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An Introduction to Platforms

Michel Foucault, discussing the work of conductor and composer Pierre Boulez, once said that the most passionate Western intellectual debates were about form, not content.[1] And indeed, if one looks back at the twentieth century, questions of form—in literature, music, the visual arts—have consistently overridden issues of content. As far as literature goes, just think of the (no longer so "nouveau") *nouveau roman* and its strategy of systematically disrupting traditional narrative conventions. Yet, in spite of limited and not entirely convincing attempts to import "new literary forms" into the field of science and technology studies,[2] history and the social sciences have resisted attempts to subvert the standard scholarly rules of presentation. This book is no exception, except for a modest attempt, in its opening chapters, to introduce its subject matter progressively, through the accretion of several layers of examples. A few colleagues (and, most important, referees!), fearing that such an approach would put off hurried readers, urged us to capture their attention immediately by beginning with a somewhat more traditional summary of the argument. We comply.

The Argument Summarized

In this book, we introduce the notion of *biomedical platform* and use it to analyze the development of innovations and routines in postwar biomedicine. Our analysis entails the articulation of three well-known dichotomies: biology/medicine, science/technology, and innovation/routine. Concerning the first, we claim that, since World War II, biology and medicine have come together, both institutionally and intellectually, in a hybrid practice that is neither syncretic nor synthetic. We show, through example, that a new way of conducting research in biology and medicine has emerged and that this modality aligns normal

and pathological phenomena and their representation in a novel way. Within this problematic space of scientific representation, truly biomedical entities—e.g., cell-surface markers, oncogenes, DNA profiles, etc.—exist as both normal biological entities and as pathological signs, i.e., as *biomedical* substances with regard to their origins, their uses, and their meanings. We argue that these entities are constitutive of biomedical platforms and their products.

Figure 1.1 is a 1991 representation of a hierarchical set of procedures used to diagnose blood cancers. As the figure suggests, a patient expressing the relevant clinical signs will generally undergo a biopsy. The tissue sample will then be investigated with the help of histochemical dyes using different techniques beginning with morphological diagnosis to examine the architectural arrangement and the shape and size of the cells in the sample. A form of diagnosis called immunophenotyping follows this initial investigation. Here, panels of standardized antibodies that are often combined with the use of computerized, laser-based equipment detect distinctive molecules at the surface of the malignant cells. Molecular genetics analysis is the last step. Suspicious cells are examined for culpable RNA, DNA fragments, and genes using molecular biologi-

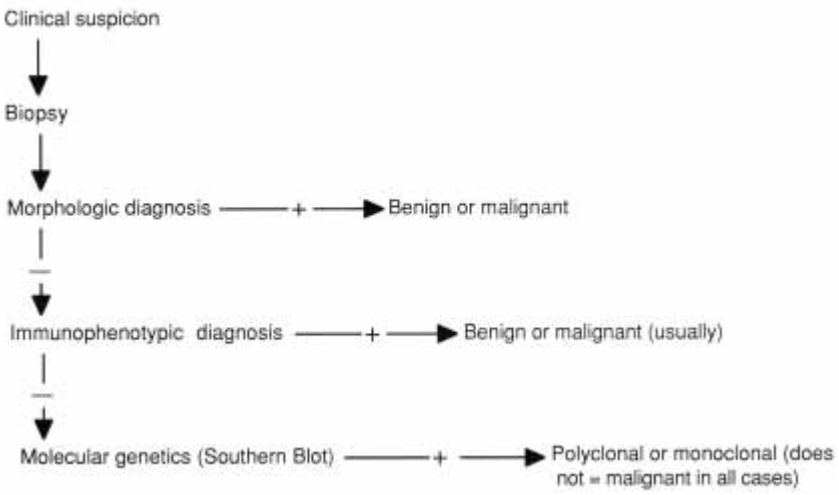

Figure 1.1
A diagnostic algorithm for lymphoid tumors showing platform hierarchies. (From: Whittaker and Willman. "A Practical Guide to the Use of Molecular Genetic Techniques in the Diagnosis of Lymphoid Malignancies," 124. © United States and Canadian Academy of Pathology. Reprinted by permission.)

cal techniques. We believe that each of these steps mobilizes a distinctive biomedical platform. We will thus speak of the morphological platform, the immunophenotyping platform, and so on.

Our subsequent analysis of biomedical platforms focuses on the interlaboratory level of scientific and medical research. Unlike laboratory research, research at this level concerns less the production of local and unprecedented "epistemic things"[3] than the constitution and circulation of protocols, instruments, and substances between laboratories and the establishment of conventions that allow them to be used in the generation of biomedical facts. Usually neglected as a field of mundane regulatory activity, here, accepted divisions between science and technology and innovation and routine break down. We show, thus, how modern biomedicine requires a description of scientific practice that offers a distinctive place for technology and its development other than that of a simple tool for the furtherance of intellectual goals. In particular, we show that biomedical research programs are embedded in technology in the form of substances produced on biomedical platforms and that regulatory activities conducted at all levels of research are constitutive of platforms and their effective functioning as agents of change within the biomedical sciences.

