History of the Department of Cell Biology at Yale School of Medicine, 1813-2010

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The Department of Cell Biology at the Yale University School of Medicine was established in 1983. It was preceded by the Section of Cell Biology, which was formed in 1973 when George E. Palade and collaborators came to Yale from the Rockefeller University. Cell Biology at Yale had its origins in the Department of Anatomy that existed from the beginning of classes at the Medical Institution of Yale College in 1813. This article reviews the history of the Department of Anatomy at Yale and its evolution into Cell Biology that began with the introduction of histology into the curriculum in the 1860s. The formation and development of the Section and Department of Cell Biology in the second half of the 20th century to the present time are described. Biographies and research activities of the chairs and key faculty in anatomy and cell biology are provided.

ESTABLISHMENT OF THE MEDICAL INSTITUTION AND ANATOMY AT YALE

The predecessor of the Department of Cell Biology at Yale was the Department of Anatomy, which has a history going back to the beginning of the School of Medicine. The School of Medicine was established by the passage of a bill in the Connecticut General Assembly in 1810 granting a charter for “The Medical Institution of Yale College” [1,2]. The institution was formally opened in 1813 with 37 students, and the first degrees were conferred the following year. In 1814, $1,000 was spent for a library and an anatomical museum. One of the five original faculty members of the school was Jonathan Knight, MD (1789-1864) [2] (Figure 1). Knight graduated from Yale College in 1808 and received his medical license in 1811. He then attended two courses at the University of Pennsylvania, studying anatomy with Caspar Wistar, under whose guidance he purchased anatomical teaching materials for use in the medical school at Yale. Cadavers for dis-
section were difficult to obtain, and citizens of New Haven rioted in 1824 when the body of a young woman that had been missing from her grave in the Grove Street Cemetery was found buried in the basement of the medical school [1]. Knight was Professor of Anatomy and Physiology from 1813 to 1838 and Professor of Surgery from 1838 to 1864. 1

The Medical Institution of Yale College was located at Grove and Prospect streets. In 1838, a new dissecting room, well supplied with subjects, was completed at the school. Charles Hooker (Figure 2), a descendent of one of the founders of the town of Hartford, became Professor of Anatomy and Physiology in 1838 [1,2,3]. He became the first dean of the school in 1845. He provided medical care for the Africans from the Amistad when they were imprisoned and on trial in New Haven [1,2]. Hooker was followed by Leonard J. Sanford, MD, who was Professor of Anatomy and Physiology from 1863 to 1879 and Professor of Anatomy from 1878 to 1888.

MICROSCOPY AND HISTOLOGY AT YALE, 1734-1891

The study of microscopy as a separate entity in the curriculum was introduced in 1860. Yale College, however, made use of the microscope long before this. Yale was the first college in America to obtain a compound microscope [4]. In 1734, Yale purchased a Culpeper/Loft “double microscope” from Edward Scarlett in London for 3 pounds and 3 shillings [5]. President Stiles listed in 1789 “a microscope” among the available “machines for a course in experimental philosophy” [6], indicating the microscope was used in courses in the 18th century. In 1813, Benjamin Silliman, Sr., Professor of Chemistry and Natural History, gave a lecture on the microscope, describing the different types of mi-

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1Lists of faculty and descriptions of courses are found in catalogs and bulletins at Yale University Library Manuscripts and Archives: Catalogue of the Officers and Students in Yale College; Catalogue of Yale University; Yale University, Department of Medicine; Bulletin of Yale University School of Medicine.

2Years denote length of time on faculty.
Moses Clark White (1819-1900) ([1,2,7] (Figure 3), a graduate of the Medical Institution in 1854, was appointed Instructor in Microscopy and Botany in 1862. Prior to that, he was a Methodist missionary in China. With the introduction of microscopy, the first laboratory at the medical school was established at the 150 York Street building that housed the medical school from 1860 to 1925. White was appointed Professor when the Corporation authorized a chair in Microscopy and Pathology in 1867. He was variously Professor of Microscopy, Pathology, and Histology. White served as medical examiner for New Haven from 1883 until his death in 1900. He wrote on microphotography and the study of blood stains.

