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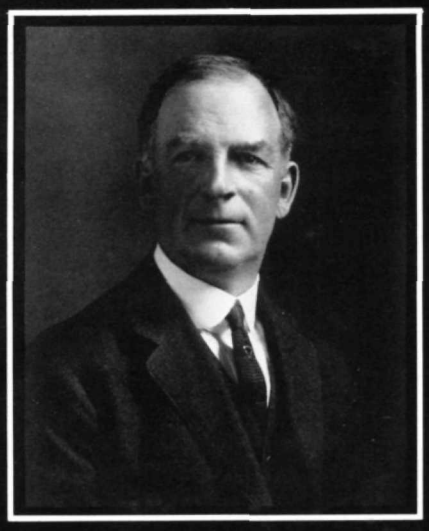

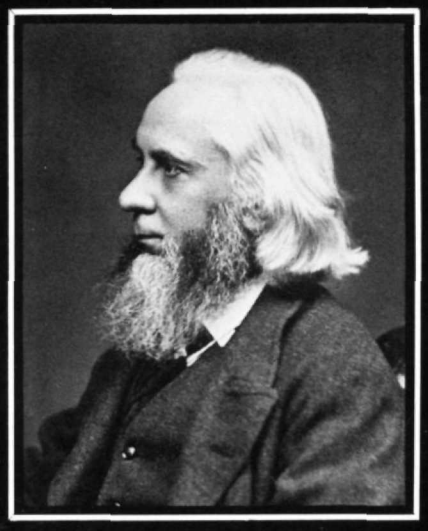

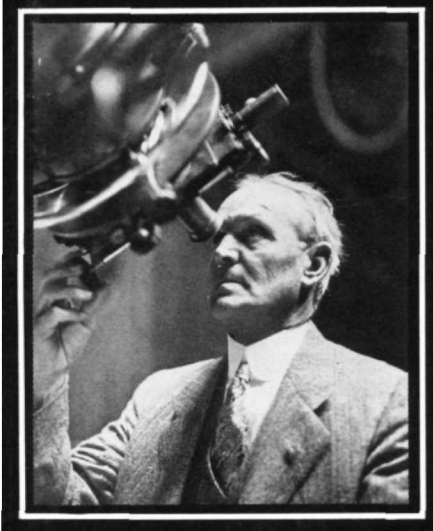

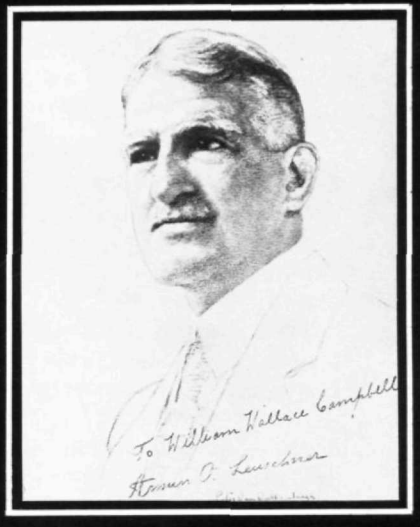

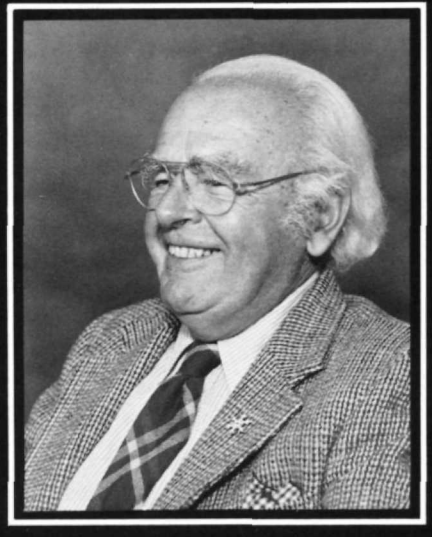

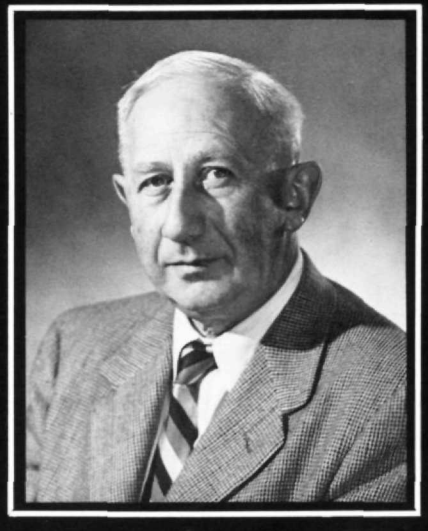

In this issue: **The Bruce Medalists**

A Brief History of the Bruce Medal of the A.S.P.

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The Bruce Medal. (A.S.P. archives.)

Astronomers have always liked medals. Perhaps it is to make up for the lack of pecuniary rewards for seeking the secrets of the universe. The Royal Astronomical Society began bestowing its Gold Medal in 1824, and its counterparts in Paris and Berlin have long made similar awards. So it should not be surprising that the institution of a medal was one of the first items to be considered at the founding of the Astronomical Society of the Pacific.

Speaking to the newly formed Society — six Lick Observatory astronomers and thirty-four San Francisco area laymen — at its first meeting March 30, 1889, founding President (and Lick Observatory Director) Edward S. Holden presented among his list of objectives for the Society:

> It is tolerably certain that the time has not yet come for us to perform another function of an astronomical society. I refer to the foundation and to the bestowal of the medal of the society as a reward for astronomical work of the highest class. It is certain, however, that in the future, if such a medal were founded, and if it were bestowed only for work of the highest class. . .that the responsibility of the award would constitute an important stimulus to the society itself, which would have to judge of the merits of the various works proposed to be rewarded; and that such awards, if always bestowed with judgment and discretion, would soon make the voice of our society respected everywhere. In fact, there is probably no way in which the society could do more good, and in which it could be more quickly influential, than by the bestowal of its medal upon those astronomers whose works fully deserve it.

A.S.P. founder Edward S. Holden. (Photograph from the A.S.P. archives.)

