Molecular Biology: The New Modes

Invisible Frontiers. The Race To Synthesize a Human Gene. STEPHEN S. HALL. Atlantic Monthly Press, New York, 1987. xviii, 334 pp. $19.95. Paperback version, Microsoft Press, Redmond, WA, 1988. $8.95.

Natural Obsessions. The Search for the Oncogene. NATALIE ANGIER. Houghton Mifflin, Boston, 1988. xviii, 394 pp. + plates. $19.95.

These two books show the human face of fast-track academic molecular biology. Hall tells the story of the bi-coastal race among academic research groups in the 1970s to clone the insulin gene: the Boyer, Rutter, Riggs, and Goodman coalition based in San Francisco *vs.* the Gilbert group at Harvard. He describes how their research program was affected, even generated, by the industrial support of academic research. Angier portrays a major player in the 1980s effort to define the makeup of the human oncogene. She contrasts Robert Weinberg's group at MIT and its research style with the enterprise of a close competitor, Michael Wigler of Cold Spring Harbor.

The protagonists are established investigators, with few exceptions long gone from the bench, who coordinate groups of graduate students, post-docs, and technicians. The organizational style of the groups and the relationships among the members are as much a part of the story as the exploits of individual scientists, senior or junior. These mid-sized groups of a dozen or so persons combine elements of patriarchal authority and egalitarian social relationships. Neither a research bureaucracy like a high energy physics facility nor collaborations of two or three persons, they constitute a distinctive model of research enterprise with many of the attributes of a small firm.

The literary model for these books is James Watson's *The Double Helix*. That account of collaboration and competition, insight and intrigue in laboratory and pub, demonstrated that the social life of science is as integral to the discovery process as model-building, data collection, and theorizing. What takes these works of science journalism beyond replication is the normative change that science has undergone in its transformation from an individual to a group practice.

Traditional teamwork in academic science consists of a collaboration of equals such as two or three professors or an apprenticeship relationship of a professor and a few students. The former typically arises from mutual generation of an idea by colleagues, discussions between a theorist and an experimentalist, or combination of complementary research skills to solve a problem. These interactions are temporary relationships. Even when they are repeated over time, they typically exist for individual projects and continue only until the problem is solved or discarded. Similarly, the traditional relationship of student to faculty member is on an individual basis, even when the faculty member is advising a number of students. Each student works by himself or herself on a mutually agreed upon problem and periodically seeks advice from and reports results to the supervisor. The combination and expansion of these older forms of collaboration have resulted in the contemporary research group characterized by a complex division of labor, persistence over time, and continuity of research focus despite shifts in membership.

The success of such collaborations is based upon the ability to generate fruitful research ideas, recruit group members, and maintain a continuous flow of outside funding. As the leaders of research groups pursue their scientific goals more intensely through a collective medium they perforce assume organizational tasks of coordinating internal activities and obtaining external support. Even as principal investigators on grant applications requesting support for a team, they still typically view themselves as individual scientists and are so viewed by their colleagues. Although they do not assume the title of their counterparts in industry, these academic scientists have become research managers of quasi-firms within the university.

Focusing on laboratory groups and their members, Hall and Angier have updated *The Double Helix* for a new generation. The implicit message is that academia is a real world, not an ivory tower, and that deal-making is not confined to movie moguls or real estate developers. Not just in their forays into the business world in forming biotechnology firms but in the operation of their research groups within the university, the academics that lead these groups spend much of their time as fund-raisers and managers. However, they are not the Taylorite managers of a rigid mass-production enterprise but the consensus-generating leaders of artisanal workshops, designing one-of-a-kind custom articles.

The authors offer a series of snapshots in writing of laboratory groups at work. Scenes include lab chief and student negotiating research tasks; students at times rejecting suggestions; professors, at times, pressuring for assent; post-docs undertaking under-the-table experiments too audacious or foolhardy to be approved in advance; professors alternately sharing and hoarding research materials depending upon the strength of claims of reciprocity among groups or the competitive struggle between them; the forming and breaking of collaborations within groups, often as the result of the strain between the desire for individual credit for results and the need to arrive at them quickly through a cooperative division of labor that blurs the autonomy of individual achievement. This flux makes it difficult at times for the participants to hold to the order of authorship negotiated at the outset of a collaboration and results in after-the-fact renegotiations.

