YALE JOURNAL OF BIOLOGY AND MEDICINE 85 (2012), pp.551-558.

PERSPECTIVES

A Short, Informal History of the Biological Sciences at Yale University

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In May 2012, Yale University's Graduate School of Arts and Sciences held a reunion for all who have received doctorates from Yale in the biological sciences. The proceedings began with two presentations on the history of biological research at Yale: one focused on the Medical School, and the other centered on the rest of the University. This essay is a lightly edited version of my account of the history of the biological sciences outside the Medical School.

INTRODUCTION

As everyone knows, biology, broadly construed, is today a vast, lavishly supported, scientific enterprise that attracts the interest of a larger and more heterogeneous group of scientists than any other branch of science. Given its prominence in today's scientific universe, it may come as a surprise that biology was the last of the major scientific disciplines to become fully incorporated into the academic structure of Yale University. Indeed, the history of biology at Yale has been full of twists and turns that still affect the way biology is done in New Haven.

In the first place, unlike the other major branches of science (e.g., physics, chemistry, astronomy, geology, etc.), biology has never had a single departmental home at Yale, nor has there ever been a de-

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†Abbreviations: DPA, Department of Philosophy and the Arts; EEB, Ecology and Evolutionary Biology; MB&B, Molecular Biophysics and Biochemistry; MCDB, Molecular, Cellular and Developmental Biology.

partment focused on biology that could claim to be more than first among equals. Today, there are a large number of departments outside of the Medical School in which biology is done. Those include the obvious suspects — Molecular, Cellular and Developmental Biology (MCDB†), Ecology and Evolutionary Biology (EEB), and Molecular Biophysics and Biochemistry (MB&B) — but they also include Chemistry, Geology, and Biomedical Engineering. In order to understand how biology came to be scattered all over the University, you need to go back to the beginning.

BEGINNINGS

In its first century, the 18th century, Yale College offered its students a modest level of instruction in the natural sciences and mathematics, but systematic instruction in the sciences did not begin until 1804, when Benjamin Silliman took up his duties on the faculty of Yale College. His title was "Professor Chemistry and Natural History," the latter being a catchall phrase applicable to all branches of science including geology, which interested Silliman a lot, and whatever aspects of biology Silliman found amusing.

In 1810, only 6 years after Silliman's appointment, the Yale Corporation took the first of the many steps it has taken since that ensured that the biological sciences would never have a single home at Yale. It agreed to the establishment of the "Medical Institute of Yale College," which was to be a joint venture of Yale College and the Connecticut Medical Society. It is now called the Yale Medical School. In its original manifestation, the Medical Institute was no more than a trade school, but by the second half of the 20th century, there was more biological research being done at the Medical School than in the entire rest of the University.

Since its founding, the Medical School has been viewed by Yale as the proper home for most, if not all, human biology, and little more will be said about it here because the focus of this essay is the history of the biological sciences outside the Medical School.

THE 19TH CENTURY: THE SHEFFIELD SCIENTIFIC SCHOOL

It is impossible to understand what happened to biology at Yale outside the Medical School in the century that followed Silliman's appointment if you do not know something about the history of the division of the University that began in 1846 as the Yale School of Applied Chemistry. For the record, a year later, Yale established a subdivision called the Department of Philosophy and the Arts (DPA), which was charged with supervising post-bachelor's degree education in all fields other than Law, Theology, and Medicine. Today we refer to it as the Graduate School of Arts and Sciences. (Similar ventures were launched at other institutions of higher education at about the same time.)

The first two faculty appointments in Applied Chemistry were John Pitkin Norton, Professor of Agricultural Chemistry, and Benjamin Silliman, Jr., Professor of Practical Chemistry. Their appointments had some important fine print attached. The Corporation stipulated that neither man was to instruct students enrolled in Yale College, nor was either to be supported by Yale College funds. It may seem odd to the reader that the Corporation would have been willing to establish two new positions, but unwilling to support them. However, this paradox has a simple explanation: The Corporation had no money. Nevertheless, the Corporation's demand that Applied Chemistry be self-financing led ultimately to its downfall, as we shall see.

