CELL LIFE, PHYSIOLOGICAL TIME, AND MICROCINEMATOGRAPHY, OR THE CHICKEN THAT ATE MANHATTAN

Scott Curtis, Northwestern University

I'd like to start with some headlines, which I found in a story from a November 1925 edition of the *New York Herald Tribune*:

> *"'Immortality' Is Achieved in Chicken Heart."*
> *"Tissue Fed by Dr. Carrel Since 1913 Pared Daily to Prevent Frankenstein Monster, Prof. Green Says."*
> *"It Might Live Forever."*
> *"Flesh in Rockefeller Institute Would Cover Manhattan if Not Trimmed."*

Never known for its balanced reporting, the *Herald Tribune* goes on to explain that, according to Arthur G. Green, a former professor of chemistry at Leeds University who recently visited the Rockefeller Institute, "a bit of tissue from a chicken's heart kept alive since 1913 would have grown large enough to blanket Manhattan had it not been cut every 24 hours." Furthermore, Dr. Alexis Carrel and his team made a motion picture record of the tissue's growth:

> *"It was one of the most amazing things I ever saw," Professor Green said. "The film of the growth of the tissue was taken during twenty-four hours and must have involved a vast amount of reel. What takes place in the twenty-four hours is reduced [...] to a comparatively few minutes. You see on the screen a growth and a development nothing short of cosmic. Combustions, spirals, pulsations – all the marvels of biology seem to condense themselves into those few moments."* [1]

The experiment to which Professor Green refers was not the product of some mad scientist intent on dominating the world with chicken skin. It is, in fact, one of the most famous experiments in the biological research method of tissue culture, in which fragments of tissue from an animal or plant are transferred to an artificial environment in which they can continue to survive and function. With the cell population thus isolated, the researcher can better examine and manipulate cell behavior. In this case, Carrel, a Nobel-prize-winning physician and a member of the Rockefeller Institute, created a culture of cells from the heart of an embryonic chick in January 1912.[2] Carrel did successfully maintain the culture until he left the Institute in 1938, and (theoretically speaking) the culture could have doubled its volume every 48 hours, but whether Carrel's methods were rigorously scientific and repeatable was and is a matter of controversy.[3] Still, noted biologists have admired Carrel's technique and results, dubbing them "the single greatest achievement in the field of tissue culture."[4]

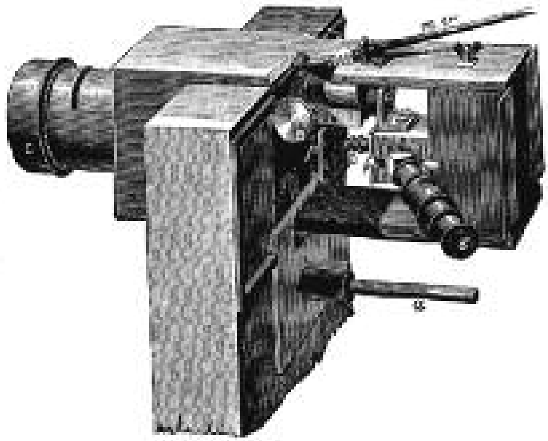


Figure 1: Marey's chronophotographic microscope, 1894

What matters here is not so much the validity of the experiment as its cinematic record. Professor Green describes seeing films of cell life and behavior made by Carrel at the Institute. Green may not know much about how these films are made, but his reaction to them is fairly typical, even in the scientific community: "You see on the screen a growth and a development nothing short of cosmic. Combustions, spirals, pulsations – all the marvels of biology seem to condense themselves into those few moments." These films of cell life contain within them a fascinating paradox: that a world so small could have "cosmic" dimensions and implications; that a cinematic record of cell time – recorded in the smallest possible increments – could result in the impression of an almost frightening acceleration of life. The sense of awe triggered by these films is not unrelated to the sense of awe provoked by Carrel's experiment. In fact, I would argue that the rather incredible idea that a tissue culture could overrun New York City is due in large part to the use of motion pictures in the study of cell behavior. This essay, then, will offer an exploration of the influence of early microcinematography on biological conceptions of cell life.

