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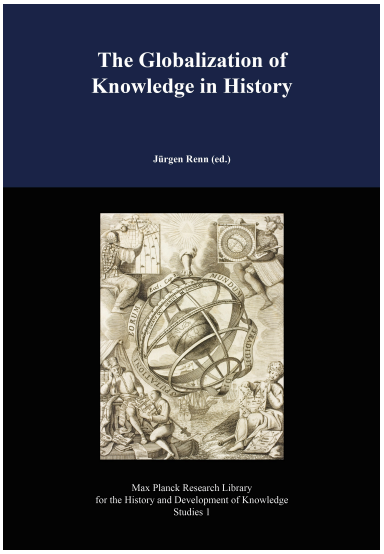

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Chapter 29
Internationalism and the History of Molecular Biology

Hans-Jörg Rheinberger

29.1 Introduction

The history of molecular biology has been told a number of times over the past three decades, and its historiography has thereby experienced a number of reorientations.[1] Questions of periodization, as usual, have been and still are a matter of debate, but most observers will probably agree that the history of molecular biology can be conveniently divided into three major phases. The first is marked by a new conjuncture of physics, chemistry, and biology, roughly between 1930 and 1950. It was characterized by a set of innovative research technologies, with a focus on protein analysis and genetics. The second spanned approximately the decades between 1950 and 1970, extending from the physical elucidation of the structure of the DNA double helix, through its climax, the biochemical deciphering of the genetic code in the early 1960s, to its eclipse, the advent of a properly molecular biological gene technology in the early 1970s. The third phase took its starting point from the construction of the first transgenic DNA molecules in the early 1970s and resulted a decade later in the human genome project. Gene technical biology has since become the science of a thoroughly constructive and synthetic manipulation of living cells at the molecular level of hereditary instruction.

The history of molecular biology has many facets. According to the theme of this volume, I will concentrate on the *international* aspects of its development. Internationalism took distinctively different forms within the three periods mentioned above. These different forms are, on the one hand, intimately connected to the changing national and international political contexts: the interwar period and World War II; the Cold War era; and the time of post-communist globalization. On the other hand, they are at the same time an epistemic function of the evolving and diversifying objects of molecular biology.

[1] This paper was presented at the XXII International Congress of History of Science, Beijing, 23–30 July 2005, Symposium 3 *History of International Scientific Collaborations*. An earlier version of it has been published in *Annals of the History and philosophy of Biology* 11 (2007): 249–254.

29.2 The Early Years: 1930s and 1940s

First, we will look at the 1930s and the 1940s. It has repeatedly been pointed out by historians of science that philanthropic institutions—in particular the Rockefeller Foundation with its head of the natural sciences division, Warren Weaver—played a vital role in the early days of setting the stage for what was to become molecular biology. As Pnina Abir-Am (1993), Robert Kohler (1991) and others have argued, Weaver was dedicated to fostering transdisciplinary research on what he then called "vital processes" and he did so by funding physicists, chemists and mathematicians who were willing to engage with biological questions and, moreover, to direct their often novel research instruments toward biological objects. Protein research and genetics were in the foreground of his research agenda. He not only thought in interdisciplinary but also in international categories. Through Wilbur Tisdale and Harry Miller, the Rockefeller Foundation officers in Paris, Weaver spun a network of funding that went far beyond the United States and included interdisciplinary collaborations in post First World War Europe's major research sites as well. The Rockefeller Foundation thus vitally contributed to re-establishing international scientific bonds that had been broken by the hostilities of World War I and the immediate postwar turmoils. Most of the individual research projects during this time, however, featured local collaborations and were not international in themselves. In order to compensate for this deficit, the Rockefeller Foundation sponsored international workshops and conferences. In addition, through its fellowship program, it funded young European scholars to spend a postdoctoral year in major American or other European laboratories.

When the Nazis came to power in Germany and initiated an unprecedented exodus of Jewish and politically liberal and leftist scientists from Germany and other European countries to be occupied by Nazi Germany or having fascist governments themselves, the Rockefeller Foundation helped many of them to settle in their new surroundings. It can be stated that this exodus, in a way, initiated a kind of compulsory internationalism that had a deep impact on the early history of molecular biology. A cursory look at the roster of persons who count among the founders of the new biology shows that many of the leading figures of the first generation were either enforced or voluntary émigrés: Erwin Chargaff, a chemist from Czernowitz at Columbia University; Max Delbrück, a physicist from Berlin at the California Institute of Technology (Rockefeller fellowship); Salvador Luria, a medical doctor from Turin at the University of Indiana (Guggenheim fellowship) and then at the University of Illinois; Severo Ochoa, a medical doctor from Asturia at the University of New York; Max Perutz, a chemist from Vienna at Cambridge, England; Gunther Stent, a refugee from Berlin and later a physical chemist at Berkeley, and many others as well. This traffic was one-way however; the following World War II resulted in a thorough international isolation of a sub-

stantial part of the European continent's scientists, and this not only in the realm of emerging molecular biology.

