A Brief History of Light & Photography

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A Brief History of Light & Photography
by Rick Doble

INTRODUCTION

The word photography comes from the Greek and means "light writing" (photo = light, graphy = writing). We photographers are light artists. Drawing with light is very different than drawing with a pen. It requires light sensitive material, optics, dark enclosures and the ability to fix an image so that it does not fade. The history of how all this came to be is intertwined with our understanding of our place in the solar system and the universe. Is there any story more epic, more fascinating?

The modern scientific understanding of light evolved along with the development of the camera and photography -- making photography a unique art form that has always been inseparable from science. Digital photography, for example, came about as a result of the discovery of quantum physics, specifically the insights of Albert Einstein. My mentor, Ross Scroggs who ran the UNC-CH photo lab and who had worked at Kodak for decades, used to call photography that "odd hybrid discipline that combined optics, physics and chemistry." Today we might say: that combines optics, physics and computers.

The development of optics/photography is closely related to astronomy with Galileo, Kepler, Newton, Maxwell, Einstein and Hubble making significant contributions in both fields. In fact, Kepler coined the term "camera obscura" which has been shortened today to "camera." The words come from Latin in which "camera" means "vaulted chamber/room" and "obscura" is translated "dark" so a camera is a "dark chamber/room" -- and the early camera obscuras were quite large, room size in fact -- so a dark room was an accurate description. In addition, starting as early as 1840, cameras were designed to take photographs with astronomical telescopes. After 1900 large telescopes were optimized for photography rather than for observation -- making them essentially telephoto cameras.

In this timeline, I could not help mentioning how often intuition, imagination, accident, spiritual feelings and even poetry played key roles in the scientific understanding of light. While these are more often associated with art, this timeline shows that science and art are often closely related.

I believe this timeline also shows that since the very beginning photography has evolved and will continue to evolve. And as our understanding of light itself improves, this will change photography as well.

PREHISTORY

Our feelings about light undoubtedly go back millions of years -- to the changing light of the seasons and the discovery and use of fire. Light is fundamental to existence. And because of this it has always had important religious significance. Many of the 'light scientists' held a deeply spiritual feeling for the subject.

== In Christianity in the third line of the *Bible*, "God said, 'Let there be light'; and there was light. And God saw that the light was good." (Genesis, 1:3-4) Light is a key element in the celebration of Christmas.

== The Festival of Lights, known as Diwali, is a major event celebrated by Hindus and many others in South Asia and other places around the world. For the Hindus it marks the triumph of the return of the good deity Rama and the death of the evil demon Narakasura.

Beginning around 200 A.D.and for the next 1400 years the geocentric astronomy of Ptolemaeus was the accepted view of the universe. This picture is a drawing of the Ptolemaic System which fairly accurately described the movement of the sun and planets as circles that orbited the Earth, although the full explanation involved many epicycles within each orbit. It was the first scientific view of the universe. The Earth was in the middle -- surrounded by circles of water, air and fire then followed by the moon, sun, planets and finally the stars. *De Sphaera Mundi* by Johannes De Sacrobosco, 1230. (commons.wikimedia.org/wiki/Category:De_sphaera_mundi)

