2. For a Sociology of Disciplinary Cultures

Referring to a notion of scientific or academic disciplines[15] to describe the institutions of science has today become somewhat marginal in science studies discourses, particularly in science and technology studies (STS). Originally, the concept of disciplines was used in an institutional approach in the sociology of science, which linked the formal organization of a scientific community to a set of shared norms and rules for scientific practice (see Roth 2022). In this context, disciplines were regarded as providing vital social infrastructures for the coordination of scientific knowledge production on different levels.

Instead of answering questions about the formal organization of *science*, however, STS has a long tradition of focusing on the messy constitution of *research* practices (Felt et al. 2017: 8ff., 21ff.). Already in the 1970s, with the influence of the Sociology of Scientific Knowledge (SSK), which introduced the principle of studying scientific failure and success symmetrically by looking at social factors, science studies scholars turned away from investigating formal structures toward the social and discursive practices of science, thereby sidelining investigations of disciplinary formation (e.g., Barnes et al. 1996, see also Schweber 2006: 15). Beginning with the 1980s, through pioneering ethnographical work in research laboratories, STS revealed the scientific enterprise to be a messy and heterogeneous business not easily compartmentalized into homogenous scientific disciplines (e.g., Latour/Woolgar 1986, Knorr Cetina 1981). Though practices in research cultures also follow rules, these do not primarily derive from scientific epistemologies or "paradigms" (Kuhn 2012) as the institutional tradition claimed. Instead, they are seen as determined by the local sociotechnical conditions of research laboratories.[16]

Next to a concentration on research cultures instead of scientific disciplines, some authors in the field furthermore contend that the system

15 I will be using the terms "scientific disciplines" and "academic disciplines" interchangeably throughout the text.

16 The Käte Hamburger Kolleg: Cultures of Research (c:o/re) at RWTH Aachen University currently provides fresh approaches to studying research cultures, charting their complex transformations in light of the digitalization of science and of pressing societal issues, such as climate change, from a philosophical, sociological and historical perspective: https://khk.rwth-aachen.de.

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of science had undergone crucial structural changes in the late twentieth century. The diagnoses of the arrival of "post-normal science" (Funtowicz/Ravetz 1993) or of the switch of the scientific system to a "mode 2" of knowledge production (Gibbons et al. 1994) have contributed to an idea of disciplines as remnants of an antiquated form of science.[17] In this process, science is thought to have lost its disciplinary foundation in favor of new configurations such as inter-, multi- and transdisciplinarity – changes that seem to have been announcing themselves since the early twentieth century, when public and private institutions began housing scientific research next to the university (Ash 2019). As a result, the academic communities defining disciplines are regarded as having "become diffuse, and consequently, the university structures of faculties and departments, institutes and centres that create and sustain these communities become less relevant" (Nowotny et al. 2001: 89). If disciplines no longer play a major role in the social study of science, why then employ such a seemingly antiquated analytical concept? What distinguishes the idea of research cultures from disciplines? And why does it require that we revive the disciplinary frame to study the development of medical science?

On closer inspection, the notion of disciplines seems far from being an obsolete analytical category. Instead, scholarly discourses on the social studies of science continue to depend on the idea of scientific disciplines, although the concept has been criticized by authors for depicting a conservative image of scientific organization. While STS scholarship thus largely gives off the impression that disciplinarity, as an antiquated mode of science, can be analytically discarded, the field nevertheless continues to rely heavily on the term. In the fourth and current edition of the *Handbook of Science and Technology Studies*, a collection of contributions by leading scholars in the STS field, for example, there is indeed a chapter on the "social and epistemic organization of scientific work", although it tells readers that "studies of disciplines and specialties are written in a highly variable vocabulary" that ranges from "paradigms, social worlds, epistemic cultures" to "thought styles and cultures, ways of knowing, styles of scientific reasoning, and many more" (Hackett et al. 2017: 739). The book includes no other systematic elaboration of disciplines, nor does it

17 These diagnoses have subsequently been criticized for their schematic understanding of historical developments in science and for primarily deriving from political motivations rather than from genuine scientific insights (Pestre 2003, Shinn 1999, see also Kaldewey 2013: 91–101).

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index the item at the end (Felt et al. 2017).[18] Somewhat surprisingly, however, given the limited space devoted to disciplines conceptually, a simple full-text search of the digital version of the *Handbook* retrieves roughly one-hundred and sixty hits for "discipline" and "disciplines".[19] Despite the availability of alternative concepts, therefore, in terms of pure figures, each of the handbook's thirty-six chapters on average references the term more than four times. It would be worth investigating whether the term is indeed always referenced negatively, in contradistinction to the inter-, multi- and transdisciplinary alternatives.

A search on the *Web of Science* for mentions in scholarly publications in the field of STS reveals a similar picture. It shows a slight but steady uptake in relative numbers for the topic of "academic" or "scientific disciplines" in leading STS journals: from about 1 % of publications referencing the concept in the early 1990s to about 5 % in the late 2010s.[20] Not only do these figures stand in stark contrast to the general theme running through much of STS, of disciplines as a largely negligible analytical category; its continued use – even increase – furthermore points to a fundamental sociological problem in the social study of science, namely, that STS lack a viable explanation of the concept of scientific or academic disciplines that transcends its use as an antithesis to multi-, inter- and transdisciplinarity.

My purpose in this chapter is to fill this lacuna by proposing a concept of disciplinary cultures that satisfies both the intellectual interests of STS and of sociological studies that focus on the formal organization of science. The crucial problem with both perspectives is that they trivialize the focus of the other tradition. Put differently, while STS emphasize the relevance and complexity of research practices, they at the same time downplay the importance of institutional structures, which ultimately enable and sustain such practices (e.g., Knorr Cetina 1999). Conversely,

18 The index does, however, list "interdisciplinary integration", "multidisciplinarity", and "transdisciplinary research", while an entry for "disciplines" or its equivalent is missing (Felt et al. 2017: 1169, 1173, 1188).

