THE GREAT ACHIEVEMENTS AT HALE'S OBSERVATORIES
www.journeytopalomar.org

Yerkes Observatory
Lake Geneva, Wisconsin
http://astro.uchicago.edu/yerkes

The Yerkes 40-inch refracting telescope, dedicated in 1897, is still the largest refractor in the world. It was financed by Chicago streetcar baron Charles T. Yerkes. George Ellery Hale directed the building and operations of the observatory for the University of Chicago.

Traditional European observatories since the time of Galileo had been designed for visual observing with the goal of determining the motions and positions of the planets and mapping stars in what was thought to be a static, unchanging universe. At Yerkes, Hale began a revolution, uniting chemistry and physics with astronomy to create the new science of "astro-physics." Yerkes was the first observatory completely equipped with laboratories, dark rooms and machine shops to build the instruments needed for photograph and spectroscopy. Astronomers began to photograph and compare the spectra of light from the stars to spectra created in the laboratory to unravel the chemical composition and physical properties of stars. Greatly influenced by Charles Darwin's stunning 19th century revelations about evolution on earth, astronomers also sought to determine whether stars evolved, and whether heaven and earth were made of similar material--a new idea at the time.

The archive of early astronomical photographs at Yerkes is extremely useful for comparison with present-day photographs and spectra. Many of the greatest astronomers of the 20th century have trained at Yerkes Observatory and today education is still one of its foremost missions.

Mount Wilson Observatory
Pasadena, California
www.mtwilson.edu

Beginning in 1904 on rugged untamed Mount Wilson near Los Angeles, with funding from steel magnate Andrew Carnegie, Hale built the next biggest telescope in the world, a 60-inch reflecting telescope (with a 60-inch diameter mirror, rather than lenses). He also built three solar telescopes to study the sun--our nearest star. In 1918, he followed with yet another giant reflector funded by L.A. hardware king John D. Hooker, the Hooker 100-inch telescope, once again biggest in the world.

At Mount Wilson Observatory astrophysics was dominant and most of the revolutionary astronomical discoveries of the 20th century occurred. Highlights:

• George Ellery Hale discovered the sun's magnetic field in 1908 (magnetic fields in sun spots). Also establishes first international network of solar observing stations, continuously observing the sun.

• Harlow Shapley verified our true location in the Milky Way (1917)--on the outskirts, rather than at the center, completing the revolution started by Copernicus.

• Albert Michelson accurately determined the speed of light.

• Edwin Hubble (with Milton Humason) discovered that our Milky Way galaxy is just one among countless other galaxies--"island universes"--in an apparently limitless universe (1924).

• Edwin Hubble saw that the galaxies were rushing away from each other at incredible speeds, increasing with distances. This implied an expanding Universe, inspiring the "Big Bang" theory of the origin of the Universe.

• Walter Baade found that stars are born "evolve" and die (verifying concept of stellar evolution), passing along their materials to new generations of stars and even producing the elements comprising the human body.

• The Mount Wilson telescopes established a quest for ever larger telescopes (to collect "more light") that led to the Palomar 200-inch telescopes and continues today.

• Cutting edge science continues at Mount Wilson today. In July of this year, The CHARA interferometer (Center for High Angular Resolution Astronomy) operated by Georgia State University was able to make a direct photograph of another star besides our sun for the very first time. Except for light pollution from Los Angeles, Mount Wilson is still one of the best places for astronomy in the world. So infrared astronomy continues, using the Hooker 100-inch telescope.

Palomar Observatory

Palomar Mountain, California
www.astro.caltech.edu/palomar

In 1928, Hale and his colleagues believed it was possible to create a mirror 200 inches in diameter, about the size of an average living room--17 feet across and two feet thick (vs. 8 feet for the 100-inch mirror). Double the diameter, meant the mirror would have 4 times the surface area of the Mount Wilson 100-inch mirror. The glass disc would weigh nearly 15 tons. The telescope's steel tube and base would tower six stories high and weigh more than twice as much as the Statue of Liberty--500 tons, yet it would have to move with the accuracy of a Swiss watch. Even the Bureau of Standards said it couldn't be done.

Funded by the Rockefeller Education Board, American industry gave its all over two decades to build the giant machine, through the Great Depression and the second World War, inventing the technology as they went along. The telescope was finally dedicated by the California Institute of Technology on June 3, 1948 as "The Hale Telescope." George Ellery Hale never saw his greatest masterpiece; he had died 10 years earlier. Begun by a man born just after the Civil War, the telescope reigned supreme as the biggest in the world until 1993 and is still being used for cutting edge astronomy today.

The Palomar 200-inch Hale Telescope has taken human exploration to the very edge of time. Highlights:

• The first major discovery at Palomar was by Mt. Wilson astronomer Walter Baade. Using the new 200-inch telescope Baade more accurately measured the distance to the galaxy Andromeda (our closest neighbor) to be two million light years, doubling the size of the known universe from two billion to five billion years old.

• With advances in photography (better photographic plates, emulsions, etc.), astronomers began to reach further into the universe than anyone could have imagined. Rudolph Minkowski and Allan Sandage discovered an object that was nearly half the age of the known universe.

• In the early 1960s, Allan Sandage discovered a whole new class of objects he called "quasi-stellar radio sources," later shortened to "quasars." These were strange objects whose light Maarten Schmidt and Jesse Greenstein discovered was so far shifted into the red end of the spectrum that they would have to be moving at inconceivable speeds. These were the most distant objects in the universe, billions of light years from earth, meaning they were also billions of years old. They were extremely bright, emitting as much light as an entire galaxy of stars in an area only about the size of our solar system.

• Edwin Hubble had begun to establish the rate of expansion of the universe at Mt. Wilson. By studying the "red shifts" of distant objects like quasars at Palomar, Allan Sandage began to refine Hubble's "constant" (the rate of expansion) and determine the size and age of the universe, based on the rate of speed that objects were expanding away from each other.

• Astronomers began to understand how galaxies formed and what the large scale structure of the universe is, refining our understanding of the origin, nature and structure of the universe, the concept of "cosmology."

• In the 1980s, Jim Gunn his Caltech colleagues replaced photographic plates with CCDs, giving the Hale Telescope 100 times more light gathering power. This new CCD technology developed at Palomar led to the Hubble Space Telescope and the incredible images of space we see today.