The school went to great lengths to establish and strengthen histology. In 1858, Rudolph Virchow articulated what became the accepted form of the cell theory, omnis cellula e cellula (“every cell is derived from a [preexisting] cell”) He founded the medical discipline of cellular pathology, namely, that all diseases are basically disturbances of cells. It followed that if cells comprised the organism and could grow and divide and that diseases arose in cells, cells were extremely important subjects for research and teaching. It was recognized that the school needed to include the study of cells in its curriculum. Histology was a new and modern science, and for a school to remain relevant and competitive, it had to have a representation in this emerging field. A comparable situation would occur a hundred years later when it became necessary to establish and strengthen the new field of cell biology at Yale.

The catalog of 1869 stated under Microscopy, “Histology and Pathology are illustrated by a sufficient number of compound microscopes and a large collection of the best preparations. It is believed that no institution in this country furnishes the student greater facilities for acquiring exact knowledge in this department.” The latter statement has validity as few American schools had facilities for histology at this time. In 1878, it was stated, “The Lectures on Histology and Pathology are illustrated by the daily use of five or six compound achromatic microscopes, on which two sets of preparations are exhibited at every lecture.”

In 1880, the faculty wanted to make the school preeminent in histology and recommended an endowment of $25,000 to pay the salary of a Professor of Histology. At that time in America, there were no opportunities for a faculty member to devote full time to teaching and research. Faculty income was meager and derived from student fees for lectures and clinics paid directly to the professor. As a result, almost all faculty held other jobs, usually practicing medicine, to earn sufficient income. In 1880, the school agreed to collect the fees from students and pay the faculty $300 a year. The faculty hoped that T. Mitchell Prudden, MD, 1875 [8], who had studied in Germany, would accept the position in histology. However, he had just taken a position at Columbia and decided to stay in New York. Prudden was then offered $1,200 to come to Yale one day a week to teach histology, which he did from 1880 to 1886 [1]. This caused disgruntlement on the part of some faculty members who were earning $300 a year.

In 1881, teaching of histology was described as “Practical Normal Histology is taught in the microscopical laboratory by Dr. T. Mitchell Prudden. Each student is furnished with a microscope and the requisite accessories, and is taught how to prepare and study the tissues and organs, of which he makes sketches and a typical collection of his own for future reference.” Prudden introduced the preparation of histological slides by students, a practice that continued
for many years afterward. In 1881, Prudden published the first edition of *A Manual of Practical Normal Histology* [9].

Histology was taught by Thomas G. Lee, MD, Lecturer in Histology, from 1886 to 1891. Samuel Wendell Williston was Professor of Anatomy from 1888 to 1890 and was a distinguished paleontologist [10]. The anatomy and histology courses were described in the Yale Medical School catalog for 1886-87: “The instruction in anatomy aims at thoroughness and comprehensiveness by means of lectures, recitations, and dissections;” “The course in histology consists of lectures, recitations, and practical work with the microscope in the laboratory. The student receives a number of specimens of each tissue and organ of the body, which are carefully prepared for him in various ways, so as fully to illustrate the different points of structure, of which he makes drawings. In addition to this each one receives practical instruction in injecting, hardening, cutting and preserving tissues and specimens after the most approved methods.”

DEPARTMENT OF ANATOMY, 1891-1974

Robert O. Moody was Instructor in Histology from 1891 to 1893 and received his MD degree from Yale in 1894. Harry Burr Ferris began teaching histology in 1892. The microscopical laboratory in the Medical Hall at 150 York Street (Figure 4) was described in 1893 [11] as “a room measuring fifty feet by twenty-five feet, is well lighted with north and west light, and thoroughly equipped with microscopes, students’ lockers, work tables, and every facility for satisfactory instruction in normal and pathological histology. The microscopical laboratory is supplied with an excellent set of microscopes, and with microtomes and other laboratory requisites for the best work. Each student is provided with a locker and a set of reagents and apparatus for his own use. There is a large cabinet of sections which may be drawn upon for illustrations and for special work, and also a large collection of photographs and transparencies made from plates and photomicrographs of tissues.”

