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Obituary

Jesse Leonard Greenstein (1909–2002)

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Bruce Medallist Jesse Leonard Greenstein died 21 October 2002, three days after falling and breaking a hip at his home in a retirement community in Duarte, California. His wife, Naomi Kitay Greenstein, whom he met in 1926 and married in 1934, had died a few months earlier, ending a long decline into Alzheimer's disease. They are survived by sons George S. Greenstein (an astronomer at Amherst College, who, approximately, followed his father's work on white dwarfs by studying neutron stars) and Peter Greenstein, of Oakland, California.

Greenstein can reasonably be said to have put Caltech on the map in astronomy and the bottom on the HR diagram. Twenty years after his arrival in Pasadena, the first faculty member hired as an astronomer, with the charge to build up a teaching and research program, it had become one of the five highest ranked in the country. When he published his first white dwarf paper (Greenstein 1954a), only a handful of these faint stars had even approximately known colors, luminosities, masses, or spectral types. By 1959, he was a recognized expert, writing the chapter on "Spectra of Stars below the Main Sequence" for the *Stars and Stellar Systems* ("Kuiper") compendium (Greenstein 1960), as well as editing the *Stellar Atmospheres* volume. By the time he stopped observing faint stars in the 1980s, he had added data on several hundred white dwarfs and large numbers of subdwarfs, faint red dwarfs, and related types.

His contributions in this field continued long past normal retirement age, and included the demonstration (Greenstein 1984a) of the extreme narrowness of the locus of well-observed white dwarfs in a color-magnitude diagram (implying a very narrow range of masses for most of them), and the discovery (Greenstein 1984b) of the Lyman-alpha line in the magnetic white dwarf Grw +70°8247, which permitted accurate calculations by Greenstein and others of how the multiple degenerate lines of hydrogen split up in strong magnetic fields and wander all over wavelength space. Components that remain at about the same wavelength over a range of fields (stationary lines) can thus be used to measure surface fields in excess of 10^8 G (Forster et al. 1984; Angel, Liebert, & Stockman 1985; Greenstein, Henry, & O'Connell 1985).

But the name Greenstein will perhaps be remembered longest in the astronomical community for the coordination of the

National Academy of Sciences study published in 1972 as "Astronomy and Astrophysics for the 1970s" (the Greenstein report), which was the first of these decadal studies to include all of astronomy (except planetary science) both ground-based and space-based and at all wavelengths, and arguably the last to have all of its recommendations implemented in a reasonably timely fashion. The highest ranked facility was the Very Large Array (of radio telescopes in Socorro, New Mexico, still, after several upgrades, a front-line instrument).

Greenstein received many honors for his scientific work, among them the American Astronomical Society's Henry Norris Russell Lectureship in 1970, the Astronomical Society of the Pacific's Catherine Wolfe Bruce Medal in 1971 (see Weaver 1971), and the Royal Astronomical Society's Gold Medal in 1975. He also accepted, with great grace, the curious distinction of being the first person ever defeated in a modern election for the presidency of the American Astronomical Society, whose nominating committee had put forward only a single candidate for the office until 1972–1973. The change was part of the re-organization that also included the establishment of divisions. He had previously served the AAS as vice-president (1955–1957) and councillor (1947–1950), and the International Astronomical Union as president of Commission 29 (stellar spectra) from 1952 to 1955.

Jesse was born in New York on 15 October 1909, one of two children in a family that had definitely prospered after his grandfather brought them to the United States in 1888. He attended the Horace Mann School for Boys starting at age 11, skipping through the grades to start his college career at Harvard at 16. Access at home to a small telescope (a gift from that same grandfather), a prism spectrograph, amateur radio equipment, and scientific books had already begun to prepare him for a life in astronomy. But, after receiving an AB in 1929 and an AM in 1930, and being prevented by illness from taking up a fellowship at Oxford, Jesse returned to the Greenstein family business in manufacturing and real estate to help see it through the Depression. In the process, he learned how to communicate with people from business and industry with a skill that remains rare in academe and that proved invaluable in his service to astronomy and to the California Institute of Technology. He also learned how to handle money, what poverty could do to good people, and the unattractive nature



FIG. 1.—Photograph of Jesse Greenstein, taken in about 1966 by Leigh Wiener. It is reproduced with permission and courtesy of the Archives, California Institute of Technology.

of politics of extremism. From the Mann School, he carried away an abiding love of good, contemporary literature and the ability to read Latin.