Taken together, these works can also be read as an account of the social evolution of molecular biology during the past two decades: the shift from a scientific specialty located in the academy to an ethical and political issue debated in Congress and to an industrial practice generating new firms and attracting old ones. Hall sets the 1970s scene with a portrayal of the controversy over the potential safety hazards and ethical implications of biotechnology. The Cambridge biology community, previously united in its opposition to the Vietnam war, split over the proposal to build a P3 lab at Harvard and participated on both sides in the debate in the Cambridge City Council over the safety of experiments. Hall locates Gilbert's group in this context and shows how its research program was affected by the restrictions in force at the time. Similarly, he shows how scientists were affected by the emergence of commercial opportunities in molecular biology. Genentech funding made it possible for a research project rejected by NIH to go forward, and a conference called by the Lilly company helped focus the attention of researchers on the challenge of cloning the insulin gene. Genentech support also made possible the four-way collaboration among the California groups.

Whereas Hall locates his group in their social context and shows how their science was affected by it Angier takes a narrower view. She concentrates on the internal workings of the research group, focusing on the lab chief as patriarch. The model is established at the beginning of the book, as author and students are shown working on the construction of the mentor's weekend home. With the exception of a depiction of the medical implications of oncogene re-

search and a brief discussion of the controversy over the Whitehead Institute, there is little discussion of social context. Though the 1980s research scene was set by the constriction in federal funding and the proliferation of firms from academic biology laboratories, Weinberg's own involvement in a firm receives only passing mention and there is no discussion of its effect, either positive or negative, on his academic research group. We are left to speculate whether his increasing distance from his group, noted by Angier at that time, was connected to his commercial involvement or simply to temporary discouragement over research setbacks. Although her book is set in a later time period, Angier provides us with a "before" portrait of molecular biology, without the safety, ethical, and commercial issues of the 1970s and '80s.

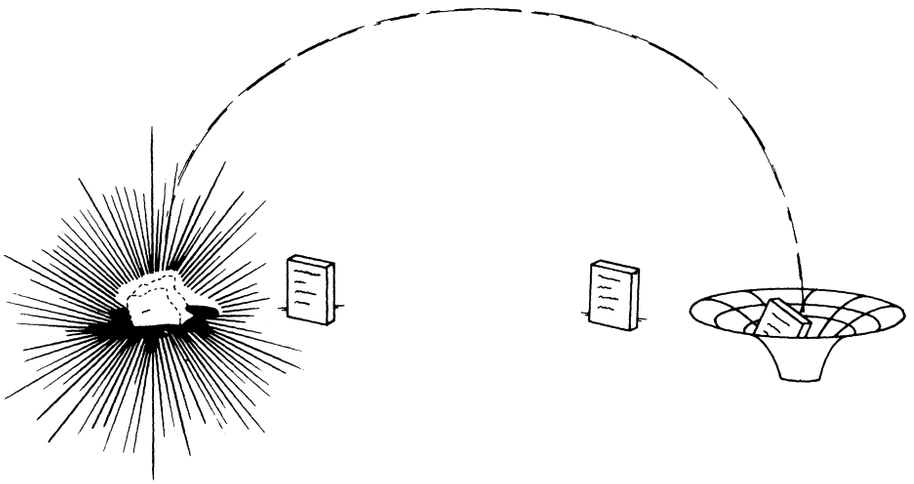
Both authors combine internalistic and externalistic approaches, explaining the intellectual content of the science and the organization of group research. Ironically, the dynamics of research groups are often left out of laboratory studies conducted by social scientists, who, following the reductionist approach of many of the scientists they study, make the conduct of science the virtual equivalent of the output of instrumentation. By contrast, these books read like nonfiction novels. Their depictions of lab groups and gene clonings are the academic counterparts of Tom Wolfe's portrayal of esoteric enclaves of auto buffs or Truman Capote's account of a murder. Short of running celluloid past a camera lens, *Invisible Frontiers* and *Natural Obsessions* are as close as we are likely to come to a motion-picture double feature of post-war academic science in the United States.