Like most histories of scientific motion pictures, the story of microcinematography begins with Etienne-Jules Marey. The precise date of the first moving pictures taken through a microscope has not been recorded, but Marey devotes a chapter to the technique in his 1894 book, *Le Mouvement*. Even at this early date, Marey recognized the technical issues that would continue to pester micro-cinematography: illumination, vibration, and the ability to focus and expose the image simultaneously. Marey's design was such that the researcher had to shoot "blind;" while he could find and focus on the object with a microscope, a prism stood between the preparation plate and the film plane: "On pressing this knob [Knob *P* in figure 1 indicates the prism mechanism in Marey's device], the prism is brought into play, and the image of the preparation is projected along the tube of the microscope; on pulling the knob out, the prism is removed and the image falls directly upon the ground glass or upon the sensitized plate."[5] Once the focusing is complete, then, the knob has to be pulled and the photographic process initiated, by which time the cells may be out of frame or the observed behavior completed.

Marey's experiments were continued by various disciples, most of them working at the Marey Institute. Lucien Bull, for example, collaborated with Professor Antoine Pizon in 1903 to record the multiplication of a colony of *Botryllus*, or sea squirts.[6] His apparatus aligned the camera and microscope horizontally, a partial solution to the focusing issue, but left unresolved were problems with illumination and vibration. In 1909, Julius Ries, a biologist who worked at the Marey Institute, fashioned a similar device, and encountered the same difficulties as Marey, although his experiments had great success and enabled him to make important claims based on his microscopic films.[7] Another disciple of Marey and pioneer in the field, François-Franck, adapted Marey's apparatus and made chronophotographic plates of a variety of biological phenomena from 1902 to 1908.[8] Lucienne Chevroton, who worked at the Collège de France alongside François-Franck, used a comparable design in 1909 (figure 2) to record microcinematographic investigations of a sea urchin egg (figure 3).[9]

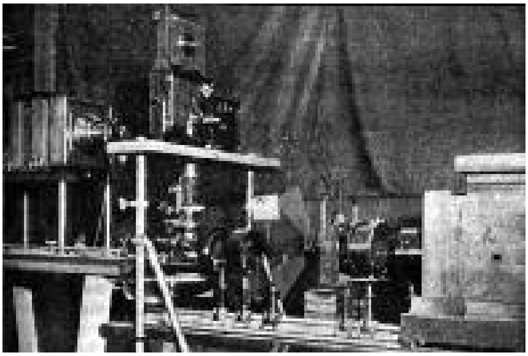
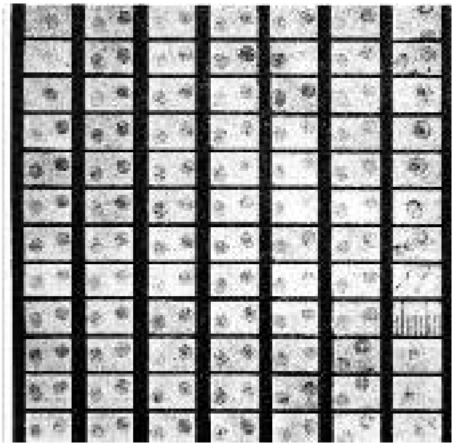


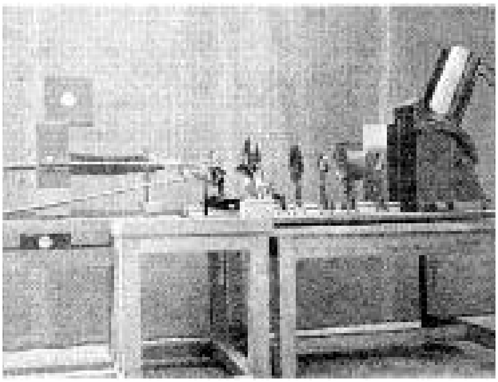
Figure 2 (left): Chevroton's apparatus

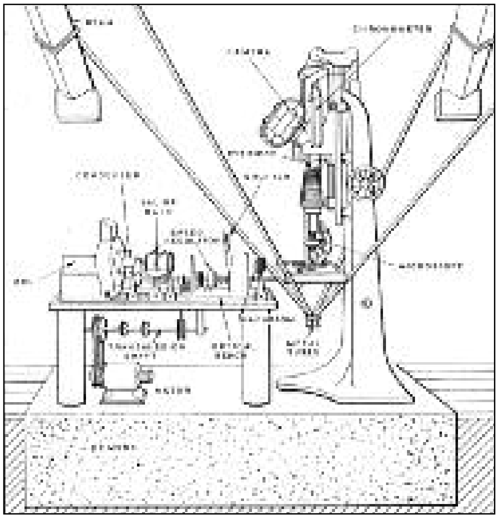
Figure 3 (right): Sea urchin eggs, Chevroton, 1909