Greenstein's (1930) AM thesis attempted to establish a color-temperature scale for the O and B stars, which Cecilia Payne had already noted sometimes seemed very cool, given the high ionization and excitation temperature implied by their line spectra. He concluded that color temperatures were lowest for stars in the direction of Orion and toward the Galactic center. Sadly, he explained this reddening as a seasonal systematic error in atmospheric extinction. It was, of course, a pre-discovery of systematic interstellar extinction and reddening, as published later that year by Robert Trumpler (1930) and considered off and on, but rejected by most astronomers at least as far back as Jacobus Kapteyn in 1908.

A search for variable stars in the globular cluster M3 (on plates taken by J. Schilt) enabled Greenstein (1935) to keep his hand in astronomy while out of graduate school. Payne (later Payne Gaposchkin), the first woman to receive a Harvard PhD, was the person to whom he became closest in the early Harvard years, as she turned more of her attention to variable stars. Her underutilized brilliance and resulting frustration undoubtedly colored his later views on women in science, which were decidedly mixed. He claimed in principle to be opposed and was the program director when the first, eventually successful, female applicant for an astronomy PhD was turned down on the grounds that women would not be able to tolerate the long, cold nights observing on mountain tops. But, in practice, four of the first six women to receive Caltech astronomy PhD's (including the present author) carried out either their second-year research projects or their dissertations under his guidance.

Jesse, by then married to Naomi, returned to graduate work

at Harvard in 1934, with a \$400 scholarship, to learn atomic physics from Donald Menzel and star counting from Bart Bok. He completed a dissertation (Greenstein 1937, 1938a) on the properties of dust and dust clouds and the interstellar reddening law, analyzing data he had obtained himself, in 1937. This combination of observing and examining data in light of the best available physics at any given time remained characteristic of his work thereafter.

Greenstein was probably the first conventionally trained astronomer to take radio astronomy seriously. Soon after Grote Reber's 1933 discovery of "cosmic static," he and Fred Whipple co-authored the first attempt at theoretical interpretation, finding that the only emission mechanism they, or anyone else at the time, could think of failed by a factor of 10,000 to match the observed brightness (Whipple & Greenstein 1937). In the 1940s and 1950s, he showed that conventional emission by hot gas failed equally spectacularly to match the radio waves coming from sources we now recognize as supernova remnants and radio galaxies, and he was in large measure responsible for the initiation of a radio astronomy group at Caltech, initially bringing John Bolton from Australia to head it.

A National Research Council Fellowship for 1937–39 (with a stipend of \$2,200, a considerable increase over the \$700 for his last year in graduate school) enabled the Greensteins to go to the Yerkes Observatory at the University of Chicago, where Otto Struve was rapidly reshaping its structure to include theoretical astrophysicists (of whom S. Chandrasekhar was the best known) as well as observers. Following this fellowship, he became a faculty member at Chicago and a staff member of the brand-new McDonald Observatory in Texas (1939–1947), helping to design an optimal spectrograph for work on extended objects, with which he obtained the spectral energy distribution of M31 for use in determining K -corrections to galactic apparent brightnesses (Greenstein 1938b), and, in collaboration with Louis Henyey, showing that H II regions were really just the peaks in H-alpha emission to be found almost all over the sky (Greenstein & Henyey 1938). Other important work during that period included (a) demonstration that interstellar dust grains were made of common substances like silicates and ices and (b) the second-ever detailed analysis of a star (Upsilon Sgr; Greenstein 1940) whose chemical composition differed from the normal mix, originally established by Payne, found in the Sun and elsewhere. The first such star was R CrB, studied by Louis Berman. Such studies of anomalous stars were keystones in the 1957 achievement of understanding how all the other elements were produced in stars from hydrogen and helium (Cameron 1957; Burbidge et al. 1957).