THE DISCOVERY OF THE CAMERA

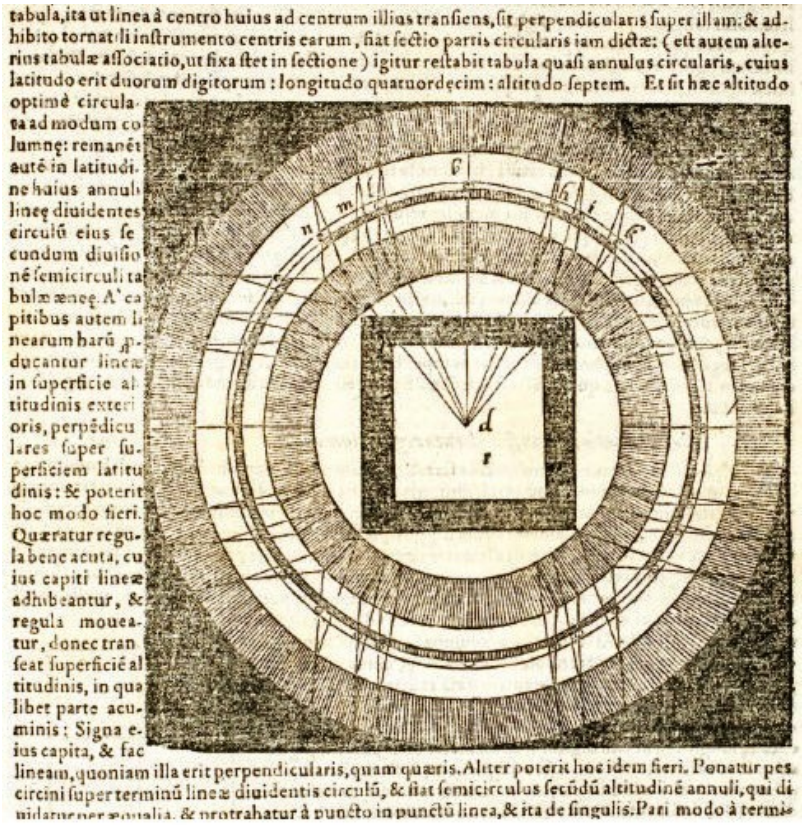
According to legend, the discovery of the camera may have begun thousands of years ago with desert nomads who saw scenes outside their tents projected upside down on the back wall when a tiny hole in their dark tent let in light during the bright day. This phenomena was known even to the ancient Greeks, such as Aristotle, and others.

Personal note: I experienced this by accident myself, when I stayed in a room on the Mediterranean with two shutters that when closed completely darkened the room. I awoke one morning to see crashing waves in bright sunlight projected on the back wall, as a tiny hole between the shutters created a pinhole camera in my room

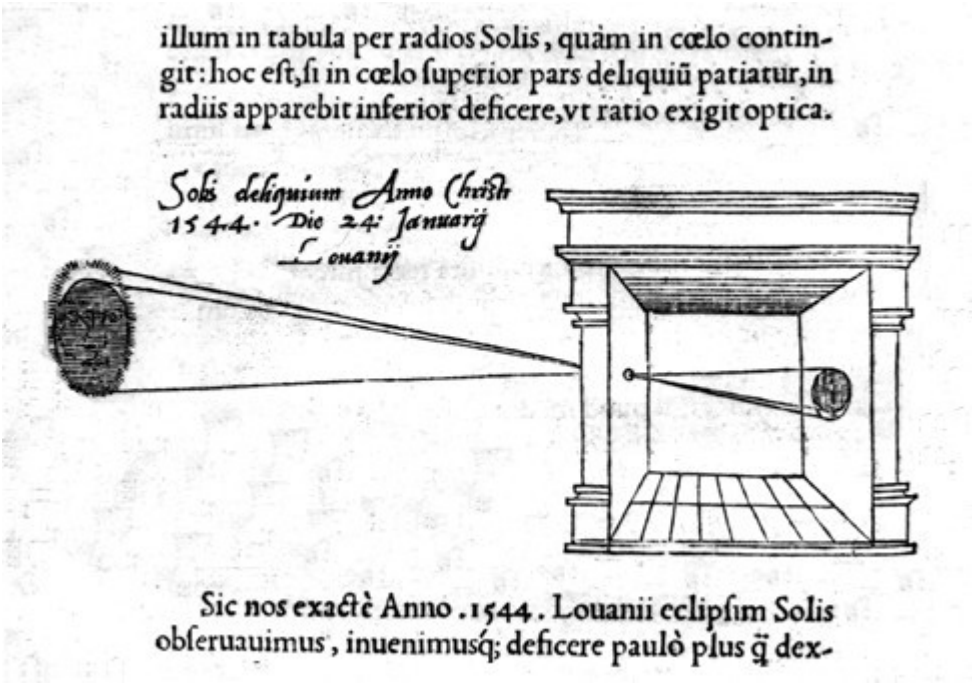
1000 YEARS AGO

In 1021 Arab scientist Alhazen defined the basic nature of light and optics scientifically in his seven volume Book of Optics -- considered the most important book on the subject for the next 600 years.