19 I used the extended search function in my pdf-reader to scan the digital version of the *Handbook*, searching for exact matches of the above-mentioned keywords ("scientific" and "academic discipline/s"). Results include a minimum number of mentions listed in the references of the chapters.

20 The search was conducted on February 22, 2021, and included publications in the journals *Configurations*; *Minerva*; *Science and Technology Studies*; *Science as Culture*; *Science, Technology, & Human Values*; and *Social Studies of Science* between 1991 and 2020 (n=4,624). Searches were in publication titles and abstracts and the search string was designed to eliminate hits on the topics of inter-, multi-, or transdisciplinarity as well as discipline as a concept of power formation.

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while sociological studies underscore the importance of formal structures, they understate the significance of research praxis for the development of scientific institutions (e.g., Turner 2000). STS largely disregard the role of institutions for providing the necessary socialization and training of scientific recruits.[21] In turn, crucial features, such as academic education and recruitment, are largely thought of without recourse to the work going on in research facilities in sociological studies on disciplines.

The notion of disciplinary cultures, which I employ here, can function as an amendment to these complementary blind spots by providing a perspective on the interaction between local research institutions and the organizing social structures. It offers a link between concrete practices of knowledge production and global narratives of science. Such narratives not only transport societal expectations and visions of science in society, but they also have an ordering function that reflects in the formal organization of the scientific system. Think of the division of labor implied in narratives of "basic research", for example, where uninterested investigations form the platform for future applied research and implementation (Schauz 2014). Such divisions become institutionalized in faculties and university departments, determining the order of disciplines and the distribution of their jurisdictions. The narratives implied in the concept of "pure science" played an important role in ordering medical science in the nineteenth and early-twentieth century, for instance. Pure science tells the story that even epistemic objects of practical concern like clinical care need to be studied without any interest in application. This meant that medical science, even on practical matters, was kept strictly separated institutionally from the actual practice of clinical medicine. The point is that this perspective on disciplinary cultures emphasizes how both formal structure and research praxis are connected in social and cultural imaginaries of science in society (see also Jasanoff/Kim 2015). Biomedical or clinical science as disciplinary cultures, in other words, were not only designations for local programs of research praxis revolving around matters of health and disease. They also embody visions of the concrete role that medical science plays for improving clinical practice and health care more generally.

Moreover, referring to a concept that combines the notion of research cultures with the more formal understanding of disciplines overcomes one-sided concentrations on either *research* or *science*. By showing that both

21 By reducing the idea of science to research work, some scholars in STS do not see the university course as a crucial moment of academic socialization, acknowledging the process only as part of a mature scientific career (e.g., Felt et al. 2013).

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are intimately connected via societal expectations and global narratives, there no longer is a need to distinguish analytically between the *practices* of scientists on the one side and the formal *organizations* in which they operate on the other side. Rather, such an understanding of disciplinary cultures is conceptually prolific because it shows how professional behaviors, conventions and values not only refer to research praxis, but always also convey social values, norms and convictions. Tracing the disciplinary identity work that corresponds to these cultures reveals how the representation and positioning of scientific practices always incorporates a, what today is called "research policy", dimension. Next to the rules and norms of a research culture, this also points to the institutional space of a given discipline (Roth 2022). Stated in very general terms, the decision to employ a certain method, technique or concept for knowledge production in a certain field always also entails a political decision about how to position a discipline vis-à-vis society and its expectations.

In what follows, I will be reviewing central works in the sociology of science and in STS that study the organization of science and research. I want to thereby operationalize my theoretical approach and method for the cases that follow, by highlighting the analytical concepts that inform the empirical investigation of my book. The study of the discipline of medical science, therefore, neither takes on the form of an ethnographic investigation of concrete research practices nor of a sociological theory of the formal organization of the scientific system. Instead, I will tackle the sociological-historical issue of how cultures of science create their disciplinary identity, establish themselves institutionally and legitimize themselves socially through their *(self-)depictions of work in academic and science policy discourses*.

I. Academic Knowledge and the Social Structure of Science

My study holds on to the idea of disciplines but wants to update it to be able to also capture the messy constitution of research practices central to works in STS. This is not specific to the notion of disciplines, which imply (abstract) knowledge as one of their central features. In the traditional understanding of the medieval and early modern European university, "disciplina" described the context of higher learning. It consisted of a systematic body of theoretical knowledge ("doctrina"), which was not necessarily scientific in the modern sense, and specific rules of learning that students needed to master (Stichweh 1992). Only since the turn from

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the eighteenth to the nineteenth century have disciplines also become places of academic research and therefore a central structural element in the modern system of science (Stichweh 1984). As a sociological concept, the institutional understanding of scientific disciplines has the important function of answering questions about how academic areas of knowledge and social structures in science are related. In what can be called "the sociology of scientific disciplines",[22] disciplines transcend the simple idea of being bodies of theoretical knowledge. Instead, in modern disciplines, specific aspects of that knowledge are connected to social functions like knowledge production or transmission. In this view, the organization of science into disciplines is largely congruent with that of university institutes and departments, where scientists advance disciplinary knowledge and secure recruitment into their ranks through formal training and by providing official credentials (Turner 2000).

Thomas S. Kuhn's (2012 [1962]) famous book *The Structure of Scientific Revolutions* proved highly influential in relating knowledge to social organization. Though it is primarily a philosophical work, it was nevertheless foundational for both STS and the sociology and history of science.[23] His notion of a paradigm, with its sociological connotation, allows to conceptualize academic disciplines as *scientific communities*. According to Kuhn, a paradigm is a central point of reference for such a community, since it provides samples or models of professional action based on past achievements (Kuhn 2012: 10ff., 175ff., see also Hacking 2012: xviiff.). Paradigms distinguish a community, because they are imperative, telling members what can be known, what issues to pursue, how to pursue them, and what can serve as legitimate methods and answers. For Kuhn, a consistently shared paradigm is the precondition for science to proceed in its everyday operations. In this mode of "normal science", scientific practice comprises mostly puzzle- and problem-solving in the still unknown areas staked out by the paradigm (Kuhn 2012: 35ff.).

