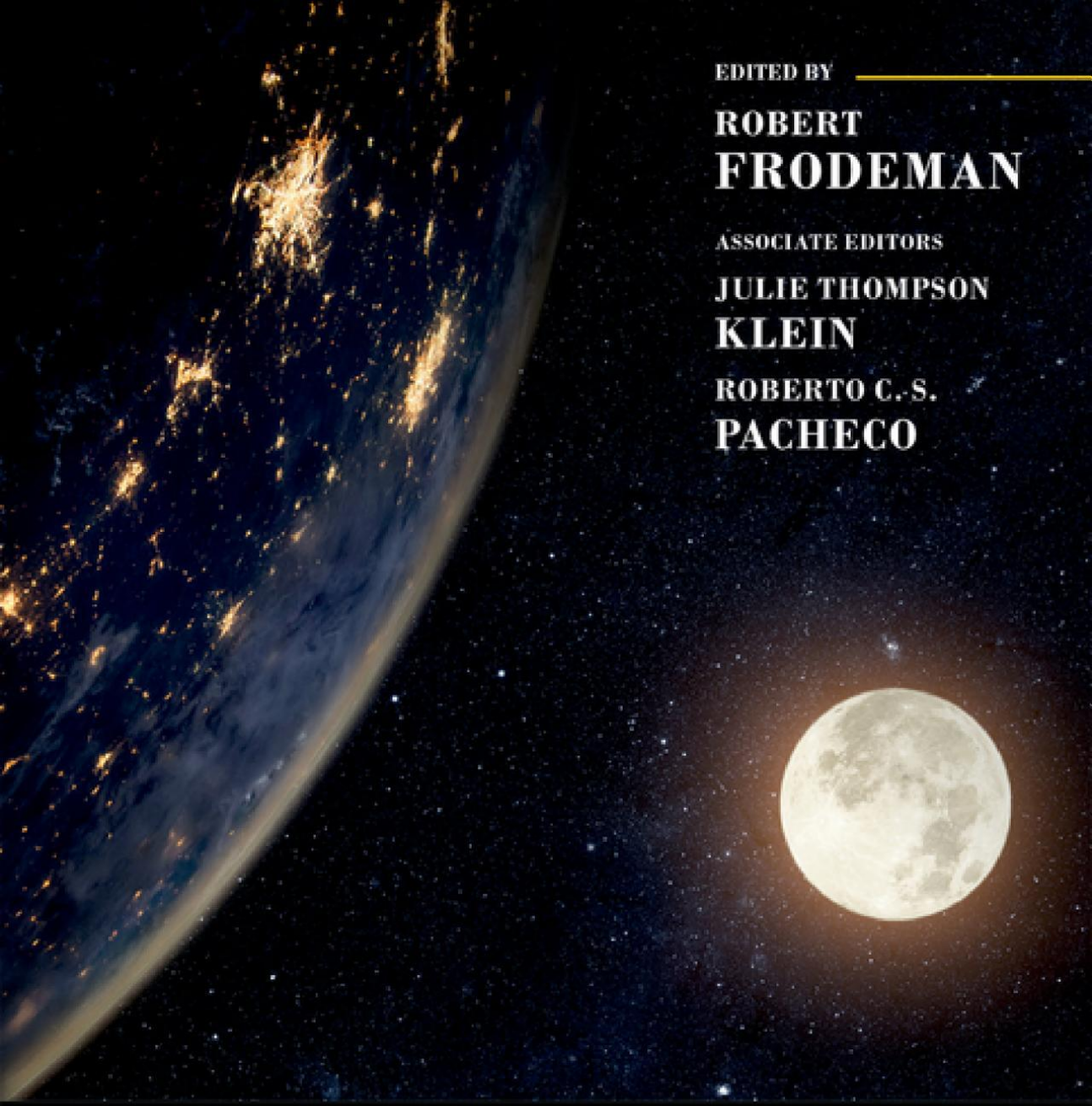

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The Oxford Handbook *of* INTERDISCIPLINARITY

SECOND EDITION

THE OXFORD HANDBOOK OF

INTERDISCIPLINARITY

SECOND EDITION

Editor-in-chief
ROBERT FRODEMAN

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and
ROBERTO C. S. PACHECO

OXFORD
UNIVERSITY PRESS

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Great Clarendon Street, Oxford, OX2 6DP,
United Kingdom

Oxford University Press is a department of the University of Oxford.
It furthers the University's objective of excellence in research, scholarship,
and education by publishing worldwide. Oxford is a registered trade mark of
Oxford University Press in the UK and in certain other countries

First Edition published in 2010
Second Edition published in 2017

The moral rights of the authors have been asserted
Impression: 1

Published in the United States of America by Oxford University Press
198 Madison Avenue, New York, NY 10016, United States of America

British Library Cataloguing in Publication Data
Data available

Library of Congress Control Number: 2016952283
ISBN 978–0–19–873352–2

DOI: 10.1093/oxfordhb/9780198733522.001.0001

Printed and bound by
CPI Group (UK) Ltd, Croydon, CR0 4YY

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PART I

THE LANDSCAPE OF KNOWLEDGE

CHAPTER 1

THE FUTURE OF INTERDISCIPLINARITY

An Introduction to the 2nd Edition

ROBERT FRODEMAN

> As a simple fact, interdisciplinarity responds to the failure of expertise to live up to its own hype.
>
> —Fuller and Collier 2004

It might seem odd to begin the *Oxford Handbook of Interdisciplinarity* with the question of whether interdisciplinarity has a future. For both individually and as a whole, the 46 chapters that follow illustrate the utility of the concept as well as its importance in prompting innovation in both research and pedagogy. On the other hand, some clarity concerning the goals of the field, as well as the overall goals of this book, would be helpful. I speak for myself rather than my fellow editors or authors; but given the fraught nature of conversations surrounding the term, the varied and even contradictory meanings assigned to it, and its sometimes function as an empty honorific, an exploration of the future prospects of interdisciplinarity seems worth some attention.

The issue is in part one of definition. But here we have to define definition. It could mean the demarcation of interdisciplinarity in comparison with its cognate terms—disciplinarity, multidisciplinarity, and transdisciplinarity—as well as the swarm of other phrases that pass in and out of usage (antidisciplinarity, meta- and infradisciplinarity, cross-disciplinarity, etc.). Julie Thompson Klein's chapter in this volume does an admirable job of making sense of these terms, and there is no point in replicating that effort. I have in mind something else: the way in which ambiguities in the meaning of key terms have functioned within the political economy of knowledge—and whether those ambiguities have now outlived their usefulness.

Several of the subsequent chapters touch on related themes. Carl Mitcham and Wang Nan's chapter examines the inter- and transdisciplinary nature of ethics (whereas the focus here is on the ethics and politics of interdisciplinarity). Anne Balsamo's chapter addresses the ethics of interdisciplinary research via an Aristotelian account of what she calls interdisciplinary

Frodeman, R., *The Future of Interdisciplinarity: An Introduction to the 2nd Edition.* In: *The Oxford Handbook of Interdisciplinarity, Second Edition.* Edited by Robert Frodeman, Julie Thompson Klein, and Roberto C. S. Pacheco: Oxford University Press (2017). DOI 10.1093/oxfordhb/9780198733522.013.1

shift work. Steve Fuller's chapter on the military-industrial stimulus to interdisciplinarity recognizes that we have been too ready to dismiss outside influences on the academy as neoliberal "interference." Michael O'Rourke's chapter reviews ongoing debates about the nature (or existence) of an interdisciplinary method. Playing off of these accounts, my focus is on what can be broadly called the rhetorical dimensions of interdisciplinarity.

Both "interdisciplinarity" and "transdisciplinarity" have functioned as boundary objects that have had different meanings at different times and for different groups. Interdisciplinarity is most commonly used as a portmanteau word for all more-than-disciplinary approaches to knowledge, with the overall implication of increased societal relevance. This is how it is used in the title of this volume, even though the term more specifically refers to the intra-academic integration of different types of disciplinary knowledge. Similarly, transdisciplinarity has often referred to Hegelian-like syntheses of all knowledge—again, an academic goal—although today it is more commonly used to designate knowledge that is coproduced, where academics work with nonacademic actors of one type or another. (This has also been called Mode 2 knowledge; see Gibbons et al. 1994.)

These ambiguities have served a strategic function. In both cases they have allowed academics to gesture toward conducting research that's more relevant than "normal" disciplinary knowledge, while avoiding the painful task of actually working with people outside the academy. If this sounds critical of the community of interdisciplinarians, it is a criticism that applies here as well as to others. In part, this failure is simply a matter of the *deformation professionnelle* that all academics are prone to: our tendency to get caught up in inside-baseball debates. But there is more at work here than that.

We should not romanticize the matter: Working with nonacademics can be arduous. In fact, the topic has an ancient pedigree: The question of public engagement, and its various difficulties, is a dominant theme of Plato's work. The fate of his mentor illustrates the dangers of public engagement—that is, of seeking to be relevant. In response to Socrates's judicial murder, Plato developed the dialogue form as a means for safely and artfully presenting controversial ideas. Plato, after all, never appears in the dialogues; his beliefs have to be sussed out from the exchanges between different speakers. His reliance on the dialogue form suggests that Plato believed that a philosophical rhetoric was as crucial to thinking as any particular epistemic account of things. It is through skillful rhetoric, after all, that ideas come alive within a community. Of course, "rhetoric" is usually taken as "manipulative speech"; but for Plato (and Aristotle) rhetoric was concerned with the question of how to make sure that audiences truly "get" what is at stake.

On this account, then, interdisciplinarity consists of not only the study of how to integrate various kinds of disciplinary knowledge—call this the epistemic task—but just as much the analysis of the challenges surrounding effective communication to different audiences—call this the political and rhetorical element. While exceptions abound, the latter has been neglected within accounts of interdisciplinarity (see, for instance, O'Rourke's description of his own toolbox project in chapter 20).

Beyond *deformation professionnelle*, the incentives and disincentives of academic culture have led interdisciplinarians away from philosophical rhetoric and toward a preoccupation with epistemology—or as it appears in the literature, "method." It is a case of disciplinary capture (Frodeman & Briggle 2016): Researchers on interdisciplinarity *mean* to increase the relevance of academic work, but over time the community becomes insular, and recreates the accoutrements of disciplinary culture—a recondite vocabulary, a canon, a closed group,

conferences, and journals. Some movement in this direction is appropriate; but too much becomes what Fuller calls "epistemic rent-seeking." (While in her chapter for this volume Bammer argues that the disciplining of interdisciplinarity is precisely what is called for.)

The problem arises when the need for epistemic bona fides within one's own reference community overwhelms attention to the larger dimensions of interdisciplinarity. Rhetorical issues such as timeliness, an eye for the main point, and a commitment to the needs of a specific audience, while important to interdisciplinarians, lack the intellectual excitement of debates among the cognoscenti. Similarly, political questions, such as who speaks and who gets listened to, and how authority is distributed among the participants in a conversation, get marginalized. As a prominent interdisciplinarian once put it to me, while discussing whether policy makers and user groups should be involved in a conference on interdisciplinarity we were planning: "Nah—we'd have to dumb things down."

Policy makers are not dumber than academics; but they are less in tune with in-group epistemological niceties. Of course this (the dominant) approach to interdisciplinarity views itself as concerned with practical needs, but it does so via a tacit embrace of a disciplinary model of dissemination where insights are first worked out by experts. These insights then trickle down to the "lay" public without much (inter) active engagement. Abstract principles of a methodology are offered with less attention given to working things out on the fly, in *media res*. The implicit message is that the experts remain in charge. Put differently, interdisciplinarity has functioned at a distance from the field of policy studies, whose concerns are fundamentally rhetorical in nature, focused on the uptake of academic knowledge by the larger world. Put differently again, interdisciplinarians have a tendency to abandon their status as thinkers of the "in-between" and to join the ranks of the specialists.

Now, too much can be made of this contrast between method and rhetoric. Of course there is a "method" to one's rhetoric; otherwise it is just ad libbing. But in contrasting a focus on interdisciplinary method with the need for a philosophical rhetoric I want to highlight the importance of something closer to improvisational comedy or jazz. While the jazz musician comes armed with knowledge (of, e.g., chord progressions), the real business occurs while riffing with others. A rhetorically sensitive interdisciplinarity begins with the needs and perspective of a specific audience in a particular context, armed with a toolbox of approaches that can be tweaked as needed. This contrasts with a top-down, methodological attitude that develops a set of principles which are then programmatically applied to different situations (cf. Frodeman 2013). If done right, one's interlocutors sees no "method" at all.

But if these ambiguities have served multiple purposes and audiences—providing the appearance of responsiveness on the one side, professional legitimacy and the pleasures of tenure on the other—one wonders whether their usefulness may be coming to an end. We may have reached peak interdisciplinarity.

Treat this analogy advisedly, for just as with "peak oil," it may turn out to be an often predicted but never-quite-reached point of decline. Interdisciplinarity may yet become central to the transformation of the twenty-first-century university. Note, however, that people outside of universities already rely on a different vocabulary. Politicians and citizens speak of impact, or accountability, or relevance. It is worth asking what difference it will make if talk of "interdisciplinarity" shifts toward conversations centered on one or another of these terms—how it will affect the range of goals that universities are organized around, as well as who is in charge of the conversation.

In terms of remaining in charge, don't bet on the academics. The cluster of terms just mentioned already represents a countermovement that, while sharing some of the intuitions surrounding interdisciplinarity, has its own distinct imperatives. It is also backed by the power of the vote and the public purse. The changed landscape I speak of does not only mean the increasing influence of corporate models for the university. More fundamental—and less susceptible to shifts in political ideology—is the growing role of knowledge processes throughout society, driven by the ongoing revolution in information and communication technology. The result may have become a cliché—the "knowledge society"—but that does not make the point any less portentous.