We have chosen a specific biomedical platform known as "immunophenotyping" and describe its emergence as an experimental system with roots in biology (immunology) and pathology (oncology). We then show how this experimental system was transformed into a biomedical platform, initially for the diagnosis of leukemia, at first in one, then in many laboratories. Our description does not resort to the diffusion of ideas or instruments but details the interlaboratory constitution of conventional substances—in our case cell-surface markers—and the equipment, procedures, and clinical and scientific categories required for the conduct of interchangeable activities on a global level. By targeting this level of practice, we avoid two pitfalls commonly associated with the description of scientific activities. First, by concentrating on the platforms that link laboratories, we avoid the action-at-a-distance causality that underlies descriptions of science as a paradigm-ordered or theory-driven activity. Second, although we occasionally describe experiments in individual laboratories, our analysis of activities that seek to stabilize existing practices and the entities they produce allows us to outline conditions for the production of novelty and routine within a single laboratory.

Our analysis of the immunophenotyping platform draws together a range of activities in contemporary biomedicine running from

laboratory research to clinical trials and routine diagnosis. This enables us to describe biomedical platforms as specific combinations of techniques, instruments, reagents, skills, constituent entities (morphologies, cell-surface markers, genes), spaces of representations, diagnostic, prognostic, and therapeutic indications, and related etiologic accounts. More specifically and more abstractly, our study enables us to define biomedical platforms as material and discursive arrangements that act as the bench upon which conventions concerning the biological or normal are connected with conventions concerning the medical or pathological.

Finally, through comparison of different clinical instantiations of the immunophenotyping platform, we observe that while platforms form the locus of biomedical innovation and routine, the development of a new platform does not necessarily result in the replacement of the previous platform. Rather, new platforms are often articulated and aligned in complex ways with existing ones, and thus integrated into an expanding set of clinical-biological strategies.

Readers will find below a short chapter-by-chapter overview of the book. For the moment, we ask them to accompany us through the doors of a hospital.

A Visit to a Hospital

The tertiary hospital provided specialized care to patients afflicted with rare or deadly diseases such as leukemia and lymphoma, cancers affecting the cells and organs of the hemopoietic (blood cell–forming) system. The large American flag in front of the massive building reminded us that we were in the United States. Overhead, emergency helicopters flew patients in from the tristate catchment basin on an around-the-clock basis. Upon entering the premises, we were struck by a giant quilt on the walls of the entrance hall (figure 1.2a). Although the "quilt" turned out to be made of ceramic tiles, the recent revival of the American tradition of quilting in response to the AIDS crisis had immediately brought the term to mind.[4] Cancer patients had designed the individual tiles that featured childlike drawings of cartoon characters and that consequently reminded onlookers of the emotional lives of children with leukemia.[5] Short texts, in adult handwriting, occasionally accompanied the tiles and expressed heartfelt gratitude—sometimes to God, sometimes to a doctor—for successful therapy (figure 1.2b).

(*a*)

(*b*)

Figure 1.2
Overview (*a*) and close-up (*b*) of the "quilt" on the walls of an American cancer hospital. (Photographs: A.C.)

The quilt interwove numerous narratives of personal despair and suffering and of hope.

We had come to the hospital to visit an important laboratory medicine team and to learn about recent developments in the diagnosis and prognosis of cancer. We hoped to gain firsthand knowledge of old and new procedures and to gather oral-historical information from the head of the local hematopathology (blood pathology) unit. The tile "quilt" confronted us with the patient's view of the medical developments we had come to investigate. Was this the voice of the "lifeworld," i.e., the subjective experience of disease, as opposed to the voice of medicine, i.e., the objectifying language of medical diagnosis, as expressed in numbers and esoteric terminology?[6]

Past the entrance hall, several flights up, we followed a sign reading Hematopathology to a large laboratory. Hospital policy excluded patients, in the ordinary sense of the term, from these rooms. We nonetheless encountered a number of "patients" in the form of blood and bone marrow samples undergoing inspection by a team of pathologists and technicians. Although these patients were clearly metaphorical, it was not our metaphor. Having taken us out to lunch, the chief laboratory pathologist had told us somewhat nervously partway through the meal that he had to "rush back to his patients." We had assumed that he had planned to visit patients in the wards—an unusual move for a pathologist—but as soon as we reentered the laboratory he pointed to a set of blood and marrow slides (figure 1.3), saying, "Here are my patients." Is this further evidence of the divorce between the voice of the lifeworld, where it only makes sense to speak of patients as whole persons, and the voice of medicine, where patients can be reduced to body samples exposed to the objectifying gaze of healthcare professionals and automated laboratory equipment?

