegis of the NIH and the NSF. The report accordingly states that the different institutes of the NIH allow for research to be assigned to potentially "all of the special disciplines that comprise the life sciences", enabling a broad coverage of research funding. And it concludes: "Thus, we may say that the primary *de facto* mission of NIH is the stimulation and support of a very broad range of health-related or biomedical research" (NIH Study Committee 1965: 3). Though talk is of the same sort of research activities, therefore, and while the idea of life sciences comprised basic research in biological and medical fields and institutions that promised to contribute to overall social progress, the NIH presented biomedical science as a broad discipline that benefitted social progress through its public health mission.

76 The NSF's terminology is used throughout the main text, showing that "life sciences" was also by then a normal category in the science and health policy discourse (NIH Study Committee 1965: 2, 3, 5, 7, 14, 23).

The term biomedical science has defined a disciplinary identity comprised of virtually the same research culture as that of the larger category of life sciences. The crucial difference, though, was that, in contrast to the latter, the former identity was bound to a linear legacy – the explicit promise that research in the discipline *will* lead to improvements in the nation's health.

IV. The Linear Legacy of Biomedicine

It is hard to gauge when exactly the noun biomedicine became a popular category. But by the 1980s it seems to have been widely in use. The important aspect, at least in the context of my analysis, is to consider the appearance of the noun as a manifestation of the general acceptance of the promises that are associated with the idea of basic biomedical research. In current parlance, the term biomedicine embodies the expectation that the research areas grouped under its heading will necessarily contribute to practical improvements in health care. However, removed from clinical reality, replaced in its role by clinical science and indistinguishable from the research culture of the life sciences, I argue that this feature of biomedicine is above all rhetorical.

Accounts in the sociological and historical studies of biomedicine, as already implied above, critique the idea of a linear relationship between biomedical innovation in the laboratory and their implementation in everyday clinical practice as a popular myth. Commentators have argued instead that the category describes the reality of a much more complex path to clinical innovation than is commonly captured by the post-war idea of basic research: "the existing body of scholarly work in the history of biomedicine does not support the view that laboratory research is the main (or only) source for therapeutics" (Strasser 2014: 14). For Keating and Cambrosio, the novelty of biomedicine is precisely that it "break[s] down the dichotomy" between "biomedical innovation and the translation of that innovation into a variety of medical practices" (2003: 323). Innovations in biomedicine, in other words, are the result of the collective work of scientists, clinicians, patients and other involved actors organized in relationships of a non-linear fashion – this understanding is today captured by the concept of translational research, although, authors like Keating and Cambrosio deny that the characteristic configurations of biomedicine had "to await the invention of the term 'translation research'" (ibid: 47).

The point I want to make in conclusion to this chapter is not that the scheme of the linear model adequately describes the actual processes of research, development and innovation in the medical system. I want to draw attention to the fact that the concept of biomedicine embodies such an understanding, since it was born in the climate of basic science, and that we should keep this in mind when being confronted with the expectations associated with it. Different from what some of the social studies of biomedicine claim, the promises inherent to the concept of biomedicine seem convincing not because the category transcends the linear conception underlying the ideology of basic science, but precisely because it is imbued with it. I want to illustrate some of the ideological power of the biomedical category in the current discourse by having a closer look at its semantic function.[77]

David Kaldewey has argued that despite assertions in the sociological and historical literature toward the end of the twentieth century that the so-called "linear model of innovation" was "dead", the content that the concept transports is still very much alive today (2013: 371–383). The idea of a linear model of innovation is associated less with academic than with industrial research, however. In this context, the basic understanding of the category is that the fundamental work being pursued in industrial laboratories, for instance, needs to be less abstract than academic work, to not question its future utility; it needs to be somewhat circumscribed with practical implications so that it has the possibility of offering the basis for further scientific application (ibid: 382f.).

In the current social and historical literature, as Kaldewey shows, due to a sense of crisis in science, the category has nonetheless been discarded as a viable concept in exchange for notions such as "blurring boundaries" between basic and applied research or research and development (ibid: 383). But even such conceptual renewals, which expressly distance themselves from the concept of a linear model, nevertheless transport the idea that relatively undirected basic research leads to social benefits, i.e., moves from one realm to the other (ibid: 381). A similar narrative emerged in the nineteenth century, which stated that "pure science provides the foundation for technological innovation" (Schauz 2020: 217). According to Schauz, this narrative has not lost its importance, although conceptual innovations like "technoscience" are meant as antitheses to this old understanding, standing the conceptual relationship between the natural sciences and

77 Keating and Cambrosio do, however, point to approaches in the second half of the twentieth century that "clearly suggested a hierarchy running from the biological to the clinical, with researchers in the latter sphere acting as applicators for knowledge produced in the former" (2004: 365).

technology on its head (ibid.). The crucial point more generally is that the semantic replacements to describe the connection of the different phases of research implied by the linear model still do not allow it to be dissociated from its underlying, century-old idea. Through "narrative means" even they postulate "a causal connection between different forms of research activities" (Kaldewey 2013: 383).