These processes are leading to the displacement of the university from the center of knowledge production. The ubiquity of knowledge—Google in our pocket—raises the value of knowledge while at the same time lessening the distinctiveness of what occurs within what we once called the ivory tower. Thus Google today, to stay with this example, has approximately as many PhDs in its employ (~2000) as does Stanford. Now, universities remain conspicuous places for both the production (research) and consumption (education) of knowledge, and they may continue to be so in the future. But until very recently they were not merely conspicuous; they were singular, a role they have filled across various institutional permutations since the eleventh century. Students today have to be reminded that in the days before the Internet (1990!) one had to actually travel to a particular place (a library) to acquire what was then called "book learning." No longer: Knowledge production has gone rogue. Nor is the point limited to the ubiquity of the Internet: There is now more knowledge produced outside the academy than within it. In 2013 the top 10 companies in terms of research expenditures, from Volkswagen to Merck, spent more than 100 billion USD on research (Casey & Hackett 2014). By comparison, the budget of the US National Science Foundation in 2013 was $6.9 billion; the European Commission's Horizon 2020 averages around 11 billion euros a year from 2014 to 2020; and the 2014 budget of the Deutsche Forschungsgemeinschaft, the largest national research organization in Europe, was 2.8 billion euros.

These trends suggest that interdisciplinarity, as the totem of academic innovation, must embrace a different set of projects if it is to remain relevant across the next decades. The most pressing need is for an examination of the changing role of the university within society in an age of ubiquitous knowledge. Ironically, while interdisciplinarians criticize disciplinarity for a piecemeal approach to knowledge, they have not taken up the task of thinking through the function of the university as a whole. One way to frame this need is in terms of critical university studies (Williams 2016). For Williams, this implies an account of "the corporatization of American higher education over the past three decades." Fair enough: There are any number of indices, such as the rise of a contingent academic labor force (e.g., adjuncts) that support this point. But while neoliberalism represents a genuine challenge to academia—certainly among the distinctive aspects of the university are those elements that cannot be reduced to a paying basis—even more basic questions press themselves on us. What are the distinctive elements of the university that should remain viable in the future? What elements can be dispensed with, and which should be added? The STEM disciplines readily make arguments concerning their practical (that is, economic) efficacy, but the humanities have mostly failed in this regard. Can the humanities—especially at public universities—refashion themselves for an era focused on "impact?"

Ironically, given the wholesale attacks directed their way, the humanities may constitute the central feature of the twenty-first-century research university. Humanists are partially at fault here: They have been signal in their failure to provide an undated account of the impact of philosophy and of the humanities on society. The point should not be that difficult to make in an era when cultural products, creativity, style, and cultural imagination constitute so much of both the business and political worlds. But if an account of the impact of the humanities is needed, just as pressing is the need to develop a philosophy of impact. Questions of impact receive a great deal of attention within policy studies, but it is remarkable how little attention humanists, professors generally, and universities have given to the topic (Frodeman 2016).

Still the disciplinary division of labor remains paramount: Academic work remains piecemeal, even in those areas (i.e., the humanities) which used to claim with Hegel that "the truth is the whole." Thus a Google search for "institute/center for the future of the university" returns no hits; the same with attempts to locate academic programs devoted to the future of the university. Of course these are only indices; and as noted above, institutionalizing the nascent field of critical university studies presents its own problems in terms of disciplinary capture. There is still a crying need for a Manhattan Project–level effort to understand the place of the university within the ecology of twenty-first-century knowledge production and use.

What, then, is the problem that interdisciplinarity seeks to solve? I suggest it is one of politics, democracy, and technocracy. Interdisciplinarity is the bridge between academic sophists and the rest of society. "Sophist," of course, has come down to us as a term of disapprobation, but disciplinarians are by definition sophists, that is, people who are experts, who "know things." This is well and good, as long as we understand the limits (both political and epistemic) of expertise. But it does highlight the need for a class of thinkers who are adept at questioning rather than only providing answers, at opening up conversations, and at practicing the translational and transactional skills needed to connect the disciplinary sophistry to the community. To say it again, the point of interdisciplinarity is fundamentally rhetorical in nature: to figure out how to relate disciplinary expertise to the needs of the community while protecting the academic from undue harm.

By "undue harm" I mean the need to insulate academics from the negative consequences of speaking truth to power. Tenure has its problems, but its main one is that academics too rarely do anything that would demand its protections. On the other hand, the professorate should be justly held accountable when it does not recognize its dual loyalties—to the community that supports them (like Hegel, most of us are employed by the state) as well as to their disciplinary community. Academics, humanists included, are obliged to work on issues that connect up with the interests of the general public—though of course they do not owe that public the answers they desire.

As noted above, these questions were first identified by Plato. In the scholarly literature it has come down to us as "the relation of the philosopher to the *polis*." But put the point in contemporary terms: Society now demands greater accountability in return for its support of the academy. How are we to translate disciplinary knowledge into particular circumstances? What step-down functions do we have? Do we need disciplines to protect academics and/or to solve problems? And how do we at least partially sequester ourselves from simply becoming, or becoming seen as, one more political actor?

In sum, interdisciplinarity constitutes an implicit philosophy of knowledge—not simply an epistemology, but a general reflection on whether and to what degree knowledge can help us achieve the perennial goal of living the good life. It is a contemporary expression of a very old question.

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CHAPTER 2

KNOWLEDGE FORMATIONS

An Analytic Framework

STEPHEN TURNER

Knowledge is socially distributed, and the distribution of knowledge is socially structured, but the distribution and the structures within which knowledge is produced and reproduced—often two separate things—have varied enormously. Disciplines are one knowledge formation of special significance, for reasons that are explained in this chapter. They can be thought of as very old, or as a very recent phenomenon: In the very old sense, disciplines begin with the creation of rituals of certification and exclusion related to knowledge; in the more recent sense they are the product of university organization, and especially that part of university organization that joins research and teaching, knowledge production and reproduction, in the modern research university.

Interdisciplinarity, as an identifiable phenomenon with its own justification, begins as a response to disciplines in the modern sense of the term, and to the specific forms of the organization of disciplines in the modern research university as it emerged in the United States in the first two decades of the twentieth century (Graham & Diamond 1997). Interdisciplinary work has generated its own knowledge formations, which we consider at the end of the chapter. Yet interdisciplinarity, transdisciplinarity, and multidisciplinarity can also be thought of in terms of the older senses of "disciplines," and thus be given a long history.

In this chapter I give a general picture of the structural constraints on knowledge formations, introduce the idea of disciplines, and discuss the historical alternatives to disciplines and the motives for finding alternatives. I conclude with a discussion of the more recent history and some issues with current nondisciplinary forms. There is a literature on these issues, concerning such things as the internal organization of disciplines (Whitley [1984] 2000; Jacobs 2013; Collins 1998; Fuchs 1996). My approach is slightly different: to provide a general account of the preconditions and constraints under which knowledge formations that produce and reproduce knowledge operated, with a stress on the tensions between these constraints, and the various ways in which these tensions are managed.

Turner, S., *Knowledge Formations: An Analytic Framework*. In: *The Oxford Handbook of Interdisciplinarity, Second Edition*. Edited by Robert Frodeman, Julie Thompson Klein, and Roberto C. S. Pacheco: Oxford University Press (2017). DOI 10.1093/oxfordhb/9780198733522.013.2

2.1 Some Basics of Knowledge Formation

To understand the range and differences between the various forms of the social organization of knowledge production and reproduction, it is useful to keep in mind some basic constraints that all of these forms operate under. These constraints can be handled or solved for in different ways, and it is the different combinations of solutions that produce the different forms. The issues of disciplinarity and those of forms of nondisciplinarity and interdisciplinarity make more sense in relation to these considerations, as do arguments for the reform of the current disciplinary order and its replacement. What follows is a list of what can be regarded as the basic elements of knowledge formations, of which disciplines are only one type.

2.1.1 Knowledge Sources

Knowledge has a history and source, and the sources constrain the way a knowledge formation is configured. There are multiple sources of "knowledge" but a basic set of distinctions might be borrowed from one of the most deeply rooted and historically important bodies of knowledge—law. A traditional distinction is made between (1) revelatory law, (2) rational law, and (3) customary law. A version of this might be adapted more generally: There is (1) knowledge that is eternal and unchanging and comes from a source appropriate to it; (2) empirical or factual knowledge, with a source in the changing world of empirical fact or socially constructed fact or even literary fashion; and (3) nonexplicit knowledge, involved in application, such as craft knowledge, or things learned as a tacit precondition to possessing the other kinds of knowledge. There is a difference between fields in which the participants generate the knowledge and those in which there are external sources, or supposed external sources, such as revelation, or the law as enacted by legislatures or passed down, that provide the core content of the subject matter. The type of knowledge involved is important as a determinant of the way in which it is taught, though arguably there are elements of each of these three sources in every knowledge formation.

Each of these, as a living body of knowledge that is transmitted and taught, involves a common language and a common understanding of that language, which is often specialized and distinct from ordinary language, as well as accepted forms of argument and reasoning, which are "shared" as a result of more or less standardized training or education of some kind that is a condition of communication rather than a form of communication. This tacit background may be highly specialized or relatively open and extensive, consisting of conversation and shared activity, or may be the product of quite rigid training hurdles, or a matter of overlapping areas of mutual intelligibility in which some of the common ground is very partial and unsystematic (see Galison 1997; Warwick 2003).

In the traditional disciplines central to the history of the European university there were dogmas—theological and legal—that students needed to master. Applying them was

a different matter. Empirical knowledge and discovery played no role in these fields, but they did change through doctrinal refinement and gap filling. There were, moreover, tensions between these kinds of knowledge—between theory and practice, legal orthodoxy and application, and so forth—that generated new forms of knowledge production, including such things as casuistics and modes of empirical revision of principles and innovations in craft knowledge. The kinds of knowledge involved constrain the other parts of the knowledge formation.

2.1.1.1 Resources

Producing and reproducing knowledge requires people whose lives are to a significant extent dedicated to these tasks, and this means they must have sources of income that support the intellectual work that they do. The Romans sometimes had Greek slaves who advised and taught; tutors, secretaries, and librarians have often played this role, as have monks and priests. The arrangements vary widely, but both antedate and parallel the model of the university teacher.

2.1.1.2 Means of Communication

To the extent that new knowledge is generated or new interpretations are proposed, or even when the doctrine of the knowledge in question holds it to be complete or fixed but requires it to be taught and applied to new situations, some means of communicating this to others—"publication" in the literal sense of making known to some relevant persons—is essential.

2.1.1.3 Norms of Conduct and Conventions of Discourse and Exchange

Robert Merton wrote about the norms of science ([1942] 1973), describing a world that has largely vanished; Edward Shils did the same with the academic ethic (1984), and philosophers discuss the epistemic norms and values of science. Norms are part of the conditions for knowledge production and also of the reproduction of knowledge. These may vary significantly by field, and across time, but without them it is difficult for communication and exchange to result in something commonly recognized to be "knowledge." These norms, however, limit as well as facilitate communication, and because they vary from group to group and discipline to discipline, they are also the source of mutual incomprehension and disagreement.

2.1.2 Exclusion/Inclusion and Marks of Recognition

A pervasive feature of intellectual communities is the existence of marks of membership, explicit or implicit. Certification in the form of degrees, membership in societies or academies, peer review in a variety of contexts implying a definite notion of "peer," and the like are examples. Often there is a symbolic or ceremonial representation of membership, such as the granting of a degree, or some sort of physical evidence of having been trained.

2.1.2.1 *External Legitimacy*

Normally the community or group communicating knowledge has some sort of respect and recognition by nonmembers. This may be highly formal and come with a developed theory of the status of the particular kind of knowledge. The theory may be accepted by those who do not share the knowledge, or be part of the rationale for a particular institutional structure, such as an education system, bureaucratic order, or religious system. In the institutional history of the European university a particular hierarchy of faculties and their relations was important, had consequences for the development of knowledge, and was linked to the larger ecclesiastical order and its legitimacy. Schemes of public understanding of science and popular science as well as science education designed to instill respect for science are contemporary examples of proactive attempts to secure legitimacy, as is the use of press releases to announce research findings.

2.2 Solving for a Workable Structure: Why Disciplines Work

The conflict between teaching and research in the modern university is a familiar example of the tension between the constraints arising from the different problems of knowledge production and reproduction. The ideal of the scholar-teacher is a response to this tension, which solves the problem of resources by embedding the role within a university that supplies certification and generates income to support the scholar-teacher, and has acquired a generalized legitimacy on which the scholar-teacher can rely. This solution, in its usual forms, is associated with disciplinarization, because certification is done within the university mostly in terms of disciplines. Knowledge production is possible within this system because of the surplus extracted from the paying activity of reproduction or teaching, though this is increasingly supplemented and even replaced by the grant system, which diminishes, sometimes to nil, the role of reproduction. This provides one opening for going beyond disciplinarity, but nevertheless making such alternatives work requires that they provide a solution for the other constraints identified above.

One may think of the problem in this way: The constraints are a problem space in which there are many "solutions"—namely, knowledge formations, which need to achieve a certain stability over time, but which allow for a great deal of variation in the emphasis placed on each constraint and for a great deal of variation in the way each constraint is dealt with. The issue of legitimation is an example of the possible variations in solutions for a single constraint. Legitimation is for an audience. But audiences may vary, and may be satisfied in various ways. The model of "public understanding of science," to which we return later, is the product of a long history of thinking about the fundamental problem that results from the dependence of science on the public for support and the inability of the public to understand the content of science. A tradition that can be dated at least from Condorcet and expressed forcefully in the writings of Karl Pearson ([1892] 1911, 1919) argued that science education for the public was necessary, and that it should produce respect for scientists. Pearson went so far as to call for the public to regard scientists as priests (1888, p. 20). This idea was associated with a particular presentation of science through science education, directed especially at

the working class, which taught elementary science with an eye to impressing students with the absoluteness of scientific truth and the power of science to manipulate the world.

An external presentation such as this does not determine an account of the nature of scientific knowledge internal to science itself, but it presents a problem of consistency: The practices of science and the practices and justifications internal to scientific practice cannot, unless there are barriers of secrecy, self-deception, and so forth, ignore the fact that what is taught externally takes a different form. The doctrine that there is a scientific method is a case in point. Long ridiculed by philosophers, and difficult to apply to much of what is normally recognized as science, the idea nevertheless persists as an external validator and means of policing the boundaries of science. The constraints involve both facing inward, to the community of knowers, and outward, to a public audience. Slogans like "the aim of science is to predict and control" serve similar purposes.