As we soon learned, to construe the pathologist's utterance—"Here are my patients"—as evidence of the narrow, reductionist nature of "the biomedical model,"[7] overlooked the fact that clinicians generally initiate chemotherapeutic treatment of patients presenting the clinical signs of acute leukemia after the diagnosis has been confirmed by laboratory analysis. It can literally be a matter of hours before it is too late to reverse the course of the disease. This is why the laboratory we visited was staffed on a 24-hour basis and this is why the microscope slides, ultimately integrated with "whole" patients waiting in the wards for lifesaving or, at least, life-prolonging therapy, were of crucial importance to their treating physicians.[8] In other words, there was, despite appearances, no deep

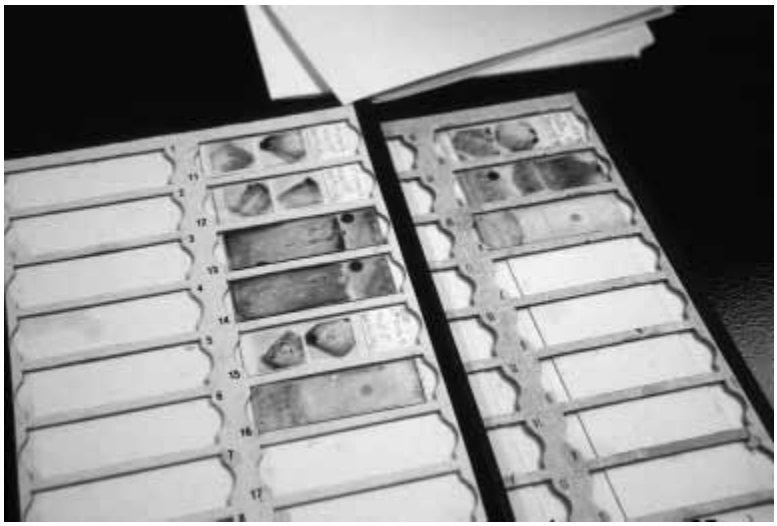

Figure 1.3
"Here are my patients": blood and bone marrow slides in a pathology laboratory. (Photograph: A.C.)

division between the patient and the laboratory. Indeed, in contemporary hospitals all sorts of body samples leave the patient to travel routinely and frequently to diagnostic laboratories. But they also return to the patient in the form of results that acquire meaning as part of the therapeutic relationship that exists between patients and increasingly complex teams of healthcare professionals. Traces of this process can easily be found in the material and organizational structure of hospitals that have been redesigned to take into account the large flow of samples (see chapter 2).

In this book, we examine the social and historical conditions for the establishment of both discursive and material relations between bodies and samples. Commonly referred to as links between the clinic and the laboratory, these relations are defined by the intersection of distinctive arrangements of instruments and programs that seek to articulate biological and population data with diagnostic and prognostic singularities. We call such configurations of people and equipment, several of which have been developed during the second half of the twentieth century, "biomedical platforms." We will show that the latter are a critical site of biomedical innovation and that new biomedical entities, produced, managed, and regulated on the platform, become defining elements of

patients' bodies and, as such, channel the actions of the physicians who deal with them.

Scientific and clinical research and practice create and reproduce new entities, new actors.[9] Initially confined to the esoteric space of the laboratory, they (or, at least, some of them) subsequently redefine not only the patient's clinical identity but also our daily lives. Indeed, as Silverman has noted, medical discourse "has entered into our own accounts of ourselves, thus making the distinction between 'lifeworld' and 'medicine' itself problematic."[10] Microorganisms are a case in point[11]: we wash our hands and take care to prevent the deleterious effects of "microbes," entities that most of us have never seen or manipulated.[12] As Porter suggests, in the case of germs, medicine has migrated "from the laboratory to the lavatory," infiltrating our imagination and transforming "everyday beliefs, experiences and habits."[13] Actions and behaviors, both individual and collective, have been (re)constituted to accommodate the new entities produced by modern biomedicine.

While the case of bacteriology is particularly well documented, the argument applies just as well to the entities generated more recently by other medical specialties such as hematology and immunology, or, more precisely, by the development of the biomedical platforms used by those specialties. T4 cells, also known as CD4 cells, the white blood cells attacked by the virus human immunodeficiency (HIV) and whose sharp decline signals the passage from HIV-positive status to AIDS, provide a significant contemporary example. Less than thirty years ago, T4 cells did not exist in laboratories or medical textbooks. Chapters 4 and 5 reconstruct the complex chain of events that, independently of the impending AIDS pandemic, resulted in the production of the biomedical platform that lies behind the existence of T4 cells. For the moment, let us simply note that they are now taken for granted in both medicine and everyday life. Anyone strolling through downtown Paris in 1997, for instance, saw the magnified pictures of T4 cells hanging from the city walls (figure 1.4). For AIDS patients, T4 cells had by then become a daily reality. Counting the T4 cells contained in a cubic millimeter of blood produced a number that, following initial diagnosis, continuously mediated their subjective bodily experience and narratives. Consider the following AIDS patient who experienced a dramatic recovery after the initiation of triple therapy:

Look at me now!—says a young HIV positive patient while executing a *pas de deux* in the corridors of the Cochin hospital—Six months ago I could feel death taking over, I was at zero T4, I was skinny, I had one infection after another, I was witnessing my own passing away. Since the beginning of triple-therapy, I have 180 T4s, my viral load is undetectable, I have put on 3 kilos, I will start working again, and I am even asking myself whether or not I should have a child.[14]