In 1909, at the same time that Ries and Chevroton were publishing their work on cinemicrobiology, Jean Comandon presented his first films to the French Academy of Sciences.[10] With the resources of Pathé Frères behind him, Comandon was able to solve the most vexing problems of this technique and to create films of unprecedented clarity. His design combined the best of previous efforts to overcome lighting and vibration problems. In microcinematography, illumination is particularly troublesome as higher magnifications require stronger light sources. If the source is too dim, the film will be underexposed; but if the light is too hot, it will kill the specimen. Like François-Franck and Chevroton, Comandon used an arc light far away from the microscope; as in the Marey device, a shutter interrupts the light rays and protects the organisms from overheating. Vibration is the largest obstacle to microcinematography: at high magnification, any movement at all can cause blurring. Comandon separated each of the parts of the apparatus (light system, microscope, and camera) so that they were free from contact with each other and bolted them securely to a wall (figure 4). By 1930, Comandon had modified his design to make an even steadier apparatus, built on concrete and secured via four pylons to the ceiling (figure 5).[11] Yet the results of his 1909 equipment – clear, steady films with good contrast and excellent magnification – have rarely been equaled (figure 6).

Pathé Frères' support of Comandon coincided with the company's plan to expand its production of educational films for theatrical and non-theatrical distribution.[12] Charles Urban had already had some success as early as 1903 with a series of microcinematic edu





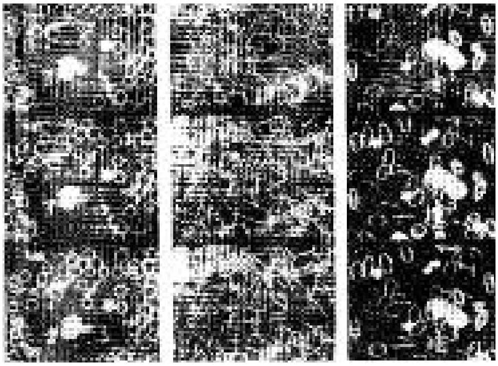


Figure 4 (left above): Comandon's apparatus, 1909

Figure 5 (above): Comandon's apparatus, 1930

Figure 6 (left): Trypanosomes and spirochetes Comandon, 1909

cationals titled *The Unseen World*, and both Gaumont and Éclair would soon follow Pathé Frères' lead.[13] Shortly after Comandon started his cinematographic studies, Charles Pathé made him director of the scientific branch of Pathé Frères, giving him a special studio and laboratory for his work. From 1909 until 1920, Comandon produced a wide variety of microcinematographic studies for Pathé Frères, which were seen by scientists and the public alike, including a 1913 study that attempted to capture Carrel's results by recording cellular growth in a tissue culture taken from the spleen and heart of a chicken embryo.[14] With this proliferation of images – after all, film, like cells, reproduces easily and multiplies at an alarming rate – the boundary between science and its popularization is hard to draw. The same films that were shown to professional gatherings of physicians and biologists were distributed in Europe by Pathé and in North America by George Kleine. The same awe that nickelodeon audiences expressed was expressed by men of science. One such observer waxed eloquent:

> *To see the micro-organism move, evolve, and revolve in the midst of normal cells, the spirochetes uncoil and undulate in the fluids which they inhabit, to see them hide behind the blood corpuscles, or in clumps of fibrin, turn, twist, and rotate inside of a red corpuscle as if in a cage – to see them apparently screw into each other as in a strange conjunction; to see trypanosomes moving back and forth in every direction, displaying their delicate undulating membrane, shoving aside the blood cells that are in their way, while by their side the leucocytes lazily extend or retract their protoplasmic pseudopods – is to realize that we are in*

the presence of an unknown world, a world of the infinitesimally small, but a world as real and as complex as that which is visible to our eyes.[15]