Disciplines solve the problem of resources by tying their internal processes—journal communication, associations, departments, degree programs, and so forth—to a hierarchical system that is both an internal and external market (Whitley [1984] 2000). The external market is the nonacademic market for graduates; the internal market is the exchange of graduates, both at the level of graduate students and PhDs and the movement of post-PhD scholars from position to position within the hierarchy. The strength of this system depends on its hierarchical character, for reasons that are explained shortly, and on its exclusive or monopolistic character. The issue of exclusive control is central: A discipline defines its domain, its objects of knowledge, and rejects the claims of others to intellectual authority over these objects. This does not mean that there is no contestation over topics and over who understands them best. But the tendency is for this contestation to be resolved by mutual respect for boundaries and the legitimacy claims that disciplines make externally and to other disciplines.

Disciplines prize their legitimacy and autonomy, and protect both in various ways: by standards, certification practices, licensing, and through the control of accepted means of communication. Typically disciplines have a professional association, a set of journals, meetings, and other structures. Facts like these go without saying: They are part of the everyday professional experience of contemporary academics. But these structures did not always exist, and the legitimacy of the disciplines themselves had to be established. The market character of the exchange of scholars—the fact that disciplinary departments are both buyers through hiring and sellers through producing—determines hierarchy, a hierarchy of market valuation of a degree from a certain department or graduate advisor, publication in a certain outlet or by a certain publisher, and so forth. The achievements of a scholar are implicitly valued and ranked. The value of an achievement is revealed by the importance that is placed on it in competitions for positions, grants, and so forth. Credibility, and the power to coerce other scholars to respond and take seriously particular work, is closely associated with these markers.

The phenomenon of intellectual "imperialism" is stigmatized precisely because it represents a disruption of these boundaries and a breakdown of the legitimacy claims on which they depend. Nevertheless, as Uskali Maki points out (2009, p. 353), expanding the explanatory domain of a theory is generally regarded as a good thing. It is evidence of the power of the theory and a source of new explanations for the target subject. So there is a tension between boundaries and monopolistic claims and quite ordinary processes of intellectual improvement. This conflict is at the heart of many of the criticisms of the system of disciplines (Jacobs 2013).

We can think of this conflict as arising from the way in which disciplines bind two things together: the production and reproduction of knowledge, teaching and research. There is nothing absolute about this binding: It is possible that, and indeed there are many cases in which, the production of knowledge is entirely divorced from any sort of training or instructional function. The story of how this happened can be briefly recapitulated. There were many knowledge formations that preceded the university, and existed—and to some extent still exist—parallel to and largely independent of universities. The university model is usually taken to have originated in the Islamic world, where there was a differentiation of faculties and a form of recognition of study, as well as funding by wealthy patrons, presumably with religious motivations, which also supported legal and clerical careers for the graduates.

In Europe, universities themselves initially followed one of two basic models. The universities of southern Europe were focused on law (especially canon law) and medicine, while those of northern Europe, principally Paris, but also later Oxford and Cambridge, focused on theology. In each of the latter cases they were essentially training schools for clerics. The colleges of the new world, such as Harvard and the Universidad Nacional Autnonoma de Mexico, founded in 1551 under the name Royal and Pontifical University of Mexico, were also oriented to this task. Harvard, until the twentieth century, was primarily a training school for Congregational ministers, and providing ministers was the motivation for founding many later American colleges.

The teaching of theology and law, as well as medicine, was not explicitly concerned with the *production* of knowledge: The sources of knowledge were given, external to the university, and took the form of dogma. "Discipline" meant the protection of the dogma. As late as the middle of the seventeenth century, "a Doctor of Medicine was compelled by the English College of Physicians to retest a proposition he had advanced in opposition to the authority of Aristotle under threat of imprisonment" (Rashdall [1895] 1936b, p. 453). Training was training in dogmas. There was a need to formulate these dogmas, and apply the dogmas in new circumstances, through legal and theological casuistry, and this led to a certain amount of innovation. But innovation was not prized.

These patterns were the distant source of a key element of the model of disciplines. It is worth recalling that much of what we take for granted today as a part of university education was inherited from the medieval university, which was oriented to the transmission of dogma alone. As the authors of the Cambridge historical survey of the medieval universities put it,

> It is not necessary that a definite line of study should be marked out by authority, that a definite period of years should be assigned to a student's course, or that at the end of that period he should be subjected to examination and receive, with more or less ceremony, a title of honour. All this we owe to the Middle Ages. (Rashdall [1895] 1936b, p. 459)

This was part of the inheritance of disciplinarization, but disciplines themselves, that is to say well-defined identities with markets of exchange of scholars and graduates, did not yet exist. Yet the rudiments of a market were there. The system, by licensing graduates of certain universities to teach anywhere, provided the means of mobility, and, through the system of disputations, scholars could distinguish themselves without doing anything to produce new knowledge.

Internal disciplinary hierarchies follow their own market logic: What is prized within the discipline is prized because it meets internal market needs. This is the basic fact of disciplinarity that runs through this chapter. The medieval universities had a form of this as well. The source of prestige in the market of the early university was the ability to attract students, especially students from afar. The thing that attracted them to the Italian universities was the systematic exposition of universal legal concepts in Roman and Canon law. In the case of law, adapting Roman law to local legal orders was an activity that was not general and not tied as closely to training in the system of Roman legal concepts. Hence it was not prized.

This, however, is a case of a fundamental conflict between activities in a predisciplinary setting. The great achievement of the legal scholars was the production of glosses on ancient texts. This is what they were there to lecture on and expound: legal dogma. The standardization of understandings of the law was essential to its value for students: Legal knowledge became transportable to other places, indeed "universal" at least to the universe of Europe. But this had a bad effect on scholarship. The original glossators were great scholars, and their influence was enormous. Their successors chose, or were condemned, to comment on them.

> The professors had come to busy themselves more with the gloss than with the text. Instead of trying really to develop the meaning of the text, they aimed at tediously exhaustive recapitulation and criticism of all the glosses and comments they could collect. In short, they lost sight of the aim of their work, which consequently became more and more stagnant and pedantic. (Rashdall [1895] 1936a, p. 257)

This was true, mutatis mutandis, of other domains of thought as well. In theology, "the 'Sentences' of Peter the Lombard" had "the same narrowing influence" (Rashdall [1895] 1936a, p. 256). The granting of advanced degrees reflected this emphasis on mastering a scheme of dogma or a system. Ironically, the key to the academic culture was disputations—over the received texts. Performance in these disputations was a mode of knowledge exhibition; but it was not oriented to sources of knowledge outside the canonical texts, either of theology or law. Philosophy was taught in the same way. Yet at the same time the teaching of dogmas was a solution to the problem of what it was that the scholars could sell. Students got what they wanted: They learned a common language that opened up to them the possibility of careers in state administration and the law, or in the Church.

One might wonder how the great philosophers of the period, such as Occam, Aquinas, and Duns Scotus, survived in this system. In fact they did not: Although they typically spent some time at the universities, for the most part they were part of the parallel educational system internal to the monastic orders. The monastic orders whose members contributed to intellectual life, such as the Dominicans and Franciscans, solved the problems of money and external legitimacy, in different ways. Both of these orders were mendicant, and in any case had their own hierarchies, which freed some of their members from other duties, and they had forms of collegial communication that extended across Europe, as well as means of publication through manuscripts and libraries maintained by the orders and Cathedrals—which themselves constituted an educational system.

2.3 The Scientific Revolution

The medieval university was a structure that lasted for centuries. It solved the problem of responding to the constraints listed above. It was, however, not good for the development of science. The scientific revolution happened for the most part outside the universities, and in different organizational forms, and with a different structure of patronage. The reformation and counter-reformation produced more changes, and the Protestant universities of the north, such as Leiden, freed from the limitations of clerical control, developed in new ways. These two stories, the development of nonuniversity knowledge formations and the development of the university into the modern disciplinary form, require some background.

The scientific revolution was carried out for the most part by nonacademics organized in groups and communicating with one another, as well as by some academics who were participants in learned circles outside the university and supported by patrons. They were either courtiers, such as Galileo (Biagioli 1993), often with positions such as court mathematician; or supported by their own wealth, such as Tycho, or by sinecures which allowed them to pursue their scientific work; or monks. A representative figure is Galileo's friend and supporter Federico Cesi (1585–1630), who founded the Accademia dei Lincei, a novel kind of institution whose "members lived communally and almost monastically in Cesi's house, where he provided them with books and laboratory equipment." The participants included Galileo, "the mathematician Francesco Stelluti, the physician Johannes Eck from the Low Countries, and the polymath Anastasio De Fillis" (Rice University http://galileo.rice.edu/gal/lincei.html). This list is a good indication of the range of participants in the scientific revolution. There was a moral content to their work as well: "not only to acquire knowledge of things and wisdom, and living together justly and piously, but also peacefully to display them to men, orally and in writing, without any harm," as a 1605 document of the academy put it (Rice University http://galileo.rice.edu/gal/lincei.html). This was an external face, but an internal code as well, and one at variance with that of the university, which prized its control of authority over knowledge.

The term "Renaissance man" is apposite: These people were not specialists in a discipline, but dabbled in various branches of knowledge, including theology and astrology. They benefited from personal contact with one another as well as from the circulation of books, a new technology of communication of the time, and the synergies provided by intellectual work in different domains and in contact with persons with different and varied interests. They also communicated with other circles, especially by letters but also by the new technology of printed books.

This process of creation of new communities combined with patronage continued in many more famous cases—the Royal Society, which began as meetings with no name at Gresham College—a nonuniversity non-degree-granting institution—before gaining Royal sponsorship in 1660. Paris followed in 1666, and other ambitious states and courts followed with their own versions. Leibniz convinced the elector of Brandenburg to establish what eventually was to be called the Prussian Academy of Science in 1710. It was funded, at the suggestion of Leibniz, by granting it a monopoly on the sale of calendars. One important innovation of these societies, a change both confirmed and advanced by the explicit rules generated by the British Royal Society, was in the rules of discourse (Lynch 2001). The practice of disputation,

which had both defined and limited the medieval university, was replaced by the practice of experimental proof, and topics that were part of the tradition of disputation and not subject to experimental evidence were excluded. The academies were models of exclusion and inclusion that set the identity and hierarchy of scientists (Hahn 1971). Yet they were also schemes that solved problems of external legitimacy, especially by serving the state, and of course solved the problem of finance without depending on teaching.

The university system was not wholly resistant to the changes outside of it. Teaching, the primary activity, eventually morphed, in nonlegal and nontheological contexts, from teaching and disputing dogmatic systems into teaching one's own system. This was an evolution with peculiar intermediate points. As Constantine Fasolt points out, the expectation for a dissertation in the seventeenth century, and in many places long after, was that the student write up the professor's lectures. In many cases the professor wrote the dissertation himself (Fasolt 2004, pp. 96–97). The emphasis was on the defense, or *disputatio*, which proved the competence and in some sense the originality of the student performing the defense. There were many variations on this, but the idea that the student would reproduce and systematize the lectures of his teacher reflected the idea that one was transmitting a dogmatic system. But on becoming a professor, one presented lectures transmitting the system one propounded.

Freed of the control of the Church, the Protestant universities of northern Europe became hotbeds of this kind of teaching. This morphed again into a system in which a "Seminar" or protodepartment organized under a professor would teach the same doctrine, so that eventually there emerged multiple variant doctrines. Well into the last half of the twentieth century, indeed, this system prevailed at some universities, especially in Scandinavia. This was still not disciplinarization, however. That would require something more—an exchange of professors and students under a common label and a more or less common idea of the boundaries and exclusions implied by the label, and of the signs of membership. But the rise of Protestant universities, by freeing the market from the involvement of the church, allowed for a step in this direction.

The two major forms of knowledge organization, the Royal (and later national) Academies of science and the universities, together with various nonuniversity forms of public education and lecturing, developed in parallel over the last half-millennium, taking various forms, but sharing many features. Universities remained wedded to the practice of education as indoctrination into a dogma, proof of competence to some form of "defense" or disputation, and the building of intellectual systems by professors. The importance of each of these elements varied, but they were wedded to one another. Disciplinarization built on these practices, but transformed them in a different direction. Internal legitimation did not rest, as much on the power of individual professors to attract students or attract them to the system propounded by the professor, as on education in the discipline itself. Disciplines themselves sought and gained external legitimacy as disciplines, that is to say as the locus and guardian of specific competences and bodies of knowledge shared with others trained in the same discipline. And the definition of originality changed to reflect the practices of nonacademic circles, especially in science. Now something akin to discovery was a requirement for obtaining an advanced degree—though in reality discovery was rare, and the notion of originality extended to the most common kind of originality, the extension of established dogmas.

Between 1800 and 1910 the modern model of disciplinarization emerged and solidified. Along with it came discontents and anxieties about disciplinarization, involving the sense of a loss of the unity of knowledge (Weingart 2010). The process was led by the reformed

universities of Germany, notably Halle and Göttingen (which demoted theology—a sign of the breakup of the old hierarchy of the university). Reform allowed new models of disciplinarization to develop. At Geissen, the chemist Wilhelm Liebig attracted and trained many foreign students, started a fertilizer and meat extract business, and became the model for modern science, combining research, teaching, and economic impact within the framework of a strong disciplinary structure. This model proved to be transportable: Its elements are found in the Land-grant universities of the United States in the last half of the nineteenth century, modified to become the ideal of teaching, research, and extension. In the late twentieth century this became the notion that a professor was to contribute to teaching, research, and service.

By the end of the nineteenth century a worldwide revolution in practice was beginning, with the idea of combining research and teaching at its core, and new hierarchies between universities developed, and new investment in universities, motivated by nationalism. The desire to emulate German universities led to the modern university in one country after another. Disciplines developed in association with licensing regulations or their de facto surrogates, and disciplinary organizations developed to define portions of academic turf. By 1910 the modern disciplines, and the modern research university, had been defined. The attempt to overcome disciplinary divisions followed in the twenties, under the influence of the Rockefeller philanthropies, and led in the 1950s to a movement for interdisciplinarity in teaching.