If the descriptions of facilities and courses sound somewhat like advertisements, they were, in part, that. Yale required a college degree or examination for entrance, graded courses, and a three-year course [1,12]. These were high standards and made it difficult for Yale to attract students. There were a large number of medical schools at the time and many were simply diploma mills with low standards and few
requirements. Abraham Flexner investigated the medical schools and in his 1910 report recommended that only 31, one of which was Yale, of 155 medical schools should be retained.

The Sterling Hall of Medicine was dedicated in 1925 with the Department of Anatomy occupying the second, third, and fourth floors of the Cedar Street wing [13]. The full-time faculty in 1924 consisted of H.B. Ferris, MD, Professor of Anatomy; R.G. Harrison, PhD, MD, Professor of Comparative Anatomy; H.S. Burr, PhD, Assistant Professor of Anatomy; L.S. Stone, PhD, Instructor; and R.K. Burns, MS, Assistant. The annual budget for the department was $24,000, with $15,000 for staff salaries; $5,900 for janitor, technicians, and clerical help; and $3,000 for current expenses, including research. In teaching, 360 hours were devoted to anatomy, 130 hours to microscopic anatomy, 60 hours to developmental anatomy, and 60 hours to the central nervous system.

In the Department of Anatomy, there was a lecture hall on the second floor that could hold 73 people (the Anatomy Lecture Hall). There were also staff rooms, secretary’s office, research laboratories (Figure 5), anatomical museum, and museum preparation room. On the third floor, there were three large histology and neuroanatomy teaching laboratories. These three teaching labs remained essentially unchanged until 1970. An adjacent room served as a histological preparation room and laboratory for the research technician. There were four dissecting rooms and a topographic anatomy and study room. The fourth floor had a bone preparation room, an animal operating room, a recovery room for animals under observation, and a roof for bleaching bones and making corrosion preparations. The subbasement contained a cadaver storage room, a refrigerator capable of holding six cadavers, a large electrically driven band saw, embalming room, and storage space for skeletons and dissections.

Harry Burr Ferris (1865-1940) [14] received his BA degree in 1887 and his MD degree from Yale in 1890. He was appointed Instructor in Anatomy in 1891 and taught for...
42 years until his retirement in 1933. In 1897, he was appointed the Ebenezer K. Hunt Professor of Anatomy. He was the first full-time member of the Department of Anatomy and, from 1895 to 1911, the only one. He cut the histology sections and prepared demonstration slides during that time (Figure 6). He was extensively involved in teaching all aspects of anatomy and was considered an outstanding teacher (Figure 7). It is said that his knowledge of anatomy was prodigious and his memory frightening. His lectures were unforgettable. Because of his heavy teaching load, he had little time for research. However, he wrote a paper on mitotic division of cancer cells, several papers on the neuron, and later on the history of medicine.

Ross Granville Harrison (1870-1959) [15] (Figure 8) received an AB degree from Johns Hopkins in 1889 and a PhD in 1894. In 1892-93, he worked with Moritz Nussbaum at the University of Bonn. After receiving his PhD, he returned to Bonn and received an MD degree in 1899. He became an instructor in the new Johns Hopkins Medical School. He taught histology and embryology from 1896-1907 and was Associate Professor of Anatomy from 1899-1907, when he came to Yale as Bronson Professor of Comparative Anatomy. He was active in the medical school and held the title of Professor of Embryology. He moved into the new Osborn Laboratory, where he had a research laboratory and taught embryology. He was Chairman of the Department of Zoology from 1913 to 1938 and Sterling Professor of Biology from 1927 to 1938. He maintained an influential relationship to medicine on a national scale. He advised Abraham Flexner and Simon Flexner, director of the Rockefeller Institute, during the crusade to improve medical training. After retiring from Yale, he was Chairman of the National Research Council from 1938 to 1946. His decisions formed the basis of some of our national science policy during World War II and in the critical days of atomic development. The production of penicillin in large quantities in this country was arranged through channels that had their origin with Harrison.