Alhazen was the first to use experimental methods and logical reasoning to define the essential aspects of light: that it emanated from an outside light source, that light traveled in rays, and that the rays traveled in straight lines. Although not the first to use a camera obscura, he was the first to describe how to construct one; in addition he described how to magnify an object with a lens and to make a sharper projected image with a pinhole by reducing the size of the pinhole.


tabula, ita ut linea à centro huius ad centrum illius transiens, sit perpendicularis super illam: & adhibito tornatili instrumento centris earum, fiat sectio partis circularis iam dictæ: (est autem alterius tabulæ associatio, ut fixa stet in sectione) igitur restabit tabula quasi annulus circularis, cuius latitudo erit duorum digitorum: longitudo quatuordecim: altitudo septem. Et sit hæc altitudo optimè circula- ta ad modum co lumnę: remanèt autè in latitudi- ne huius annuli lineę diuidentes circulũ eius se cundum diuisio nẽ semicirculi ta bulæ æneę. A' ca pitibus autem li nearum harũ p- ducantur lineæ in superficie al titudinis exteri oris, perpẽdicu lares super su- perficiem latitu dinis: & poterit hoc modo fieri. Quæratur regu- la bene acuta, cu ius capiti lineæ adhibeantur, & regula moueatur, donec tran seat superficiẽ al titudinis, in qua libet parte acuminis: Signa eius capita, & fac lineam, quoniam illa erit perpendicularis, quam quæris. Aliter poterit hoc idem fieri. Ponatur pes circini super terminũ lineæ diuidentis circulũ, & fiat semicirculus secũdũ altitudinẽ annuli, qui di- uidatur per æqualia, & protrahatur à puncto in punctũ linea, & ita de singulis. Pari modo à termi-

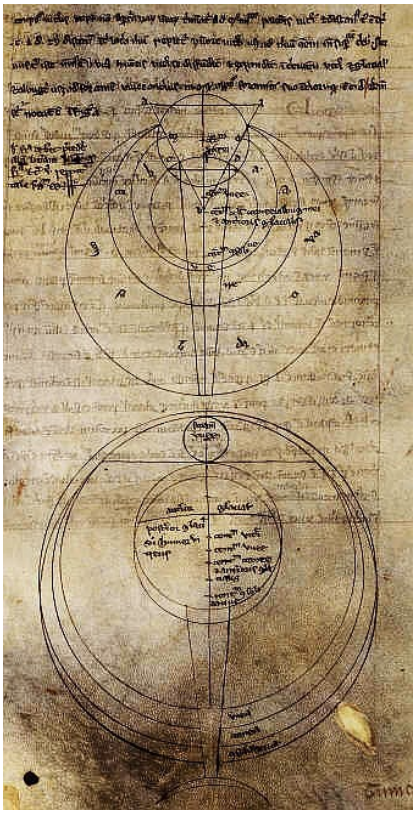
Page of illustration from the Latin translation of Alhazen's *Book of Optics*, published in 1572. (Niels Bohr Institute)



A building with a pinhole, used to watch an eclipse, based on ideas from Alhazen's *Book of Optics*. This is the first illustration of such a room.
'De Radio Astronomico Et Geometric Liber' By Gemma Frisius,1545. (marygrove.edu)

ROGER BACON AND THE INVENTION OF EYEGLASSES

In 1267 Friar Roger Bacon of England brought Alhazen's discoveries to the west in his book *Opus Majus*. Reading a translation from Arabic to Latin of Alhazen's *Book of Optics*, he was the first in the west to fully describe a magnifying glass. This led to the creation of eyeglasses in Italy around 1286. Roger Bacon also made major contributions to the science of optics, the camera obscura and "focussed on the spiritual quality of light as the fundamental unit of all creation." (http://h2g2.com/dna/h2g2/A2875430).