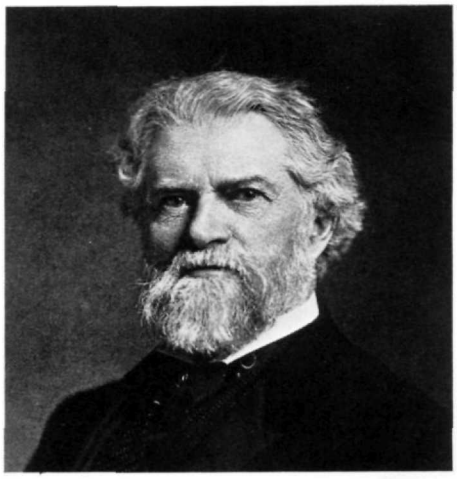
Whatever his faults,[1] Holden was an honest man. Isolated from the centers of astronomy in Europe and the eastern United States, he wanted to win the respect of the scientific community. He hoped that the A.S.P. would bring financial support for astronomy from its lay members, and that some of them would also provide political support in his struggles with the Regents of the University of California. The medal, if he could establish it, would bring the A.S.P. — and with it West Coast astronomy — to the attention of astronomers everywhere. He readily admitted that he expected the medal to bring more honor to the A.S.P. than to its winners — at least initially.

But first he had to find the money.

Catherine Wolfe Bruce

Catherine Wolfe Bruce was an accomplished woman who devoted her life to travel, literature, languages, and art. She translated, illustrated, and privately published a medieval Latin hymn. She donated $50,000 to establish a branch of the New York Public Library in memory

1. For an account of Holden's difficult relations with others see the article by Donald Osterbrock in the Sep/Oct 1978 issue of *Mercury*.



Simon Newcomb, the first Bruce Medalist. (Photograph courtesy of the Mary Lea Shane Archives of Lick Observatory and from the A.S.P. slide set "Astronomers of the Past".)

of her father, a Scottish immigrant who became the most successful type-founder in nineteenth century America (and who further enlarged his fortune in New York real estate.) She lived a quiet life in New York with her sister, and, although it has been suggested that the stars had long fascinated her, she had no direct connection with astronomy until the age of seventy-two.

Edward C. Pickering in about 1895. Pickering was Catherine W. Bruce's close advisor during the Bruce Medal's establishment; he was also the seventh winner of the Medal. (Photograph courtesy of the Mary Lea Shane Archives of Lick Observatory and from the A.S.P. slide set "Astronomers of the Past".)

It was then, in 1888, that she read a magazine article in which Simon Newcomb, the most acclaimed astronomer of the age, suggested that most significant astronomical discoveries had already been made. She wrote Newcomb in protest: "Such a blow from a friend! I thing we are beginning — else why set to work [on] Photography, Spectroscopy, Chemistry and soon but perhaps not in this generation Electricity. . .The world is young." At about that time she read a circular by Edward C. Pickering, director of the Harvard College Observatory, asking for a donor to give $50,000 to build a telescope specially designed to make a photographic survey of the entire sky. On her own initiative, Miss Bruce gave Pickering the money.

This was the beginning of a long relationship. In her remaining eleven years, most of them spent as a reclusive semi-invalid, Miss Bruce gave a total of $174,275 to astronomers, much of it channeled through Pickering.[2]

Most of her gifts were of $500 or $1000 to enable an astronomer to hire an assistant for a year or to purchase a piece of auxiliary equipment, but a few were of $10,000 or more. About half the recipients were Europeans. In Heidelberg, a grateful Max Wolf, recipient of one of the largest awards, named the first asteroid discovered by photography "Brucia" in her honor. In all of her giving, Miss Bruce relied on Pickering for advice.

In 1890, and again in 1895, Holden received $500 from Catherine Bruce for use at the Lick Observatory. In 1896 she gave him $1000 to buy a large comet-seeker and photometers for visual use with the 36-inch refractor. So it was natural for him to turn to this generous benefactor to establish a medal for the A.S.P., and it was equally natural for her to ask Pickering for his opinion. Her sister Matilda wrote the Harvard director on March 8, 1897:

> My sister appears to look with favor upon Prof. Holden's idea of giving "a gold medal not oftener than once a year to that Astronomer whose work has most deserved it." Does that mean that it will necessarily be given every year? Some years there will be no remarkable work. The decision seems to rest with the Officers & Directors of the Astronomical Society of the Pacific. Are they likely *ulways* to bestow it intelligently?
>
> Apparently some gold medals are more prized than others. I suppose on account of the care used in awarding them, or their rarity. Prof. Holden mentions *about* $2750 as the sum required. Perhaps he knows that that is really the exact sum.
>
> If I understand the large spirit of Astronomers this medal may be gained by any astronomer of no matter what country. Is it not so?

Pickering assured her that the Society could be relied upon. Within a month Matilda Bruce wrote back:

> She is willing to give the $2750. She prefers that the medal be international as in accord with the generous spirit of Astronomy. As she supposes our instruments & opportunities of observation on this side of the Atlantic are as good as those of the old World our Astronomers would be at no disadvantage. As you say a medal should only be given "when a suitable candidate can be found," so should not be restricted to "the work done between certain dates." My sister would like the medal to be as prized & sought for as much as those of Great Britain or France.