Greenstein's war work, some of it with Henyey, Daniel Popper, and George van Biesbroeck, was in optical design for gunsights, periscopes, fast lenses, and so forth, needed because US industry had imported most optical components from Germany since the 1920s. Spin-offs included a fast system for



FIG. 2.—The Yerkes Observatory (Williams Bay, Wisconsin) staff in 1946. Greenstein, with moustache, is seated between the director, Otto Struve (in three-piece suit), and Gerard Kuiper in the “power row,” which also includes S. Chandrasekhar (third from right), Louis Henyey, George van Biesbroeck (with beard), and William W. Morgan (fourth from left). Those who joined Jesse in Pasadena over the next few years include, in the front row, Guido Munch (also with moustache) and, in the back, Arthur Code, Armin Deutsch, and Irene Hansen (who crossed the country as Irene Osterbrock, wife of Donald). John Phillips, Victor Blanco, and Arne Sletteback are also spotted. Not all of the women were support staff; the front row includes astronomers Nancy Grace Roman and Anne B. Underhill. (Photograph courtesy of Yerkes Observatory, Richard Dreiser.)

X-ray fluoroscopy of the digestive system and wide-field optics that could be used both for motion picture projection and for photographing the Galaxy as a whole, showing its edge-on spiral structure. Jesse also learned about another new class of people and how to interact with them, the military, which was of importance in building up a post-war base of funding for astronomy from the Office of Naval Research, which, for many years, supported his work on faint stars, and from the Air Force Office of Scientific Research, which supported the work of his group on stellar abundances from 1957 to 1970.

In 1948, Greenstein accepted an appointment as the first professor of astronomy at the California Institute of Technology, which included the responsibility for creating a graduate school in the subject, recruiting the faculty for it, and assembling the staff for the newly opened and Caltech-owned Observatory on Palomar Mountain. Several of his post-war associates at Yerkes, including Guido Munch, Donald Osterbrock, Armin Deutsch, and Art Code, were soon also part of the Pasadena/Palomar scene. The first handful of PhDs coming out of the new program included Helmut Abt (editor



FIG. 3.—The staff of Hale Observatories in 1966. Greenstein, still with moustache, is again seated in the power row. Astronomers he had brought from Yerkes were Guido Munch (*far right*) and Armin Deutsch (seated next to Henrietta Swope). H. C. (Chip) Arp (next to Deutsch) and Allan Sandage (*standing, fifth from left*) received Caltech PhD's early in the Greenstein years and remained in Pasadena. Observatory director Horace W. Babcock is between Arp and Greenstein. Greenstein did not encourage Robert Kraft (*seated right*) to do graduate work at Caltech, but changed his mind later. Swope, who appears in a subset of the staff photos from the late 1950s and early 1960s, is the only woman to do so in the first 70-some years of the Observatories' existence. (Photograph courtesy of the Observatories of the Carnegie Institution of Washington.)

emeritus, in succession to Chandrasekhar, of the *Astrophysical Journal*), Halton (Chip) Arp (discoverer of novae, interacting galaxies, and, perhaps, non-cosmological redshifts), Allan Sandage (plotter of the first globular cluster HR diagrams to show the main sequence and blue stragglers and custodian for half a century of the Hubble constant), John Mathis (maven of nebulae), George Abell (compiler of catalogues of clusters of galaxies and of planetary nebulae and author of the quintessential non-major introductory astronomy textbook), William Tifft (of quantized redshifts), and George Wallerstein

(the 2002 AAS Russell Lecturer for work on stellar compositions and populations).