Harrison is best known for making one of the great scientific contributions of the century. He developed the technique of tissue culture, which he used to study outgrowth of fibers from nerve cells. Harrison took cells from the spinal cord and placed them in hanging drops of lymph fluid withdrawn from the lymph heart of the frog. Processes then grew out from the nerve cell bodies. He described the growth cones at the tips of the growing fibers. This not only established tissue culture as a practical technique, but also confirmed Cajal’s neuron doctrine that neurons are separate structural and functional units. It is considered an injustice that he did not receive a Nobel Prize for this discovery. He was actually the first American zoologist to be voted the Nobel Prize. However, it was never awarded because The Caroline Institute ruled that no awards be made in Physiology and Medicine during World War I (1914-1918), and since the vote was in 1917, the award was not made.

Harold Saxon Burr (1889-1973) [16] (Figure 9) did his graduate work under Ross G. Harrison and was granted the PhD degree from Yale in 1915. In 1914, he became Instructor in Anatomy. On the retirement of Harry Burr Ferris in 1933, he was appointed E.K. Hunt Professor of Anatomy. He was a neuroanatomist and published 93 papers on the development of peripheral nerves and the central nervous system and on bioelectric phenomena in various organisms. Leon Stansfield Stone (1893-1980) received his PhD from Yale in 1921 and became an Instructor in the same year. He was Bronson
Professor of Comparative Anatomy from 1940 to 1961. He performed research on regeneration of the visual system in amphibians. Edgar Allen (1892-1943), previously Dean of the University of Missouri School of Medicine, was professor and Chair of Anatomy from 1933 to 1943 [17]. He was a leading authority on the mechanism of sex hormones and discovered estrogen.

In 1927, a new elective course, Advanced Microscopic Anatomy, was offered. This course represented a significant advance over histological observation of tissues in that it included correlation of histology and pathology, consideration of the physiological function of tissues, and identification of chemical constituents of tissues through histochemistry.

William U. Gardner, PhD, (1907-1988) became Chairman of Anatomy and E.K. Hunt Professor of Anatomy in 1943. He was a superb teacher of gross anatomy and introduced the teaching system named prospection, which is used nationwide today. He was also very active in research and in later years investigated the influence of hormones on cancer. He maintained thousands of mice bearing different malignancies in a small brick building called the “mouse house,” which stood between the Boyer Center and the EPH building.

Thomas R. Forbes, PhD, (1911-1988) (Figure 10) joined the faculty in 1945 and became the E.K. Hunt Professor of Anatomy in 1977. Also a fine teacher of gross anatomy, he was a distinguished researcher in the field of reproductive endocrinology, particularly the assay and physiological action of progesterone. In later years, he turned to study of the history of medicine. He was also Associate Dean of Students and for 21 years was Chairman of the Admissions Committee. Edmund S. Crelin (1923-2004), Professor of Anatomy, was another outstanding teacher of gross anatomy and performed research on bone and connective tissues. He published a widely used book on the anatomy of the newborn in 1969. With Allen, Gardner, and Forbes, the department was especially strong in the emerging field of endocrinology in the mid-20th century. The long and distinguished existence of the Department of Anatomy ended in 1974.

BEGINNINGS OF CELL BIOLOGY, 1949-1973

Anatomy departments in the first part of the 20th century traditionally had four sections or parts organized around their teaching missions. These were gross anatomy, microscopic anatomy, neuroanatomy, and embryology. In the 1960s, the research activities of faculty in microscopic anatomy became increasingly devoted to cell biology; those in neuroanatomy to neurobiology; and those in embryology to developmental biology. As faculty became increasingly subcellular and molecular in their approaches, “anatomy” was no longer an appropriate description for the departments. Anatomy departments were modified, combined with other disciplines, or abolished at many medical schools. In their place, departments or sections of molecular biology, cell biology, structural biology, neurobiology, genetics, and developmental biology were created.

Although the Department of Anatomy was composed mostly of classical anatomists,
it was recognized that the department needed greater representation in the newly emerging field of cell biology. Sanford L. Palay (1918-2002), who took the first electron micrographs of nerve cells and was a foremost neurocytologist, was a member of the faculty from 1949 to 1956. Russell J. Barnett was recruited to Yale from Harvard in 1959 in order to build up the department’s strength in cell biology. Thomas L. Lentz, a student of Barnett, joined the faculty in 1964. Walter J. Gehring, a developmental biologist, was an Associate Professor from 1969 to 1972.