His central thesis, however, is that true progress in science does not result from the aggregation of knowledge produced by the problem-solv-

22 The label "the sociology of scientific disciplines", adopted from a text by Rudolf Stichweh (1992) on the historical formation of disciplinary structures in the transition to the modern system of science, is, strictly speaking, *not* the name of a scholarly tradition. Rather, I use it here to group sociological works, which have made disciplines their central object of analysis (e.g., Abbott 2001, Jacobs 2013, Turner 2000, Weingart 2000).

23 See, e.g., the special section on Kuhn's influence after fifty years in *Social Studies of Science* volume 42, no. 3 (June 2012).

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ing actions. Instead, it depends on the occurrence of "revolutions", in which a scientific community is placed on a completely new basis. A given paradigm only legitimizes researchers' everyday practices until they begin to encounter anomalies in their work processes – aspects not explainable within the frame of practices and norms set up by a paradigm. The more of these anomalies aggregate, the more practitioners are compelled to design and use new theories and methods that question the governing paradigm. Work according to the old paradigm becomes increasingly incommensurable with the new intellectual practices. Eventually, once the old is replaced by the new, the constitution of the academic field is fundamentally transformed: "as if the professional community had been suddenly transported to another planet where familiar objects are seen in a different light and are joined by unfamiliar ones as well." (Kuhn 2012: 111).

For the sociological understanding of disciplines, it is central that an idea of scientific communities determined by paradigms allows conceptualizing the relationship between epistemic and social structures with reference to the mechanisms of socialization and institutionalization. The social and intellectual connection between research and teaching is a fundamental principle of scientific disciplines, which will also play an important part in my study. If we conceive of disciplines as scientific communities, we can see how academic role structures are connected to the prospect of scientific careers. These bind academic recruits to a discipline and to specific research practices (Stichweh 1984: 87). Through the institutions of lectures and courses, canonical textbooks and practical training, students acquire a certain paradigm through academic socialization that guides their work. In the words of Kuhn, members of a community "have undergone similar educations and professional initiations; in the process they have absorbed the same technical literature and drawn many of the same lessons" (Kuhn 2012: 176). Accordingly, in scientific disciplines, areas of knowledge are connected to academic education and the formal organization of scientific work. They organize the academic labor market by providing formal credentials to graduates, which confirm that they possess the required means to pursue tasks in a certain academic field (Turner 2000). "A discipline is a form of social organization that generates new ideas and research findings, certifies this knowledge, and in turn teaches this subject matter to interested students" (Jacobs 2013: 28).

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II. From the Culture of Science to Cultures of Research

There were major points of critique, coming especially from the STS side of science studies, against the sociological concept of disciplines. The first was that the empirical reality of research work did not confirm the neatly structured conception of science. Instead, with a view to research praxis, science appeared as a messy business. The second, as I already mentioned in the introduction, was that disciplines were seen as tending only to matters of importance to themselves, ignorant of any societal relevance and thereby barring themselves from interdisciplinary activity. I will mainly look at the first objection here since it immediately concerns the organization of science and research and the concept of disciplines. The second, in contrast, takes on the form of a normative pitting of disciplinarity against inter-, multi- and transdisciplinarity. This line of argument, though, is of little relevance for my discussion here.[24]

Kuhn had developed his theory of scientific revolutions in front of the history of physics, a very homogenous field in which there is a high degree of consensus on rules and norms. This means that his thoughts were already biased against disciplines exhibiting a range of different paradigms, rules or norms like sociology or biology. For scholars in STS, however, this older understanding of science as a monolithic and unitary institution needed to be abandoned for a new idea of science in which research, understood as a socially heterogenous and complex form of action, is the main feature of the scientific system. Thus, the study of concrete scientific practices has received special prominence in science studies, especially in order to supersede the theory- and knowledge-centered traditions of the field (Lenoir 1997: 45ff.). This induced a shift in perspective and important protagonists welcomed the departure from the investigation of the "culture of science" to examining the many "cultures of research" instead (e.g., Pickering 1992, see also Galison/Stump 1996). As Bruno Latour – a pivotal figure in STS – once programmatically explained in an article in *Science*:

> "Science is certainty; research is uncertainty. Science is supposed to be cold, straight, and detached; research is warm, involving and risky. Science puts an end to the vagaries of human disputes; research creates controversies. Science produces objectivity by escaping as much as pos-

24 See my brief overview of the debate in Roth (2022). Authors in the "sociology of scientific disciplines" also offer a more complementary view of disciplinarity and interdisciplinarity, rather than the oppositional view dominating STS discourses (see Abbott 2001, Jacobs 2013, Turner 2000).

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> sible from the shackles of ideology, passions, and emotions; research feeds on all those to render objects of inquiry familiar" (Latour 1998: 208).

The so-called laboratory studies of the 1980s helped to set the focus on research cultures instead of on science as a (homogenous) system. Through rich anthropological investigations into the work conducted in research laboratories, authors showed that "science" could be understood as something that takes place in everyday practices and in negotiations over the (mundane) technicalities of research approaches (Knorr Cetina 1981, Latour/Woolgar 1986, Lynch 1985). These studies disclosed the messy and contingent processes that preceded the orderly and unambiguous publication of scientific findings in journal papers. In fact, scientists spent most of their time manipulating their research objects or arranging their data in ways to fit the propositions they were trying to make. Most crucially for my purposes, however, this perspective on the research laboratory also revealed that the integration of scientists into communities did not happen on the basis of disciplinary affiliation or by sharing values and paradigms. Instead, it is the work on concrete problems through which researchers collectively identify themselves.