The Establishment of the Medal

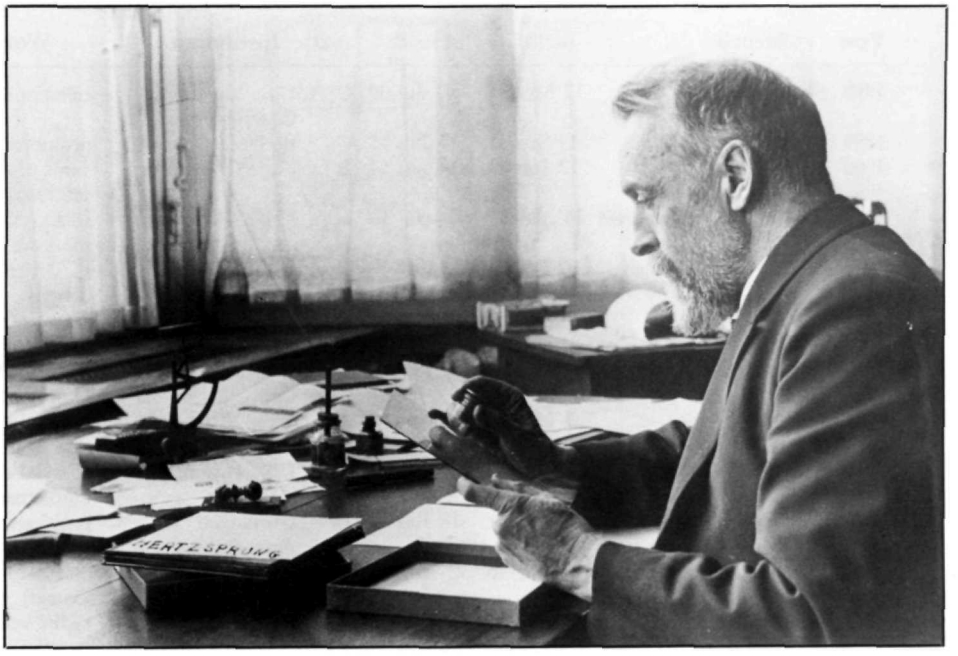
At Miss Bruce's request Pickering drew up the rules for the award of the medal. It was specified that each year the directors of six observatories, three American and three foreign, would be asked to nominate from one to three candidates "worthy to receive the medal for the ensuing year." The A.S.P. Board of Directors quickly announced that they would construe that phrase to cover "services rendered during the lifetime of the nominee." It was also specified that the award would be "international in character, and [might] be awarded to citizens of any country and to persons of either sex." The A.S.P. Board could select any of the candidates nominated by any of the observatory directors or might choose to make no award in a given year. No one could receive the award twice. In any year the Board of

2. A complete list of her contributions appeared in *Popular Astronomy*, vol. 8, p. 235 (May 1900) as part of a memorial tribute by W.W. Payne.

Directors might change one, and only one, of the six observatories, and then only by unanimous vote.

Of the $2750, $250 went for making dies, and the interest on the remainder was to pay for the gold medal and its engraving each year.

Initially the six observatories whose directors were asked to nominate candidates for the medal were Harvard, Yerkes, and Lick in this country, and Greenwich, Paris, and Berlin abroad. The First World War led to the substitution of the observatory of Cordoba for Berlin in 1919, and the Second World War caused Stockholm to replace Paris in 1944. The third change came in 1957 when Cordoba was replaced by Mt. Stromlo Observatory in Australia. In 1965 the A.S.P. Board adopted what amounts to a rotation system. Since then an observatory has been changed every year or two, so that a great many of the world's observatories, from the Crimean Astrophysical Observatory to the National Observatory of Mexico, have now participated. The wording of the request has also changed. In these more democratic times, observatory directors are asked to consult their staffs in making nominations.



Ejnar Hertzsprung, 1937 Bruce Medalist. (Photograph courtesy of the Niels Bohr Library of the American Institute of Physics and from the A.S.P. slide set "Astronomers of the Past".)

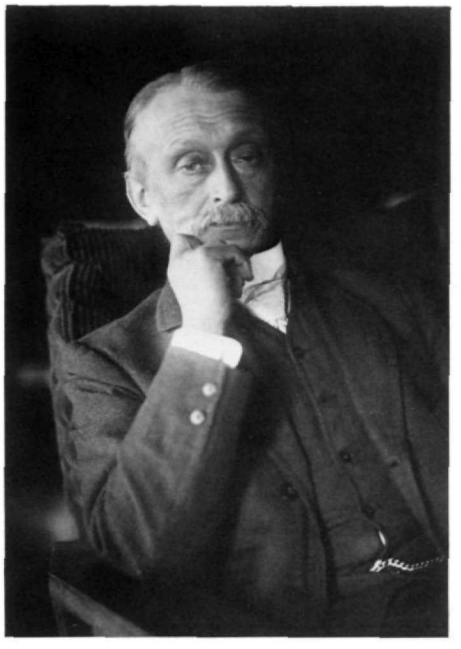
The Winners

A complete list of the seventy-eight Bruce Medalists through 1985 is given in the table. It is difficult to say whether the medal is "as prized & sought for as much as those of Great Britain or France," but it is clear that the medal has been awarded to most of the major figures in astronomy of the last century. The great names are there: Huggins, Eddington, Russell, Hertzsprung, Hubble, Shapley, and Chandrasekhar. The work they have done has greatly changed our understanding of the universe and its contents.

It must have been difficult for the early A.S.P. Boards, most of whose members were San Francisco businessmen, to judge the nominees of the observatory directors. The first year was easy: four of the six directors nominated Simon Newcomb.[3] The retired head of the Nautical Almanac Office of the U.S. Naval Observatory was already the most honored astronomer in the world. He had produced the most accurate tables known for predicting the motions of the Sun, Moon, and planets; he had measured the speed of light, the distance to the Sun, and the constant of precession, and he was widely considered one of the greatest scientists of all time. It was a safe choice.

Newcomb was an American (he had come to the U.S. from Canada at eighteen, reversing the emigration of his grandparents), but the next five winners were Europeans. Medals have now been awarded to citizens of ten countries, and Miss Bruce was right: "our instruments & opportunities of observation on this side of the Atlantic are as good as those of the old World," and "our" astronomers have been at no disadvantage. After a slow start, Americans won eleven of the first twenty-six medals, thirteen of the next twenty-six, and sixteen of the last twenty-six. But U.S. astronomy has been greatly enriched by immigrants: ten of the American medalists were born abroad.