Since the education of students who already had college degrees was a major component of its mission, the School of Applied Chemistry was initially part of DPA. In 1852, Yale established a School of Engineering, which was also incorporated into DPA, and two years later, Applied Chemistry merged with the School of Engineering to create the Yale Scientific School. For many years, DPA was little more than a wrapper organization for the Scientific School, which was the branch of the University that educated the overwhelming majority of the students on whom DPA

bestowed advanced degrees. This should not come as a surprise; the Ph.D. degree was devised by German universities in the mid-19th century for the training of professional scientists.

Norton, who was Yale's first biochemist, died only a few years after the Scientific School was founded, and he was replaced by John Addison Porter, a recent Yale College graduate who had been teaching at Brown. In 1856, Porter single-handedly solved the daunting financial problems that the Scientific School confronted in its early years by marrying Josephine Sheffield. She was the daughter of Joseph Sheffield, a railroad tycoon who lived in New Haven, and through his son-in-law, Joseph became sufficiently interested in the Yale Scientific School to give it several gifts so large that in 1861, in gratitude, the Corporation renamed it the Sheffield Scientific School.

Thereafter, the Scientific School was a financially independent subdivision of Yale that ran its own degree programs in science and engineering, and at Joseph Sheffield's request, it was provided with its own Board of Trustees. It appears that the Corporation acquiesced to this peculiar arrangement in anticipation of future gifts from Sheffield, which, gratifyingly, did ultimately materialize. In addition to the income the School received from tuition and from Sheffield's benefactions, it received government funds due to the fact that from 1863 to 1893, it was Connecticut's land grant institution.

The Sheffield School offered its students several bachelor's degree programs in engineering, as well as a variety of graduate programs in science and engineering. In addition, it also ran a non-specialized, 3-year bachelor's degree program that included not only the math, science, and engineering you would have anticipated, but also courses in the humanities, including English, which was not taught at Yale College in that era. (Wilbur Cross, the man after whom the Graduate School medal bestowed on its most distinguished alumni is named, taught English in the Sheffield School before going on to a remarkable career in politics that included the governorship of the State of Connecticut.) There was a stark contrast between the forward-looking curriculum of the Sheffield School and that of the 4-year bachelor's program offered at Yale College, which still emphasized Greek, Latin, and Philosophy, just as it had a century before.

Why should any of this ancient history be of concern to recent recipients of advanced degrees in the biological sciences from Yale? The reason is that from 1860 to about 1920, the Sheffield School was the home of most of the biologists at Yale outside the Medical School. Some of them were pretty good. For example, around the turn of the last century, Lafayette Mendel collaborated with Thomas Osborne at the Connecticut Agricultural Experiment Station on a series of nutritional experiments that, among other things, demonstrated that lysine and tryptophan are essential nutrients for mammals. Their work also contributed mightily to the discovery of the first vitamin: vitamin A. There were other respectable biologists on the Sheffield faculty, e.g., Chittenden in Physiological Chemistry, Beecher in Paleontology, Brewer in Botany, and Sinnott in Plant Genetics. (Sinnott's textbook on genetics was still in use in the late 1950s, as the author can attest from personal experience.)

For many years, the President of Yale attended Sheffield commencement ceremonies, which in those days included a research talk given by one of its advanced degree recipients. Thus, Noah Porter was on hand in 1879 to hear a talk entitled "The Anatomy of the Common Gray Mussel." Afterward, to the amusement of all within earshot, Porter was heard to remark: "Wonderful. That young man got more out of that clam than most people would get out of an entire cow."

Although Sheffield was certainly the home of much of the science being done at Yale in the second half of the 19th century, it was not the home of all of it. The Yale College faculty at that time included some substantial scientists, e.g., Dana in Geology and the formidable J.W. Gibbs in Theoretical Chemistry. Nor did the two divisions of the University act entirely independently. There

was some cross-listing of courses so Yale College students could take courses in Sheffield, and vice versa, but nevertheless, an observer of the scene in New Haven around 1900 would have been astonished to discover a single institution running two undergraduate programs so totally different in character. Furthermore, it is likely that this observer would have concluded that in many ways, the Sheffield School was a much more lively and forward-looking institution than Yale College.