This trend was indeed revolutionary in the Kuhnian sense: it set the social and cultural research into science on a completely new footing and revealed a never-before-studied dimension of the scientific system. Despite the rejection of his theory, Kuhn's work also provided some crucial inspiration. In their iconic ethnographic study of lab work at the Salk Institute, Latour and Woolgar, for instance, see him set "the general basis for a conception of the social character of science" (Latour/Woolgar 1986: 275). Instead of focusing on the institutionalization of paradigms in the form of research chairs, lectures or textbooks, though, the authors here emphasize "the correspondence between a particular group, network, or laboratory and a complex mixture of beliefs, habits, systematized knowledge, exemplary achievements, experimental practices, oral traditions, and craft skills" (Latour/Woolgar 1986: 54). Latour and Woolgar go on to note that, although "referred to as 'culture' in anthropology, this latter set of attributes is commonly subsumed under the term paradigm when applied to people calling themselves scientists" (Latour/Woolgar 1986: 54). However, by calling it "culture" instead of "paradigm", they shift the focus from pompous scientific theories, and the rather abstract level of organizing professional behavior, to the local and quotidian activities making up research, "the set of arguments and beliefs to which there is a constant appeal in daily life and which is the object of all passions, fears,

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and respect" (Latour/Woolgar 1986: 55). My idea of disciplinary cultures accepts a similar mix of informal and formal, tacit and explicit knowledge forms as constitutive of groups of researchers.

Connected with this reformulation of the empirical reality of the scientific system came a further objection against the sociological concept of disciplines. This objection was directed against the general notion that disciplines were an indication of the scientific system's formal unity, since the same basic operational mechanisms were at work in every discipline (e.g., Stichweh 2007). Instead, STS and other works in science studies with a focus on practices demonstrated the disunity of science; or even that what is called science was in reality a highly fragmented patchwork of different research cultures. Karin Knorr Cetina's work on "epistemic cultures" provided a sociological foundation for this understanding of science (Knorr Cetina 1999, Knorr Cetina/Reichmann 2015).

According to Knorr Cetina, such cultures of knowledge work incorporate the complex material, social, technical and cognitive structures that guide scientific practices – the "texture" of science, which is not congruent with disciplinary differentiation and is found only in "the deep social spaces of modern institutions" (Knorr Cetina 1999: 2). This is exemplified in the idea of the laboratory, which can range from the biological workbench to the vast apparatuses of high energy physics. Knorr Cetina revealed how the ongoing messy and contingent processes making up scientific practices are regulated on a micro-social dimension particular to each individual research area (Knorr Cetina 1999: 23–45). Different from Kuhn's idea of paradigms, therefore, which described the relation between theory and professional work, the notion of "culture" receives prominence in this context because it is meant to denote more broadly "the frames of meaning within which people enact their lives"; but it is also taken on the other hand to signify the idea of a plurality of fields of research, which use "different vocabularies of knowledge" or target "different objects of study", and which also form radically unique "realties" with their own ontologies (Knorr Cetina/Reichmann 2015: 873f.). Knorr Cetina's central thesis with respect to the integration of science is therefore that, in contrast to the institutional understanding of sociology of science, the knowledge practices of contemporary science are not defined by professional or organizational interests. They are rather determined by the baselines that govern the handling of research objects and by the routines for solving technical issues that are particular to research work in a specific social and material setting.

From the idea of epistemic cultures thus emerges a picture of science that is typical also for other works with a focus on scientific praxis: in

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contrast to the homogenous image given by scientific disciplines, these studies emphasize the cultural fragmentation of science (Galison/Stump 1996). They emphasize the "multiplicity, patchiness, and heterogeneity of the space in which scientists work", instead of presupposing the idea "of scientific culture as a single unity" (Pickering 1992: 8). Science is portrayed as "not one enterprise but many", all of which form "a whole landscape – or market – of independent epistemic monopolies producing vastly different products" (Knorr Cetina 1999: 4).[25]

While my study supports the idea of science as being composed of a heterogenous field of different research cultures, to project them in stark isolation from one another seems exaggerated. As noted above, disciplinary cultures share an orientation to societal problems and expectations by adhering to the overarching narratives of science, i.e., even the vastly disparate fields of molecular biology and high-energy physics necessarily subscribe to popular understandings like that of basic research to justify their endeavors in front of society. As the case of medical science will show, though cultures here tended to fragment and separate from one another, they nevertheless retained an identity as *medical* research fields (sometimes even when it was hard to see their medical relevance). For me, therefore, it seems more plausible to argue for the simultaneity of the patchiness of the research culture landscape and the semantic unity of science provided by basic concepts and overarching narratives. Both, spoken idiomatically, are different sides to the same coin.

III. The Emergence of Disciplinary Cultures in the Modern Research University

My book accordingly aims at elucidating a middle ground – a meso-level view of science (see also Schweber 2006) between the macroscopic perspective of institutional sociology and the microscopic view of laboratory studies in STS. The concept of disciplinary cultures that I want to introduce helps focusing on this meso-level of disciplinary formation. It thereby enables viewing relevant processes somewhere between the abstract level of formal organization and the local level of material-epistemic practices. As I will illustrate, many of the now seemingly objective descriptions of

25 Surprisingly, queries for "scientific" or "research culture/s" (in the singular *and* plural) in the current *Handbook of Science and Technology Studies* total up to only ten mentions. That is an almost negligible figure compared to the number of "discipline/s" used in the text (see note 19 above).

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medical science emerged from very specific institutions, research groups or laboratories. Overall, it can be said that disciplinary cultures received special significance with the emergence of modern science. Before that, the identity of a discipline was mainly determined by a body of philosophical knowledge, as noted above. In a classic account, Stichweh argues that modern disciplines emerged (in Germany) in a transitional period between the mid-eighteenth and the start of the nineteenth century (Stichweh 1992, 1984, see also Weingart 2010). During this process, the pursuit of science was relocated from the academy into the university, and disciplines developed from being classifications for epistemic subjects into social organizations or *scientific communities*. Before the nineteenth century, Stichweh shows, "the history of the term *disciplina* was closely linked to the history of the term *doctrina*" (1992: 4). In other words, disciplines were the context of learning in which students received the recorded doctrines, the teaching of a systematic set of philosophical knowledge.