Another fact that stands out from the table is the enormous productivity of the Dutch school of astronomers begun by Kapteyn. Five Dutch astronomers, including the Belgian-born Minnaert, have been Bruce Medalists. In addition there is Hertzsprung, Kapteyn's son-in-law,



Jacobus Cornelis Kapteyn, the 1913 Bruce Medalist. In his address awarding the Medal in 1913, A.S.P. President Heber D. Curtis said of Kapteyn that "His observatory has been his desk and a room filled with instruments for measuring photographic plates; his subject matter photographic plates and observations of star positions made by other astronomers; his tools the methods of mathematical analysis." (Photograph courtesy of the Mt. Wilson Observatory and from the A.S.P. slide set "Astronomers of the Past".)

3. Yerkes Observatory Director George Hale, then 29, made only one nomination: James Edward Keeler. The nomination of the 40-year-old Allegheny Observatory spectroscopist expressed Hale's great admiration for astrophysics in general and Keeler in particular, and it might also have indicated his disdain for the "old astronomy" exemplified by Newcomb. For more on Keeler see Donald Osterbrock's article in *Mercury*, Mar/Apr 1985.

The Bruce Medalists (1898-1985)

Year	Medalist	Birth	Death	Nat[1]	Institution	Work	Type[2]	Age	Ref[3]
1898	**Simon Newcomb**	12 Mar 35	11 Jul 09	C/A	U.S. Naval Observatory	celestial mechanics	T	63	PASP 10,49
1899	**Arthur Auwers**	12 Sep 38	24 Jan 15	G	Berlin	positions & motions of stars	O	61	PASP 11,61
1900	**David Gill**	12 Jun 43	24 Jan 14	B	Cape Observatory	sun's distance, positions & motions of stars	O	57	PASP 12, 49
1902	**Giovanni V. Schiaparelli**	14 Mar 35	4 Jul 10	I	Milan Observatory	solar system descriptions, stellar motions	O	67	PASP 14,37
1904	**William Huggins**	7 Feb 24	12 May 10	B	Upper Tulse Hill Obs, London	spectroscopy of stars, nebulae, comets	O	80	PASP 16,49
1906	**H. Carl Vogel**	3 Apr 41	13 Aug 07	G	Potsdam Obs.	spectroscopy, radial velocities of stars	O	65	PASP 18,101
1908	**Edward C. Pickering**	19 Jul 46	3 Feb 19	A	Harvard College Obs.	photometry, spectroscopy, photography	A,O	62	PASP 20,55
1909	**George W. Hill**	3 Mar 38	16 Apr 14	A	West Nyack, New York	celestial mechanics	T	71	PASP 21,51
1911	**J. Henri Poincaré**	29 Apr 54	17 Jul 12	F	University of Paris	celestial mechanics, mathematics	T	57	PASP 23,73
1913	**Jacobus C. Kapteyn**	19 Jan 51	18 Jun 22	D	Groningen Astronomical Lab.	positions, motions, distances of stars	T	62	PASP 25,15
1914	**J. Oskar Backlund**	28 Apr 46	29 Aug 16	S/R	Pulkovo Observatory	celestial mechanics (Encke's Comet)	T	68	PASP 26,15
1915	**W. Wallace Campbell**	11 Apr 62	14 Jun 38	A	Lick Observatory	radial velocities, spectroscopic binaries	O,A	53	PASP 27,153
1916	**George Ellery Hale**	29 Jun 68	21 Feb 38	A	Mt. Wilson Observatory	sun, spectroscopy, observatories	A,O	48	PASP 28,12
1917	**Edward Emerson Barnard**	16 Dec 57	6 Feb 23	A	Yerkes Observatory	photography of Milky Way, comets, Amalthea	O	60	PASP 29,77
1920	**Ernest W. Brown**	29 Nov 66	22 Jul 38	B/A	Yale University	celestial mechanics (moon's motion)	T	54	PASP 32,85
1921	**Henri A. Deslandres**	24 Jul 53	15 Jan 48	F	Meudon Observatory	spectroscopy, sun	O	67	PASP 33,71
1922	**Frank W. Dyson**	8 Jan 68	25 May 39	B	Greenwich Observatory	stellar motions, distances	O	54	PASP 34,2
1923	**E. Benjamin Baillaud**	14 Feb 48	8 Jul 34	F	Paris Observatory	celestial mechanics	T,A	75	PASP 35,2
1924	**Arthur Stanley Eddington**	28 Dec 82	22 Nov 44	B	Cambridge Observatory	stellar structure & evolution, relativity	T	42	PASP 36,2
1925	**Henry Norris Russell**	25 Oct 77	18 Feb 57	A	Princeton U. Obs.	stellar evol., atmospheres, lab spectroscopy	T	48	PASP 37,2
1926	**Robert G. Aitken**	31 Dec 64	29 Oct 51	A	Lick Observatory	binary stars	O	62	PASP 38,2
1927	**Herbert Hall Turner**	13 Aug 61	20 Aug 30	B	Oxford University	stellar positions, photography	T	66	PASP 39,2
1928	**Walter S. Adams**	20 Dec 76	11 May 56	A	Mt. Wilson Obs.	spectroscopic parallax, radial velocities	O	52	PASP 40,2
1929	**Frank Schlesinger**	11 May 71	10 Jul 43	A	Yale Univ. Obs.	stellar parallaxes	O	58	PASP 41,8
1930	**Max Wolf**	21 Jun 63	3 Oct 32	G	Heidelberg Obs.	photography of galaxies, nebulae, asteroids	O	67	PASP 42,5
1931	**Willem de Sitter**	6 May 72	19 Nov 34	D	Leiden Obs.	celestial mechanics, relativity & cosmology	T	59	PASP 43,125
1932	**John S. Plaskett**	17 Nov 65	17 Oct 41	C	Dominion Astrophysical Obs.	stellar spectroscopy, radial velocities	O,A	67	PASP 44,5
1933	**Carl V.L.Charlier**	1 Apr 62	5 Nov 34	S	Lund Observatory	celestial mechanics, statistical distr. stars	T	71	PASP 45,5
1934	**Alfred Fowler**	22 Mar 68	24 Jun 40	B	U. of London	spectroscopy: laboratory & stellar	O,T	66	PASP 46,87
1935	**Vesto M. Slipher**	11 Nov 75	8 Nov 69	A	Lowell Obs.	spectroscopy of planets & galaxies	O	60	PASP 47,5
1936	**Armin O. Leuschner**	16 Jan 68	22 Apr 53	A	U. of California, Berkeley	celestial mechanics, education	T	68	PASP 48,5
1937	**Ejnar Hertzsprung**	8 Oct 73	21 Oct 67	Da	Leiden Obs.	stars: positions, motions, color-mag relation	O	64	PASP 49,65
1938	**Edwin P. Hubble**	20 Nov 89	28 Sep 53	A	Mt. Wilson Obs.	galaxies: distances, classes, redshift law	O	49	PASP 50,87
1939	**Harlow Shapley**	2 Nov 85	20 Oct 72	A	Harvard College Obs.	galactic structure, variable stars	O,A	54	PASP 51,77
1940	**Frederick H. Seares**	17 May 73	20 Jul 64	A	Mt. Wilson Obs.	photographic photometry of stars	O	67	PASP 52,69
1941	**Joel Stebbins**	30 Jul 78	16 Mar 66	A	Washburn Obs., U. of Wisc.	development of photoelectric photometry	O	63	PASP 53,5
1942	**Jan H. Oort**	28 Apr 00		D	Leiden Obs.	galactic structure	T	42	PASP 58,229
1945	**Edward A. Milne**	14 Feb 96	21 Sep 50	B	Oxford Univ.	stellar atmospheres & structure, cosmology	T	49	PASP 57,65
1946	**Paul W. Merrill**	15 Aug 87	19 Jul 61	A	Mt. Wilson Obs.	stellar spectroscopy	O	59	PASP 58,81
1947	**Bernard Lyot**	27 Feb 97	2 Apr 52	F	Paris Obs.	solar atmosphere, instrument development	O	50	PASP 59,53
1948	**Otto Struve**	12 Aug 97	6 Apr 63	R/A	Yerkes Obs.	stellar spectroscopy, atmospheres, evolution	O,T,A	51	PASP 60,155
1949	**Harold Spencer Jones**	29 Mar 90	3 Nov 60	B	Greenwich Obs.	sun's distance, solar system motions	O,A	59	PASP 61,61