Coming from the context of the post-war basic science ideology, the concept of biomedicine precisely preserves this underlying causal notion with reference to health care – and there is public testimony to the fact that this is the central understanding of the concept. For Appel, in her account of the NSF's spending in biological fields, "the tremendous growth" of involvement of the federal government in the support of basic research in biological and related fields "vitally depended on NIH's superior ability to link research to the politically popular imperative of conquering disease" (Appel 2000: 142). Accordingly, the emergence of the category was accompanied by serious doubts about whether such a high expenditure for laboratory research could indeed deliver the promised health care benefits to the nation. In an extensive review of the Woolridge-Report in *Science*, Joseph D. Cooper, a high-ranking US government administrator and author, questions whether the health research policy of the NIH was at all structured toward any other intention than justifying large amounts of federal research spending in basic life sciences. Asking whether the agency represented a "health agency" or rather a "science agency", he concludes:

> "In short, the report [by the Woolridge Committee] states that NIH is not a disease-oriented organization. It is, rather, engaged in the support of fundamental research into life processes along normal disciplinary lines. While NIH justifies its programs to the Congress and to the public in terms of drives on various disease fronts, these are merely 'practical' expedients through which NIH has to operate" (Cooper 1965: 1435).

Critics of the NIH's spending behaviour, moreover, tend to measure the idea of biomedicine by its linear promises. In a book that elaborately and critically surveys the NIH's funding history, Edward Ahrens saw that the money being spent on basic laboratory research in the name of health care was grossly out of proportion, since its relation to clinical medicine was highly questionable:

> "The very large body of biomedical research is best described as separate from [other] categories of clinical research. These studies are performed in such varied disciplines as chemistry, physics, biology, zoolo-

gy, anatomy, biochemistry, and microbiology. While they contribute importantly to new understandings of biological processes, they are not directly related to clinical issues and do not originate in stated or implied questions dealing with human health or disease" (1992: 42).

Strictly speaking, Ahrens is critiquing the research discipline of *biomedical science*, which developed in the disputes over funding jurisdictions between the NIH and the NSF, as I just demonstrated, for making promises deriving from the supercategory of *biomedicine* – namely, as an inclusive category for a vast array of research comprising the academic health care system, which has, however, not sufficiently led to direct health care-related outcomes (Ahrens 1992). In relation, one reviewer of Ahrens' book, the American cardiologist Alvan Feinstein, even decried the category as merely a political scheme: "The hybrid term biomedicine was devised to justify the NIH's diversion, into basic molecular biology, of funds allocated for the study of human disease and health" (1995: 289).

While there can be legitimate doubt about the substance of the concept's promises, it is clear from these statements that its rhetoric worked flawlessly in convincing state officials, medical actors and the public of a linear relationship between biomedical research and the improvement of public health. An important aspect, however, is that the category could function in this way – and still does so – because of being supported by medicine's modern history. Historical events in the progress of medicine, something historian Bruno Strasser, in a recent report to the Swiss Science and Innovation Council, has termed "the collective memory of biomedicine's public successes" (2014: 13), have retrospectively undergirded the linear notion inherent in the concept of biomedicine. Among these are such famous cases as Paul Ehrlich's "magic bullet" Salvarsan, as the first cure for Syphilis (Lenoir 1997: 179–202), or the discovery of Penicillin as an antibiotic by Alexander Fleming (Bud 2007). "The rise of biomedicine," Strasser notes, "as well as its current legitimacy, owes much to the power of these stories and memories of success" (2014: 13). Thus, from society's current perspective, such (hi-)stories function as evidence for the convincing promises that the transfer of knowledge from basic research in the laboratory to the clinic will improve the reality of medical practice. But the quotes above also show how these promises have been broken in the aftermath of biomedicines ascendance. I will try to illustrate in the next chapter how actors up until now have nevertheless been able to avert a crisis of biomedicine.