In this respect, disciplines were not yet endowed with a specific social function, but "served as repositories of certified knowledge" (Weingart 2010: 4). In this configuration, knowledge was purely theoretical, and the cultural features focused on teaching and learning exclusively (Stichweh 1994b). Even in the higher faculties of law, medicine and theology, disciplinary knowledge neither instructed practice nor did it encourage scientific innovation, but only granted the graduating student the right to practice the corresponding profession because of scholarly credentials. As the sociologist Stephen Turner notes: "the key to academic culture was disputations – over the received texts" (2017: 15). Institutionally, the doctrines of *disciplina* were organized in the hierarchical structure of the medieval and early modern university. This structure was determined by the epistemic status of the different branches of knowledge – with the lower philosophical faculty and its propaedeutic teachings in the liberal arts as the basis for the higher faculties.[26]

Prior to the development of modern science, the university thus primarily constituted a place for scholarly and vocational training. Academic discourse happened mainly in the academies and learned societies, which were also responsible for the advancement of scientific knowledge. Their operational radius accordingly comprised mainly the natural and mathe-

26 Therefore, students of medicine had to first master "undergraduate" courses in the philosophical faculty before moving on to pursue a doctorate in medicine through education in a curriculum that contained specifically medical subjects like anatomy and physiology.

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matical sciences.[27] The faculties of law, theology and medicine were generally excluded – and physicians, if they were a part, only partook in their capacity as natural researchers. Stichweh accordingly sees academies in this period characterized by three main features: The small number of personnel appeared to enable the conducting of "meaningful scientific work"; academies reflected the beginnings of the modern concept of science, which was oriented on the disciplines of the philosophical faculty; and the limitation of these institutional structures offered the opportunity to see and formulate an idea of *research* as a category that "distinguished the included from the excluded sciences", i.e., the natural sciences and mathematics from law, theology and medicine (1984: 67).

The cultural attributes of academies were also differentiated from those attributes central to university teaching and learning. An important feature of academies was that they defined "rules of discourse" for participation in scientific activities. Most prominently, institutions like the British Royal Society and the Prussian Academy of Science adopted the "practice of experimental proof" in the early eighteenth century, so that "topics that were part of the tradition of disputation and not subject to experimental evidence were excluded" (Turner 2017: 17, see also Shapin 2012: 89–116). According to Stichweh, such rules then became attributes of the modern university because of a "factual exodus of science out of the academy" at the end of the eighteenth century (1984: 69).

With the complex changes that (German) society underwent at the turn from the eighteenth to the nineteenth century, new social roles and demands for knowledge emerged. To educate the recruits to fill these new professional positions it required a high number of schoolteachers, who, in turn, had to be trained academically (McClelland 1980). Consequently, secondary education could no longer depend on the institutional authority of the family. Relocated to Gymnasia and *Realschulen*, it now rested on the epistemic certainty of the subjects that were taught and on their association with scientific knowledge. In the universities, this led to what Stichweh calls a "functional association between education and science" (ibid: 79). At the same time, scientific knowledge grew steadfast and fragmented, demanding criteria for its selective handling, and, because of its increasing mathematization, became more abstract and specialized (Weingart 2010: 5f.).

27 A historic-philological class was later added in Germany, but not in other European countries (Stichweh 1984: 68).

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Under these conditions, the undifferentiated approach to scientific knowledge of the academies increasingly became unsustainable. Tending to all the areas of science, as it was now demanded by society, required a differentiated approach to academic subject areas. But the members of the academy were mostly private and not professional researchers; and their small number no longer provided the necessary labor forces for producing and transmitting knowledge in the different disciplinary fields. With the creation of new professions associated with secondary and university education, however, and the corresponding organizational growth of the university, the institution provided a combination of academic role structures and disciplinary categorizations, from which scientific careers could develop to accommodate the "different, quite heterogeneous, disciplines with their specific 'cultures' and the pursuit of research in the modern sense" (Weingart 2010: 7, see also Stichweh 1984: 87). As a result – and this is a common theme uniting sociological research on science since Kuhn – the cognitive differentiation and diversification of scientific knowledge could now rely on the organizational structure of the academic disciplines in the university for recruitment, bringing rules that defined the conduct of scientific activities into the institution, which replaced the traditional definition of disciplines as places of *doctrina*.[28] The teaching in universities now primarily comprised the transmission of these cultural properties instead of only teaching and learning the philosophical knowledge of a subject area. Stichweh refers to this change as the "dogmatization" of "scientific knowledge bases which are not dogmatical in themselves" (Stichweh 1994b: 191). Stated differently, the philosophical basis of a discipline was replaced with a set of "methods" or "practices" that were characteristic for the production of knowledge in a particular area. As Turner aptly concludes, disciplines now gained legitimacy "as the locus and guardian of specific competences and bodies of knowledge shared with others trained in the same discipline" (Turner 2017: 17).

IV. Academic Tribes and Disciplinary Territories

How can a systematic account of disciplinary culture be formulated in front of this historical genealogy? The aim is to provide a concept of

28 In this context, Stichweh speaks of "an exchange of functions", so that universities became places of research, while academies become refuges for learnedness (1984: 73).

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disciplinarity that lies somewhere between the sociology of science and STS laboratory studies. I will draw on anthropological views of academic disciplines to develop this account. Already the American cultural anthropologist Clifford Geertz suggested an ethnographic look at disciplines in his book *Local Knowledge*, thereby anticipating my aim of finding a compromise between formal structure and local practice (Geertz 1983). He presented the prospect that such an analysis would reveal the different intellectual, political and moral relationships of members of a scientific community to each other and to the larger societal context; that it would bring to light the career structures and modes of socialization specific to individual disciplines; and that, moreover, "the vocabularies in which the various disciplines talk about themselves to themselves" could provide access "to the sort of mentalities at work in them" (1983: 157).