Following the move to Caltech, Greenstein became increasingly polarized between relatively private research and very public administration and service. On the research side, the discovery of interstellar polarization by Hall (1949) and Hiltner (1949) led Davis & Greenstein (1951) to propose that it was the result of scattering by non-spherical dust grains with their spins aligned by magnetic fields along the spiral arms of the Milky Way (making it the third entity in the universe, after

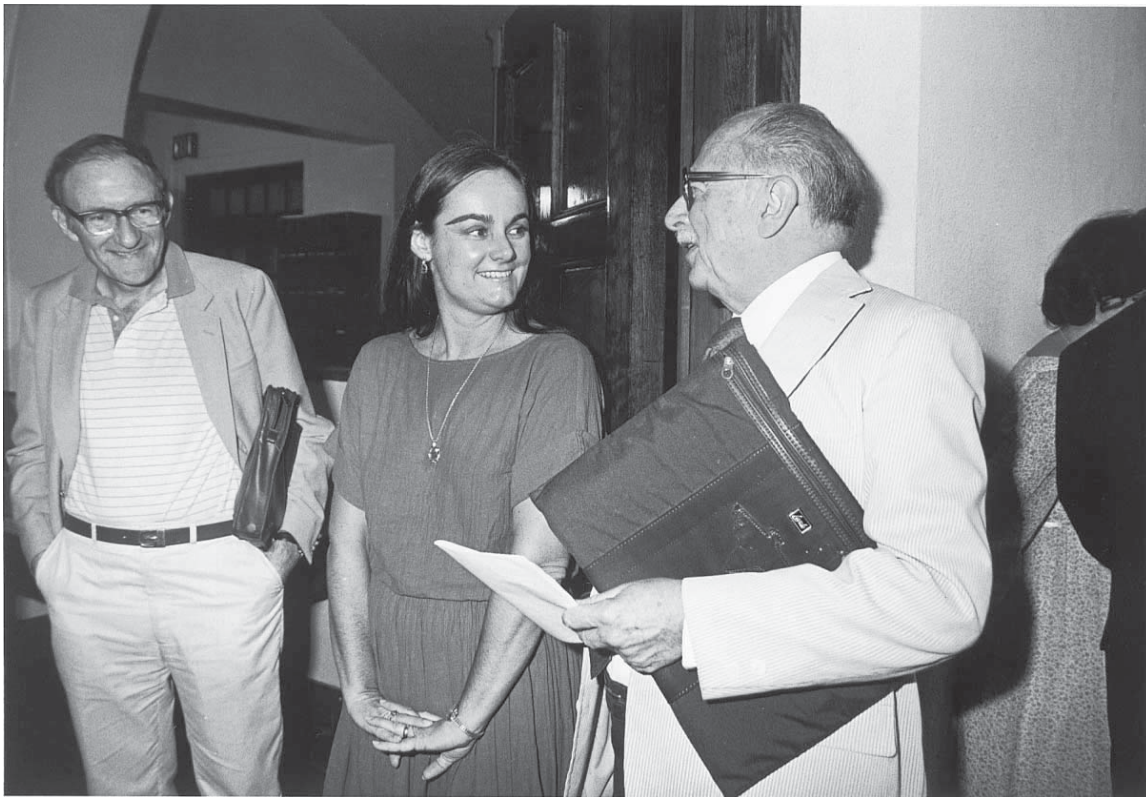


FIG. 4.—Greenstein with Robert F. O’Connell (of Louisiana State University), who was also involved in the identification of hydrogen lines in white dwarfs with very strong magnetic fields, and the present author, at a fall 1984 symposium on faint stars, celebrating Greenstein’s 75th birthday. The dark head on the far right is Judith Cohen, who co-organized the symposium. She was also one of Greenstein’s PhD students at Caltech and is now a faculty member there. (Photography courtesy of the California Institute of Technology.)

the Earth and Sun, to have a magnetic field). Jesse much later said that it had been talks by Fermi about cosmic-ray acceleration at Chicago shortly before he left that had put magnetic fields in the field of his gunsights. Other contributions during this period included (a) the recognition of the reaction $C^{13}(\alpha, n)O^{16}$ as an important source of neutrons for *s*-process nucleosynthesis of heavy elements (Greenstein 1954b), (b) analysis of metal-poor stars (Helfer, Wallerstein, & Greenstein 1959, and Aller & Greenstein 1960 are among the most-cited of his 60 papers on stellar abundances), and, of course, (c) the work on white dwarfs and other faint stars, which cranked into high gear with the first large samples of such stars with good measured apparent magnitudes, colors, and spectral types (Eggen & Greenstein 1965a, 1965b, 1967; Greenstein 1976, 1979, 1980), and continued with discovery of their typically slow rotation, thoughts on the rarity of very faint white dwarfs (Greenstein 1969), and the measurement of the first large sample of gravitational redshifts, which you could not reasonably expect me to leave out (Greenstein & Trimble 1967, Trimble & Greenstein 1972).