It goes without saying that much of the medieval regime of doctrinal reproduction persists in academic life, in part because of its preservation by the system of disciplinarization, which used its forms, especially the degree system. What separates researchers in different disciplines today is the way they are trained, and this includes "paradigms" and everything that is associated with them, as well as methods of argument, tacit understandings, instrumentation and the knowledge of how to use it, and so forth. However, perhaps the most important consequences of the system of disciplines for the intellectual substance of disciplines result from the hierarchies that develop through the market competition in the exchange of graduates and in the competition for research funds and other subsidies. The economist Milton Friedman, after retiring, while visiting a group of young economists, complained about the direction the discipline had taken, which he thought involved a substitution of mathematical prowess for intellectual substance. One of the younger economists responded by observing that this was what the market—by which he meant the internal market in economics as a discipline—demanded (cf. Frodeman, 2014). Because conformity is rewarded, the market produces a level of coercion that inculcates standards and attitudes that are very resistant to change.

2.4 The Interdisciplinary Alternative

This points to one of the three major strands of critiques of disciplinarity and to the various motivations for interdisciplinarity. The earliest critiques in the nineteenth century involved the ideal of the unity of knowledge, which disciplinarization threatened. Similar charges were made in the twentieth century about the threat to liberal education of a system which taught and rewarded disciplinary rather than educationally significant topics,

or simply ignored topics that were not prestigious in the disciplines in which they would have been taught, such as film studies, a neglected child in both English departments and the Arts (Damrosch 1995, p. 61), but were nevertheless deserving of attention. Jerry Jacobs (2013) highlights several cases in which this kind of concern has led to interdisciplinary movements, but notes that they have tended to disciplinarize themselves. This should be no surprise: Teaching, or student demand for these areas, is the only available source of significant funding.

The important Rockefeller philanthropic response of the 1920s and 1930s concerned practical value: In the social sciences, for example, the Laura Spelman Rockefeller Foundation program supported the improvement of the social sciences in a "realistic" direction, with an aim of more or less rapidly producing useful knowledge. In the sciences, Rockefeller support was important to the phage group, a well-funded effort at integrating physics and biology that led to the molecular biology revolution: something that would not have occurred in the normal course of development within disciplinary zoology and botany departments. In the course of doing so they created new relationships through such institutions as Cold Spring Harbor. Philip Mirowski (2002) has pointed to the wartime RAND experience of many future economists with operations research and how its distinct cognitive value of minimalistic mathematical representation—in a nonacademic collective work setting—had major consequences for the development of postwar economics. The postwar bombing surveys, which brought together social scientists, psychologists, and psychiatrists, had formative effects on the postwar attempt to constitute these "behavioral sciences."

A significant part of these changes had to do with the creation of new, and for the most part temporary, social formations. But these needed to solve in some fashion the problems of coping with the constraints discussed earlier—particularly funding, external legitimacy, common norms and language, and so forth. Yet short-term structures like these can have long-term effects: The works of Aristotle were produced in an interesting collaborative "interdisciplinary" institution in one generation, but reproduced for two millennia.

Present discussions of changes in science and scholarship generally, notions of postacademic, postnormal, and Mode 2 science, have attempted to theorize these new forms of research, which are beyond the disciplinary. But they are faced with the same constraints; they simply deal with them in different ways. Each of the advantages of disciplinarity comes with limitations: the need to service students, the intellectual coercion that results from the disciplinary hierarchy that comes from the market exchange of students, the constraints on communication resulting from common training and norms, and the exclusions and limitations that go with them. Each limitation and exclusion produces an alternative unpopulated space, often involving practical problems, that "belong" to no discipline and cannot be easily addressed by any of them. The difficulties, however, are commensurate with the opportunities.

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CHAPTER 3

TYPOLOGIES OF INTERDISCIPLINARITY

The Boundary Work of Definition

JULIE THOMPSON KLEIN

Typologies classify phenomena based on similarities and differences, whether sorting artistic genres, medical symptoms, animal and plant species, or forms of knowledge. Over the course of the twentieth century, knowledge in the Western intellectual tradition was classified into specialized domains within a larger system of disciplinarity. In the latter half of the century, though, that system was supplemented and challenged by an increasing number of interdisciplinary activities. The most prominent way of organizing them has been to construct typologies that group related activities into categories labeled by technical terms.

The first major set of terminology appeared in 1970, created for an international conference co-sponsored by the Organization for Economic Cooperation and Development (OECD). It classified interactions of disciplines into categories of multi-, pluri-, inter-, and trans-discipinarity (Apostel 1972). Other labels soon followed, resulting in a profusion of jargon some have likened to a tower of Babel. Harvey Graff (2015), for one, faults the "name game" for generating more confusion than clarity, charging, "The endless typologies, classifications, and hierarchies of multi-, inter-, and transdisciplinarities are not helpful." Graff himself, though, adopts a hierarchical distinction between multi- and inter-disciplinarity throughout his comparative study of interdisciplines in order to reinforce integration as a primary criterion. More significant for this chapter, dismissing terminology fails to recognize its value for tracking definitions over time. Terms are sometimes used interchangeably, but patterns of consensus reveal continuities and discontinuities in theory and practice.

Typologies are neither neutral nor static. They reflect political choices of representation by virtue of what is included or excluded, which activities are grouped within a particular category, and how narrow or wide the field of vision is in a spectrum ranging from small academic projects to society at large. Taken together these choices constitute a form of boundary work in a semantic web that indexes differing purposes, contexts, degrees of integration and interaction, organizational structures, and epistemological frameworks. Thomas Gieryn (1983) coined the term "boundary work" in a study of demarcating science from non-science. He defined boundary work as an ideological style that constructs boundaries rhetorically in three major ways: expanding authority or expertise into other domains,

Klein, J. T., *Typologies of Interdisciplinarity: The Boundary Work of Definition*. In: *The Oxford Handbook of Interdisciplinarity, Second Edition*. Edited by Robert Frodeman, Julie Thompson Klein, and Roberto C. S. Pacheco: Oxford University Press (2017). DOI 10.1093/oxfordhb/9780198733522.013.3

monopolizing authority and resources, and protecting autonomy over professional activities. Interdisciplinary terminology performs all of these functions. It asserts alternative forms of research and education, often pegged against disciplinary specialization as the foundation of knowledge. It prioritizes some forms over others, in subcategories of interdisciplinarity and the heightened imperative of transdisciplinarity. And, networks and organizations use labels to stake claims for particular kinds of work. The three most widely used terms in the OECD typology constitute a core vocabulary amplified by technical distinctions for particular contexts.

The chapter distinguishes the first two generic terms—*multidisciplinarity* (MD) and *interdisciplinarity* (ID)—followed by major variants of methodological and theoretical ID, bridge building and restructuring, instrumental and critical ID. It then examines the current momentum for transdisciplinarity (TD) and closes by reflecting on implications of new typologies. Table 3.1 depicts key terms and their characteristics, degrees of integration, and contrasting types that appear throughout the chapter.

Table 3.1 Table of Definitions

Key Terms and Characteristics		
Multidisciplinarity	Interdisciplinarity	Transdisciplinarity
Juxtaposing Sequencing Coordinating	Interacting Integrating Focusing Blending Linking	Transcending Transgressing Transforming

Degrees of Interdisciplinary (ID) Integration	
Lack of Integration	Integration
Encyclopedic ID Indiscriminate ID Pseudo ID Contextualizing ID Composite ID	Generalizing ID Integrated ID Conceptual ID Structural ID Unifying ID

Contrasting Types	
Auxiliary Disciplinary Relations	Supplementary Disciplinary Relations
Bridge Building	Restructuring
Borrowing	Hybridization
Shared ID	Cooperative/Collaborative ID
Narrow ID	Broad or Wide ID
Methodological ID	Theoretical ID
Instrumental ID	Critical ID
Strategic or Opportunistic ID	
Endogenous ID	Exogenous ID
	Trans-sector Transdisciplinarity
	Coproduction of Knowledge

3.1 Multidisciplinary Juxtaposition and Alignment

Most definitions of ID, Lisa Lattuca found in a literature review, treat integration of disciplines as the "litmus test." In fields that prioritize critique of knowledge, this premise is disputed. Nevertheless, integration is the most common benchmark (2001, pp. 78, 109). The OECD typology classified MD as "[j]uxtaposition of various disciplines" (Apostel 1972, p. 25). Juxtaposition fosters wider scope of knowledge, information, and methods. Yet, disciplines remain separate, retain their original identity, and are not questioned. This tendency is widespread in conferences and publications that present serial views of a shared topic or problem. Likewise, many purportedly "interdisciplinary" curricula and research projects combine separate disciplinary approaches without proactively integrating them around a designed theme, question, or problem. The keywords in Rebecca Crawford Burns' typology of integrative education capture the limited relationship of disciplines and subjects. When placed in parallel order they are in a *sequencing* mode and when intentionally aligned a *coordinating* mode (1999, pp. 8–9). In both cases, however, integration is lacking.

3.1.1 Encyclopedic, Indiscriminate, and Pseudo Forms

This part of the spectrum of definition is often deemed superficial, reinforcing a boundary between MD and ID. As the keywords "sequencing" and "coordinating" suggest, MD is encyclopedic in nature. In a six-part typology, Margaret Boden deemed *encyclopedic ID* a "false" or "weak" form, citing loose communication in joint degrees and co-located information on the World Wide Web (1999, pp. 14–15). Similarly, Heinz Heckhausen categorized encyclopedic forms as *indiscriminate ID*, citing the *studium generale* of German education and exposure to multiple disciplines in professional education. Mindful of false claims, Heckhausen added the concept of *pseudo ID*, embodied in the proposition that sharing analytical tools such as mathematical models of computer simulation constitutes "intrinsic interdisciplinarity" (in Apostel 1972, pp. 87). Certain disciplines are also deemed "inherently interdisciplinary" because of their synoptic scope, including philosophy, literary studies, and religious studies as well as anthropology and geography. Synoptic identity signifies breadth more than integration of multiple parts. Despite falling short of ID, however, MD plays a valuable role in expanding the knowledge base for a given project or program and has even been deemed a characteristic of contemporary disciplines because of their plurality of practices.

3.1.2 Contextualizing, Informed, and Composite Relationships

The practice of applying knowledge from one discipline to contextualize another further illustrates the limits and value of MD. A philosopher might use history to inform readers about a particular movement in philosophy or, vice versa, use philosophy to provide epistemological context for a particular event. Boden's classification *contextualizing ID* is evident in another familiar practice, organizing discipline-based chapters serially in books on

the same theme or topic. Proximity widens scope, but here too integration around shared themes or questions is lacking (Boden 1999, pp. 15–16). Heckhausen's term *composite ID* labels another familiar practice—applying complementary skills to address complex problems or to achieve a shared goal. He cited societal problems such as war, hunger, delinquency, and pollution, while calling peace research and city planning "interdisciplinarities in the making" because they simulate exploring interdependencies (in Apostel 1972, p. 88). Even with a common framework, though, knowledge production retains a strong disciplinary thrust. In biosciences, for example, technical knowledge from many fields and expensive instruments are often shared. Despite crossing boundaries, however, disciplinary relations do not necessarily change or individuals collaborate.

3.2 Interdisciplinary Integration and Collaboration

The OECD definition of ID was wide, encompassing any interaction ranging from "simple communication of ideas to the mutual integration of organizing *concepts, methodology, procedures, epistemology, terminology, data,* and organization of research and education" (in Apostel 1972, p. 25). Simple communication, though, does not entail key traits that Burns and Lattuca argue constitute ID. Integrated designs prioritize focusing, blending, and linking. In education for instance, courses achieve a more holistic understanding of a cross-cutting question or problem by combining historical and legal perspectives on public education or biological and psychological aspects of human communication (Burns 1999, pp. 11–12; Lattuca 2001, pp. 81–83). Scope varies though, ranging from narrow to wide or broad ID depending on the number of disciplines involved and the compatability of their epistemological paradigms and methodologies.

Many believe that ID is synonymous with collaboration. It is not. However, heightened interest in teamwork to solve complex intellectual and social problems has amplified the connection while fostering greater attention to the interaction of cognitive and social integration. Degrees of cooperation differ, though. In Boden's concept of *shared ID* groups tackle aspects of a complex problem. Yet, collaboration does not necessarily occur. In contrast, *cooperative ID* requires teamwork, exemplified by the collaboration of physicists, chemists, engineers, and mathematicians in the Manhattan Project to build an atomic bomb and in research on public policy challenges such as energy and law and order (1999, pp. 17–19). Differences are further evident in methodological versus theoretical ID.

3.2.1 Methodological Interdisciplinarity

The motivation in methodological ID is to improve the quality of results, typically by borrowing a method or concept from another discipline to test a hypothesis, to answer a research question, or to help develop a theory (Bruun et al. 2005, p. 84). Degrees of influence vary, though. If a borrowing does not result in a significant change in practice, Heckhausen explained, disciplines are in an *auxiliary* relationship. If it becomes more sophisticated and

enduring dependence develops, the relationship is *supplementary*, exemplified by incorporation of psychological testing into pedagogy and neurophysiological measures in psychology (in Apostel 1972, pp. 87–89). In a six-part typology, Raymond Miller identified two forms of interdisciplinary work that are methodological in nature. The first, shared components, includes methods shared across disciplines, such as statistical inference. The second, cross-cutting organizing principles, are focal concepts or fundamental social processes used to organize ideas and findings across disciplines, such as "role" and "exchange" (1982, pp. 15–19). New engineering and technological methods were also developed during World War II, stimulating postwar borrowings of cybernetics, systems theory, information theory, game theory, and new conceptual tools of communication and decision theories. And, the roster of shared methods includes techniques such as surveying, interviewing, sampling, polling, case studies, cross-cultural analysis, and ethnography.