A page from Roger Bacon's book, 'Opus Majus' in 1267 -- relating to his exploration of the properties of optics. (commons.wikimedia.org)

During the Renaissance pinhole imagery and the camera obscura was discussed by: Leonardo da Vinci in his *Codex Atlanticus* (1502), Gemma Frisius in his book *De Radio Astronomico Et Geometric Liber*, 1545 (see illustration earlier) and Giovanni Battista della Porta in *Magiae Naturalis*, 1558. Plus optical and viewing refinements to the camera obscura were suggested by Girolama Cardano in 1550 and Daniel Barbaro in 1569. During this time the camera obscura became widely used for both scientific and artistic purposes.

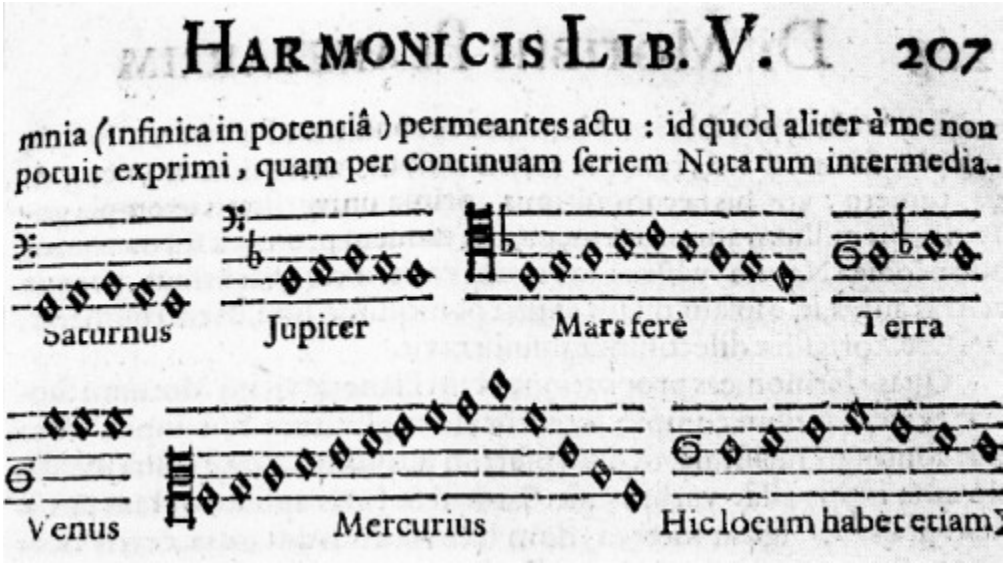
A modern building used as a camera obscura at UNC-Chapel Hill, my alma mater. You can see the pinhole about half way up the second panel, left of the door. (en.wikipedia.org, gradschool.unc.edu)

THE CAMERA BECOMES PORTABLE

Kepler, Johannes
== Contributions To Optics and Photography:
In 1604 Kepler published the first modern western book on optics in *The Optical Part of Astronomy (Astronomiae Pars Optica)*, designed the first portable camera obscura with a rotating lens and mirror to project the image onto a drawing board in 1620 and coined the term 'camera obscura' which has today evolved into the modern word 'camera'.

A drawing of a Kepler movable tent-type camera obscura
-- the type designed by Kepler in 1620. (commons.wikimedia.org)

== Contributions To Astronomy:
Building on the Copernican theory of a heliocentric solar system about 60 years earlier, Johannes Kepler was the first to accurately describe the orbits of the planets.
== About His Insights:
Although a scientist who spent decades making careful measurements, observations and calculations, his inspiration was spiritual; he wanted to discover a harmony of the spheres, a medieval idea that described the harmonious relationships between earthly and heavenly realms. In his book *Harmonices Mundi* in 1619 (*The Harmony of the World*), Kepler laid out the third law of planetary motion along with an assertion that the movement of the planets related to each other in musical harmony. Kepler's three laws of planetary motion were fundamental to Newton's discovery of gravity.