ON THE REVOLUTION OF 1919 AND ITS AFTERMATH

Sadly, by the first decade of the 20th century, the Sheffield School's relationship with Yale College, which had never been all that amicable, turned sour. About 1907, the University acquired Pierson Sage Square, the area often referred to today as Science Hill, and at about the same time, Yale College added Ross Harrison to its faculty. Harrison was a distinguished biologist who made major contributions to the development of tissue culture techniques. He was lured to New Haven from Johns Hopkins with an offer that included a promise that he would be housed in a new building on Science Hill — Osborn Memorial Laboratory — and that a new department would be set up for him: Zoology. The Sheffield School was pressured into moving its biological programs into Osborn Memorial Laboratory, which it had largely done by World War I. Given its long and successful involvement in the biological sciences, the Sheffield Board might well have felt it deserved to be treated as the senior partner in this new, joint venture with Yale College, but the Corporation had other ideas.

Toward the end of World War I, the Corporation appointed a committee of alumni to consider ways in which the University might be reorganized so as to improve both its governance and its efficiency. The Corporation had substantial reasons for concern on both counts, not the least of them being many duplications of academic effort in the different divisions of the University. For example, in 1918, Yale was supporting several separate German departments, which must have seemed as lunatic then as it would today. That committee's recommendations, which were announced in 1919, led to revolutionary changes in the way Yale is organized and governed that included the establishment of the office of Provost. Nothing as cataclysmic has taken place at Yale since.

Among the many recommendations of the Committee were several that taken together amounted to nothing less than a call for the dissolution of the Sheffield Scientific School. Not surprisingly, these recommendations met with passionate opposition for reasons that in hindsight appear compelling. In fact, the Sheffield trustees were advised by their attorney that they would be in breach of their fiduciary duties if they were to accede to the liquidation of the School. The response of the Corporation, which was dominated by unsympathetic Yale College graduates, was to reduce the Sheffield School's sentence from instant execution to a slow death by a thousand cuts that continued until about 1956. The demise of the Sheffield School as an independent component of the University left behind myriad problems having to do with the education of engineers that Yale has still not satisfactorily solved. The fact of the matter is that Sheffield was destroyed by the University that had created it, not because it had failed financially or in any other way, but because it had become too successful and too independent.

In the years that followed, many of the Departments that had been components of the Sheffield School were dispersed throughout the University. For example, Physiological Chemistry moved to the Medical School in 1923, where it eventually became the Department of Biochemistry. Sheffield's botanists were integrated into a Zoology-Botany operation in Osborn Memorial Laboratory. The non-physiological parts of Sheffield Chemistry merged with the Yale College Chemistry program that had been educating undergraduates for about 30 years, and in the early 1920s, the newly

merged department moved into Sterling Chemistry Laboratory.

CHEMISTRY AND BIOLOGY

This is not the place to provide an account of the subsequent history of the Department of Chemistry, but its long involvement with the biological sciences needs to be acknowledged. In the first place, it is important to point out that for many years the phrase "organic chemistry" meant the chemistry of the molecules found in living organisms, rather than the chemistry of all compounds that contain carbon. Secondly, many of the Department's faculty contributed to our understanding of biochemistry. For example, one of the people Chemistry obtained from the wreckage of the Sheffield School was Treat B. Johnson, an organic chemist who did a lot of important work on the chemistry of pyrimidines, nucleic acids, and proteins. Rudolph Anderson, who joined Chemistry in the mid-1920s, was Editor of the *Journal of Biological Chemistry* for 21 years. John Kirkwood, who was entrusted with the reorganization of the Department of Chemistry in the 1950s, was a theorist interested in, among other things, the physical chemistry of biological macromolecules, and he established a tradition of research in biophysical chemistry within the Department of Chemistry that continues to this day.