And then there was Jesse’s not entirely happy (Greenstein 1984c) involvement with quasars. A few high-latitude faint blue

objects, like Ton 202, were already in his collection of presumed white dwarf spectra to be analyzed some day (and he later was frequently to be heard saying that his assumption of luminosities for them of $10^{-3} L_{\odot}$ or thereabouts was surely a world record error in comparison with the $10^{12} L_{\odot}$ truth, exceeding even the large failures of his early thermal calculations for the radio flux from the Milky Way). But the nadir came with his 200-inch prime-focus spectra of 3C 48, an object more or less inherited from Allan Sandage, who had first observed it in 1960. A blue continuum, of course, and broad emission lines at what seemed to be the rest wavelengths of O VI and He II. And a paper saying so, along with other proposed identifications for features in magnetic white dwarfs and supernovae, based on anomalous compositions for all, had already been submitted to the *Astrophysical Journal* when the breakthrough identification of Balmer lines in the spectrum of 3C 273 was made by Schmidt (1963). The moment Greenstein saw the lines in 3C 273 as being hydrogen at $z = 0.16$, he recognized that the 3C 48 features must be the same lines at $z = 0.37$, and Greenstein & Matthews (1963) appears as part of the discovery package of papers saying so. Fred Hoyle had been given a glimpse of the 3C 48 spectrum the year before,

and later felt that he could have solved the puzzle if given more time to study it. Unfortunately, we cannot go back and run the film with the alternative story line. The paper by Greenstein & Schmidt (1964), showing that the redshifts could not be gravitational (because you couldn't have enough low-density gas at sufficiently uniform potential to make the emission lines) followed, and marked more or less the end of the quasi-stellar Greenstein.

The sum total of these research endeavors was a bibliography that gained by about 100 papers per decade from 1949 to 1979. Simultaneously, the public Greenstein delivered about 75 named lectures, served on 50 major committees (peaking at more than 20 simultaneously), dedicated three buildings in one year, and, of course, coordinated the Greenstein report. He chaired the Caltech faculty board (1965–1967) during years that he was also on the Harvard Board of Overseers (1965–1971) and the National Academy of Sciences Committee on Science and Public Policy. He had advised against the use of nuclear weapons in Korea (advice much appreciated by George Wallerstein, who was stationed there at the time) and in favor of siting the NASA Infrared Telescope Facility on Mauna Kea and the Space Telescope Science Institute in Baltimore. Among the sadder lessons that he learned is that scientists get bored too quickly with the tasks involved in establishing new programs and new facilities, and that “someone within the bureaucracy must carry the burden of internal persuasion, of interminable briefings, and hearings, with little personal reward” (Greenstein 1984c).

The service-mode Greenstein was also a successful fund raiser for Caltech, for Harvard, for Palomar (including the reconditioning of the 60-inch with private funds), and for other public institutions, especially the Pacific Asia Museum in Pasadena, which has become the recipient of much of the Greensteins' extensive collection of Japanese art.

In between the public servant and the private researcher came the Greenstein of song and story. The most notable song was sung by a cheeping egg, created by two graduate students as a prototype of what they hoped would be a successful commercial product. The first example was installed in Greenstein's office during his absence. A few days later, there came from a corner of the basement office occupied by the students a much lower, more sinister cheep. Tracking it down, they found the egg, modified by an extra capacitor to give it a bass voice, accompanied by a note explaining that it had been redshifted. This was, of course, the quasar era, and, though Jesse's interaction with quasars was a spotty one, when asked to select a paper as a highlight of the century, he picked Greenstein & Schmidt (1964), and his commentary (1999) was his last published paper, 69 years after his first.