No longer confined to the hospital or to the bodies of individual patients, T4 cells have entered the political arena, further reinforcing their status in medical settings.[15] A case in point is the decision by the U.S. Centers for Disease Control and Prevention (CDC) to modify the definition and staging of AIDS. The latter had initially been based solely on clinical criteria (a list of opportunistic diseases and clinical conditions). In 1985, following the identification of HIV, the CDC added the results of the HIV antibody test. Then, in 1993, the CDC ruled that a cell count of less than 200 CD4 (T4) cells/mm^3 combined with an HIV-positive status defined AIDS. The switch from a clinical to a laboratory-based definition generated considerable controversy, for it immediately produced a major increase in the prevalence of official AIDS cases and created the possibility of diagnosing patients with AIDS before the expression of symptoms.[16] Prior to the 1993 decision, the CDC had organized an extremely adversarial meeting with lay activist groups.[17] The transcripts of the meeting on the implications of the change in the definition of AIDS contain many angry personal narratives from HIV-positive patients who contrasted their lived experiences with the objectifying nature of laboratory-generated values purveyed by the CDC's medical experts.

Yet, as chronicled in Steven Epstein's detailed analysis of AIDS activism, when lay groups such as ACT UP confronted the medical establishment, contesting, for instance, the design of clinical trials, they turned themselves into "lay experts" making full use of the biomedical entities that inhabit clinical discourse.[18] Challenging, for example, the use of a patient's death as an appropriate endpoint for clinical trials, AIDS activists promoted, instead, CD4 counts as "surrogate markers."[19] CD4 counts, as we have seen, had become routine components of the therapeutic management of AIDS both from the medical and the patient's point of view. By accepting the clinical significance of CD4 cells, patients and activists operate on the biomedical platform that has generated and reproduced those entities. In other words, while medical and lay actors position themselves vis-à-vis a given platform, contributing, for instance, as in the present case, to its further entrenchment, they cannot

(*a*)

Figure 1.4
ACT UP posters displaying CD4 cells on the walls of buildings in downtown Paris (*a*), and a clean version (*b*) of one of the posters. (Photographs: A.C.)

operate "off" the platform, unless, of course, they decide to opt out entirely from Western medicine by embracing alternative medical cosmologies.

The situation we just described can be analyzed as part of the long-term historical trend whereby physicians no longer rely on narratives of symptoms offered by patients during a medical encounter, but turn instead to an expanding collection of diagnostic signs.[20] Yet, as we argue in chapter 3, the post–World War II period, rather than simply corresponding to a quantitative extension of this process, has led to a quali-

(*b*)

Figure 1.4
(continued)

tative transition aptly captured by the neologism "biomedicine." If then, in an important sense, being a patient now is quite different from being a patient several decades ago, this is not simply because a growing number of the entities, such as CD4 cells or, say, cancer susceptibility genes, that are constitutive of those diagnostic signs are of recent origin. Rather, it is because the understanding of these entities resides at the intersection of medicine and biology or, in other words, is linked to the emergence of a new configuration of the relations (conceptual, material, and institutional) between the normal and the pathological. We

conceived of this book as a contribution to the study of this profound transformation of modern medicine, which we will track through the analysis of the development of biomedical platforms. Before going any further, then, we must outline, by way of a concrete example, the notion of "biomedical platform."

Platforms: An Example

Here is an excerpt of a message posted to a clinical electronic discussion forum used by cancer pathologists seeking help in difficult diagnoses:

> I have a bone marrow biopsy on a 63 yr. old male with severe peripheral pancytopenia. Biopsy is atypical lymphoid infiltrate consistent with [non-Hodgkin's lymphoma] small cleaved cell. . . . The phenotype . . . seems to fit best with follicular lymphoma except for the CD10 negativity. I wonder what others of you may think about this phenotype?[21]

For the moment, ignore the compressed nature of the message,[22] and consider the description of a biopsy featuring simultaneously an "atypical lymphoid infiltrate," "small cleaved cell," and a "phenotype" with "CD10 negativity." What do these terms mean?

"Lymphoid infiltrates" and "small cleaved cells" belong to the richly descriptive language of pathological morphology. Typically, pathologists examine blood samples, as well as bone marrow and tissue specimens surgically obtained from patients (biopsies), under a microscope to detect cells and tissues that have pathognomonic value, i.e., that are characteristic of a given disease or subclass thereof. The term "infiltrate," in this context, designates unusual cell growth patterns or the migration of cells to tissues other than those of origin, both signs of cancer. In this same context, "small cleaved cells" refer to a particular kind of white blood cell (lymphocyte) presenting a characteristic deformation: their nuclei display infoldings or deep indentations. Figure 1.5 shows three pathologists examining the same slide under a multiocular microscope. The chief pathologist controls the settings of the microscope, exploring different parts of the slide and increasing or decreasing magnification to observe individual cells or the overall cell pattern. While doing so, he solicits the opinion of his colleagues, and, together, they reach a diagnosis before moving to the next slide/patient.[23]

"Phenotypes" (or "immunophenotypes," as they are also called) arise in a significantly different practice. Here, sophisticated equipment

Figure 1.5
The collective production of morphological diagnosis: pathologists looking into a multiocular microscope. The chief pathologist (on the left) operates the microscope. One of the oculars is connected to a camera, allowing additional observers to follow the diagnostic session on the television screen. (Photograph: A.C.)