Russell J. Barnett (1920-1989) (Figure 11) received his MD degree from Yale in 1948 and joined the Department of Anatomy in 1959. He was Chairman from 1967 to 1974. From 1974 to 1979, he was Chairman of the Section of Cytology. He was a pioneer in the development and use of cytochemical techniques for the localization of enzymes and other substances in tissues and cells. With David Sabatini and Klaus Bensch, he discovered the use of glutaraldehyde as a fixative for electron microscopy. He was extremely enthusiastic about science and was supportive of young investigators.

Thomas L. Lentz (1939- ) (Figure 12) came to Yale as a medical student in 1960 and worked on his thesis in Russell J. Barnett’s laboratory. He received his MD degree in 1964 and was hired as an Instructor in Anatomy to establish a laboratory in cell biology. His research interests during his career included study of primitive nervous systems, development of the neuromuscular junction, structure-function relationships of the neurotoxin-binding site on the nicotinic acetylcholine receptor, and cellular receptors and intra-cellular trafficking in neurons of the neurotropic rabies virus. He authored a book, *Cell Fine Structure* [18], widely used in teaching cell biology. He was appointed Professor of Cell Biology in 1985. In 1972, he became chair of the Committee on Admissions for the School of Medicine. He was appointed Assistant Dean in 1976 and Associate Dean for Admissions and Financial Aid in 2000. He was Vice Chairman of the department from 1992 to 2006. He retired in 2006 and currently directs the microscopic anatomy laboratory as Senior Research Scientist and Professor Emeritus of Cell Biology.

The Department of Anatomy was abolished in 1974 with gross anatomy becoming a Section in the Department of Surgery and microscopic anatomy becoming the Section of Cytology. Neuroanatomy was taught by outside instructors until 1978, when Pasko Rakic was recruited by George Palade to head a Section of Neuroanatomy, now the Department of Neurobiology.

**SECTION OF CELL BIOLOGY, 1973-1983**

Although the Department of Anatomy had taken steps to introduce cell biology, it was recognized that a major expansion of cell biology was necessary if Yale was to be competitive in this field. Yale became pre-eminent in cell biology when George
Palade, along with Marilyn Farquhar and James Jamieson, came to Yale from the Rockefeller University and formed the Section of Cell Biology in 1973. The second floor of the C-wing was extensively renovated in preparation for the new Section of Cell Biology.

The sections of Cell Biology and Cytology were merged in 1979 to form the Section of Cell Biology with George Palade as chairman. The primary faculty at that time consisted of George Palade, Marilyn Farquhar, James D. Jamieson, and Russell J. Barnett (Professors); Thomas L. Lentz (Associate Professor); and Anne Hubbard, Richard Galardy, and J. David Castle (Assistant Professors). Each year in the 1970s and 1980s, Nicolae and Maya Simionescu came to Yale from Romania as Visiting Professors for a semester to teach histology and do research. Palade often had to intervene with the President of Romania in order for the Simionescus to obtain permission to leave, as the Communist regime feared they would not return.

George Palade was dedicated to teaching and made the cell biology course for medical students — Cell Biology 102, later Cell Biology 502 — an outstanding course in the basic sciences at the medical school and in the country. The course, largely unchanged today, focuses on the structural basis of cell and tissue functions in mammals. The lectures are grouped in two main series. The first deals primarily with the structure and function of cell organelles, including the plasma membrane, nucleus, mitochondria, lysosomes, microtubules, endoplasmic reticulum, and Golgi complex. In the second series, the major organ systems (integumentary, muscular, circulatory, respiratory, urinary, digestive, nervous, reproductive, and endocrine) are discussed in terms of the integrated functions of their constituent cell populations. The laboratory section of the course is concerned with microscopic anatomy. The structure and organization of cells are analyzed at the subcellular, cellular, tissue, and organ levels using the light microscope and electron micrographs.

A graduate program in cell biology was instituted in 1973 by the Section of Cell Biology. Since then, more than 100 students have received their PhD degrees in the department. In addition, many medical students and MD-PhD students have done their thesis work in the department.