Borrowing across social sciences and humanities also illustrates methodological ID. In 1980, Clifford Geertz identified a broad shift within intellectual life in general and social sciences in particular. The model of physical sciences and a laws-and-instances explanation was being supplanted by a case-and-interpretation model and symbolic form analogies borrowed from humanities (see Krohn, this volume). Social scientists were increasingly representing society as a game, a drama, a text, or a performance, rather than a machine or a quasi-organism. They were borrowing methods of speech-act analysis, discourse models, and cognitive aesthetics, crossing the traditional division of explanation and interpretation. And, social sciences were not immune from the influences of existentialism and phenomenology, structuralism, deconstruction, poststructuralism, neo-Marxism, and comparative cultural studies. On the other side of the disciplinary fence, humanists were taking anthropological, sociological, political, and historical turns in scholarship while borrowing concepts of "motives," "authority," "persuasion," "exchange," and "hierarchy." Conventional rubrics remain, Geertz concluded, but they are often jerry-built to accommodate a situation that is "fluid, plural, uncentered, and ineradicably untidy."

3.2.2 Theoretical Interdisciplinarity

Theoretical ID connotes a more comprehensive general view and epistemological form embodied in creating conceptual frameworks for analyzing particular problems, integrating propositions across disciplines, and synthesizing continuities between models and analogies. The Academy of Finland Interdisciplinary Research (AFIR) team cited a project to develop a model of mechanisms that mediate mental stress experiences into physiological reactions and eventually coronary heart disease. Previous studies emphasized correlation of single stress factors or separate personal traits associated with the disease. In contrast, the project aimed to develop an interdisciplinary theory based on integration of psychological and medical elements and testing the conceptual tool of inherited "temperament" (Bruun et al. 2005, p. 86).

Theoretical forms of ID are often ranked as more "genuine" than methodological forms. For Boden, the highest levels are *generalising ID* and *integrated ID*. In generalizing ID, a single theoretical perspective applies to a wide range of disciplines, such as cybernetics or complexity theory. In integrated ID, which Boden deems "the only true interdisciplinarity," concepts and insights of one discipline contribute to problems and theories of another,

a process evident in computational neuroscience and the philosophy of cognitive science. Individuals may also find their disciplinary methods and theoretical concepts modified as a result of cooperation, fostering new conceptual categories and methodological unification (1999, pp. 19–22). Comparably, Lattuca considers *conceptual ID* the "[t]rue or full" form of ID. Core issues and questions lack a compelling disciplinary basis, and critique of disciplinary understanding is often implied (2001, p. 117). Parallels also arise in the difference between bridge building and restructuring.

3.3 Bridge Building versus Restructuring

In 1975 the London-based Nuffield Foundation's Group for Research and Innovation identified two basic metaphors of ID—bridge building and restructuring. Bridge building occurs between complete and firm disciplines, while restructuring detaches parts of several disciplines to form a new coherent whole. A third possibility occurs when a new overarching concept or theory subsumes theories and concepts of several disciplines, akin to the notion of TD (Group for Research and Innovation, 1975, pp. 42–45). Landau, Proshansky, and Ittelson's typology of two phases in the history of interdisciplinary approaches in social sciences illustrates the difference between bridge building and restructuring. The first phase, dating from the close of World War I to 1930s, was embodied in the Social Science Research Council and University of Chicago school of social science. The interactionist framework at Chicago fostered integration, and members of the Chicago school were active in efforts to construct a unified philosophy of natural and social sciences. The impacts were widely felt, and occasionally disciplinary "spillage" led to formation of hybrid disciplines, such as social psychology and political sociology. However, traditional categories of knowledge and academic structures remained intact.

The second phase, dating from the close of World War II, was embodied in "integrated" social science courses, a growing tendency for interdisciplinary programs to become "integrated" departments, and the concept of behavioral science. Traditional categories anchoring disciplines were questioned and boundaries blurred, paving the way toward a new theoretical coherence and alternative divisions of labor. The behavioral science movement, in particular, sought an alternative method of organizing social inquiry rather than tacking imported methods and concepts onto traditional categories. In addition, the concept of "area" posited greater analytical power while stimulating a degree of theoretical convergence also potential in the concepts of role, status, exchange, information, communication, and decision-making (Landau et al. 1962, pp. 8, 12–17).

3.3.1 Interdisciplinary Fields, Interdisciplines, and Hybrid Specializations

The formation of new interdisciplinary fields is a major case of restructuring. Miller identified four categories in a typology of interdisciplinary approaches. *Topics* are associated with problem areas. "Crime," for instance, is a social concern appearing in multiple social

science disciplines as well as criminal justice and criminology. "Area," "labor," "urban," "environment," and "the aged" also led to new academic fields. *Life experience* became prominent in the late 1960s and 1970s with the emergence of ethnic studies and women's studies. *Hybrids* are "interstitial cross-disciplines" such as social psychology, economic anthropology, political sociology, biogeography, culture and personality, and economic history. And, *professional preparation* led to new fields with a vocational focus, such as social work and nursing.

Some new fields are considered a hybrid type of ID. When new laws become the basis for an original discipline, Marcel Boisot contended, a more formal *structural* relationship emerges, such as electromagnetics and cybernetics (in Apostel 1972, pp. 94–95). Heckhausen also deemed the point at which biology reached the subject matter level of physics and biophysics an example of *unifying ID* (in Apostel 1972, pp. 88–89). Proposing hybridization as a general process of development, based on studies of innovation in social sciences, Dogan and Pahre identified two stages. The first is specialization, and the second continuous reintegration of fragments of specialties. They also identified two types of hybrids. The first type becomes institutionalized as a subfield of a discipline or a permanent cross-disciplinary program. The second type, exemplified by the topic of "development," remains informal. Hybrids, moreover, beget other hybrids, especially in natural sciences where higher degrees of fragmentation and hybridization are present (1990, pp. 63, 66, 72).

The emergence of new communities of practice and networks often leads to proclamations of a new discipline, perpetuating an oversimplified belief that the interdiscipline of today is the discipline of tomorrow. This generalization, however, ignores wide variances in both interdisciplines and disciplines (Graff 2015). Some areas, such as systems science, have gained disciplinary status, anchored by shared principles, unifying core concepts, and a new community of knowers with a common interlanguage. Others though, such as nanoscale research, are widely dispersed and bounded within individual domains. Economic and social capital are also powerful determinants in the political economy of ID. The growth of area studies, for instance, was facilitated by significant amounts of funding from the Ford Foundation. Molecular biology also enjoyed a level of support lacking in social psychology, and the same discrepancy appears today in the differing status of biomedicine and digital humanities.

More than one label might apply in the same field as well, depending on which points of interaction and degrees of integration are being described. Richard Lambert (1991) called the field of area studies, for example, a "highly variegated, fragmented phenomenon, not a relatively homogeneous intellectual tradition." Much of what could be called "genuinely interdisciplinary" work, he judged, occurred at the juncture of four disciplines providing the initial bulk of area specialists: history, literature and language, anthropology, and political science. At that hybrid space, a historically informed political anthropology developed using material in local languages. Blending of disciplinary perspectives occurred most often at professional meetings and in research by individual specialists. In scholarly papers the dominant pattern was broadly defined themes, creating a collective "multidisciplinary" perspective with the topic of any one event driving the disciplinary mix. At the same time, area studies research is "subdisciplinary" when concentrated in particular subdomains, even as the field at large is deemed "transdisciplinary" in scope.

3.4 Instrumental versus Critical Interdisciplinarity

The difference between instrumental and critical ID is another fault line in the discourse of ID. In an analysis of forms of interdisciplinary explanation, Mark Kann identified three political positions. Conservative elites want to solve social and economic problems, without concern for epistemological questions. Liberal academics demand accommodation but maintain a base in the existing structure. And, radical dissidents challenge the existing structure of knowledge, demanding ID respond to the needs of oppressed and marginalized groups (1979, pp. 187–188). Methodological ID is "instrumental" in serving the needs of a discipline or field. During the 1980s, however, another kind of instrumental ID akin to Kann's first political position gained priority in science-based areas of economic competition such as computers, biotechnology and biomedicine, manufacturing, and high-technology industries. Peter Weingart labeled related activities *strategic* or *opportunistic ID* that serves the needs of the marketplace and the nation (2000, p. 39).

In contrast, critical ID interrogates the dominant structure of knowledge and education with the aim of transforming it, raising questions of value and purpose silent in instrumental ID. New fields in Miller's "life experience" category were often imbued with a critical imperative, older fields such as American studies took a "critical turn" in the 1960s and 1970s, and a "new interdisciplinarity" emerged in humanities and cultural studies signified by "anti," "post," "non," and "de-disciplinary" labels. Indicative of this trend, Lattuca found an increasing number of faculty in humanities and social sciences do interdisciplinary work with the explicit intent of deconstructing disciplinary knowledge and boundaries, blurring boundaries of the epistemological and the political (2001, pp. 15–16, 100).

Critical ID also refigures the relationship of disciplinarity and ID. Giles Gunn (1992) depicted differing constructions of the relationship in a typology of interdisciplinary approaches in literary studies. The simplest approach to mapping is tracking relations with other disciplines, for instance literature *and* philosophy or anthropology. Each coupling exposes cross-secting influences, such as hermeneutics in the relationship with philosophy or ethnography with anthropology. The conjunctive strategy, though, remains on disciplinary ground. The map changes if asking a different question. What new subjects and topics have emerged? Other examples appear, such as history of the book, psychoanalysis of the reader, the sociology of conventions, and ideologies of gender, race, and class. Studies of textuality also evolved into studies of representation. "The threading of disciplinary principles and procedures," Gunn found, "is frequently doubled, tripled, and quadrupled in ways that are not only mixed but, from a conventional disciplinary perspective, somewhat off center." They are characterized by overlapping, underlayered, interlaced, crosshatched affiliations, collations, and alliances that have ill-understood and unpredictable feedbacks. The final development is the most difficult to map. Correlate fields such as philosophy and anthropology have themselves changed, challenging assumptions about the strength of boundaries while working to erode them. Gunn concluded, "The inevitable result of much interdisciplinary study, if not its ostensible purpose is to dispute and disorder conventional understandings of relations between such things as origin and terminus, center and periphery, focus and margin, inside and outside."

The distinction between instrumental and critical forms, it should be said, is not absolute. Research on problems of the environment and health often combine critique and problem solving. Nonetheless, a clear division appears in typologies. Observing trends in the medical curriculum, Bryan Turner (1990) argued that pragmatic questions of reliability, efficiency, and commercialism take center stage when ID is conceived as a short-term solution to economic and technological problems. In contrast, in social medicine and sociology of health ID emerged as an epistemological goal focused on the complex causality of illness and disease. Researchers focused on psychological, social, and ethical factors in an alternative holistic biosocial or biopsychosocial model that is critical of the limits of the traditional hierarchical biomedical model.

(See Frodeman [2013] and Jacobs [this volume] for two contrasting views of the relationship of disciplines and ID, the first asserting dissolution of disciplines while prioritizing problem-focused TD and the second reasserting the primacy of disciplines.)

3.5 Transdisciplinarity

The recent ascendancy of TD is a prominent development in the history of ID. In the OECD typology, TD was defined as a common system of axioms that transcends the scope of disciplinary worldviews through an overarching synthesis, such as anthropology conceived as the science of humans. Three participants in the OECD seminar differed, though, in elaborating the concept. Jean Piaget treated TD as a higher stage in the epistemology of interdisciplinary relationships based on reciprocal assimilations. Andre Lichnerowicz promoted "the mathematic" as a universal interlanguage, and Erich Jantsch embued TD with social purpose in a hierarchical model of the system of science, education, and innovation (in Apostel 1972). Since then, the term has proliferated. Four major trendlines appear at present.

The first trendline is a contemporary version of the epistemological quest for systematic integration of knowledge. The quest for unity spans ancient Greek philosophy, the medieval Christian *summa*, the Enlightenment principle of universal reason, Hegelian philosophy, Transcendentalism, the search for unification theories in physics, and E. O. Wilson's theory of consilience. Reviewing the history of TD, Joseph Kockelmans (1979) found it has tended to center on educational and philosophical dimensions of sciences. The search for unity today, though, does not follow from a pregiven order. It must be continually "brought about," Kockelmans emphasized, through critical, philosophical, and supra-scientific reflection. It also accepts plurality and diversity, an underlying value of the Centre International de Recherches et Études Transdisciplinaire (CIRET). The center is a virtual meeting space for a new universality of thought and type of education informed by the worldview of complexity in science.

The second trendline is an extension of the OECD definition of synthetic paradigms. Miller defined TD as "articulated conceptual frameworks" that transcend the narrow scope of disciplinary worldviews. Leading examples include general systems, structuralism, poststructuralism, Marxism, phenomenology, feminist theory, and sustainability. Holistic in intent, these frameworks propose to reorganize the structure of knowledge by metaphorically encompassing parts of material fields that disciplines handle separately (1982, 21; see also Stribos, this volume). In the early twenty-first century a variant of this trendline

emerged in North America in the concept of "transdisciplinary science" in broad areas such as cancer research. It is a collaborative form of "transcendent interdisciplinary research" that creates new methodological and theoretical frameworks for analyzing social, economic, political, environmental, and institutional factors in health and wellness (see Hall et al., this volume).

The third trendline is akin to critical ID. Transdisciplinarity is not just "transcendent" but also "transgressive." In the 1990s, TD began appearing more frequently as a label for knowledge formations shaped by critical imperatives in humanities, critiques of disciplinarity, and societal movements for change. Tracking the history of ID in Canadian Studies, Jill Vickers (1997) linked TD and "antidisciplinarity" with movements that reject disciplinarity in whole or in part, while raising questions of sociopolitical justice. Examples include women's, native/aboriginal, cultural communications, regional, northern, urban, and environmental studies. Antidisciplinary positions have also moved beyond the academic sphere, favoring materials in ways dictated by students' own transdisciplinary theories, cultural traditions, lived experience, and connotations of "knowledge" and "evidence."

The fourth trendline prioritizes problem solving. It was evident in the late 1980s and early 1990s in Swiss and German contexts of environmental research. By the turn of the century case studies were reported on an international scale and in all fields of human interaction with natural systems and technical innovations as well as the development context. The core premise is that problems in the *Lebenswelt*—the lifeworld—need to frame research questions and practices, not disciplines. This connotation is strong in projects, such as Global TraPs (Global Transdisciplinary Processes on Sustainable Phosphorus Management), and in groups such as td-net (Network for Transdisciplinary Research). Co-production of knowledge with stakeholders in society is a cornerstone of this trendline, realized through mutual learning and a recursive approach to integration (see also Pohl et al., this volume).