(known as flow cytometers) and exquisitely specific immunological reagents (antibodies), classified according to an internationally accepted CD nomenclature (see chapters 6 and 7 for a detailed discussion of flow cytometry and the CD system), conspire to produce a quantitative analysis of the cell populations found in normal and pathological blood and bone marrow specimens. The CD reagents bind to molecularly distinct yet visually indistinguishable structures (so-called markers; see chapters 4 and 6) on the surface of cells, and fluorescent substances linked to the reagents allow the cytometer's laser beam, optical detectors, and photomultipliers to detect a given set of markers. Figure 1.6 shows a pathologist sitting in front of a flow cytometer looking at results on the equipment's computer screen. We discuss the distinctive imagery produced by the cytometer in chapters 7 and 8. For now, suffice it to say that, as shown in figure 1.7 (see also figures 7.7 and 9.1), it bears no resemblance to the morphological shapes pathologists have painstakingly learned to recognize and name.

Figure 1.6
A pathologist sitting in front of a flow cytometer, inspecting phenotypic imagery on the computer screen. (Photograph: A.C.)

Let us return to our electronic message. The patient mentioned in the excerpt had a marked reduction in the number of cells normally present in the blood (pancytopenia). The author of the message interpreted this symptom as indicating a type of cancer known as lymphoma. He wondered how to further classify the disease since the two *platforms* on which he routinely relied—morphological analysis and phenotyping—provided contradictory answers. Morphology pointed to one of the most common subtypes of lymphoma in the United States, follicular (itself a morphological term)[24] lymphoma, but, were this so, then the cells should have been CD10 positive.

Reactions to the message varied. Some respondents favored exclusive reliance on the morphological platform: "the actual pattern of the lymphoid infiltrate would be more helpful in suggesting follicular lymphoma."[25] Others favored a hierarchical ordering of both platforms, with morphology as "the gold standard."[26] Yet others gave precedence to phenotyping over morphology:

I think that we are all gratified that the continual evolution in lymphoma classification has begun to utilize immunophenotypic descriptions more and

Figure 1.7
Printed samples of phenotypic images posted on a glass partition in a diagnostic laboratory. (Photograph: A.C.)

more—this is long overdue. However, we must remember that all of the historical classifications, especially those including such terms as "follicular," "mantle," etc. are based on (highly subjective in my view) morphology.[27]

Some perceived this last opinion as a threat not simply to the morphological platform, but, more important, to the biological and clinical reality of the disease entities defined on the basis of that platform. While admitting that there were "those gray cases which are not typical for anything and the state of the art is such that we can't give an accurate diagnosis and must give a best guess," the author of the following message maintained that

> Mantle cell lymphoma has a characteristic morphology, immunophenotype and [genotype]. It also has a clinical prognosis that is distinct from other [related kinds of cancer]. It is not a subjective morphological diagnosis. Any good hematopathologist can diagnose a typical mantle cell lymphoma. Follicular lymphoma is even easier and again not only has morphologic, immunophenotypic and genotypic criteria but there is also an associated clinical prognosis. Follicular lymphoma is a disease that we know a lot about, not a subjective morphological classification.[28]

The previous message implicitly acknowledged the existence of multiple platforms that somehow converged to lead to the differential diagnosis of distinct (and "real")[29] disease entities. And indeed, the issue of how the different platforms should be aligned became the focus of subsequent discussion, for, as is obvious, as soon as clinical laboratories routinely produce data generated by different platforms, alignment becomes a practical and pressing necessity. Alignment, however, does not necessarily mean overlap or triangulation[30] insofar as it entails hierarchies (e.g., "gold standards"), choices, and the production of unexpected events. It is itself a controversial procedure, as shown by the juxtaposition of the following three excerpts:

> We are asking for a lot of confusion, and we are doing ourselves a disservice, if we keep trying to align morphologic descriptions with specific immunophenotypes.[31]

> Modern classification of lymphoma combines [morphologic, immunologic, and genetic] features, and in most cases the morphologic features fit very well with the immunophenotype. . . . Adding these other methods allows us to further define entities, but should not entirely replace the significance of the morphologic features. When immunologic features do not fit the morphologic features, I go back and review the morphology again.[32]

> I would suggest that it is in the process of "trying to align morphologic descriptions with specific immunophenotypes" that we make progress in sorting out which morphologies and which immunophenotypes actually define true pathological entities. . . . The efforts to correlate these various criteria (morphologic, immunologic, genetic, and clinical) clearly result in the recognition and better understanding of specific disease entities.[33]