British higher education scholars Tony Becher and Paul Trowler have brought an anthropological perspective to bear on a systematic investigation of academic disciplines in their book *Academic Tribes and Territories* (2001). Based on extensive data from inquiries into fields in the humanities, social and natural sciences they argue that the knowledge structures of different disciplines ("territories") lead to the formation of specific disciplinary cultures ("tribes"). This means that the general behavior and the values of members constituting such cultures are formed by the practices, which they use to tend to their territory: "the ways in which academics engage with their subject matter, and the narratives they develop about this, are important structural factors in the formation of disciplinary cultures" (Becher/Trowler 2001: 23).

They develop a matrix that allows classifying disciplines into different categories. It relates epistemological properties of research areas with specific social aspects of disciplinary culture. Very briefly put, depending on whether the task of a group of researchers comprises working on "hard" or "soft" and "pure" or "applied" knowledge territories – e.g., whether that work concerns abstract and universal laws of the natural world or particular insights into the social world; and whether that knowledge is meant simply to explain or instead to inform social practices and professions – the resulting cultures can be categorized as being either "convergent" or "divergent" and "urban" or "rural", i.e., as tightly knit with lively exchange between members, and in which most researchers tend to the same or similar objects, or communities where members tend to different knowledge areas and have less interaction than in tightly knit communities. (Becher/Trowler 2001: 35ff., 183ff.).

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What is crucial to my argument is that the authors go beyond Kuhn's notion of homogenous paradigms and scientific communities as well as beyond the sociology of scientific disciplines' formal dimensions of organizing science. Very much in the vein of Geertz (and of works in STS), they show how cultures of disciplines vary empirically regarding, e.g., career structures, publication practices or scientific standards.

> "In particular, the examination of the cognitive and social aspects of intellectual inquiry has highlighted a remarkable diversity in the activities that go to make up the academic enterprise. Knowledge areas, professional networks and individual career patterns can be classified, and operationally distinguished one from another, in a multiplicity of different ways" (Becher/Trwoler 2001: 194).

Put differently, Becher and Trowler identify for academic disciplines what scholars in STS identified for cultures of research – they constitute a vast landscape of heterogeneous fields with different approaches and social constitutions. However, by adhering to the concept of disciplines, the authors preserve part of the institutional perspective. For them, beyond the informal "patchwork[s] of overlapping groups, networks, and communities of practice" (Hackett et al. 2017: 739), which are characteristic of many works in STS, still lies a more formal dimension of organizing science. This provides an angle to incorporate theories about research cultures with those about the social institutions of science.

V. Disciplines as Political Institutions

Taking the broader perspective of culture, as I argued in the introduction, has the benefit of understanding science as the discursive and symbolic products of actors and of being able to historicize the idea of cultural formation. In the next two chapters, I set out to demonstrate how local cultures established and influence formal structures of science in Germany. Cultures, according to Becher and Trowler, can be defined as "sets of taken-for-granted values, attitudes and ways of behaving, which are articulated through and reinforced by recurrent practices among a group of people in a given context" (2001: 23). However, in their book, Becher and Trowler still assume the existence of an "epistemological core" as deterministic of the cultural characteristics of disciplines (see also Trowler 2014). Like Kuhn's paradigms, the essential link between a scientific epistemology and the social factors in disciplinary cultures, i.e., the norms, values and

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trajectories that form the basis to research work, is incompatible with the idea of science as cultural space. As Shapin notes, science constitutes "a diverse set of cultural practices, which may not have common methods, conventions or concepts, or at least common features to distinguish them from 'non-science' or common culture" (Shapin 1992: 346). The integration of these diverse cultural elements, as Harris (2005) argues, happens through reference to the "supercategory" science.

The form of essentialism implied in *Academic Tribes and Territories* can be avoided by complementing the idea of disciplinary cultures with a position like that of Pierre Bourdieu's *habitus*. Fundamentally, *habitus* describes "systems of durable, transposable dispositions […], principles which generate and organize practices and representations that can be objectively adopted to their outcomes without presupposing a conscious aiming at ends or an express mastery of the operations necessary to attain them" (Bourdieu 1990: 53). It means that the possibilities of acting are not predetermined by explicit rules, which stem from overarching epistemic conditions like those given by knowledge areas nor are they simply determined by the local socio-material research settings. Instead, the notion of disciplinary cultures historicizes the possibilities for such actions. They are generated by immersion in the *tradition* of a disciplinary culture, through the "embodiment" of its history as the collective practice of pursuing science. *Habitus* "ensures the active presence of past experiences, which, deposited in each organism in the form of schemes of perception, thought and action, tend to guarantee the 'correctness' of practices and their constancy over time, more reliably than all formal rules and explicit norms" (Bourdieu 1990: 54).

What could be called a disciplinary *habitus*, therefore, incorporates "ways of knowing" and acting (Pickstone 2000), i.e., different forms of tacit (and explicit) knowledge coming from different scholarly traditions that students acquire through socialization into a specific disciplinary culture (Becher/Trowler 2001: 44ff.).[29] "Culture is both enacted and constructed," Becher and Trowler note, "played out according to structurally-provided scripts as well as changed during that process" (Becher/Trowler 2001: 24).

29 The past exemplars that determine Kuhn's paradigms, in contrast, are the express basis for consciously deriving rules to guide scientific activity. Becher and Trawler speak of "folkloric discourses and codes of practice and convention" and list elements, such as tacit and explicit knowledge, a special language, and practical, methodological, or theoretical devices commonly employed, which make up the values, attitudes and ways of behaving within a respective field (Becher/Trowler 2001: 48).

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In a Foucauldian sense, moreover, one could also say that scholars are *disciplined* into programs for specific ways of scientific action that become embodied as routine techniques and patterns of cognition and communication (Lenoir 1997: 47ff.).[30] Being part of a disciplinary community therefore comes with "a sense of identity and personal commitment" that provides a cultural frame determining much of one's everyday life (Becher/Trowler 2001: 47, see also Knorr Cetina 1999: 129f.). Having defined being part of a disciplinary culture through the embodiment of the different schemas of perception, thought and action, members of a discipline also embody a specific way of life, a "scientific life" (Shapin 2008), something that actors strive to maintain and defend.