There is also an epistemic aspect to internationality in this early phase in the history of molecular biology. As already mentioned, it rested technically on an array of new analytical instrumentation, such as ultracentrifugation, electron microscopy, electrophoresis, X-ray crystallography, UV-spectroscopy and other sophisticated apparatus targeted at allowing diverse phenomena of life to be tackled at a macromolecular level. Initially, there were only a few privileged places where these different instruments were constructed and eventually put to biological use. This also meant that the knowledge going into their operation was thoroughly local, if not monopolized by one research team, at least for a certain period of time. In this phase of technological development, the instruments did not travel; rather, the people who wanted to construct or learn to work with these instruments had to travel, thereby crossing national boundaries—and disciplinary boundaries as well, since the operation of most of these instruments intrinsically necessitated a collaboration between physicists, chemists and biologists. Protein crystallography was particularly strong in Cambridge, England and at the California Institute of Technology; ultracentrifugation in Uppsala; UV-spectroscopy in Stockholm and New York; electron microscopy at RCA's New Jersey laboratories, just to give a few examples. As we will see, this epistemic situation continued over the first decade after World War II. It was not until the late 1950s that these technologies became black-boxed and began to spread widely.

29.3 The Immediate Post World War II Period

After World War II, the political situation in the Western world changed radically.[2] With respect to molecular biology, within a few years an international network of researchers formed and organized itself around a few centers, among them the phage group with Max Delbrück at Caltech and Cold Spring Harbor with its annual phage course, the Medical Research Council Unit for the Study of Molecular Structure of Biological Systems around Max Perutz and John Kendrew in Cambridge, the Pasteur Institute around Jacques Monod and André Lwoff in Paris, but also less well-known ones such as the electron microscopy unit organized around Jean Weigle at the University of Geneva, or the Rouge-Cloître group of biologists, physicists and biochemists around Jean Brachet at the University of Brussels. There were frequent personal exchanges among these groups. Postdoctoral visits across the Atlantic resumed and international scientific figures like Leo Szilard, a newcomer to the field, promoted the new biology on their relentless travels. These exchanges temporarily slowed down at the height of the Cold War

[2]The historiography of molecular biology in the Soviet Empire is still in its early stages, see (Abdrakhmanov 2006, 333–339). Another story would have to be written here, a story of failed internationalism in science as a result of the Cold War.

at the beginning of the 1950s, where, for example, Linus Pauling was forbidden to travel to Europe and Jacques Monod was denied a visa to enter the United States.

The particular history of each of the groups mentioned above is, meanwhile, well-documented with case studies by Lily Kay (1993) on Caltech, Jean-Paul Gaudillière (2002b) on Paris, Soraya de Chadarevian (2002) on Cambridge, Bruno Strasser (2006) on Geneva, and Denis Thieffry (1997) on Brussels. Rich and abundant material has been accumulated. There is also a recurrent pattern to be found in these studies that appears to be pertinent to this discussion of early molecular biology's internationalism. Soraya de Chadarevian has expressed it for the British center in Cambridge as follows:

> It has been argued that molecular biology—profiting from an increased mobility of people created especially by new science policies and funding schemes in the Cold War era—constituted itself in an international space (Abir-Am 1993). My view is that the increase in international exchanges modified the relations between local settings, and thus the local settings themselves, but did not do away with them. (de Chadarevian 2002, 247)

For the Institut Pasteur in Paris, Jean-Paul Gaudillière has similarly observed

> a scientific strategy taking as its starting point the exploitation of a local system quite different from the dispositifs privileged in the United States. [...] On the one hand, the mobilization of a vast array of human and material resources offered by the United States; on the other hand the preservation of a home-made approach that granted the autonomy and the possibility of an alternative to the bacterial genetics at Caltech, Cold Spring Harbor, or Columbia. (Gaudillière 2002a, 259)

In their assessment of molecular biology in postwar Europe, de Chadarevian and Strasser talk about a "glocal" picture in this respect (de Chadarevian and Strasser 2002).

What does that mean epistemically though? There is a message here that appears to be characteristic of the development of molecular biology in the two and a half decades after World War II, in which the new approach toward the molecular basis of living systems became scientifically visible and during which the tag *molecular biology* was increasingly used for the self-identification and self-vindication of those who wanted to be perceived as partisans and participants in the new biology movement. In this phase, molecular biology formed itself into a patchwork of different experimental systems, often centered around a particular technology, sometimes a big and demanding research instrument such as an electron microscope or an X-ray machine. However, this was not always necessarily so: small scale tools such as radioactive tracing or biochemical in vivo and in vitro assays were equally important—and also just as demanding in their fine-tuning.

Together, these experimental systems formed a landscape of experimentation, with neighboring systems sharing material constituents, and with only indirect links to systems further away. It resulted from a differential exploitation of the vast array of research technologies described for the previous period that were initially disconnected from each other, but became increasingly adapted to sophisticated biological applications in various experimental systems and therefore linked to each other. Secondly, it rested on the cultivation of a few distinct model organisms, in particular lower fungi, bacteria and a variety of viruses and phages. Each of these organisms required a certain amount of idiosyncratic manipulative knowledge. On the other hand, the standardization of certain model organisms such as Escherichia coli served as a reference point not only for those who worked with them, but also for those comparing and judging their results obtained from other organisms, and in this way the models also became connected to each other. From a third perspective, the formation of this landscape involved different interdisciplinary skills—biophysical, biochemical, biomedical, biomathematical, in slightly different local combinations.