The electronic exchange just reported concerned the diagnosis of lymphoma, i.e., the determination of the type or category of lymphoma from which the patient suffered. A similar discussion occurred a year later concerning "staging," i.e., the determination of the specific extent of spread of the disease following diagnosis. Typically, in a procedure known as a bone marrow aspiration, the surgeon inserts a needle into the patient's hip bone and extracts liquid bone marrow, which is then examined morphologically under a microscope and phenotypically with flow cytometry. The opening message of this exchange read, in part:

> If the pathologist did not see any abnormal cells, and the immunophenotyping showed a small clearly monoclonal population of, say, 1–2% of the nucleated cells, how would this information get used, in terms of patient management and treatment? To me it seems that the gray area between when the pathologist cannot see abnormal cells and the flow ability to detect them is in the 1–5% range.[34]

A first reply came from a pathologist who represented the situation as follows:

> In my experience, what happens when you detect a small population of malignant cells that the pathologist (myself included) can't see depends on the clinician. Some clinicians here understand the power of flow and will accept .01% malignant cells. Another won't accept anything but morphology (therefore making flow almost a waste for staging).[35]

After noting that the question had been "addressed (although not totally resolved)" by a recently published consensus statement (we discuss the production of consensus recommendations in chapter 9), a second contributor, while averring that "immunophenotypic analysis of bone marrow with morphologically obvious lymphoma . . . is generally considered redundant," nonetheless conceded that

> Detection of minimal disease does at times create a therapeutic dilemma. . . . However, it does provide what most consider useful, objective information and can increase the rate of detection by another 10–20% . . . I believe a good practice is to perform flow if there is any doubt. At the very least, the combination of morphology and flow immunophenotyping will reduce the frequency of staging procedures with the final interpretation of "atypical lymphoid infiltrate, suspicious for lymphoma," which is of little value to the treating clinician.[36]

Once again, alignment between different platforms, a practical necessity derived from their coexistence under the same medical roof, turned out to be the critical issue.

Platforms: Initial Theoretical Musings

The situation depicted in this example is relevant to anyone interested in biomedical practices and, more specifically, in biomedical innovation, for we have here an instance of an older, established practice—morphological pathology—being challenged (but not superseded) by a newcomer, immunophenotyping. But who or what is challenging whom or what? In other words, how should one describe the participants in this debate, analyze its development, and, more generally, describe biomedical routines and innovation?

A traditional sociological answer to this question and one often implicitly adopted by historians treats the debate as the result of a collision or confrontation of different "social worlds," i.e., professional groups or subgroups, each characterized by a distinctive shared identity. These conflicting identities were held to have a variety of sources. In their

classic papers on "professions in process," for instance, Bucher and Strauss argued that the identity of a given group would vary according to the tasks performed by its members, the methodology and techniques they used, the clients they served, the colleagues with whom they interacted, and the interests and values they shared.[37] In spite of the recognition that shifts in methodology might lead to redefinitions of the field and give rise to debating segments, Bucher and Strauss concluded that social relations among and between members of the various segments would ultimately determine the definition of a given segment. The conflicts between groups would thus be ultimately social conflicts prompted by threatened identities. There are no things in this world: just words.

According to Bucher and Strauss, human actors make up groups and these actors just happen to "take up" techniques and instruments in the course of their professional life. More recent work in this tradition has replaced these groups or "segments" with "social worlds."[38] But a change of words does not entail a change in perspective. The expansion from group or segment to world is entirely discursive. Sociologists who use the "social worlds" perspective to examine technical, scientific, and medical issues—i.e., fields saturated with tools and techniques—focus first and foremost on human collectives, their words and deeds.[39] Although techniques, instruments, and research materials (organic or otherwise) do occasionally figure in their accounts, their appearance and status is entirely secondary. They are either black-boxed and construed as rhetorical tools mobilized in the turf struggles between competing camps, reduced to social variables, or dissolved into an increasingly vague, all-encompassing notion of practice(s). In contrast to these sociological accounts, we wish to treat objects as mediators and coordinators of biomedical activities.[40] To this end, borrowing in part from language used in the healthcare sector (see chapter 2), we have devised the notion of biomedical platforms to draw together within a single category biomedical instruments and programs and related patterns of cooperation between biologists, clinicians, and companies that produce reagents and equipment.

To explain why we have done so, it is useful to return to the debate featured in the previous section. It should be obvious to most readers that a narrow focus on human collectives and professional rivalries can hardly account for the confrontation between the morphological and the immunophenotyping platforms. True enough, a clever sociologist could always identify each of the opinions concerning a given platform as the product of a distinct group or social world, either by multiplying

the number of ad hoc distinctions between groups or by tailoring opinions to fit a predetermined group. But such divisions would be at odds with the participants' views. The researchers and clinicians who posted the conflicting messages are clearly engaged in what they perceive as the same kind of activity and thus, in some sense, belong to a single group. In other words, taken on their own terms, the actors we quoted inhabit a single world in addition to a single electronic discussion forum. This common world also houses many platforms, whose role in that world, judging from the debate we have just summarized, is far from marginal. Why, then, should the sociologists' view, according to which participants inhabit different "worlds" or partake in different "groups," take precedence over the participants' view? Clearly, there is no compelling reason to do so.