The fourth trendline also intersects with two prominent concepts in the discourse of TD—"postnormal science" and "Mode 2 knowledge production." They stand in striking contrast to the intellectual climate of the 1970 OECD seminar, shaped by the organizing languages of logic, cybernetics, general systems theory, structuralism, and organization theory. Postnormal science is associated with TD because it breaks free of reductionist and mechanistic assumptions about how things are related and systems operate. "Unstructured" problems are driven by complex cause–effect relationships, and they exhibit a high divergence of values and factual knowledge. Hence, they are associated with the concept of "wicked problems" (see Bammer, this volume.)

Gibbons et al. (1994) also proposed that a new mode of knowledge production has emerged. Mode 1 is characterized by hierarchical, homogeneous, and discipline-based work; Mode 2 by complexity, nonlinearity, heterogeneity, and TD. New configurations of research are being generated continuously, and a new social distribution of knowledge is occurring as a wider range of organizations and stakeholders contribute skills and expertise to problem solving. Gibbons et al. initially highlighted instrumental contexts of application, such as aircraft design, pharmaceutics, and electronics. Subsequently, though, Nowotny et al. (2001) extended Mode 2 theory to argue that contextualization of problems requires participation in the *agora* of public debate, incorporating the discourse of democracy. When lay perspective and alternative knowledges are recognized, a shift occurs from solely "reliable scientific knowledge" to inclusion of "socially robust knowledge."

3.6 The Reportage of Change

National reports are important barometers of change. The 2005 *Facilitating Interdisciplinary Research*, published by the National Research Council (NRC) in the United States, identified four drivers of interdisciplinarity today:

(1) the inherent complexity of nature and society
(2) the desire to explore problems and questions that are not confined to a single discipline
(3) the need to solve societal problems
(4) the power of new technologies

(Committee on Facilitating Interdisciplinary Research, 2005, pp. 2, 40).

Drivers (1), (2), and (3) are not new. They have intensified, however, in recent decades. Driver (3) escalated with mounting pressure on universities to solve "real-world" problems, and driver (4) is propelled by the expanding power of generative technologies such as magnetic resonance imaging and advanced computing power for sharing large quantities of data.

The growth of interdisciplinary fields also has implications for typology. After evaluating the methodology of classifying research-doctorate programs, members of a 2003 NRC study recommended increasing the number of recognized fields from 41 to 57, renaming biology "life sciences" while including agricultural sciences, and listing subfields to acknowledge their expansion. Mathematics and physical sciences, the authors added, should be merged into a single major group with engineering. Their final 2009 report highlighted life sciences while adding a field of "biology/integrated biomedical sciences" and noting the expanding fields of public health, nursing, public administration, and communication. In addition, Appendix C called attention to emerging fields of bioinformatics; biotechnology; computational engineering; criminology and criminal justice; feminist, gender, and sexuality studies; film studies; information science; nanoscience and nanotechnology; nuclear engineering; race, ethnicity, and postcolonial studies; rhetoric and composition; science and technology studies; systems biology; urban studies and planning (Ostriker & Kuh 2003; Ostriker et al. 2009).

In 2010 a Panel on Modernizing the Infrastructure of the National Science Foundation's Federal Funds for R&D Survey called further attention to the problem of outdated classifications. The R&D Survey provides data on spending and policy in the United States. However, the taxonomy for fields of science and engineering had not been updated since 1978. The terms "typology" and "taxonomy" are often used interchangeably, but typology is technically conceptual in nature and "taxonomy" is an empirical ordering based on measurable characteristics. The methodology of measurement in the R&D survey was outdated, failing to capture increases in the multi- and interdisciplinary character of science. Also, activities were lumped into a large category of "not elsewhere classified" that includes new subfields, emergent fields, established interdisciplinary fields, cross-cutting initiatives, problem-focus areas, and the amorphous designation "other." In their final report, the Panel recommended capitalizing on new technologies to federate, navigate, and manage data while citing the

National Institutes of Health Research Condition and Disease Classification (RCDC) database as a model of a bottom-up approach to taxonomy and permitting users to construct crosswalks among categories.

A final report accounts for new horizons of research and the growing momentum for TD. The 2014 NRC volume *Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond* defined convergence as an "expanded form of interdisciplinarity" that fosters a higher level of synthesis connoted by TD (Committee on Key Challenge Areas for Convergence and Health 2014). The report positioned convergence historically as a stage beyond two earlier "interdisciplinary" revolutions of molecular and cellular biology and of genomics. Convergence represents a new stage in bringing together bodies of specialized knowledge to constitute "macro" domains of research activity that generate ideas, discoveries, tools, and methodological and conceptual approaches. Tangible outcomes include tissue engineering, advances in cognitive neuroscience, and improved energy storage for securing food supplies in a changing climate. Convergence advances basic research but it also leads to new inventions, treatment protocols, and forms of education and training while fostering partnerships among academic researchers and stakeholders in private and public sectors. In prioritizing product development and speeding up translation of findings from the scientific bench to bedside, convergence does not just blur the boundaries of the academy, industry, and government. It erases them, while aligning ID and TD with academic capitalism.

Reflecting on the current discourse of ID and TD, Weingart identified a common topos among claims for new modes of knowledge production, postnormal and postmodern science, and newer forms of inter- or transdisciplinary research. They are all oscillating between empirical and normative statements, reinforcing democratic and participatory modes while resounding the theme that triggered escalation of ID in higher education reform during the 1960s. Now, however, claims are situated in the context of application and involvement of stakeholders in systems that are too complex for limited disciplinary modes portrayed as too linear and narrow for "real-world" problem solving. New TD and counterpart ID forms, though, are not without their own "blind spots," including failing to recognize opportunistic dimensions of both presumably "internal" academic science and strategic research for nonscientific goals. Moreover, theoretical claims are frequently overstated. Mode 2, postnormal science, and other schemes, Weingart contended, look at phenomena only on the surface, describing institutional changes rather than a new epistemology (2000, pp. 36, 38).

Ultimately, the question of knowledge cannot be separated from how we talk about it. Terminology is not simply a reflection of reality. It is a form of boundary work that filters and directs attention. Proclaiming that ID or TD has only one purpose—be it holism or problem solving—ignores the fact that ID is a contested discourse. One strand of problem solving, for instance, centers on collaborations between academic researchers and industrial/private sectors for innovations in product development. A different type occurs when academic experts and actors in society coproduce knowledge in the name of democratic solutions to the challenges of sustainability. Plurality does not spell cacophony, however. Terms are rhetorical signposts of continuity and change, tradition and innovation. They reassert, extend, interrogate, and reformulate existing classifications to address both ongoing and unmet needs.

Acknowledgments

I thank Robert Frodeman and Roberto Pacheco for feedback on an earlier version of this chapter and thank Pacheco for designing the table of definitions.

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The Need for Disciplines in the Modern Research University

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In this century, the adjective "interdisciplinary" has come to have a generally positive valence, as it is used as a synonym for concepts such as "innovative research" and "integrated solutions" (Frodeman et al. 2010). Whatever value cross-field connections might have, it does not necessarily follow that disciplines represent a negative aspect of university life. This sidebar presents key points from my book *In Defense of Disciplines*.

Let us start at the beginning: What are disciplines, and why do they exist? As I am using the term, a discipline is a self-regulating body of researchers and scholars based in a university. In the liberal-arts context, a discipline refers to fields in which there is a department, a major, and a doctoral degree. A field may be regarded as a discipline when professors with specified credentials are typically hired to conduct research and teach students in a particular domain. This definition focuses on the social organization of a field and makes no direct claims about its internal coherence or boundaries, although some degree of intellectual integration is needed before a field can become institutionalized.

The most successful disciplines, such as psychology, history, and economics, are established at the great majority of research universities and teaching colleges in the United States. To accomplish this degree of acceptance requires a substantial degree of support, from colleagues in other fields, deans, funding agencies, prospective students, and potential employers. A successful discipline will thus have considerable cultural authority and legitimacy.

The ubiquitous disciplines are also typically broad enough in scope to convince even small institutions to include the field in their portfolios. Biology and sociology are well-established fields in most institutions, while narrower fields of inquiry such as archeology, criminology, demography, and linguistics usually do not have their own departments, majors, or degrees. The former are well-established liberal arts disciplines, while the latter are important academic specialties that are less well established.

The breadth of disciplines is accompanied by substantial internal differentiation. Specialties abound, creating lively (and sometimes unpleasant) internal politics.

In economics, for example, the *Journal of Economic Literature* classification system divides economics into 20 general categories, which in turn contain over 134 divisions and 811 areas of specialization (American Economic Association 2015). Rivalries between specialties can also generate fruitful competition. Sparks generated by intellectual conflict yield lively battles but generally propel scholarship forward. Moreover, intellectual brokers can cross-fertilize specialties within disciplines just as they do between fields.

Another question arises: Why do disciplines exist? Disciplines are an organizational manifestation of the need for an academic division of labor. The extent of contemporary scholarship is so vast that no single person could master all of it. There are currently over 30,000 academic journals that employ peer review, and this total is growing by about 3% per year due to the creation of online journals and publications based in countries striving to join the international research community (author's analysis of Ulrich Periodical data). There is thus a need to divide the intellectual terrain into fields of inquiry, even while practitioners know full well that extant dividing lines are fuzzy and sometimes arbitrary.

In addition, disciplines exist because research and scholarship have an important social dimension. It is not enough for a lone scholar to come up with brilliant insights on her own. These insights need to be recognized, organized with other relevant theories and findings, and taught to the next

(*cont.*)

Jacobs, J. A., *Sidebar: The Need for Disciplines in the Modern Research University.* In: *The Oxford Handbook of Interdisciplinarity, Second Edition.* Edited by Robert Frodeman, Julie Thompson Klein, and Roberto C. S. Pacheco: Oxford University Press (2017). © Oxford University Press. DOI 10.1093/oxfordhb/9780198733522.013.4

The Need for Disciplines in the Modern Research University (cont.)

generation. Disciplines are designed with these tasks in mind. They are forms of social organization that evaluate, organize, and disseminate research and scholarship. Moreover, insights are typically refined and extended over time, tasks that occupy the lion's share of research work.

The definition presented here belies some of the principal critiques that have been leveled against disciplines (e.g., Pearson 2015). Disciplines are not static but are dynamic. In addition to competition between individuals seeking academic stardom, internal competition between subfields and competition between departments over students, resources, faculty lines, research funding programs, and space on campus generates pressure to innovate.

Nor are disciplines isolated silos. All fields are intellectual amalgams with ideas, metaphors, and methods borrowed from other domains. As Graff (2015) has shown, the interdisciplinary roots of disciplines are evident in the formation of fields spanning the natural sciences, social sciences, and humanities.

Individual researchers can sometimes feel like they are in a silo because it is difficult if not impossible to keep up with the abundance of new research. Yet ideas and techniques from diverse sources are embraced, and often quickly. In other words, while it is difficult if not impossible for any given individual to keep up with the latest development in neighboring fields, it is also difficult if not impossible to keep new ideas out. Disciplines are porous, and active researchers find that they must keep up.

In my book, I present several distinct types of evidence to document the fact that disciplines are open to ideas from diverse fields. For one, academic research frequently draws on information from a range of sources that traverse academic boundaries. Methods such as statistics, for example, are quickly assimilated irrespective of the discipline in which they originated. For example, Cox regression and related statistics were adopted rapidly in many fields, whether they are referred to as "event history models" in sociology or measures of "survival" rates in oncology research and "failure rates" in engineering studies.

Finally, disciplines are porous not only because of their physical proximity on campus but also because of the ubiquity of research centers. Each of the top 25 research universities on average has more than 100 research centers, most of which claim to be interdisciplinary in scope (author's analysis of institutional data from Gale Ready Reference Shelf). American universities are thus hybrids—discipline-based departments coexist with interdisciplinary research centers.

This characteristic of research universities does not mean that neighboring fields accept or assimilate all of the knowledge of other fields. But those who emphasize the difficulty that scholars have in communicating across fields sometimes exaggerate. Even the anthropological study of academic "tribes," emphasizes the blurred boundaries and ease of communication between fields, especially since the 1990s (Becher & Trowler 2001).

While critics of disciplines maintain that they are narrow-minded coteries compared with broadly integrative interdisciplinary programs, evidence from the institutionalization of fields supports the opposite conclusion. Disciplines, as we have seen, are typically quite broad in scope, while many interdisciplinary topics are quite narrow in focus. An interdisciplinary area may well resemble a scholarly niche rather than broad bridge between diverse intellectual terrains.

1 Disciplines and Real-World Problems

The case is sometimes made that the world's problems are too big to be addressed by any one discipline, and that interdisciplinary teams and programs are needed to tackle the challenges posed by climate change, pandemics, global inequality, and other daunting issues (Bhaskar et al. 2010). While it is often the case that solutions require coordinated efforts, it is another matter entirely to

suggest that integrated research teams are needed to provide the knowledge base on which these strategies are based. In other words, the conclusion that we need "integrated research" does not follow from the fact that we need "integrated programmatic strategies." The philosopher Gilbert Ryle (1949) would likely have called this a "category mistake."

Take the case of the outbreak of Ebola in western Africa. An international epidemic of this scale and lethality required a coordinated response from public health officials, government agencies, and volunteer groups operating at the national and international level. Yet the outbreak of Ebola also generated a tremendous amount of new discipline-based research classified under the headings of diagnostics, therapeutics, vaccines, and basic research by the National Institutes of Health (2015), which is the source of much of the funding in this area. Biomedical scientists rushed to develop new vaccines and new treatments as well as quick and inexpensive tests for the presence of Ebola. At the same time, public health workers coordinated data from outbreaks in order to more effectively target resources, epidemiologists tracked survival rates, others designed new Ebola protective gear to reduce the risk to healthcare workers, and cultural anthropologists worked to understand local customs and beliefs that might spread the disease and impede treatment. While it is certainly important that all involved are aware of the latest news and developments, those developing vaccines do not need to help build new protective suits. Similarly, anthropologists need to understand mechanisms of diffusion but not necessarily to participate in basic research on the genetic structure of the virus. It is best to view the response to Ebola as a multifaceted challenge that requires the insights of a wide range of specialized researchers. The same holds true for other complex social issues such as climate change.