GEOLOGY AND BIOLOGY

When thinking about Biology at Yale, one should never forget Geology. Geology was the second of the sciences to be fully institutionalized at Yale. By 1812, Yale College was offering its students a course in geology that was distinct from Silliman's chemistry course, and in 1850, Dana, who was Silliman's successor, became the first Silliman Professor of Geology and Mineralogy. From a biological perspective, the single most important development in Geology in the second half of the 19th century was the appointment of Othniel Marsh to the Sheffield faculty. Marsh was a Yale College graduate (class of 1860) who persuaded his wealthy uncle, George Peabody, to fund the establishment of a museum of natural history at Yale. In 1870, Marsh, who, like some other members of the Yale faculty of his generation, was unencumbered by a Yale salary, headed off to Wyoming to collect the fossils that would ultimately fill his uncle's museum. Marsh eventually became Professor of Paleontology, a discipline that is a fundamental to evolutionary biology. Paleontology remains an important part of what is today the Department of Geology and Geophysics, as well as being a component of the Department of Ecology and Evolutionary Biology, and its association with the Peabody Museum is as strong as ever.

It is also appropriate to note the contribution made to both biology and geology by Bertram Boltwood in the first decades of the 20th century. Boltwood, who was a Sheffield graduate, was one of the pioneers in radiochemistry in the United States. He began his faculty career in Physics, but later moved to Chemistry. Boltwood was the first to date minerals by measuring the amounts of lead and uranium they contain. Isotopic dating has been a critically important tool for paleontologists ever since because it enables them to fix the fossils they collect in time.

THE BIOLOGICAL SCIENCES SINCE 1920

Compared to the upheavals that occurred in the first two decades of the 20th century, the history of the biological sciences since 1920 has been placid. By the late 1950s, there were three biology-related departments outside the Medical School: Biophysics, Botany, and Zoology. Botany and Zoology shared Osborn Memorial Laboratory and jointly taught an introductory biology course that was half zoology and half botany. From the point of view of the undergraduate curriculum of the day, bacteria were largely ignored because no one was sure what to think about them. It had only been a few years since Edward Tatum, who was a member of the Botany Department,

and his graduate student Joshua Lederberg had discovered conjugation in *E. coli*, a finding that one could argue is the single most momentous discovery ever made by Yale biologists. Molecular biology would not have taken off the way it did in the 1950s and 1960s if there had been no bacterial genetics.

In 1962, Zoology and Botany merged to form the Department of Biology, an entity that turned out to be short-lived. In the late 1990s, the Provost convened a committee that was charged with finding a solution to the problems that had arisen because of the inability of Biology's physiologically oriented faculty to agree on appointments with their evolutionary/ecological colleagues. The upshot was that although the members of the Provost's committee unanimously agreed that intellectually it made no sense whatever to separate evolution from the rest of Biology, from a purely practical point of view, it might be best if its two components went their separate ways. So it was that the Department of Ecology and Evolutionary Biology and the Department of Molecular, Cellular and Developmental Biology were born. No doubt that in another 25 years or so, the biological sciences departments at Yale will undergo yet another such reorganization. Fission and fusion events are everyday occurrences in biology.

BIOPHYSICS

Biophysics is a much younger entity than any we have talked about so far. The person most responsible for bringing it into existence was Ernest Pollard, a nuclear physicist who joined the Physics faculty in the late 1930s. After the war, he and several of his younger colleagues became interested in using ionizing radiation as a probe for studying the organization of viruses and organisms. For a number of years, Biophysics was supported by the Hartford Foundation and occupied space owned by that Foundation in Valhalla, New York. In 1959, Biophysics returned to New Haven and moved into the sixth floor of Gibbs Laboratory, which had been specially built for it. Only 2 years later, Pollard left Yale for Pennsylvania State University, precipitating a crisis both in leadership and scientific direction. In 1962, under the guidance of Frederick Richards, Biophysics became the Department of Molecular Biology and Biophysics (MB&B), a title that better reflected its scientific direction, but a dispute soon broke out with the Department of Biology over the propriety of MB&B's use of the word "biology" in its name, and MB&B was forced to become MB, i.e., Molecular Biophysics.

MB got its second B back a few years later as a result of governance problems that had arisen in the Medical School's Department of Biochemistry. These problems were solved by President Brewster by merging Molecular Biophysics with Biochemistry to produce a new entity that would have a presence on both sides of the campus. (This move returned Physiological Chemistry to the part of campus from which it had been so rudely ripped four decades earlier.) Since 1969, this arrangement has served Yale well, even though I am sure that, if asked, all of the faculty associated with MB&B, both living and dead, would tell you that physically divided departments are to be avoided whenever possible. However, the notion that it might be a Good Thing to strengthen the ties between biologists who live in the Medical School and those who reside on the central campus has obvious merit. In biology, bigger is usually better, especially for graduate students, provided institutions are able to manage size effectively.