This is not to say that patterns of segmentation between different occupational groups are absent from the biomedical enterprise. Professional and specialty divisions are common features of the latter. Indeed, some authors have characterized the proliferation of medical specialties as the hallmark of the development of modern medicine.[41] But how should one describe these segmentation processes or, to use a related term from yet another sociological tradition, this ever-evolving division of labor? Studies of the organization of craft and industrial activities have tended to define the division of labor as a division of laborers, furthermore assuming that the latter always precedes the division of the objects upon which people work: first you divide the workers, then you divide the work. This approach was, in large part, a reaction against attempts to "naturalize" the division of labor by assuming the presence of a stable, predefined division of the world into a number of discrete objects or kinds, around which different occupations would establish themselves. This latter approach makes little sense, especially in the case of modern occupations, but the former approach also raises major problems.

Reverting to our central concern, we can easily see that biomedicine does not have a stable division of labor corresponding to an unproblematic partition of the object of work, namely the human body. New specialties are created around different, overlapping organizing principles: organ systems (e.g., cardiology, ophthalmology), regions (e.g., internal medicine), gender-specific functions (e.g., obstetrics and gynecology), life stages (e.g., pediatrics, gerontology), occupational criteria (e.g., sports medicine, industrial medicine), and so on. The heterogeneity of principles does not mean, however, that biomedical practitioners can arbitrarily establish divisions within medicine and

biology in order to create distinct and independent domains of professional expertise. The independence of a biomedical specialty is inevitably relative: hematologists, for example, cannot ignore pathology reports when it comes to treating patients. In medicine, this mutual dependency is stronger than in most other modern professions, such as engineering, since the object of medicine is not the body per se, as previously suggested, but, rather, models of the body.

Not all sociologists would agree with our analysis. Some, taking their cue from historians such as Michel Foucault, have described a dispersion of "the clinical gaze" through a fragmentation of the patient's body, whereby the latter "is no longer localized in the discrete, integral body of the actual patient," but, rather, is distributed (figuratively speaking) among a number of different specialties, and (in a literal sense) simultaneously present as a set of samples in different sections of a hospital.[42] As just noted, this fragmentation of the body is, moreover, held to mimic social fragmentation, as instantiated in the increasingly complex division of labor. Yet, to speak of a fragmentation of the patient is to lose sight of all the work that goes into keeping everything together, into making sure that, for instance, the sample that has left the body will rejoin it in terms of meaningful (for the task-at-hand) results.[43] The apparent body fragments are, in fact, body *samples*, which in turn are always samples of some-thing or some-body. Of some-body because they come from a given patient (to whom, for instance, a medical record containing the various laboratory reports is attached),[44] and of some-thing because sampling operates less on the actual body than on the body as construed through *models* of the body, such as those that decompose the latter into various bodily "systems."

The twin practices of modeling and sampling correspond to sequential patterns of representation and intervention.[45] Samples and test results, be they numbers or images, circulate between the laboratory performing the tests, the general practitioner who ordered them, the specialist to whom the patient and his or her double, the medical record, have been referred, and so on. They thus both presuppose and give rise to patterns of cooperation that cannot be dissociated from the tools used to produce representations of body parts and, ultimately, to intervene upon the patient's body. The dominant pattern is not one of diverging, competing segments (although this is also part of the story) but, rather, as we have noted, one of consult and mutual dependency.[46] Since, as we will see in chapters 8 and 9, individual tools acquire consistency and meaning only through the regulatory activities generated by a given

platform, such interdependency patterns are, in a strong sense, platform dependent. This also means that platforms (such as immunophenotyping) cannot be reduced to human collectives such as medical specialties or defined in terms of the social ties that keep those specialties together. Without platforms and the pattern of activities they generate, human collectives would fall apart. By choosing platforms as a unit of analysis of contemporary biomedical activities, we do not wish, of course, to promote a new sort of technological determinism. To the contrary, we provide ample room for social and cultural contingencies. The latter, however, cannot be dissociated from the configuration of material components and symbolic activities we call a platform.

The notion of platform that we advance in this book is intended to question the rigid dichotomy between the social and the technical that lies behind both technological and social determinist accounts of scientific and medical activities.[47] Readers may nonetheless suspect that the conflicts and debates that permeate contemporary biomedicine are most fruitfully approached by focusing primarily on human activities rather than on the techniques and technologies that make them possible. One could, for instance, examine how actors position themselves vis-à-vis a specific platform and argue, for example, in favor of morphology over immunophenotyping rather than examine how those platforms came to be.[48] From this perspective, platforms do not determine the actors' position; actors situate themselves vis-à-vis a platform. We would like to offer a contrasting perspective wherein, rather than caught up in a narrow dialectic of debate, biomedical platforms define new domains of clinical and scientific action. Within these domains, a variety of stances and attitudes are possible and they range from controversy to peaceful coexistence and cooperation. These positions (either individual or collective) are not grafted onto the platform, dividing it up according to exogenous criteria. Rather, they correspond to differences within platforms and between different, overlapping platforms.[49] In the rest of this book, we provide ample evidence supporting this analytical stance.