If any biologists at all frowned on the popular connotations of these films, they ultimately could not deny their utility, for a variety of reasons. First, the motion picture apparatus provided an unprecedented level of convenience for the cell biologist. No longer would he or she have to sit hunched over the microscope, waiting endless hours for something to happen. Now the cinematograph could watch for them – an automatic, untiring observer of an endless, constant process. Second, the film itself provided an inscription of the event, a recording that could be measured, manipulated, repeated, stored, and reproduced, much like the cells themselves. Third, the projected image amplified the work of the microscope by further magnifying the event, and thus making it a more public event. Until then, cell biology had been a lonely field – the majority of occurrences beneath the microscope could not be seen by fellow biologists or students. Now, the event could be shared (and publicly validated) on the big screen, altering the sense of cellular scale as well. Finally, the cinematograph – because it could also alter the scale of cellular time – could capture events that were not otherwise visible. Without the cinematograph, these events are difficult to observe; in a real sense they would not exist without microcinematography. With the advent of cinema, scientific events become, as Walter Benjamin noted, our "optical unconscious." The world is revealed by cinematography in the same way that our psychic unconscious is revealed by – and comes into being by virtue of – psychoanalysis.[16]

The very existence of microcinematography not only supports cell biology's research agenda, it also redirects it and influences the questions the field asks.[17] This dependent relationship is most lucid in cell biology and cytology's (cytology is the study of cells) new emphasis on cell function, which coincides with the development of microcinematography. In his 1931 article "The New Cytology," Carrel complains that, for nearly a century, cytologists have "contented themselves with the study of form, and overlooked that of function. [...] When cells are considered only as structural elements, they are deprived of all the properties that make them capable of organizing as a living whole."[18] From the invention of the microscope to the twentieth century, biologists had focused their efforts on descriptive morphology, on the anatomy and structure of the cell. With the development of microcinematography and tissue culture, the cytologist can consider the cell in relation to its environment and, most importantly, to time. Carrel again:

A tissue is evidently an enduring thing. Its functional and structural conditions become modified from moment to moment. Time is really the fourth dimension of living organisms. It enters as a part into the constitution of a tissue. Cell colonies, or organs, are events which progressively unfold themselves. They must be studied like history.[19]

Microcinematography allows this unfolding to occur, allows this new emphasis on function. In one sense, the history of microbiology replays Ernst Haeckel's maxim "ontogeny recapitulates phylogeny," the idea that the development of the individual mimics the development of the species.[20] The move from the still image of the microscope to the moving image of microcinematography is replicated in the move in cell biology from anatomy (structure, stillness) to physiology (function, movement).

Microcinematography influenced cell biology in more subtle ways as well. The language of cytologists, how they describe cell behavior, indicates a change in their conception of cell life. An early handbook on tissue culture signals this shift:

> *The observations described in this chapter emphasize the important fact that the cell is essentially dynamic. Even in the vegetative stage it has been shown that no cell organ is wholly at rest, whilst mitosis [cell division] marks a paroxysm of activity in which every structure is in almost violent movement.*[21]

This description of cell behavior, which actually occurs with almost glacial slowness, is only possible under the influence of time-lapse cinematography. The new emphasis on cell function and duration combines with microcinematography to generate notions of cell life as continuously moving, dynamic, constantly growing. And from the idea of cellular development as a constant, violent, and unstoppable process, it is only a small leap to "The Chicken That Ate Manhattan." In contrast to other types of time-lapse films, such as that of a flower blooming, cell microcinematography shows thousands upon millions of individual organisms running about chaotically, teeming with alarming life. By condensing cellular time, time-lapse microcinematography gives the impression of the expansion of cellular space.

Carrel best illustrates this cinematic connection between cellular time and space in his theory of physiological time, in which he expresses his fascination with the different rates at which our bodies heal – faster when we are young, slower when we are older. Clearly, according to him, our bodies keep time in a way that is sometimes incompatible with both our subjective conception of time and with what he calls "physical time," the time of the outside world. Inside our bodies, we function at different rates at different times. Like many of his generation, Carrel was impressed by Henri Bergson's conception of time and duration, and acknowledges his debt to the philosopher:

> *Physiological time is part of the body, while physical time is foreign to it. The present of a living organism does not pass into nothingness. It never ceases to be, because it remains in the memory and enters in the tissues. Bergson has clearly shown how the past persists in the present. The body is obviously made up of the past. While the present glides into the past, it seems to assume a spatial form. During development, an animal extends simultaneously in time and in space. Temporal extension is absolutely indispensable to spatial extension.*[22]