The Bruce Medalists (1898-1985)

Year	Medalist	Birth	Death	Nat[1]	Institution	Work	Type[2]	Age	Ref[3]
1950	**Alfred H. Joy**	23 Sep 82	18 Apr 73	A	Mt. Wilson Observatory	variable stars, radial velocities	O	68	PASP 62,33
1951	**Marcel Minnaert**	12 Feb 93	26 Oct 70	Be/D	Utrecht Obs.	solar spectrum, atmosphere	O	58	PASP 63,265
1952	**Subrahmanyan Chandrasekhar**	19 Oct 10		In/A	Yerkes Obs., U. of Chicago	astrophysics, esp. white dwarfs, atmospheres	T	42	PASP 64,55
1953	**Harold D. Babcock**	24 Jan 82	8 Apr 68	A	Mt. Wilson Obs.	spectroscopy: laboratory and solar	E,O	71	PASP 65,65
1954	**Bertil Lindblad**	26 Nov 95	25 Jun 65	S	Stockholm Obs.	galactic structure	O,T	59	PASP 66,109
1955	**Walter Baade**	24 Mar 93	25 Jun 60	G	Mt. Wilson & Palomar Obs.	galactic structure, distances, supernovae	O	62	PASP 67,57
1956	**Albrecht Unsöld**	20 Apr 05		G	U. of Kiel	stellar atmospheres	T	51	PASP 68,89
1957	**Ira S. Bowen**	21 Dec 98	6 Feb 73	A	Mt. Wilson & Palomar Obs.	spectroscopy, optical instruments	E	59	PASP 69,105
1958	**William W. Morgan**	3 Jan 06		A	Yerkes Obs.	stellar spectroscopy, spectral classification	O	52	PASP 70,129
1959	**Bengt Strömgren**	21 Jan 08		Da	Institute for Adv. Study	physics of stars & nebulae	T	51	PASP 71,79
1960	**Viktor A. Ambartsumian**	18 Sep 08		R	Biurakan Obs., USSR	radiative transfer, evol. of stars & galaxies	T	52	PASP 72,73
1961	**Rudolph Minkowski**	28 May 95	4 Jan 76	G/A	Mt. Wilson & Palomar Obs.	planetary nebulae, supernovae, radio galaxies	O	66	PASP 73,85
1962	**Grote Reber**	22 Dec 11		A	National Radio Astron. Lab.	radio astronomy	O	51	PASP 74,183
1963	**Seth B. Nicholson**	12 Nov 91	2 Jul 63	A	Mt. Wilson & Palomar Obs.	solar system, sun, radiometry	O	72	PASP 75,305
1964	**Otto Heckman**	23 Jun 01	13 May 83	G	Hamburg Obs.	proper motions, cosmology	O,T	63	PASP 76,135
1965	**Martin Schwarzschild**	31 May 12		G/A	Princeton U. Obs.	stellar structure & evolution	T	53	PASP 77,233
1966	**Dirk Brouwer**	1 Sep 02	31 Jan 66	D/A	Yale U. Obs.	celestial mechanics	T	64	PASP 78,195
1967	**Ludwig Biermann**	13 Mar 07	12 Jan 86	G	Max Planck Inst.	interstellar medium, stars, galaxies, sun	T	60	PASP 79,197
1968	**Willem J. Luyten**	7 Mar 99		D/A	U. of Minnesota	proper motions of stars	O	69	PASP 80,247
1969	**Horace W. Babcock**	13 Sep 12		A	Mt. Wilson & Palomar Obs.	mag. fields in sun & stars, instruments	O	57	PASP 81,179
1970	**Fred Hoyle**	24 Jun 15		B	Cambridge Univ.	stellar evolution, nucleosynthesis, cosmology	T	55	PASP 82,567
1971	**Jesse Greenstein**	15 Oct 09		A	Hale Obs., Caltech	stellar spectroscopy, white dwarfs	O	62	PASP 83,243
1972	**Iosif S. Shklovsky**	1 Jul 16	3 Mar 85	R	Sternberg Astr. Inst., USSR	solar physics, radio astronomy, supernovae	T	56	Merc 1,4,6
1973	**Lyman Spitzer, Jr.**	26 Jun 14		A	Princeton Univ. Obs.	plasma physics, interstellar medium, space astr.	T	56	Merc 2,4,4
1974	**Martin Ryle**	27 Sep 18	14 Oct 84	B	Cambridge Univ.	radio astronomy, interferometry, cosmology	O	56	Merc 3,5,24
1975	**Allan R. Sandage**	18 Jun 26		A	Hale Obs.	cosmology, stellar evolution	O	49	Merc 4,6,2
1976	**Ernst J. Öpik**	23 Oct 93	10 Sep 85	Es/B	Armagh Obs., N. Ireland	solar system, stellar statistics, cosmology	T	83	Merc 5,4,25
1977	**Bart J. Bok**	28 Apr 06	5 Aug 83	D/A	Steward Obs., U. of Ariz.	galactic structure & evolution	O	71	Merc 6,4,1
1978	**Hendrik C. van de Hulst**	19 Nov 18		D	Leiden Obs.	interstellar medium, radio astronomy	T, O,A	60	Merc 7,90
1979	**William A. Fowler**	9 Aug 11		A	Calif. Inst. Tech.	nuclear astrophysics	E,T	68	Merc 8,75
1980	**George H. Herbig**	2 Jan 20		A	Lick Obs., UC, Santa Cruz	stellar spectroscopy, early stellar evolution	O	60	Merc 9,159
1981	**Riccardo Giacconi**	6 Oct 31		I/A	Harvard-Smithsonian CFA	development of x-ray astronomy	O	50	Merc 10,182
1982	**E. Margaret Burbidge**	12 Aug 19		B/A	U. of Calif., San Diego	spectroscopy of stars, galaxies, quasars	O	63	Merc 11,154
1983	**Yakov B. Zel'dovich**	18 Mar 14		R	Space Research Inst., USSR	relativistic astrophysics	T	69	Merc 12,187
1984	**Olin C. Wilson**	13 Jan 09		A	Mt. Wilson & Las Campanas	stellar chromospheres & activity	O	75	Merc 13,187
1985	**Thomas G. Cowling**	17 Jun 06		B	Univ. of Leeds	stellar evol, magnetic fields, plasmas	T	79	Merc 14,40