29.4 The 1950s and Early 1960s

An ideal situation for international circulation had thus been created that resulted in cooperative effects of an unparalleled scale. And, indeed, if we look at the major findings that punctuated the establishment of molecular biology as a new discipline in the course of the 1950s and the early 1960s, we realize that many, if not the most important of them, resulted from international cooperation between two or three individual researchers from different local cultures in different countries. To start with, the elucidation of the structure of the DNA double helix in 1953 was the result of a collaboration in Cambridge between a British scholar, Francis Crick, and an American scholar, Jim Watson, one of them a physicist, the other a biologist by training. The work that led to the identification of messenger RNA was done in Paris by the Pasteurians Jacques Monod and François Jacob in cooperation with Arthur Pardee from Berkeley; at Caltech by Jacob from Paris, Sidney Brenner from Cambridge—himself a South African MD—and Mathew Meselson from Pasadena; at Harvard by François Gros from Paris and James Watson from Cambridge/MA. The deciphering of the first code words happened at the National Institutes of Health in Bethesda and involved the American biochemist Marshall Nirenberg and the German physiologist Heinrich Matthaei. The Swiss physicist Jean Weigle from Geneva published phage work together with Delbrück as well as with Meselson from Pasadena. Frederick Sanger in Cambridge worked on the primary structure of the insulin chain—the first protein to be completely sequenced—together with the Austrian biochemist Hans Tuppy from Vienna. Many more international and interdisciplinary couples such as these could be named here. Throughout the 1950s, they all conveyed to molecular biology its appearance as a paragon of an international science. It was based on distributed, locally embedded resources that

lent themselves to being triggered and led to major results by sometimes minor inputs from neighboring, slightly different experimental systems.

Around 1960, the visibility of rising molecular biology had reached the planning circles of European governments and became, to a certain extent, a state affair. Throughout the following decade, molecular biology became a target for national science advancement plans aiming at a reorganization of research and teaching in the life and biomedical sciences. This led to the foundation of molecular biological research institutes in all major European countries. For Germany, it was Max Delbrück who assumed a leading function in the process. The perception of a necessity to balance the perceived American supremacy in the field also gave rise to increasing efforts for advancing molecular biological research at a European level. These efforts finally resulted in the foundation of a European Molecular Biology Organization and eventually a European Molecular Biology Laboratory. John Krige has argued that it was not the distributed character of molecular biological technology—as sometimes purported—that prevented the early establishment of a facility for molecular biology like that of CERN, the European organization and laboratory for particle physics.[3] According to Krige, it was, rather, the perception of national deficits that put the national strengthening of molecular biology first on the agenda of the major European countries, and left a common European laboratory as a matter for the next step (Krige 2002). Arriving at this order of events, however, despite Krige's argument, could, after all, have something to do with the distributed and therefore locally entrenched character as described for what we can call—in view of the subsequent developments—the classical period of molecular biology.

29.5 The Gene Technology Era

Toward the end of this extremely compressed overview of forms of internationalism implied in the development of molecular biology, let me briefly come to the third phase, the era of gene technology. After a few years of self-imposed caution, the recombinant DNA technologies that emerged in the early 1970s in the United States led to a major rearrangement of the field. On the one hand, molecular biology, now in the form of a genetic technology, entered the world of commerce, and with that, of international economic competition. Gene patenting, on the one hand, has brought back constraints for transnational collaboration. On the other hand, the advent of powerful gene sequencing technologies opened up the perspective on projects like the human genome project, which by their very size and nature necessitated a more or less stringent international collaboration, no longer just as a spontaneous activity of individuals, but now as a coordinated effort of the major players of the scientific community. Molecular biology entered the era of global, planned, large-scale collaborations. In parallel, the vast amounts of genomic information resulting from these collaborative enterprises necessitated

[3] See chapter 28.

the construction of new kinds of collectively usable data pools. They have become a major target of bioinformatics of our day, wiring together the contemporary bio-molecular laboratories from all over the world in a virtual space and creating an unprecedented form of scientific communication over an ever-increasing pool of shared information.

However, we also stand before possible applications of gene technology in reproductive biology and genetic germ line intervention that urgently call for international regulations. Today, such regulations are far from being established. Different countries in the world respond to these challenges with quite different rules. An internationalism of a particular slant could result: a kind of science tourism that would lead ambitious scientists who feel themselves restricted by their national regulations choosing work in countries where such restrictions do not apply. Internationalism, after all, is not one singular, well-defined thing or relation. On the contrary, it comes in numerous guises and many variants. The history of molecular biology certainly displays some of the major forms it took throughout the long second half of the twentieth century, and, as we have seen, it combines them with patterns that incorporate shifting global political trends as well as changing epistemic configurations.

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