Operating under the sign of Bergson, Carrel articulates the uniquely modern idea that there are different types of time: physical (or clock time), psychological, and here physiological. His theory brings attention to the relativity of physiological time, relativity that Einstein and Proust have stressed in physics and literature, respectively. With Carrel, the biological idea of "growth" becomes recast as a connection between time and space; not merely as a mathematical equation – that is, a physical development of the organism taking place over time. Both Bergson and Carrel argue that time – the past – *imbeds itself* in the organism, that time eventually *becomes* space. Once imbedded, once reified, time is analyzable only through marks and traces left in space, like the rings of a tree. But cinema's ability to separate kinds of time – via time-lapse or slow motion – offers the opportunity to explore this relation between time and space as it occurs.[23] Time-lapse cinematography allowed biologists to indulge in the distinctly modern attempt to separate and examine different types of time. The exaggerations inherent in time-lapse microcinematography's depiction of cellular scale eventually influenced their conceptions of cell life and time, while simultaneously conjuring up nightmare visions of growth.

1 "'Immortality' Is Achieved in Chicken Heart," *New York Herald Tribune* (November 22, 1925), p. 26. This clipping can be found in folder 123, box 75, Alexis Carrel Papers, Special Collections, Lauinger Library, Georgetown University, Washington.

2 Alexis Carrel, "On the Permanent Life of Tissues outside of the Organism," *Journal of Experimental Medicine*, no. 15 (1912), pp. 516-528. A survey of the Carrel Papers' clipping files indicates that Carrel's remarkable experiment received considerable publicity over the years, with peaks especially in May 1912, after the initial announcement, January 1924, marking the 12th anniversary, and November 1925 after an AP wire story was picked up by dozens of papers. The *Herald Tribune* story is a result of this last wave of publicity. Alexis Carrel (1873-1944) won the Nobel Prize for Medicine in 1912 for his development of a technique for suturing blood vessels. After moving to the United States from France in 1904, Carrel joined the staff of the Rockefeller Institute for Medical Research in New York City and began his tissue culture experiments. He returned to France during WWI and, with English chemist Henry Drysdale Dakin, developed both an ideal wound antiseptic and the Carrel-Dakin method of treating wounds with the solution. Carrel returned to the U.S. in 1919.

3 See, for example, J. A. Witkowski, "Alexis Carrel and the Mysticism of Tissue Culture," *Medical History*, no. 23 (1979), pp. 279-296; and J. A. Witkowski, "Dr. Carrel's Immortal Cells," *Medical History*, no. 24 (1980), pp. 129-142.

4 Ross Granville Harrison, "The Status and Significance of Tissue Culture," in Sally Wilens (ed.), *Organization and Development of the Embryo* (New Haven: Yale University Press, 1969), p. 88.

5 Etienne-Jules Marey, *Movement*; trans. by Eric Pritchard (New York: D. Appleton and Company, 1895), p. 296. Other researchers continued to struggle with the problem of focusing and exposing at the same time: Scheffer's device (built by Oskar Messter's company) allowed the researcher to focus on the film plane itself – a fine innovation – but which required that the researcher stick his or her head into a light-tight black bag while viewing the phenomena, which was inconvenient, to say the least. See W. Scheffer, "Über mikrokinematographische Aufnahmen," *Berliner klinische Wochenschrift*, Vol. 47, no. 12 (March 21, 1910), pp. 536-537.

6 Cinémathèque Scientifique Internationale, *Les Pionniers du cinéma scientifique: Lucien Bull* (Brussels: Hayez, 1967), p. 11.

7 Julius Ries, "Kinematographie der Befruchtung und Zellteilung," *Archiv für mikroskopische Anatomie und Entwicklungsgeschichte*, no. 74 (1909), pp. 1-31.