Notes:

1. Nationality: A American, B British, Be Belgian, C Canadian, D Dutch, Da Danish, Es Estonian, F French, G German, I Italian, In Indian, R Russian (or Soviet), S Swedish. (Hertzsprung spent most of his career in the Netherlands, Baade in the United States.)

2. Type: A Administrative, E Experimental, O Observational, T Theoretical. Most medalists did some work in two or more categories, but they are listed with the primary one except for those few who were cited for substantial work of more than one type.

3. Ref: Presentation of Bruce Medal. PASP *Publications of the Astronomical Society of the Pacific*, Merc *Mercury*.

who spent most of his career at Leiden, and Brouwer, Luyten, and Bok, who were educated in the Netherlands before coming to the U.S.

The column headed "Work" in the medalist table clearly shows some of the changes that have occurred in astronomical science since 1898. Celestial mechanics (the study of orbits and motions) was a very important part of astronomy then. Seven of the first twenty-six medalists performed all or a good part of their work in this field. The number drops to three for the middle twenty-six, and to one for the last twenty-six. It is ironic that in the age when spacecraft are sent billions of miles to the outer planets and reach their destination within a second of the planned time, the people who make it happen are relatively anonymous. It is unlikely that the directors of observatories have ever heard of them; they receive no medals. Yet — thanks to the computer — they have surpassed the achievements for which astronomers won the world's acclaim just two generations ago.

What about solar system astronomers? Schiaparelli, Backlund, Barnard, and Wolf studied planets, comets, and asteroids, Nicholson discovered planetary satellites, and Öpik came up with an astonishing array of ideas on meteors, the Moon, Mars, and Venus, but that is all. Much more was learned about the solar system during the great age of planetary missions, the 1960s and 70s, but it was done by large teams of planetary scientists with backgrounds in geology, meteorology, chemistry, and biology. Like the modern celestial mechanicians, these groups win few astronomical medals.

Giovanni Schiaparelli, fourth Bruce Medalist. (Photograph courtesy of Yerkes Observatory.)

The New Astronomies

The term "New Astronomy" has been used at least three times in the history of astronomy. The first was in 1609 when Kepler published "A New Astronomy, or a Physics of the Skies." He had discovered, among other things, that the speed with which a planet moves in its orbit depends in a regular way on its distance from the Sun. This discovery, and others made at about the same time by Kepler and by Galileo, led in the next generation to Newton's laws of motion and gravity. Astronomy changed from a purely descriptive science to a mathematical one. For the next two hundred years there were two kinds of astronomers: those who charted and catalogued the sky, and those who calculated positions and motions with the mechanics and mathematics of Newton and his successors. Newcomb was acclaimed because he stood between the two groups, combining the mathematical computations with improved measurements of positions to produce better and better nautical almanacs.

Yet by Newcomb's time positional astronomy was already being upstaged. "The New Astronomy" was used again for a book title in 1888, by Samuel Langley. This time it referred to "astrophysics," meaning primarily spectroscopy, the decoding of light from celestial objects. Starting with the laboratory and solar work of the German scientists Gustav Kirchhoff and Robert Bunsen in 1859, and extending through pioneering work at the telescope by William and Margaret Huggins and Norman Lockyer in England, Henry and Anna Draper and Lewis Rutherfurd in the U.S., Johann Zollner and Carl Vogel in Germany, Jules Janssen in France, and Angelo Secchi in Italy, a new breed of astronomers, many of them dedicated amateurs, learned to determine the composition of the Sun and stars.

