# The Lick Observatory: Building the Foundation of Astrophysics

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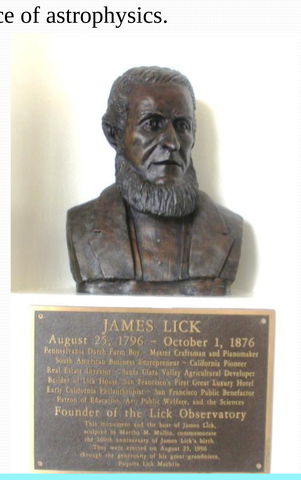
The Lick Observatory, entrance and the dome for the 36" Lick Refractor, with author Gordon Houston, prior to attending the Astronomical Society Of the Pacific Annual Meeting. Taken Sept. 11, 2009.

## ABSTRACT

•The emerging science of astrophysics began in the early 19th Century. Astronomy leading up to this moment was based on empirical observations and astrometry.
•Two distinct observational techniques changed astronomy and society forever, these were spectroscopy and astrophotography.
•These became the basic tools and instruments for the new science of astrophysics.
•The building of the Lick Observatory is an underappreciated event that impacted astronomy and astrophysics.
•Prior to this, astrophysics had three limitations, the instruments, the building, and the staff of astronomers.
•The building of the Lick Observatory changed all three and as a result built a solid foundation for the new science of astrophysics.




•JAMES LICK
Founder of the Lick Observatory
Photo: Gordon L. Houston

## ASTRONOMICAL RESEARCH BEFORE THE LICK

•Observational-mainly by wealthy amateurs
•Astrometry-the measurement of star positions
•Observatories built near their host institutions
•, therefore in poor atmospheric and light polluted conditions.
•Emergence of spectroscopy
•Beginning the development of astronomical photographic methods.

## DEVELOPMENT OF SPECTROSCOPY

•1666-Isaac Newton-passed light through a prism, seeing an array of color i.e. the spectrum.
•1800- William Herschel measured temperature changes at different points of the spectrum, discovered the infrared.
•1801-J. W. Ritter discovers the violet end of the spectrum.
•1828-Josef Fraunhofer describes 500 dark lines in the solar spectrum, light planets and moon have the same dark lines. Discusses bright-line spectra, which may correlate to the dark lines. Developed the diffraction grating, used instead of a prism.
•1859-Wilhelm Bunsen and Gustav Robert Kirchoff establish spectrum analysis on a firm basis. Kirchoff publishes a study of the chemical constitution of the sun.

## DEVELOPMENT OF SPECTROSCOPY-CON'T

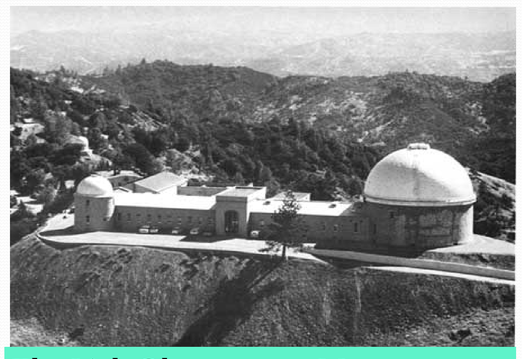
•1864-Sir William Huggins uses a spectroscope with a telescope, showing some nebula are glowing gases as they produce bright line spectra, which indicates they are at a very high temperature.
•1872-Henry Draper made the first spectrograph of a star, a photo of the star's spectrum.
•1890-Publication of the first Henry Draper Catalogue of 10,000 spectra in 7 types A, B, F, G, K, M, N.
Reference: Crowe, M. J., 1994, Modern Theories of the Universe from Herschel to Hubble.
•1888-1891 James E. Keeler's designed a spectroscope used with the Lick Refractor, a combination superior to any spectroscopy to date.

## DEVELOPMENT OF ASTROPHOTOGRAPHY

•1850-1876 Variety of methods being used in various observatories.
•1871- The introduction of dry plate astrophotography, a significant technological leap from other methods being employed
•1876-Sir William Huggins used the dry plate method to record spectra.
•1888-1890 James E. Keeler used the 36" Crossley Reflector for astrophotography, making a large reflector necessary for observatories.

## SITE SELECTION AND ARCHITECTURE THE FIRST MOUNTAINTOP OBSERVATORY

•S. W. Burnham, an expert double star observer spent two months on Mt. Hamilton.
•Mt. Hamilton is 4250 feet and is the tallest in the region, so views were unobstructed and meant less atmosphere to observe through.
•The location was above the thermal layer, providing excellent "seeing" on 49 out of 60 nights, due to low humidity.
•The number of clear nights meant substantially more observing could be accomplished.
•The bedrock or "trap" rock provided stable footing for the telescopes.
•An observatory needs a well stocked library.