Kepler's musical notations for the known planets, showing the notes he associated with them from his book 'Harmonices Mundi'.

THE INVENTION OF THE TELESCOPE

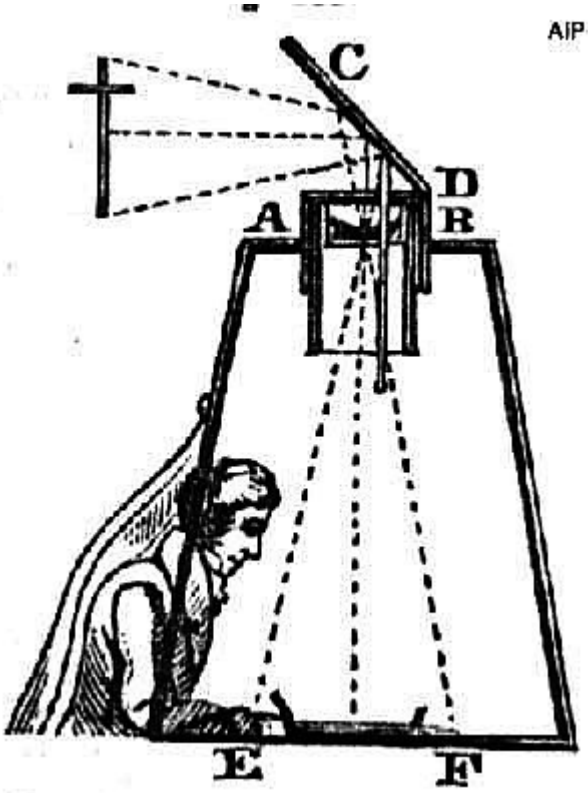
In 1608 Hans Lippershey, an eyeglass maker, invented the telescope.
== Accident Played A Key Role:
According to legend, two children were playing with spectacle lenses in an eye glass shop owned by Lippershey in the Netherlands. They happened to line up two lenses so that a highly magnified image of a weather vane on top of a church appeared. This chance discovery lead to the telescope. Lippershey used a tube to position and secure the lenses which he called the "looker" in 1608; it was the first telescope.

Galileo Galilei
== Contributions To Optics:
Starting in 1610 Galileo increased the magnifying power of the telescope up to 30X.
== Contributions To Astronomy:
While Galileo did not invent the telescope, he made a marked improvement on what was being made at the time. When he turned this instrument to look at Jupiter, he discovered four moons circling the large planet. This observation lead him to realize that Copernicus was correct, and that like the moons of Jupiter, the Earth and the other planets were circling the large Sun. Confirmation of this over the next hundred years or so, lead to a completely new understanding -- as humans were no longer at the center of the universe as had been previously thought in the Ptolemaic System (see Part 1 of this series of articles). In addition it lead to scientific observation and measurement becoming the primary way that the world was explored and that truth was established.