The stories are more numerous and include his enshrinement as “Jesse the White Dwarf” in a Captain Corona comic book, his appearance in the Caltech Play Reading Group production of *BREAKTHROUGHS!* as the Director of the Institute for the Absorption of Federal Funds, and a graduate student skit

(“The Plate Flaw That Destroyed the Earth”) in which a group of intrepid astronomy graduate students must travel back in time to fix an emulsion batch at Kodak that produced the asteroidal plate flaw. They encounter the baby Jesse, still in his crib, but smoking a cigar, looking at spectroscopic plates and muttering, “goo goo, ga ga, subdwarf, Calcium II...” His voice was persuasive even as the news announcer Walter Crankcase in the student film, “The Turkey That Ate St. Louis,” in which he was required to intone, “...and the giant gobbler is busy masticating the city of St. Louis, and the Sierra Club has declared it an endangered species.”

Many of the other items most fondly associated with Jesse by his colleagues are now also endangered species. The cigars smoked in his office, with the ashes drifting over chart paper, manuscripts, and spectroscopic plates alike. The ashes always seemed to have blown off without setting anything afire. The communal astronomy lunches at the Caltech Athenaeum, where he could be found estimating answers to rather complex astronomical queries on the paper napkins. The Athenaeum still provides paper napkins at lunch, but the astronomers no longer customarily eat together. Indeed, the 200-inch prime focus plates, less than an inch long, themselves linger only in memories and old file drawers. Jesse himself gladly switched to the more efficient electronic light-detecting devices when they became available, and developed a fondness for on-line data processing, plotters, and such. But, he felt it important to keep track of the plates. Thus, one day, when loaning one to a student, he explained, “I'm always forgetting who I've loaned plates to”; so he carefully wrote the student's name on the plate envelope and handed it back to him.

Greenstein's hobbies were of varying seriousness. His Japanese art collection was world class, and he sensibly displayed subsets in his home in rotation, so as always to be able to appreciate them anew. But an attempt to raise Burmese cats resulted in a student being paid for housesitting in Burmese kittens. His feeling for fast, sporty cars was more a passion than a hobby. He long held the time record for trips from Pasadena to Palomar, 112 minutes, set in a Mercedes, until Olin Eggen and his Triumph bested it by 10 minutes. Greenstein's test driving of potential replacements left salesmen shaken and shaking. Wavelengths were another passion. He knew an incredible number of spectral features to four significant figures and knew what sorts of objects they should appear in and at what intensity. This once enabled him to recognize an extremely cool (M9.5) star with unprecedentedly strong Balmer emission lines in the spectrum of an object rejected as a quasar candidate. This was in 1990, so the cigar ash fell on a printout rather than a plate.

The Greensteins regularly invited students and postdocs into their home, and virtually every one of his younger colleagues has some story to tell of an unexpected kindness or sympathy extended. To quote a letter read at his memorial service, “Jesse was, well, Jesse.”

Jesse Greenstein was head of the Caltech astronomy graduate

program at the time I was accepted into it as the third woman and first not part of a package deal with a husband. I remain grateful for that acceptance and for his guidance on my second-year research project. Other former Greenstein students, co-authors, and colleagues who responded to a request for information, insights, and stories include Saul Adelman, Kurt Anderson, H. C. (Chip) Arp, Todd Boroson, David Branch,

Marshall Cohen, Alex Filippenko, James Gunn, Dan Harris, Larry Helfer, John Huchra, Susan Kayser, Robert Kraft, John Landstreet, Richard Larson, Guido Munch, Lee Mundy, Robert O'Connell, Beverly Oke, Pat Osmer, Bob Parker, Douglas Richstone, Jeff Scargle, Don Schneider, Steve Shectman, Seth Shostak, Hy Spinrad, William Tifft, Larry Trafton, Richard Wade, George Wallerstein, and Steve Willner.

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