George E. Palade (1912-2008) [19,20] (Figure 13) received his MD from the School of Medicine of the University of Bucharest, Romania. He was a member of the faculty of that school until 1945, when he came to the United States for postdoctoral studies. He joined Albert Claude at the Rockefeller Institute for Medical Research in 1946 and was appointed Assistant Professor at the Rockefeller in 1948. He progressed from Assistant Professor to full Professor and head of the Laboratory of Cell Biology until 1973, when he moved to Yale as Professor and Chair of the Section of Cell Biology. He was Sterling Professor of Cell Biology from 1975 to 1983. He became a Senior Research Scientist, Professor Emeritus of Cell Biology, and Special Advisor to the Dean in 1983. In 1990, he moved to the University of California San Diego as Professor of Medicine in Residence and Dean for Scientific Affairs. He was a member of the National Academy of Sciences and the American Academy of Arts and Sciences. He received a number of honorary degrees and prizes, which include a Nobel Prize in 1974 (shared with Albert Claude and Christian DeDuve) and the National Medal of Science in 1986.

The Palade laboratory was actively involved in integrated morphological and biochemical studies of subcellular components already known to exist or discovered in the early 1950s as the result of the introduction of electron microscopy in cell research. The

Figure 13. George E. Palade 1970. Sterling Professor of Cell Biology, Chair of Section of Cell Biology, 1973-1990.
work relied heavily on the development of cell fractionation procedures and electron microscopy (Figure 14). These integrated studies led to the identification of the compartments of the secretory (exocytic) pathway; vesicular carriers at important relays along the pathway; the energy requiring steps; and isolation and partial characterization of different classes of vesicular carriers. Later, the work of his laboratory was concentrated on the vascular endothelium, especially the continuous type of endothelium in the capillaries of muscle, myocardium, and lung. It led to the identification of plasmalemmal vesicles or caveolae as the transcytotic carriers for macromolecules.

Marilyn Gist Farquhar (1928- ) (Figure 15) received her AB degree in Zoology, and her PhD in Experimental Pathology from the University of California, Berkeley. Dr. Farquhar was Professor of Pathology at the University of California San Francisco School of Medicine, Professor of Cell Biology at Rockefeller University, and Sterling Professor of Cell Biology and Pathology at the Yale School of Medicine. She was on the faculty at Yale from 1973 to 1990. Currently, she is a Professor of Pathology, and Chair, Department of Cellular & Molecular Medicine at the University of California San Diego School of Medicine. Her distinctions include the Wilson Medal of the American Society of Cell Biologists and membership in the National Academy of Sciences and the American Academy of Arts and Sciences. Dr. Farquhar’s early studies helped elucidate the function and structure of the anterior pituitary gland, including mechanisms of exocytosis and hormone packaging. She was also instrumental, along with Dr. Palade, in elucidating, by electron microscopy, the components of the junctional complex. A long-standing interest of her laboratory is in understanding the cellular and molecular basis of diseases of the kidney glomerulus.

James D. Jamieson (1934- ) (Figure 16) received his MD from the University of British Columbia, Canada, in 1960. Following medical school, he moved to the Rockefeller University where he worked with George Palade on his PhD (1966), which concerned the “Intracellular Transport of Secretory Protein: Role of the Golgi Complex.” He stayed on at the Rockefeller, progressing to the rank of Associate Professor. In 1973, Dr. Jamieson joined Drs. Palade and Farquhar at Yale as Associate Professor. He was promoted to Professor of Cell Biology in 1975 and was the first chair of the Department of Cell Biology when the Section of Cell Biology became a department in 1983. He is currently Director of the MD-PhD Program [21]. His distinctions include president of the American Society for Cell Biology (1983) and Distinguished Achievement Award, American Gastroenterological Association (1993). Dr. Jamieson’s research interests have mainly focused on identification of
components of the intracellular transport pathway in the pancreatic acinar cell as a model of a regulated secretory system.

DEPARTMENT OF CELL BIOLOGY, 1983-2007

In 1983, the Section of Cell Biology became a department with James D. Jamieson as Chairman. Ari Helenius became Chairman in 1992, followed by Pietro De Camilli in 1997 and Ira Mellman in 2000 (Figure 17). Ari Helenius capitalized on the ability of viruses to utilize the membrane traffic machinery to enter and exit cells to learn about fundamental mechanisms in membrane traffic. Ira Mellman advanced knowledge in the field of endocytosis, antigen presentation, and dendritic cell function. He was named Sterling Professor of Cell Biology in 2002. A Center for Cell Imaging was formed in 1989 and has state-of-the-art facilities for electron and confocal microscopy. A fourth floor addition containing research labs, library, and seminar room for cell biology was made to the C-wing. In 2001, the second floor was renovated to create modern research laboratories. Teaching laboratories in the new Anlyan Center for Medical Research and Education (TAC Building) began to accommodate microscopic anatomy teaching in 2003.