CONCLUDING REMARKS

It seems to me that the history of the Sheffield Scientific School may offer an explanation for an aspect of the culture of this University that had long puzzled me because it is so irrational. Even when I was a Yale undergraduate in the late 1950s, I was aware that the non-scientific parts of Yale viewed its scientific components unsympathetically. The fact that unlike all of the other universities Yale considers its peers, Yale has never had a president who began his/her career as a scientist is but one manifestation of this

persistent aspect of the Yale zeitgeist. Perhaps it is a product of the competition that developed in the 19th century between Yale College and the Sheffield School, which must have looked very threatening to the faculty of Yale College in, say, 1900.

In addition, one cannot help but speculate that had the Yale Corporation treated the Sheffield School with more respect in 1919, Yale might still be a leading school for engineering, as it was then. Might it be wise for Yale to make the investments today that would be required to revitalize engineering? Remarkably, despite all of the trauma it has suffered since 1919, Yale's engineering faculty is still big enough and strong enough to nucleate such a venture. I can think of nothing Yale could do today that would have a more positive effect on its standing in the academic world.

Turning now to more specifically biological issues, it is interesting to reflect that despite being forced to give up the phrase "molecular biology" in its name, at the time it was founded, the regular faculty of MB&B and its joint appointees did in fact include a large fraction of all of the members of the Yale faculty on both sides of the campus who were doing molecular biology. Today it would make no sense whatsoever to organize a department around the theme of molecular biology. The reason is that today, the mindset and experimental approaches of the molecular biologist pervade all of biology; one way or another, we are all molecular biologists now. This obvious fact may trigger the next big reorganization of the biological sciences at Yale.

Finally, as the 21st century unfolds, Yale will confront many issues that will bear directly on the professional lives of its biological faculty and students. How big should the biological enterprise be allowed to grow at Yale, given that outside funding is likely to be harder to obtain in the future than it was between 1950 and 2000? How should biological research done on the West Campus be integrated with that done elsewhere at Yale? Indeed, might it be better to make it free-standing? What parts of the biological enterprise are the ones that will give Yale the biggest return on its investment? The success of the biological sciences at Yale in the 21st century will be determined by the wisdom with which such decisions are made, and Yale is going to need all the help it can get to make them right. I invite its graduate alumni to make their opinions known.

Acknowledgments: I gratefully acknowledge the debt I owe to Professor William Summers, who happens to be the author of the chapter on MB&B that appears in Reference (2), for his advice on where to begin my search for information about the history of biology at Yale. I would have been lost without him.

REFERENCES

Detailed references have not been inserted into this essay sentence by sentence, lest the reader be misled into thinking that all the statements made in an essay of this sort can be or should be supported as they would be in a scientific article. That said, three works were consulted extensively in the writing of this essay.

1. Chittenden RH. History of the Sheffield Scientific School of Yale University, 1846-1922. New Haven, CT: Yale University Press; 1928.

The author of this marvelously informative, well-written, two-volume work was the last head of the Sheffield Scientific School. It is a rich source of information about the history of the Sheffield School, its faculty, and its often troubled relationship with the rest of Yale. Everything said about the Sheffield School in this essay derives from this single source.

2. Altman S. editor. Science at Yale. New Haven, CT: Yale University, New Haven; 2002.

Only 300 copies of this small volume were printed. It was published at the time of the University's tercentenary to commemorate the contributions made to Yale by its science departments. It contains short histories of the nine science departments that existed in 2000 outside of the Medical School and Engineering and Applied Science. They vary a lot in breadth and style, as is typical of multi-authored works. Never-

theless, short of spending many months that I did not have to spare burrowing through the University's archives, it would have been impossible for me to write an essay anywhere near as complete as this one without it.

3. Skinner BJ, Narendra BL. Rummaging Through the Attic; or a Brief History of the Geological Sciences at Yale. Geological Society of America, Centennial Special Volume 1; 1985. pp. 355-370.

This paper explores the early history of the earth sciences at Yale in far more detail than the terse account provided in reference (2). Like references (2) and (3), it was a delight to read.