If disciplines sustain specific ways of scientific life, it is no far leap to interpret them also as institutions that combine the intellectual interests of researchers with their social and political conditions. Taking "either a political economy or a cultural approach" (Schweber 2008: 15), some social historians of science therefore argue that scientific institutions like disciplines are formed at the intersection where the collective interests of science meet with the individual interests of researchers. In his classic institutional history *From Medical Chemistry to Biochemistry*, Robert Kohler introduces disciplines as "political institutions that demarcate areas of academic territory, allocate the privileges and responsibilities of expertise, and structure claims to resources" (Kohler 1982: 1, see also Kohler 1979: 28). He was taking his cues from the American historian Charles Rosenberg, who maintained that a scientific life needs to be regarded as a "compromise" between the "sometimes consistent and sometimes conflicting demands" of intellectual work in a discipline "and the particular conditions of an individual's employment" (Rosenberg 1997: 230). In other words, it is vital to not only look at the intellectual programs of researchers, but also at the institutional context in which they were articulated in order to understand their social significance for the development of science (e.g., Schweber 2008). "The totality of any discipline or profession", Rosenberg explains, "must be seen as a series of parallel intellectual activities being carried on in a variety of social contexts. Such rubrics as the humanities,

30 Another way of putting it – also with Foucauldian connotations – would be to invoke the idea of "epistemic virtues" at the heart of Lorraine Daston's and Peter Galison's book *Objectivity* (2010). Especially the virtue of "trained judgement", which they portray as emerging in the mid- to late-nineteenth century is compatible with the disciplinary developments that interest me, since it is based on modes of instruction, "in which students internalized and calibrated standards for seeing, judging, evaluating, and arguing" (ibid: 327).

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life sciences, or social sciences mask diversity as much as they imply unity" (Rosenberg 1997: 230).

This model of disciplines is furthermore compatible with the idea of a scientific field, the complementary concept to Bourdieu's *habitus* (Lenoir 1997: 52f.). For Bourdieu, a field is a relational analytical concept in which actors struggle over different forms of capital (symbolic, cultural, political etc.) (Bourdieu/Wacquant 1992: 97). While a field as such is unobservable (and we cannot equate disciplines with fields), the advantage of the field perspective is that we can understand the struggles going on inside of them in relation to a range of heterogeneous elements in society not immediately visible as connected to science. In concrete terms, through the concept of a field, knowledge production in a disciplinary context can be seen as linked to practical requirements of the state and administration, or to cultural and ideological frames in society, or to the industry both in terms of economic interests and as a material prerequisite for providing research technologies and lab equipment (Lenoir 1997: 239ff.). The practices of scientific actors thus become embedded in a web of social relations that determine their position within the field. The relevance of this perspective for my study is that disciplinary identity is not formed by the subject matter of a science, by specific epistemologies or by corresponding practices and methods, but by the relation of these to the expectations of stakeholders and other areas of society.[31]

Bourdieu defines the scientific field as a "locus of competitive struggle, in which the specific issue at stake is the monopoly of scientific authority" or "the monopoly over scientific competence, in the sense of a particular agent's socially recognized capacity to speak and act legitimately […] in scientific matters" (Bourdieu 1975: 19). However, scientific competence or the capacity to speak and act legitimately in matters of science is not only a product of scientific actors' epistemic endeavors. Instead, the intellectual pursuits are themselves a resource in the struggle to acquire the cultural capital, with which one can bargain for the necessary resources to pursue further scientific projects. This view deliberately blurs the distinction between a technical and political side of scientific knowledge production: "The political struggle to dominate resources is inseparable from the

31 I will show especially in the case of medical and biological sciences in the early-twentieth century USA (chapter 5) that their research practices as well as their institutional organization became virtually indistinguishable. The only distinguishing factor that remained was how actors in these fields related their academic work to social demands and expectations.

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cognitive enterprise of defining what constitutes legitimate, authorized science" (Lenoir 1997: 52).[32] From this perspective, ideas, methods or techniques receive primacy as *cultural* items over their implied *intellectual* meaning. They can be discursively mobilized as a way for individuals and groups to politically maintain their status and identity within the social system of science. Thus, the technical aspects of scientific ideas are inseparable from their political function in the context of institution-building: "Ideas and research programs are professional strategies and one cannot separate their intellectual and political aspects" (Kohler 1982: 214, see also Kohler 1979: 56f.).[33]

VI. Disciplinary Boundary and Identity Work

The political struggles over resources and influences as well as the interlinking of professional and social interests can be conceptualized as disciplinary *boundary work* (Gieryn 1995, 1999) and *identity work* (Kaldewey 2013). Disciplines, I want to accordingly propose, are institutions that are constantly in flux, their identities permanently reproduced and renegotiated according to the changing social and scientific contexts. As Kohler

32 After his discussion of Bourdieu in his cultural theory of disciplines, historian Timothy Lenoir, however, introduces a problematic distinction between "research programs" and "disciplinary programs" (1997: 53ff.). Research programs constitute the problem-oriented instrumental practices akin to those that make up research cultures; disciplinary programs, in contrast, operate on the institutional level of science, where "scientific entrepreneurs" with managerial skill promote the research work in a political economy to build the according institutions. But by separating "the labor and political work struggles involved in research work form the quite different politics and work of discipline building" (ibid: 53), Lenoir implies that the latter is not represented in the former. My point is precisely that the choice of techniques, methods and practices for scientific work are always also entangled with social and cultural values and ideals. In other words, while Lenoir implies an image of scientists of problem-solving lab drones, who's work requires being translated into cultural products that can be understood by society, I want to suggest that all researchers are always scientific practitioners and managers of scientific identity.

33 Knorr Cetina maintains, in contrast, that "those amalgams of arrangements and mechanisms" which make up epistemic cultures were simply "bonded through affinity, necessity, and historical coincidence" (1999: 1, see also Knorr Cetina/Reichmann 2015: 873). This assumption misses the central point, however, that the cultural frames, which define the actions of a given group of researchers, as well as the objects they are committed to, emerged over time.