8 For a representative sampling, see François-Franck, "La Chronophotographie simultanée du cœur et des courbes cardiographiques chez les mammifères," *Comptes rendus hebdomadaires des séances et mémoires de la Société de Biologie*, no. 54 (November 8, 1902), pp. 1193-1197; "Note sur quelques points de technique relatifs à la photographie et à la chronophotographie avec le magnésium à déflagration lente," *Comptes rendus hebdomadaires des séances et mémoires de la Société de Biologie*, no. 55 (December 5, 1903), pp. 1538-1540; "Études graphiques et photographiques de mécanique respiratoire comparée," *Comptes rendus hebdomadaires des séances et mémoires de la Société de Biologie*, no. 61 (July 28, 1906), pp. 174-

176; "Démonstrations de microphotographie instantanée et de chronomicrophotographie," *Comptes rendus hebdomadaires des séances et mémoires de la Société de Biologie*, no. 62 (May 25, 1907), pp. 964-967. Although many of his citations are incorrect, Thierry Lefebvre, "Contribution à l'histoire de la microcinématographie: de François-Franck à Comandon," *1895*, no. 14 (June 1993), pp. 35-43, is an essential introduction.

9 L. Chevroton, F. Vlès, "La cinématique de la segmentation de l'œuf et la chronophotographie du développement de l'Oursin," *Comptes rendus hebdomadaires des séances de l'Académie des Sciences*, no. 149 (November 8, 1909), pp. 806-809.

10 Jean. Comandon, "Cinématographie, à l'ultra-microscope, de microbes vivants et des particules mobiles," *Comptes rendus hebdomadaires des séances de l'Académie des Sciences*, no. 149 (November 22, 1909), pp. 938-941. See also Isabelle O'Gomes, "L'œuvre de Jean Comandon," in Alexis Martinet (ed.), *Le cinéma et la science* (Paris: CNRS Editions, 1994), pp. 78-85.

11 Anthony R. Michaelis, *Research Films in Biology, Anthropology, Psychology, and Medicine* (New York: Academic Press, 1955), p. 45.

12 Richard Abel, "In the Belly of the Beast: The Early Years of Pathé-Frères," *Film History*, Vol. 5, no. 4 (1993), pp. 363-385.

13 For more on this aspect of popular scientific cinema, see Oliver Gaycken, "'A Drama Unites Them in a Fight to the Death': Some Remarks on the Flourishing of a Cinema of Scientific Vernacularization in France, 1909-1914," *Historical Journal of Film, Radio and Television*, Vol. 22, no. 3 (2002), pp. 353-374.

14 J. Comandon, C. Levaditi and S. Mutermilch, "Étude de la vie et de la croissance des cellules *in vitro* a l'aide de l'enregistrement cinématographique," *Comptes rendus hebdomadaires des séances et mémoires de la Société de Biologie*, no. 74 (March 1, 1913), pp. 464-467.

15 Anonymous, quoted in Rudolph Matas, "The Cinematograph as an Aid to Medical Education and Research," *Transactions of the Southern Surgical and Gynecological Association*, no. 24 (1911), pp. 19-20.

16 Walter Benjamin, "Little History of Photography," in Michael W. Jennings, Howard Eiland, and Gary Smith (eds.), *Walter Benjamin, Selected Writings, Volume 2, 1927-1934* (Cambridge: The Belknap Press of Harvard University Press, 1999), p. 512.

17 I have recently found that Hannah Landecker comes to substantially the same conclusion in her "Technologies of Living Substance: Tissue Culture and Cellular Life in Twentieth Century Biomedicine," Ph.D. dissertation, Massachusetts Institute of Technology (1999).

18 Alexis Carrel, "The New Cytology," *Science*, no. 73 (March 20, 1931), pp. 297-298.

19 *Ibid.*

20 Ernst Haeckel (1834-1919), German zoologist and evolutionist, put forth his (now discredited) theories of recapitulation in a variety of books, most notably *Evolution of Man: A Popular Exposition of the Principal Points of Human Ontogeny and Phylogeny* (New York: D. Appleton and Company, 1892) and *The Riddle of the Universe at the Close of the Nineteenth Century* (New York-London: Harper & Brothers, 1900).

21 T. S. P. Strangeways, *Tissue Culture in Relation to Growth and Differentiation* (Cambridge: W. Heffer & Sons, 1924), p. 10.

22 Alexis Carrel, "Physiological Time," *Science*, no. 74 (December 18, 1931), p. 620.

23 Carrel's own summation of the importance of cinematography for cytology can be found in an unpublished manuscript, "Le mode de locomotion des cellules des tissues et du sang étudié par la cinématographie," folder 92, box 22, Alexis Carrel Papers, Special Collections, Lauinger Library, Georgetown University, Washington.