One final reservation: our argument in this book is specific to biomedicine and its empirical support is drawn exclusively from this field. Our aim, in other words, is to define and analyze *biomedical* platforms as prominent features of late-twentieth-century medicine, and not to offer some generic theoretical construct—"platforms"—that accounts for or enters into any and all social action. This specificity, we believe, strengthens our proposal. Indeed, we maintain that a study of

biomedical platforms, built on historical investigation, highlights biomedical events and processes overlooked by other analytical frameworks. In particular, and this theme runs through the book, the notion of biomedical platforms sheds new light on the articulation and the regulation of the practices focused on the normal and the pathological that characterize contemporary biomedicine.

Plan of the Book

This short introductory chapter sought to provide readers with an initial sense of the issues and topics that cluster around the notion of platform. It also sought to introduce readers to the medical domains from which we have extracted the material for this book. We designed the final discussion of social theoretical issues as an initial positioning within the social sciences. All three of these goals have been attained with the sketchiest of means.

After a short examination of the etymology and semantic field of the notion of platform, chapter 2 analyzes the recent evolution of hospital architecture, and relates it to the rise of medical biology and the post–World War II institutional and epistemological program of combining biology with medicine. We are thus led to reexamine, in chapter 3, the problem of the relation between the normal and the pathological, as initially defined by historical epistemology, in the light of more recent events, such as the rise of automated biomedical instrumentation. Chapter 3 thus details our understanding of "biomedicine" as a distinctive postwar configuration of medical work, and, in so doing, investigates the increasing importance of diagnostic examinations and the automation of laboratory tasks. As we do not intend to pursue the themes just mentioned in isolation, these two chapters provide a map of their changing relations and of the polarities (biology and medicine, the laboratory and the clinic, etc.) through which they are expressed. Thus, they take a broad view.

In contrast to chapters 2 and 3, which create the framework for our study, the subsequent four chapters describe the development of a specific platform, the immunophenotyping platform. Chapters 4 and 5 draw on a rich infrastructure of interviews, archival material, and content analysis of the published literature to examine the rise of a new field of biomedical investigations focused on the study of the cell surface. Begun in the 1950s, work on the cell surface became a dominant trend in immunology (in conjunction with the rise of cellular

immunology) in the 1970s. Cell surface studies also figured prominently in cancer research where the former came to be seen as a key to unlocking the mysteries of the transformation of normal into pathological cells. We show that two different versions of these historical events can be elaborated: the dominant biological story and a counterstory that focuses on contributions from pathology and the clinic. We furthermore show how these two lines of work converged in clinics and laboratories on both sides of the Atlantic to constitute the notion of cell or tumor marker (as both a notion and a set of reagents) and the related immunophenotyping platform. This allows us to specify how the diagnosis and prognosis of leukemia and the conduct of clinical trials for leukemia were profoundly transformed by these events.

Chapters 6 and 7, although based on numerous historical sources, are, in a way, the sociological counterpart to the two previous chapters. We argue that the immunophenotyping platform consists of core and peripheral elements and that, accordingly, there are various instantiations of the platform. This allows us to show that the platform is more than an instrument or device, but is a specific configuration of instruments and individuals that share common routines and activities, held together by standard reagents. These chapters accordingly examine the different kinds of coordination inscribed in platform components and describe the industrial contribution to their production and management. In particular, we analyze the commercial production of core components—"markers"—and the correlative constitution of an international nomenclature of reagents that established equivalences between locally produced antibodies. With regard to the peripheral components, we look at the two principal instantiations of the immunophenotyping platform, namely microscope-based slide techniques (immunocytochemistry) and the more technologically sophisticated development of laser and computer-based instrumentation. Discussion of the latter leads us into a technological underground where computer companies mingle with atomic energy facilities, space exploration agencies, academic biology laboratories, and hospital clinics.

Finally, chapters 8 and 9 bring to the surface an undercurrent of the previous chapters, the problem of regulation. We show that in order to understand how regulation enters into the production and maintenance of biomedical platforms, one has to take the larger view and go beyond the narrow sense of regulation as a form of government intervention through regulatory agencies. We will see how regulations—formal and informal, explicit and implicit—invade all practices related to platform

stabilization and maintenance. Chapter 8 analyzes the historical development of regulatory activities on both sides of the Atlantic and then goes on to examine the practices, instruments, reagents, and images that need to be managed by regulators. Regulation of these interacting components of a platform makes possible the production of meaningful results and interlaboratory and interclinical comparisons. Chapter 9 centers on the development of a key regulatory instrument of clinical work, disease classification. In this chapter, we examine the transformation of classifications through the use of new platforms and the consequent use of consensus development techniques to align different platforms.

Chapter 10 draws together the different strands of our story and shows how the notion of a biomedical platform offered in this book allows one to describe and examine events and processes that are overlooked by alternative approaches. In addition to discussing possible objections to our approach, this concluding chapter also suggests further inquiries made possible by the notion of a biomedical platform.