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makes clear right at the outset of his book, disciplines "are creatures of history and reflect human habits and preferences, not a fixed order of nature" (Kohler 1982: 1). Or as Gieryn warns readers, "The analytical danger is to reify the cultural space of science into something so stable, so 'structural', or 'institutionalized', that the significance of episodic reproductions in boundary-work is lost altogether" (Gieryn 1995: 420). In practices of discursive demarcation, actors continuously defend the status and relevance of their discipline in the institutional context of science. In their papers, pamphlets and speeches, they constantly readjust their practical work to jurisdictional claims over intellectual and societal problems. These discourses are not merely "epiphenomena" of the competition between disciplines, but important aspects through which disciplines form their social, moral and intellectual orders in the first place (Amsterdamska 2005: 46).

Olga Amsterdamska (2005) impressively examines the strategic use of ideas and methods for epidemiological discipline-building, drawing on the conceptual frame of boundary-work. She uses the approach to illuminate the "internal" border-drawing that designates "the place and the status of a specific discipline" (ibid: 20). Epidemiologists distinguished their pursuit from that of bacteriology and other medical sciences in the early-twentieth century to argue for its academic autonomy on the one hand, but also from statistics in order to claim its scientific status as opposed to being simply an instrument for public health officials on the other. In the process, academic epidemiologists employed different devices of science, such as laboratory experiment, biostatistical analysis or field observation, framing them as part of their disciplinary identity. In the interwar period, for example, actors distinguished the epidemiological concept of disease from the idea of "disease that was an object of a clinical or bacteriological investigation", in order to subject it to their statistical forms of explanation, calling for cognitive and institutional autonomy (ibid: 32). But after World War II, epidemiologists no longer contrasted the "logic of statistical inference" with the "logic of experimentation" but instead now framed statistics as a means to overcome the "possible shortcomings of [experimental] research" (ibid: 43). Such discursive boundary-drawing, as Amsterdamska emphasizes, are mainly directed at peers, "to the actual practitioners who are thus being reminded both of the scientific nature of their endeavor and of their membership in a select and distinctive community" (ibid: 46).

As research on identity work, more generally, has shown, scientific identity is constructed not only in relation to scientific peers. It is rather an interplay of scientific self-attributions and of negotiations over the role of science opposed to societal attributions and expectations (Kaldewey 2013:

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107, Schauz 2020: 22). Thereby, identity work contributes to remapping the public image of science in accordance with expectations and desires of different non-scientific actors just as much as it reorganizes intra-science relations. Disciplinary identity can thus be seen to emerge from the tension between work understood as free and only devoted to scientific truth as well as the simultaneous expectation of its social utility. Discursive identity work means exploring how actors in their communications claimed specific research techniques, methods, concepts or styles as professional markers and how they also distinguished them from other professional groups by drawing cultural boundaries. Disciplinary boundary work is thus always simultaneously an act of exclusion and inclusion. Moreover, they used these devices to position their actions between the often local social and economic conditions of their professional work and the intellectual and structural contexts of science. For example, discarding the empirical method of clinical medicine in favor laboratory practices is at the same time a strategy to stake off professional turf within medical science, just as much as it is a symbol for committing to the general ideology of cultural progress through science.

Instances of disciplinary identity work are visible in actors of the early-twentieth century US university landscape. As Rosenberg, for example, shows, scientists who held leading positions in research stations or departments at the time acted in a political and scientific double role, which he calls "scientist-entrepreneurs" or "research-entrepreneurs" (Rosenberg 1997: 159, see also Kohler 1982: 5, Lenoir 1997: 46). Their characteristic feature was, according to Rosenberg, that in order to secure the institutional viability of their disciplines, they mediated between the world of science on the one hand and the world of social and economic expectations of a certain group of clients on the other (e.g., governments, businesses, public institutions). "The successful research-entrepreneur had to not only tailor a research policy to the needs of his lay constituency, but still remain aware of professional values and realities" (Rosenberg 1997: 159). In exchange for the institutionally secured possibility to pursue research freely, agrarian scientists, for instance, began to equip the identity of their discipline with specific service functions, such as the promise to find ways to maximize yield or breed productive strains of crop. Shapin reconstructed forms of identity work using the example of the Biotech-Boom in the 1970s and 1980s, where scientists established remarkable businesses with the help of venture capital. Consequently, a figure rose to prominence that is defined by embodying the tension between science and social contexts: "They had

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one foot in the making of knowledge and the other in the making of artifacts, services, and, ultimately, money" (Shapin 2008: 210).

Next to actions of research, i.e., the actual production of scientific knowledge, working in an institution like a discipline always also entails a form of praxis that relates research to different social contexts. In their quotidian practices, scientists not only play the role of problem-solving lab drones, but also contribute to the (self-)depictions of disciplines and research cultures, which often also include promises of utility and relevance that legitimize their research practices in front of a broader public and stakeholders in society. Accordingly, discipline specific socialization, or the acquisition of a disciplinary *habitus*, comprises, next to initiation into a community's ways of knowing and acting, that students already learn how their prospective academic work is linked to expectations of services, which are often already expressed in the descriptions of study programs at universities.[34] Thus, looking through the analytical lens of disciplinary identity has the advantage of transforming the sociological issue of science's dis-/unity into an empirical question of discursive boundary and identity work (Kaldewey 2013: 107). In what follows, I will show that one can neither speak of a clear organizational unity nor of a fragmented field, but that the different research cultures of medical science are held together by the basic concepts that characterize the discipline as at the same time an intellectual and political endeavor.

34 See for example the promises of utility and social relevance in the self-description of the BA-program "Molecular Biomedicine" at the University of Bonn: https://www.uni-bonn.de/de/studium/studienangebot/studiengaenge-a-z/molekulare-biomedizin-bsc (accessed July 29th, 2021).

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