HENRY ETZKOWITZ
Sociology Board of Study, State University of New York, Purchase, NY 10577, and Rensselaer Polytechnic Institute Center for Science and Technology Policy, New York, NY 10021

A Range of Physics

Between Quantum and Cosmos. Studies and Essays in Honor of John Archibald Wheeler. WOJCIECH HIBERT ZUREK, ALWYN VAN DER MERWE, and WARNER ALLEN MILLER, Eds. Princeton University Press, Princeton, NJ, 1988. xii, 623 pp., illus. $49.50. Reprinted from *Foundations of Physics*, vol. 16, nos. 2–7 (1986).

Between Quantum and Cosmos is a collection of papers assembled in honor of the 75th birthday of John Archibald Wheeler. Before commenting on the book proper, it seems appropriate to say a few words regarding Wheeler himself. In many ways he is a unique figure. Early in his career he made important contributions to nuclear physics and general quantum mechanics. Perhaps the single most outstanding contribution of these is the analysis of nuclear fission as a non-classical (that is, tunneling) hydrodynamic instability in the framework of the liquid drop model. From this work emerged not only a successful semiquantitative theory of fission but a paradigm of how classical reasoning could be used and refined to deal with deeply quantal phenomena. The use of semiclassical techniques has become a vast and thriving activity touching upon issues ranging from the description of nucleation in phase transitions to chemical reaction theory to soliton models of elementary particles. Arguably, Wheeler's fission work nucleated the subject and his subsequent work on diffractive scattering helped spur its rapid growth.



"The laws of physics are not chiseled on a slab of granite that stands from everlasting to everlasting. Those regularities had to come into being at the big bang and be obliterated in the gravitational collapse that takes place at the center of a black hole." [Reproduced from J. A. Wheeler, *Physics and Austerity: Law Without Law* (in Chinese; Anhui Science and Technology Publications, 1982), in *Between Quantum and Cosmos*]

After notable forays into the classical theory of radiation (with his student Richard Feynman), pioneering efforts in drawing out the general implications of causality in the measurable form of dispersion relations (with Toll), and classic contributions to the theory of mu-mesic atoms, Wheeler in the mid-'50s turned in quite a different, and at the time rather unfashionable, direction—that is, to general relativity. In this field, his influence has been enormous. It has arisen not so much from his technical contributions as from his insightful, charismatic formulation of problems and his inspired teaching. It is to him, for example, that we owe the term "black hole" and the remarkable phrase "black holes have no hair." Perhaps more than any other individual Wheeler converted what had become a backwater of physics to a vital, popular subject. He was aided in this, of course, by some remarkable empirical discoveries—quasars, pulsars, and the microwave background radiation. But Wheeler saw the developing rich possibilities for observational consequences of general relativity long before they were obvious. In recent years Wheeler's interest has tended more and more toward the issues involved in synthesizing general relativity with quantum mechanics. Several of the concepts he introduced, notably wormholes and the Wheeler-deWitt equation, occupy central positions in current work in the field. He has also written extensively on the philosophical implications of physics, especially regarding the nature of this last projected synthesis (whose outlines remain, at present, quite murky).

Wheeler has been led, in pondering the problems involved in reconciling the basic ideas of relativity and quantum mechanics, to striking speculations on the nature of time, measurement, and the very concept of physical law that are widely known and quoted. For example, "Quantum mechanics promotes the mere 'observer of reality' to the 'participator in the defining of reality.' It demolishes the view that the universe exists out there." This is not the place to discuss whether these speculations form a coherent system, or what their future may be. I will only remark that the importance of Wheeler's technical contributions to physics gives his statements a weight that, coming from another source, they would not have.

Now let us turn to the book at hand. It contains 40 papers on an extremely wide range of topics, reflecting the range of Wheeler's interests. Perhaps inevitably, the