Disciplines, however messy and diverse, are essential organizational units of modern universities. They are part of a hybrid system that combines discipline-based departments and interdisciplinary research centers, blends research and teaching, is somewhat insulated from everyday demands, yet ultimately depends on legitimacy and support from multiple publics. In short, disciplines are dynamic because of internal and external competition, and also because they constitute a social structure that channels this dynamism.

Discipline-based scholars are by no means flawless. They can pursue blind alleys, ignore if not stifle the next great idea, and occupy too much of their time with unproductive infighting. Disciplinary leadership is also confronted from time to time by intellectual movements that challenge prevailing ideas (Frickel & Gross 2005). But it is one thing to try to overthrow a particular set of discipline-based heuristics and another entirely to say that we should dispense with heuristics altogether (Liu 2008). Without a self-regulating system of scholarly appraisal, it is hard to imagine how scientific and scholarly advances could be developed, appraised, refined, and taught. Academic systems can sometimes be too structured, too constraining. However, the solution is the development of alternative frameworks that are broader and more encompassing, not rejection of frameworks themselves.

2 Interdisciplinarity, Balkanization, and the Concentration of Academic Power

Interdisciplinarity can shift power from researchers and departments to deans and presidents, as critics of the interdisciplinary initiatives at the University of California, Riverside, and Indiana University contend (McMurtrie 2016). Excessive centralization can threaten innovation and creativity that make our system work so well. Creativity in the research process requires decisions by those closest to the research issues themselves. Interdisciplinary units tend to shift power

(*cont.*)

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toward the center of the university, thus perhaps unintentionally promoting more centralized decision-making.

Once matters begin to span departments, the locus of control starts to shift upward, especially in grant-rich biomedical fields. The rotation of leadership of personnel in leadership positions risks repeated reorganization without sufficient time to fully reap whatever value these changes may have to offer. In other words, a decentralized system with a long time horizon has important strengths compared with a more centralized decision-making process that can sometimes reflect shorter-term decisions.

The final irony is that interdisciplinarity is likely to result in a more balkanized university. A great many cross-disciplinary research agendas are possible. Even if we limit our focus to applied concerns, there are in fact numerous fragmented aspects of any given practical social issue. For example, after the World Trade Center bombings, Pennsylvania State University sought out research grants in this area, and the result was 21 research centers devoted to homeland security. The interdisciplinary paradox is that the impulse to remove constraints on academic freedom rooted in disciplinary structures runs the risk of creating many more units and even greater constraints rooted in a more centralized university system.

3 Conclusion

Disciplines can be intellectually messy. They have roots in diverse intellectual traditions, complex internal structures, and fuzzy boundaries. Yet for all their difficulties, they nonetheless provide an organizational basis for instruction of undergraduates and graduates, certification of new scholars, selection of new faculty, and assessment of new findings. These roles are indispensable. Any viable vision of an interdisciplinary system relies on the continued existence and vitality of disciplines. Any vision of the modern university without disciplines would have to create functional equivalents for these functions. Reforms designed to promote interdisciplinarity should build on these strengths by building bridges between them rather than seeking to overturn the disciplinary system.

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CHAPTER 4

INTERDISCIPLINARY CASES AND DISCIPLINARY KNOWLEDGE

Epistemic Challenges of Interdisciplinary Research

WOLFGANG KROHN

This chapter provides a conceptual framework and determines the place of interdisciplinarity in the context of contemporary philosophy of science and social epistemology. It describes a widespread tension between the interdisciplinary commitment to complex real-world problems and the disciplinary strategies of designing and understanding simplified models. The epistemological challenge of interdisciplinarity is to relate knowledge about cases that are complex and singular with knowledge about concepts and causalities that are purified and general. While real-world problems call for highly specific and context-sensitive solutions, disciplinary problems serve as exemplars of a more general type. Finding solutions to real-world problems usually implies shaping a piece of reality in a satisfying way; solving disciplinary problems usually means having to find a sufficient causal explanation. What are the epistemological features of interdisciplinary research if it is supposed to serve the case as well as to advance knowledge?

4.1 Overview

The main propositions of this chapter are:

- Interdisciplinary research projects constitute a relationship between individual cases and more general knowledge bases untypical for disciplinary research.
- This relationship demands a new mode of knowledge, in which learning about a case is equally important as understanding causal structures. It calls for a combination of

Krohn, W., *Interdisciplinary Cases and Disciplinary Knowledge: Epistemic Challenges of Interdisciplinary Research.* In: *The Oxford Handbook of Interdisciplinarity, Second Edition.* Edited by Robert Frodeman, Julie Thompson Klein, and Roberto C. S. Pacheco: Oxford University Press (2017). DOI 10.1093/oxfordhb/9780198733522.013.5

the "humanistic" ideal of understanding the individual specificities of just one case, and the "scientific" search for common features of different cases.
- Reflection on the character of interdisciplinary knowledge supports a critical reassessment of the received concept of scientific law and exemplary application.

If it is taken as a point of departure that most interdisciplinary research projects are organized around real-world cases, it is implied that these cases have to be understood with all their contingent features and circumstantial conditions. Each case is more or less different from every other case and has a certain value in itself. A paradigmatic example is global climate research. It aims at understanding the climate just exactly as it is, its origins and its future, in all its complexity and vagueness. Even if climate change is a broad topic, it is a unique one. It needs to be understood by means of a highly specific or even unique model to which many specialties contribute.

Interdisciplinary research also aims at cases that exist in several exemplars: cities and buildings in urban planning and architecture; prairies, sand dunes, or estuaries in restoration ecology and adaptive management; refugees in migration research; and prototypes in technological innovation. Here it seems possible to transfer knowledge gained in one case to similar cases. However, as discussed later, relying on similarities without respecting differences can be misleading. In any case, reference to real-world cases is the essential cognitive and political dimension of interdisciplinary research.

This approach deviates from other approaches in not attempting to define interdisciplinarity on the basis of and as a derivative of the disciplinary structure of knowledge. Rather it is assumed that real-world cases necessarily integrate heterogeneous knowledge bases, be these gathered under the institutional cover of a discipline or not. Any research field or research project that addresses real-world problems is considered to be essentially interdisciplinary. An advantage of this approach is its independence from unsatisfactory attempts to define institutionally or cognitively what a discipline is. In consequence, research fields that are rhetorically addressed as disciplines can be considered to be epistemologically interdisciplinary. Moran (2002) has nicely made this point with respect to the humanities—English, literary criticism, cultural studies, feminism, psychoanalysis, and the like. They are all interdisciplines, or disciplines with interdisciplinary features, because they tend to accept cases in their complexity and contingency. The same point was made earlier by Donald Campbell with respect to anthropology, sociology, psychology, geography, political science, and economics, which he called "hodgepodges" caused and shaped by real-world problems (Campbell 1969).

To start with real-world cases helps to understand certain features of interdisciplinarity. Later in this chapter the focus shifts from cases to processing contingency and complexity. The main interest is not to provide managerial and methodical solutions for cooperation between disciplines but to exploit the fruitful tension between understanding a case and searching for general knowledge. The main proposition here is that taking cases seriously implies a kind of learning considerably different from received views of inductive or deductive methods. Doing research in the context of real-world problems demands and develops skills and competencies that scholars are not used to.

4.2 Idiographic and Nomothetic Knowledge

What are "real-world" cases? The concept is meaningful only if contrasted with some "ideal world" of something. Every scientific experiment makes things simpler than they are, and theory imagines the world yet simpler. Historically, the paradigm was set by the invention of geometry. Since there is no *real* line, curve, or body that fits the demands of mathematical definition, they are ideally constructed. The ontological status of ideal objects has always been controversial, but this is not our point. The point is the epistemic change in hierarchical order. Real things, those which we can point at, are only approximations of ideal objects. The science of ideal objects is still called "earth measuring" (geometry), though there is not a single place on earth that fits its definitions. Sciences that do care for real-world measurement such as surveying, alignment, and mapping have developed methods able to determine any shape of an area. Limits to precision are not set by the methods but by changing and melting borders—as between land and water, forest and prairie, city and suburban sprawl.

Open boundaries present a very important issue in the analysis of real-world objects or systems. Geometry and surveying have fruitfully interacted in history. Surveying is real-world oriented and therefore is an interdiscipline. Geometry is a classical discipline (or subdiscipline, if mathematics is the discipline). Both come together in the earth sciences, in which on the one hand sites, events, and (hi)stories are important and on the other the objects, models, and methods of the lab. Frodeman (2003) has provided an epistemological analysis of the earth sciences showing how difficult it is to integrate the interdisciplinary strands into a coherent self-understanding of the discipline.

There are numerous other examples where, in a roughly identical segment of reality, strategies to grasp peculiar cases as they are coexist with strategies to construct cases as they are wanted for theory. The general proposition to be made with respect to this distinction is simply this: Interdisciplinary research is needed to focus on the peculiarities of given cases, while disciplinary research is characterized by substituting ideal features for given ones. Many modern research fields relate to both foci and are simultaneously driven by these two tendencies. They aim at becoming more of a discipline, as well as a place of integration for potential contributors from various disciplines. How this is balanced institutionally—in terms of journals, societies, handbooks, curricula, research sites—is of no concern here.

Call the specific features of a problem, a system, or a case its "idiographic component." And call the more general features gained by taking problems, systems, or cases as exemplifying or inducing a more abstract or idealized object of knowledge its "nomothetic component." The terminology was introduced by the neo-Kantian philosopher Wilhelm Windelband (1894). Idiographic literally means describing the peculiar, singular, and specific.[1] Nomothetic literally means setting the (scientific) law. The law-like quality of scientific knowledge is associated with certain features such as the reproducibility of experimental facts, prognosis of events, general validity of propositions, and causal explanation of correlations. Even if the definition and relation of these epistemic features are controversial, they undoubtedly strengthen the difference between something one happens to know and

[1] The likewise usual wording "ideographic" does not refer to Greek *idios* = peculiar, but to idea = form, Gestalt, which is no less appropriate.

theoretically corroborated knowledge. The ideographic structure of knowledge Windelband believed to be best exemplified by historiography. A historian who specializes in the founding of the United States of America usually does not wish to become a specialist for foundations in general, but builds his reputation on knowing everything about just this case and giving it an original and surprising interpretation. If he cared to analyze another founding—say of the Roman Empire, Brazil, or the European Union—neither factual knowledge nor interpretation schemata can be transferred from one to the other.

When Windelband introduced this terminology he was not only a famous philosopher but also rector of Strasbourgh University. He found himself in a position to reconcile a heated controversy between the natural/technical and the cultural sciences/humanities. The rapid ascent of the natural sciences led to claims that true knowledge would only reside in laws. Eventually all knowledge fields including the humanities were to be converted into law-seeking disciplines. The counterattack aimed at the assumed weak point that natural sciences are completely unable to develop a coherent understanding of something as complex as a culture and its history, or even some part of it, such as a specific city, not to mention art, literature, and religion.

In his presidential lecture in 1894, Windelband suggested equal rights to both forms of knowledge. Knowledge production is guided either by an interest to identify laws, which implies turning things into variables, or by an interest "to describe as complete as possible a singular event or chain of events spread over a limited time." Examples of events worth scholarly interest are, according to Windelband, "Actions of a person, the character and life of a single man, or of an entire people, the character and development of a language, a religion, a legal order, of a product of literature, art, or science: and each of these subjects demands a treatment corresponding to its peculiarities" (Windelband 1907, p. 363). For Windelband, the distinction is not built on different classes of objects—natural events versus human affairs—but on methods. In principle, everything can become the object of a nomothetic as well as idiographic analysis. His examples are language, physiology, geology, and astronomy. If objects in these fields are considered in their specificity, "the historical principle is carried over to the realm of the natural sciences" (Windelband 1907, p. 365). If the objects are taken as types or exemplars, the methods of the natural sciences apply.

By the traditional views of philosophy of science, it seems obvious that the sciences should search for laws, principles, and other forms of generalized explanations. It is less obvious why they should care for singular or even unique cases. Windelband assumed their relevance with respect to cultural heritage, identity, and value. Admittedly, one can never know in advance whether or not a single case turns out to be culturally relevant. But if it were considered to have no potential value at all, research would not be started. Or put in a more constructive language, a scholarly effort to study a case automatically attaches some sort of value to it. Windelband's neo-Kantian disciple Rickert offered the following equation: "There is not only a necessary connection between the *generalizing* and the *value-free* observation of objects, but also an equally necessary connection between the *individualizing* and *value-laden* perception of objects" (Rickert 1924, p. 58). Even if this general statement may be doubtful, obviously all real-world problems have a value dimension, be it economical, social, cultural, or environmental. Windelband and Rickert chose historical research as their paradigmatic field because the preservation of cultural goods and values seemed to be even more important in a society that became exposed to dramatic industrial changes. Today we would add to the historian's work pressing problems caused by misguided developments.

Real-world problems are problems because values are at stake. Solutions are only accepted if they address these values.

Concern for idiographic cases does not invalidate more general knowledge. Usually, interdisciplinary case studies are expected not only to solve single problems but also to contribute to stocks of knowledge. However, the epistemic structure of these stocks of knowledge is different from knowledge condensed in theories or paradigms. The relationship between ideographic and nomothetic orientations of interdisciplinary research needs to be analyzed and interpreted in a new way. The first step will be to better understand the nature of cases by looking at variants of the so called case-study method practiced in professional schools. Certainly, higher education of professionals and experts aims at goals different from doing research. However, the reasons why the case study method seems to be successful in professional training are important for understanding how cases contribute to interdisciplinary knowledge.

4.3 Learning Based on Case Studies

The methodology of using case studies in educational programs originated in the pioneering achievements of the Harvard University professional schools. As early as 1870, the Harvard Law School shifted the study of law from the classical systematic approach to the analysis of cases. In 1920, the Harvard Business School developed a new curriculum based on case studies. In 1985, the Harvard Medical School followed suit with its New Pathway Program, which was considered revolutionary within the field of medical training. The following presentation is concerned not with an evaluation of this educational method, but rather with the question of what can be learned from individual cases.