Pietro De Camilli [22], Professor of Cell Biology and Neurobiology, received his MD degree in 1972 from the University of Milan. He worked at the University of Milan with Jacopo Meldolesi, who had studied with George Palade and James Jamieson at the Rockefeller University. He then did postdoctoral work at Yale with Paul Greengard, who later won the Nobel Prize for Physiology or Medicine in 2000. He joined the Section of Cell Biology as Assistant Professor in 1980. After two years, he returned to the University of Milan for 6 years and returned again to Yale as Associate Professor of Cell Biology in 1988. He was promoted to full Professor and appointed as a Howard Hughes Medical Institute Investigator in 1992. He chaired the department from 1997 to 2000. He was elected to the National Academy of Sciences and to the American Academy of Arts and Sciences in 2001 and the Institute of Medicine in 2005. In 2003, he was named Eugene Higgins Professor of Cell Biology. His research has involved study of the molecular mechanisms involved in the fusion of synaptic vesicles with the presynaptic membrane, with release of neurotransmitters by exocytosis, and the recycling of vesicle membrane. He has identified and/or characterized many of the proteins including synapsin, dynamin, synaptojanin, and endophilin that participate in this process. He has applied his research to diseases and found that patients with stiff man syndrome and insulin-dependent diabetes mellitus have autoantibodies against a neuronal antigen, glutamic acid decarboxylase.

In 1979, the third floor of the C-wing was renovated to accommodate new cell biology faculty and the Section of Neu-
roanatomy. New appointments since then have been Ira Mellman and Ari Helenius (1981); Robert Levenson (1983); Susan Ferro-Novick, and Peter Novick (1985); Pietro De Camilli (1988); Spyridon Artavanis-Tsakonis, Carl Hashimoto, and Sandra Wolin (1990); Norma Andrews (1993); Michael Tiemeyer (1994); Graham Warren (1999); Karin Reinish and Peter Takizawa (2001); Gero Miesenböck (2004); Derek K. Toomre (2005); Haifan Lin (2006); Daniel Colon-Ramos, Thomas Melia, and Fred Gorelick (2009); and Joerg Bewersdorf, Shawn Ferguson, Megan King, C. Patrick Lusk, Tobias Walther, and Yongli Zhang (2010).

Beginning in the late 1970s, department retreats were held annually. These took place at the Marine Biological Laboratory at Woods Hole, Massachusetts, until 1991. They ran from Friday evening through Sunday morning. At the retreats, faculty members gave brief talks on the research being conducted in their laboratories. There was a poster session. There were also social activities including a reception, trip to Martha's Vineyard, and visits to Captain Kidd's Tavern. In recent years, the retreats have been held at locations in Connecticut and last one day. The department also held an annual picnic and holiday party. In the 1980s and '90s, the department had a softball team named the “Palade Bodies.”

In 2001, the major course taught by the department for the class of 100 medical students was Cell Biology 502, The Cellular Basis of Human Biology. Teaching of microscopic anatomy was greatly enhanced by the introduction of virtual microscopy of histological sections in 2003. The virtual microscope consists of high-resolution scans of histological sections that can be viewed on a computer screen. As with microscopes, students can scan through the section and change magnification.

Haifan Lin (Figure 18) joined the faculty in 2006 as Professor of Cell Biology and Genetics. He received his PhD in 1990 from Cornell University. After a postdoctoral fellowship with Allan Spradling at the Carnegie Institution in Washington, he was Professor of Cell Biology at Duke University Medical Center. His laboratory studies molecular mechanisms underlying the self-renewing division of stem cells. Currently, he focuses on small RNA-mediated epigenetic programming and translational regulation that are required for the self-renewal of germline and embryonic stem cells. He uses Drosophila as a pilot model to explore molecular mechanisms underlying stem cell division and the mouse as an advanced model to expand what is learned from Drosophila to mammalian and human systems. Dr. Lin is also Director of the Yale Stem Cell Center.