The new science grew rapidly. Chemistry and physics became as important to the astronomer as mathematics. Photography and a host of new instruments brought great changes. By the 1920s advances in physics made it possible for Eddington and others to discuss seriously the "Internal Constitutions of the Stars."[4] Studies of stellar interiors and atmospheres, of stellar evolution, and of the nuclear reactions that power the stars all came under the heading astrophysics. Ten of the first twenty-six, eighteen of the middle twenty-six, and sixteen of the last twenty-six medalists did much of their work in astrophysics.

In recent years, writers have begun referring to the "New Astronomies": the detection of various kinds of invisible radiation. Radio astronomy is now half a century old. It has provided most of the major discoveries since 1960: quasars, interstellar molecules, the universal microwave background radiation, pulsars, and active galaxies. The newer "New Astronomies" involve infrared and ultraviolet light, x-rays and gamma rays, and attempts to detect gravitational radiation and neutrinos. These new fields are practiced far from traditional observatories — on rockets and satellites, in laboratories, and even deep underground.

4. For more on Eddington see the author's article in the Nov/Dec 1982 issue of ***Mercury***.

Edward A. Milne. Upon being presented the Bruce Medal in 1945, Milne said "I am greatly honoured by this unexpected and undeserved award, and I may say that it is not until this moment that I feel certain of being an astronomer! Hitherto my ignorance of the right end of a telescope and of such other matters has always made me doubt my claim to the title." (Photograph from and courtesy of the Royal Astronomical Society Archives; also from the "Astronomers of the Past" slide set.)

1975 Bruce Medalist Allan R. Sandage and 1982 Medalist E. Margaret Burbidge chat during the 1982 A.S.P. scientific meeting at the University of California, San Diego. (Photograph by Andrew Fraknoi, A.S.P. archives.)

Although these "New Astronomies" have provided most of the excitement in astronomy since 1960, they have thus far produced only a few Bruce Medals. Only three radio astronomy pioneers — Reber, Ryle, and van de Hulst — and one x-ray astronomer — Giacconi — have been honored to date.[5]

Cosmology

In its modern sense, cosmology, the science of the universe as a whole, did not really enter astronomy until the twentieth century. Many astronomers of the past thought they were practising cosmology, but today we understand that the "universe" they were studying was only our solar system or the Galaxy. Perhaps the only truly cosmological observation of past centuries was that the dark night sky precludes an infinite, eternal, uniform, static universe.[6]

Much of the most-discussed astronomy of the twentieth century has dealt with cosmology. Yet for a long time astronomers have questioned whether the subject is really astronomy or physics. Some of this attitude lingers. Today many of the world's cosmologists, especially the theorists, practice their trade from within physics departments.

Perhaps this ambivalence helps to explain the curious omission of the name of the scientist who had more effect on twentieth century astronomy than any other from the list of Bruce Medalists. Albert Einstein received the Gold Medal of the Royal Astronomical Society, but he never won the Bruce Medal. Of the others who made major theoretical contributions to relativity and cosmology, Eddington, de Sitter, Milne, and Hoyle were medalists, but Alexander Friedmann (who admittedly died quite young), Georges Lemaitre, and George Gamow were not. All of the cosmologists who did win made sufficiently significant contributions to other branches of astronomy to win without their cosmological research.

The feeling that relativity belongs in physics and not in astronomy may also explain why the individuals who have made so many significant discoveries regarding black holes have not been honored (Zel'dovich excepted). Of course, most of them are still active; they may yet be medalists.

It should be noted that those who have made discoveries in observational cosmology have won their share of the medals. Slipher, Hubble, and Sandage all won primarily for observational work that expanded our understanding of the large-scale properties of the cosmos.

Notable Nonwinners

What factors determine which scientists are awarded medals and which ones are not? The first requirement is to live long enough. Anyone doing a little arithmetic with the birth and death dates in the table might conclude that astronomers are an unusually long-lived bunch. A theory might then be concocted about the healthful aspects of working alone on a mountaintop and the serenity that comes from contemplating the universe. The apparent longevity of the medalists is a good example of a *selection effect*. Astronomers of comparable achievement who died young are not on the list because they didn't live long enough to win the medal. Karl Schwarzschild, James Edward Keeler, and Carl Seyfert might well have been candidates for the Bruce Medal, but they died in their forties. The A.S.P. has tended to wait until later in an astronomer's career before awarding the medal. Only in three cases — Eddington, Oort, and Chandrasekhar — has the medal gone to astronomers under forty-eight.

Several other astronomers of considerable achievement failed to win the Bruce Medal. One was Williamina P. Fleming, a pioneer in the classification of stellar spectra. Harvard Director Edward C. Pickering wrote in 1901:

> I cannot do better than repeat my recommendation of last year that "in view of the important part taken by women in American Astronomy, and since the Bruce Medal was established by a woman, I recommend the woman who has made the most important astronomical discoveries, Mrs. W. Fleming."

Pickering, who had rescued Mrs. Fleming from a position as a maid in his household and had promoted her as her talents became evident, persisted. In 1905 he elaborated:

> Your letter asking me to nominate candidates for the Bruce Medal is received. I therefore make the following nominations:

5. Of course, this may in part just reflect the A.S.P. Board's inclination to award the medal late in the career of each recipient and the relative youth of the "New Astronomies." — *Ed.*

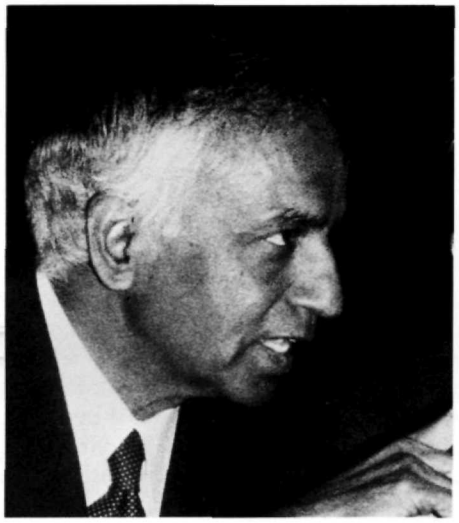
6. For more on the so-called "dark night sky paradox", see the article by E. Harrison in the Jul/Aug 1980 issue of *Mercury* — *Ed.*

First, Mrs. W.P. Fleming, for her discoveries and *continuing* researches in stellar spectroscopy, extending over the last twenty-four years. She has discovered nearly all of the Novae, stars of the fifth light and stars having hydrogen less bright which have been found during the last twenty years. See also her work published in Harvard Annals 26, 27, 50, in Harvard Circulars, . . . and publishing and editing many other volumes. [His second choice was the philanthropic Mrs. Henry Draper, and his third was W.W. Campbell.]