David Garvin—himself a faculty member of the Harvard Business School—emphasizes the three dominant goals of case study methodology: "learning to think like a lawyer"; "developing the courage to act"; "fostering a spirit of inquiry" (Garvin 2003, subheadings). Competencies from three professional fields merge here: the logical expertise of a lawyer, the decision-making capacity of a manager, and the curiosity of a researcher. Cases that have been of paradigmatic importance for the development of laws are not central to the training at the Harvard Law School. The focus is rather on those cases that are controversial within the legal profession, those that were wrongly decided or were revised. Garvin cites another member of the faculty who notes, "We have conflicting principles and are committed to opposing values. Students have to develop some degree of comfort with ambiguity" (Garvin 2003, p. 58). The analysis of individual cases frequently does not lead to a clear result. "Students often leave class puzzled or irritated, uncertain of exactly what broad lessons they have learned" (Garvin 2003, p. 59). On the contrary, they learn that general legal doctrines are rarely unambiguously applicable and that the smallest distinctions can play a role in their application. Furthermore, these cases help students practice dealing with unknown and unforeseen circumstances, with varying conditions, and with surprises.

The description of Stanford Law School's "case study teaching method" is similar to Harvard's: "Case studies and simulations immerse students in real-world problems and situations, requiring them to grapple with the vagaries and complexities of these problems in a relatively risk-free environment—the classroom" (Stanford Law School 2015). Far from

introducing individual cases in Kuhn's sense as paradigms, these are examined as unsculpted and uninterpreted as possible. This methodology is thus quite suitable to an academic policy that places value on the grasping of complex configurations, on the identification of possible action, and on the assessment of consequences. It aims at an interdisciplinary training portfolio: "Students identify for themselves the relevant legal, social, business, and scientific issues presented, and identify appropriate responses regarding those issues" (Stanford Law School 2015).

Education at the Harvard Business School is also guided by the principle that greater competence can be acquired through constant rehashing of case studies than through studying theoretical and methodical knowledge and the intended applications thereof. Underlying the choice of these individual cases are the following criteria:

> Typically, an HBS case is a detailed account of a real-life business situation, describing the dilemma of the "protagonist"—a real person with a real job who is confronted with a real problem. Faculty and their research assistants spend weeks at the company. . . . The resulting case presents the story exactly as the protagonist saw it, including ambiguous evidence, shifting variables, imperfect knowledge, no obvious right answers, and a ticking clock that impatiently demands action. (Harvard Business School, 2008; for a more recent account, see Harvard Business School 2015)

The students are presented with about 500 of these cases in the course of their studies, the main goal being to school their decision-making behavior. The large number of cases is not seen as an inductive basis for statistically generalizable knowledge, but rather as preparation for a maximum number of diverse situations. In addition to these cases studies, the program offers courses in "analytical tools." The following list of academic goals is presented in Garvin (2003):

- training of diagnostic skills in a world where markets and technologies are constantly changing
- assessment of the ambiguity of constellations
- consideration of the incompleteness of the information at hand
- recognition of the existence of a multitude of possible solutions
- preparedness to make decisions in the face of uncertainty and time pressure
- development of persuasive skills. Management is a social art; it requires working with and through

From a critical perspective, the tendency to quick decision should be noted. "The case method does little to cultivate caution. . . . Students can become trigger-happy" (Garvin 2003, p. 62). For a more balanced view, see Srikant et al. (2009).

Inaugurated in 1985, Harvard Medical School's New-Pathway Program has supplanted the classic basic training in medical fields and has with some delay affected applications at the sickbed. It also highlights the point that every single case is self-contained. To cite Tosteson, the program's founder, medicine "is a kind of problem solving" and each medical encounter is "unique in a personal, social and biological sense. . . . All these aspects of uniqueness impose on both physician and patient the need to learn about the always new situation, to find the plan of action that is most likely to improve the health of that particular patient at that particular time" (Tosteson, cited in Garvin 2003, p. 63). Since then, the program

underwent several revisions, seeking the optimal combination of disciplinary knowledge development and practical responsibility for the individual case.

Further examples of curricula that have adopted the case method entirely or partially include engineering, sociology, psychology, education, architecture, and economics. What constitutes its success if not superiority in higher education? The most notable criterion is its insistence on the individuality of cases. They are not cases in point, not exemplars of a type—at least not in the first place. The didactic concept is not to present a general structure via a number of examples, whose special features quickly retreat behind the emerging abstraction. No case can be exchanged for another, since something different is learned from each case. Concentrating on the idiographic nature of each case means to develop a sense for its details and the seemingly incidental aspects that make it special. Every case study of this kind is unavoidably connected to deficits in information, to ambivalent interpretations, and to the risky effects of possible interventions.

At variance with more traditional academic education, the focus is on grasping both the differences and the similarities between cases. Identifying case-specific gaps in knowledge is as important as applying knowledge gained from other cases. The background philosophy seems to be that professional realities are not determined by general rules or even scientific laws, but are constituted by a vast network of particular cases. The competency of the professional consists in deriving operative gain from comparing similarities and differences between cases.

Traditionally, the two pillars of scientific methodology are inductive generalization leading to theory and deductive specification via application to cases. Here, however, neither is applied. Rather, both are substituted by the expansion of a network of cases, in which the mesh density of analogous relationships is continually tightened. Does this indicate a third path that avoids the alternative between generalization and specification? Does such professional training develop a learning core not contained in the traditional theories of the growth of knowledge?

4.4 Knowledge and Skills: The Professional Perspective

The launching point for the educational programs described in the previous section is the shortcoming of academic training with respect to professional competencies. The criticism is that the academy is unable to deal with the complexities of true life, but must reduce these in accord with theoretical concepts. Academic training follows the paradigm of alternating theoretical construction and experimental research by which the object of study is subjected to the ideal conditions of the laboratory. This is not the reality that the professional expert confronts.

The case method cultivates certain capacities that are most often termed "skills." Skills do encompass rational pieces of knowledge, but equally important are routines, habits, and trained intuitions, all of them are not completely explicable components. They come into play not only for professional know-how, but in many fields of learning like the acquisition of crafts and trades, doing sports, or mastering a musical instrument. More generally,

all techniques that require the coordination of physical training with the comprehension of rules and readiness to act are based on skills. Here the study of introductory books and instruction manuals helps little. The observation of masters helps a bit more.

Decisive, however, is the continual exercise of physical practices until these become routine. Situational assessment, spontaneous coordination of action, and a repertoire of strategies are all conditions for success. The important point in our context is this: Even when skills have been developed, each individual case retains its particular meaning. There is no overarching level of competence comparable to theoretical knowledge, in which skillful action could be adequately reconstructed as theoretical objects. Although there have been attempts in the scientific analysis of sports and music to construe such levels, what ultimately count are skills in action.

The Harvard method and the teaching methods practiced in the fields mentioned above have in common the accumulation of analogies between related configurations, whereby it is as important to attend to differences as to similarities. In this way, the learner knots together a network of configurations that is fed by individual cases and used for situating further cases. This is what defines the professional expert (e.g., the lawyer, doctor, or manager), the specialized expert (e.g., the craftsman, athlete, musician), and even, if one can say so, the everyday expert (e.g., the habitual walking in uneven terrain, parenting, driving). It may be assumed that in the background of the case method a much deeper mechanism of analogical reasoning is at work, which Hofstadter and Sander (2013) have called the "fuel and fire of thinking." By the same token, analogical reasoning enables us to categorize as well as differentiate the world and makes us experts when we apply it and scale it up.

It is beyond this chapter to explore cross-links between the case method and Hofstadter's model. As applied to interdisciplinary research, one can conclude that learning from case studies is suited primarily for expanding the professional know-how of experts. In keeping with the traditional concept of professions, one could coin the term "professional researcher." Such a professional would be an expert in the investigation of open problems in contingent and complex individual cases, which occur within a certain domain of action. Their expertise is based on a network of experiences gathered and expanded case by case. From a scientific point they are not less equipped with disciplinary knowledge the use of which makes them professionals. As real-world cases usually call for several disciplinary competencies, interdisciplinary cooperation between professional experts is required for this type of research.

One of the best analyses of the design of case studies in sociology (inspired, by the way, by the Harvard methodology) confirms this grounding of research in expertise. "Common to all experts is that they operate in their fields of expertise on the basis of an intimate understanding of many thousands of concrete cases. Context-dependent knowledge and experience constitute the core of expert praxis. . . . Only through experience in dealing with cases can one develop from a beginner to an expert" (Flyvbjerg 2006, p. 222). Based on Aristotle, Flyvbjerg has developed a conceptual frame that relates three categories of doing research—the epistemic approach to universal knowledge, the technical approach to functional know-how, and the social approach to phronetic judgment or practical reasoning. As is demonstrated in several case study reports, the successful solution of complex societal problems presupposes the operative use of the three sources (Flyvbjerg et al. 2012).

4.5 Individual Case and Epistemic Knowledge

The idiographic aspects of interdisciplinary research have now been sufficiently explored. It was important to begin with these, as they are quite removed from standard philosophy of science and from learning theories of higher education. However, to end with the case method would mean to declare theory based epistemic knowledge a needless encumbrance. The important point was that sensitivity to cases cannot be derived from theory. This does not imply that theory cannot contribute to understanding cases, nor that cases cannot advance theory. The statement that contingency in interdisciplinary research cannot be eliminated gains its epistemological value only because important resources of knowledge can be tapped into, whose validity and applicability are accepted, even if they do not suffice to grasp all details of a specific case.

4.5.1 Individual Cases and Unconditional Laws

The relationship between the specification of causal knowledge toward individual cases and the generalization of on-site findings appears at first sight to be that between a deductive strategy of applying substantiated knowledge and an inductive strategy of developing hypotheses for new knowledge. But this distinction does not allow the methodological challenge of interdisciplinary research to come to light. The challenge is to balance the tension between understanding a case in its real-life context and contributing to a stock of theoretical knowledge. This section relates this tension to current discussions in philosophy of science.

In her influential book *How the Laws of Physics Lie* (1984), Nancy Cartwright presented the thesis that the fundamental laws of physics hold true only for highly idealized theoretical objects that do not exist in the real world. Strictly interpreted, these laws are false when taken as empirical descriptions of reality. The well-known example is that of Galileo's Law of Falling Bodies. Its real-world validity is modified by friction, wind force, raindrops, and the shape of the body. Cartwright loves to illustrate the problem by an example already used by the Vienna Circle philosopher Otto Neurath (Cartwright 1999, p. 27): the calculation of the trajectory of a bill dropped from St. Stephan's dome in Vienna. Even the joint forces of mechanics, fluid dynamics, and computer simulation methods would not come close to a correct prediction.

From a pragmatic point of view, Cartwright's objection seems to be of no effect. In the laboratory objects are stylized to better fit theory, and theorists acknowledge practical limitations to the absolutely perfect realization of causal assumptions. Within these limits, knowledge can be put to work. From a philosophical perspective, however, her thesis continues to provoke unrest. If under close scrutiny universal laws have no empirical content, then the project of interpreting reality through reductionism remains ungrounded. At best, it can be played through for simple cases from which one cannot extrapolate, what Cartwright called "the dappled world" (1999). This world can be scientifically captured only by a broad variety of laws with limited range and with no consistent logical order. In describing this world we can better speak of capacities, tendencies, and potentialities than of rigid

laws. Recently Cartwright and Hardie have applied her philosophy to the risks of transferring policy projects. "It is a long road from 'it works somewhere' to . . . 'it will work here'" (Cartwright & Hardie 2012, p. 6).

Cartwright's strong statement regarding the presence, if not predominance, of the idiographic in the scientific description of the world is highly controversial (see Earman et al. 2002). It has challenged the privileged position of the concept of natural law as the standard and compass for scientific theorizing. Moving beyond Cartwright's proposal, Giere (1999) suggested that the concept of law should be completely struck from the language of philosophy of science. He is of the opinion that we cannot rid ourselves of the theological origin of the concept. Only God as the external legislator of the world would be in the position to command by general rules completely obedient natural things. Since the Kantian project of anchoring fundamental laws in the structure of reason failed, for Giere no further candidate remains that could guarantee the universality and necessity of the laws of nature. In Giere's reconstruction, lawful regularities become systems of equations that pertain, not to reality, but rather to imaginary models created for their verification—an idea for which Cartwright coined the term "nomological machine." Real-world constellations cannot be grasped precisely.

Whether, despite these objections, it will remain meaningful to speak of general and unconditional laws of nature can be left an open question here. It suffices to ascertain that the classical notion of a law's universal validity no longer fully captures the "cases" that fall within the law's domain. The take-home message of this philosophical discussion concerning the relationship between the nomothetic and idiographic in science is that the tension between universal validity and exemplary cases is already contained within the unconditional laws of physics.

4.5.2 Individual Cases and Conditional Laws

Some laws of physics still possess the elevated status of being general. Laws typical for sciences as biology, psychology, and economics are burdened from the beginning with the acknowledgment that their predictions and causal explanations are valid only under specific conditions or to a certain degree. The two central problems of such laws are that (1) the respective specific conditions cannot be listed completely and definitively and (2) exceptions to the rule can always be included in the collection of excluded conditions. The difference with regard to the laws discussed in the above section is this: General laws such as the mutual mass attractions, the conservation of energy, and entropy are considered unavoidably and eternally valid, even if the calculation of concrete cases is difficult or impossible. For conditional laws such as Mendel's laws of heredity genetics, the law of diminishing return in economics, or the Gestalt laws in psychology, the lawful connections are defined for objects whose uniformity, continuity of existence in time, and independence from their environment are not guaranteed.

Following in the footsteps of the evolutionary biologist Stephen Jay Gould, Sandra Mitchell asserted the following for biological regularities: "If we rewound the history of life and 'played the tape again', the species, body plans, and phenotypes that would evolve could be entirely different. The intuition is that small changes in initial 'chance' conditions can have dramatic consequences downstream. . . . Biological contingency denotes the historical