EXPANSION OF CELL BIOLOGY, 2008-PRESENT

In 2007, Ira Mellman resigned to take a position at Genentech Inc., in California. James D. Jamieson resumed the chair as Interim Chair. In 2008, President Richard Levin and Dean Robert Alpern made a major commitment to strengthen Cell Biology at Yale University. James E. Rothman, PhD, was recruited and named the Fergus F. Wallace Professor of Biomedical Sciences and the next Chairman of Cell Biology [23]. In addition to existing space in Sterling Hall of Medicine, one floor of a building at the West Campus in West Haven and Orange, formerly the Bayer Company facility, was devoted to Cell Biology. There, James Rothman has launched a Center for High-Throughput Cell Biology. Tools and techniques have been developed to determine the cellular functions of the 25,000 known protein-coding genes in the human genome. This research should provide a basis for the development of new molecular targets for therapy of many diseases.

After completing medical school at the University of Missouri in 1973 and internal
medicine training at the University, Dr. Fred Gorelick (Figure 19) came to Yale for a fellowship in gastroenterology in 1976. He began basic science training with Dr. James Jamieson at Yale in 1978. During that period, he described calcium-calmodulin dependent protein kinase II. He subsequently worked with Dr. Paul Greengard at Rockefeller University to demonstrate how this enzyme could become calcium-independent and function in memory. His later work has focused on the mechanisms of acute pancreatitis and how digestive enzymes, such as trypsin, are activated within the pancreas during this disease. Dr. Gorelick directs a course, Cell Biology 601, Molecular and Cellular Basis of Human Disease, that helps educate physician scientists. He has been a Professor of Medicine (Digestive Diseases) since 1994 and received in addition a primary appointment as Professor of Cell Biology in 2009.

James Rothman (Figure 20) graduated summa cum laude from Yale College in 1971 with a degree in physics. He attended Harvard Medical School, but before completing his medical degree decided he wanted to pursue research in basic science. He earned a PhD in biological chemistry from Harvard in 1976. He then spent two years as a postdoctoral associate with Harvey F. Lodish at the Massachusetts Institute of Technology. In 1978, he took a position as an assistant professor at the Stanford School of Medicine. He was at Princeton University from 1988 to 1991. In 1991, he became the first chair of the Department of Cellular Biochemistry and Biophysics at Memorial Sloan-Kettering Cancer Center in New York and vice-chair of the Sloan-Kettering Institute. He was Professor of Physiology and Cellular Biophysics at the College of Physicians and Surgeons of Columbia University and the Clyde and Helen Wu Professor of Chemical Biology. He is a member of the National Academy of Sciences and the Institute of Medicine, a fellow of the American Academy of Arts and Science, and a foreign associate of the European Molecular Biology Association. He has received many honors, including the Louisa Gross Horwitz Prize and the Albert Lasker Award for Basic Medical Research in 2002. In 2010, he was awarded the Kavli Prize in Neuroscience.

James Rothman’s research involves study of the molecular mechanisms and regulation of vesicular traffic and membrane fusion in cells. He employs diverse biophysical, biochemical, and cell biological approaches to characterize the fundamental participants in intracellular transport processes. He formulated the “SNARE hypothesis” by which distinctive, complementary proteins known as SNARES expressed on both vesicles and target membranes, ensure that different classes of vesicles bind to the appropriate target membranes, and then initiate the biochemical changes leading to fusion of vesicles with the target membrane and delivery of the vesicles’ cargo to their proper destinations.

In 2010, the Department of Cell Biology at Yale comprises a dynamic and interactive group of 34 faculty members and their research laboratories that span every major area of investigation central to the field. There are also 111 postdoctoral fellows and
73 graduate students. The external grant funding is $7,700,000. While the original research focus on cellular membranes and their functions remains strong, the department has expanded its focus significantly in recent years. The Department includes major activities in neurobiology, developmental biology, nuclear dynamics, the cytoskeleton, cellular imaging, structural biology, molecular biology, and molecular medicine.

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