Mrs. Fleming never won the medal. What is more surprising, her successor, Annie Jump Cannon, never won, either. Miss Cannon became one of the most highly acclaimed scientists in the world. For classifying the spectra of over 350,000 stars and discovering 300 new variables and five novae, she received a number of honorary degrees, including the first honorary doctorate granted to a woman by Oxford University. Yet in the fourteen years 1921-1934, Harvard Director Harlow Shapley never nominated her for the medal. Neither did he nominate the other highly acclaimed female astronomer on his staff, Cecilia Payne-Gaposchkin, although he referred to her in his autobiography as a "genius-type person." Payne-Gaposchkin's contributions to astronomy included the first detailed quantitative studies of stellar atmospheres. It was she who first showed that the Sun and other stars are made up predominantly of hydrogen.

There are a number of other major contributors to astronomy among those who might have won the Bruce Medal but did not. J. Norman Lockyer was a pioneer spectroscopist and discovered helium on the Sun. Albert Michelson measured the speed of light to unprecedented precision, a measurement of great importance for determining the Sun's distance, and he used his interferometer with the Mt. Wilson telescopes to make the first measurements of stellar diameters. This was enough to win him the Gold Medal of the Royal Astronomical Society as well as the Nobel Prize, but perhaps the observatory directors or A.S.P. Boards thought of him as a physicist. Gerard P. Kuiper and Harold Urey made major discoveries in the solar system, and Knut Lundmark studied galaxies.

Those who have made a single major discovery have not fared well. Henrietta Leavitt's discovery of the period-luminosity relation of Cepheid variables led to the determination of our place in the Galaxy, the size of the Galaxy, and extragalactic astronomy. Menghnad Saha applied statistical mechanics to ionized gases and came up with the equation which made it possible to analyze stellar atmospheres quantitatively. Asaph Hall discovered the moons of Mars, Seth Chandler found the Earth's wobble, and Edward Maunder found his minimum in the sunspot counts. None won the Bruce Medal. The discoverers of the ninth planet, the 21-cm radiation of atomic hydrogen (which made it possible to map the Milky Way from the inside), pulsars, the gravitational redshift, and the universal microwave background have not yet been honored by the A.S.P., although some have won Nobel Prizes.



1952 Bruce Medalist Subrahmanyan Chandrasekhar in 1979. A.S.P. President Otto Struve, in his 1952 message of conferral of the Medal, said, "It would be hard to say whether Chandrasekhar has given more of his attention to the stars or the electrons. Most of his papers deal with both, and it is sometimes difficult to decide whether he is an astronomer, a physicist, or a mathematician. But he has elected to be called an astronomer and we therefore claim him as our own." (Photograph by Andrew Fraknoi, A.S.P. archives.)

Of course, hindsight is easy. Everyone familiar with twentieth century astronomy will have his or her own list of candidates who should have won the medal. Developments in astronomy have made it difficult for even the most conscientious observatory directors and A.S.P. directors to keep up with all that is being done. For example, those who study the Sun are now so isolated from the rest of the astronomical community that it appears unlikely that any will follow Hale, Deslandres, Lyon, and Minnaert, who won their medals for solar studies. Are solar system researchers equally isolated? or is the problem that they work in teams? What about the practitioners of all the "New Astronomies?"

To its credit, the A.S.P. Board tried to update the rules in 1965 but found that it couldn't; Catherine Wolfe Bruce and Edward C. Pickering had written them in concrete. The only change possible is to vary the nominating observatories. Perhaps the definition of observatory can be enlarged a bit; the National Radio Astronomy Observatory has already been one of the nominators. As for the question of whether the medal can be given jointly to two or more workers, the Board will have to wrestle with that. Certainly it seems unfair to disqualify those who work in teams.

But overall, Holden was right. The Society has done much good, both for astronomy and for itself. The Bruce Medal honors its recipients and those who award it. ■

The author would like to thank Sonoma State University for a sabbatical leave and the University of Massachusetts, Amherst, for its warm hospitality. The letters to and from E.C. Pickering are quoted by permission of the Harvard University Archives.

Bruce Medalist "Trivia Quiz"

See p. 125 for answers.

1.) Who was the first Bruce Medalist to accept the award in person?
2.) Who was the first Bruce Medalist who had not previously received the Gold Medal of the Royal Astronomical Society?
3.) Who were the youngest Bruce Medalists?
4.) Who received the Bruce Medal more than 40 years after first being nominated?
5.) Which Bruce Medalist was present at the ASP Board meeting where he was selected to receive the Medal?
6.) Who declined the Bruce Medal?
7.) Who won the Bruce Medal for work performed as an amateur astronomer?

Bruce Medalist Quiz Answers

from p. 111

1.) W.W. Campbell (1915), twelfth Medalist.
2.) F. Dyson (1922), seventeenth Medalist. (Dyson received the RAS Gold Medal in 1925.)
3.) A.S. Eddington (1924), J.H. Oort (1942), S. Chandrasekhar (1952). All were 42 the year of the award.
4.) E. Öpik — nominated by Harlow Shapley 1935; awarded Medal 1976.
5.) A.H. Joy (1950). "Joy, of course, was definitely embarrassed, but we told him to stuff his ears and keep his mouth closed . . ." R. Aitken to C.H. Adams 10 Dec 1949 (Mary Lea Shane Archives of Lick Observatory.)
6.) W.H. Wright (1944).
7.) William Huggins (1904) and Grote Reber (1962).