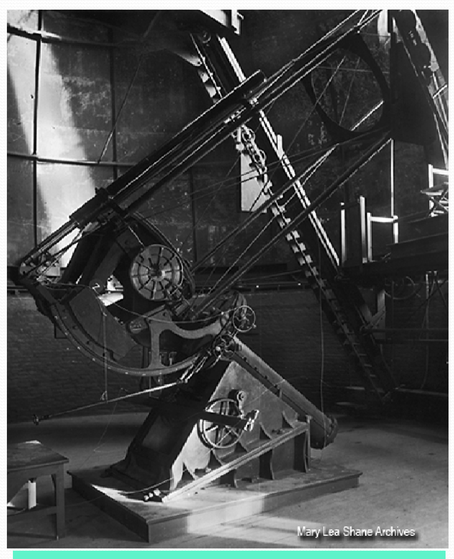


The Lick Observatory, Mt. Hamilton, Calif.
Courtesy-www.encyclopedia.com

"Telescopes……cannot be formed so as to take away that confusion of rays which arises from the tremors of the atmosphere. The only remedy is a most serene and quiet air, such as may perhaps be found on the tops of the highest mountains above the grosser clouds."
**Sir Isaac Newton, in his *Opticks*, A. D. 1730.**

## THE INSTRUMENTS

The Lick Refractor, Lick Observatory,
Taken September 11, 2009.
Photo: Gordon L. Houston




THE CROSSLEY REFLECTOR
Photo: UC Observatories
Mary Lea Shane Archives

•The Lick Refractor was the largest refracting telescope in the world when completed.
•The Lick Refractor proved that larger instruments coupled with superior cameras and spectroscopes produced superior science results.
•There were larger reflecting telescopes than the Crossley Reflector, but when paired with astrophotography, it set a standard that all observatories adhere to today

George Ellery Hale asked the astronomical community the best telescope to build prior to building the Wilson Observatory? **Edward James Pickering of the Harvard College Observatory said**, "The work of Keeler and the 36 inch Crossley Reflector …." made the large reflector a necessity for any serious work in an observatory.

## THE STAFF

The final aspect of lasting significance of the building of the Lick Observatory is the assembling of a professional staff to be dedicated to astronomical research. The original staff included Holden, Burnham, Schaeberle, Keeler, and Barnard, and assistant astronomer Hill .

### Edward S. Holden

The first director of the Lick Observatory, he along with Simon Newcomb designed the Lick Observatory.
He recruited the first staff of astronomers who each skills in complimentary areas of astronomical research.
He wrote constantly, much of which was published to viewing public. In this regard he substantially heightened the awareness of astronomy to the public (Neubauer 1950b). He pioneered in Lunar astrophotography with the Lick Refractor. His most lasting legacy, one of which is still a major contributor to the science and education of astronomy today, was the formation of the Astronomical Society of the Pacific (Franknoi 2009). All of the staff astronomers were charter members.

### James E. Keeler

He was a trained and educated astrophysicists.
He was considered the outstanding astrophysicist of the late 19th Century (Osterbrock 1979). His work with the Crossley Reflector has been mentioned. He was an expert spectroscopist with some results still equal to modern day measurements.
He was a big influence of George E. Hale, with who he co-founded The Astrophysical Journal. He was a founding member of the American Astronomical Society. Became the second Director of the Lick Observatory in 1898.

### Edward Emerson (EE) Barnard

E. E. Barnard was a self taught astronomer who had significant visual observation skills. He was one of the most prolific discovers of comets in the 19th Century (Hockey 2007). Met Simon Newcomb When he was 20 who told him to be grounded in mathematics. Worked in a photography shop for 17 years. Discovered he 5th moon of Jupiter with the Lick Refractor., the last to be discovered visually.
He had discovered the dark extended interstellar absorption regions in the Milky Way, which later became classified as Barnard dark nebulae. Left the Lick and joined Hale at the Yerkes, completing a dark Nebulae catalogue. At Yerkes, he mentored Edwin Hubble in astrophotography.

### Sherburne W. Burnham

He was an amateur astronomer and expert double star observer. He was employed to do the site evaluation at Mt. Hamilton. His report to the Lick Trustees is an essential guide of site evaluation for a all future observatories. Created an extensive double star catalogue. He was later hired by Hale at Yerkes, where he made his last observations in 1914.

### W. W. Campbell

He was an engineer. He learned spectroscopy from Keeler and took over when Keeler left. He found visual spectroscopy limiting and designed the Mills Spectrograph. It was the observation of variable radial velocities which led to the discovery of spectroscopic binaries. Became the third Director of the Lick when Keeler passed away.

### John M. Schaeberle

He was a civil engineer, mainly did meridian observations. Designed the 40 foot Schaeberle Camera taking the best photos of the solar corona.

## CONCLUSIONS

The building of the Lick Observatory was a significant moment in astronomy, advancing the new science of astrophysics, that is under appreciated today. Pioneering work was done that set the standard of the day, that still influences researchers today.