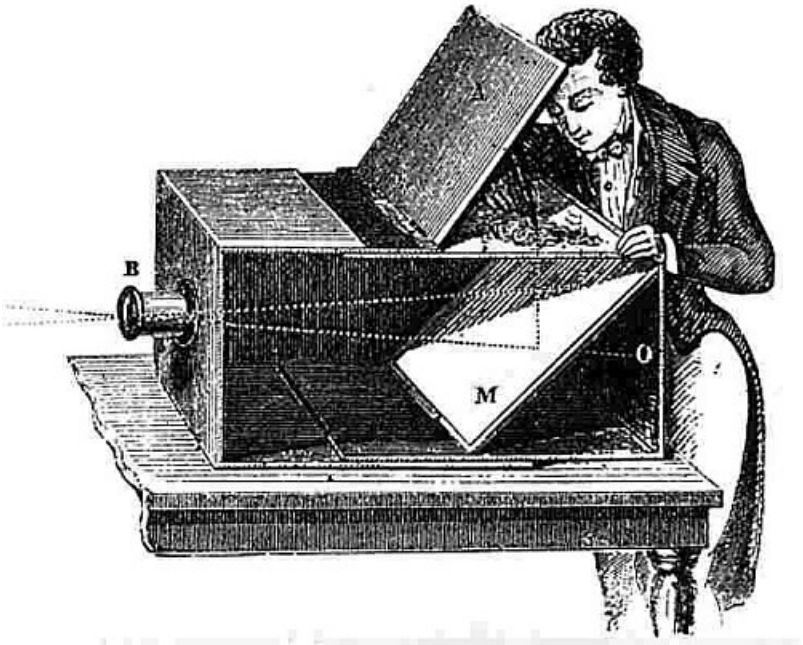
Newton, Isaac
== Contributions To Optics and The Understanding of Light: In 1704 Isaac Newton defined light as particles in his book, Opticks, and also did extensive experimentation with white light and prisms in addition to creating the first reflecting telescope.

== Contributions To Astronomy:
Newton discovered gravity and then was able to calculate with precision this force that caused apples to fall to the ground and the planets to circle the sun, creating the first great unified theory. His three books, *Philosophiж Naturalis Principia Mathematica* (often shortened to the *Principia*), are considered perhaps the most important books in science.
== About His Insights:
After John Maynard Keynes studied Newton's papers on alchemy and other subjects, he said "Newton was not the first of the age of reason. He was the last of the magicians..I fancy his pre-eminence is due to his muscles of intuition being the strongest and most enduring with which a man has ever been gifted...Certainly there can be no doubt that the peculiar geometrical form in which the exposition of the *Principia* is dressed up bears no resemblance at all to the mental processes by which Newton actually arrived at his conclusions."

This is a replica of Newton's reflecting telescope. Newton's redesign of the telescope became the basis for the space-based Hubble telescope and most other large modern telescopes both on the ground and in space. (commons.wikimedia.org)



A sophisticated camera obscura design from the book *A Treatise on Optics* by Sir David Brewster. (commons.wikimedia.org)

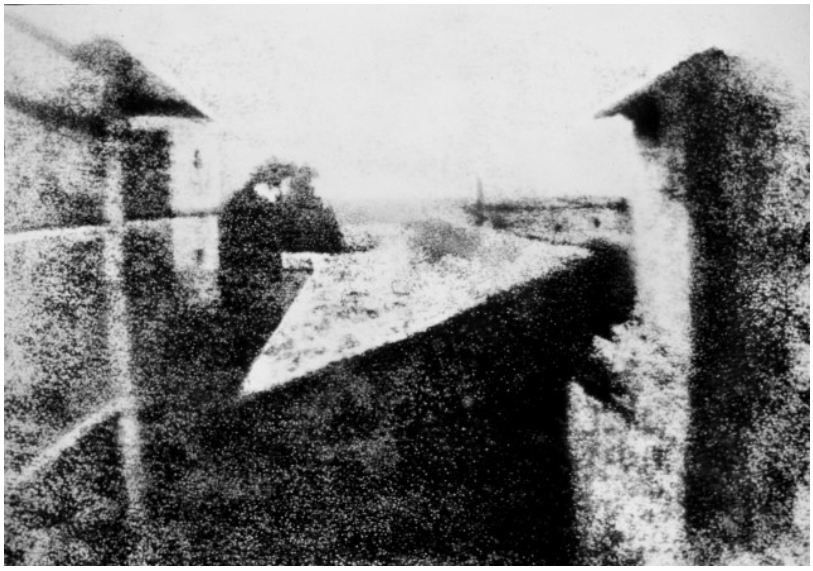


By the 18th century the camera obscura had shrunk down to a fairly small tabletop design pointing the way to studio cameras a hundred years later. (commons.wikimedia.org)

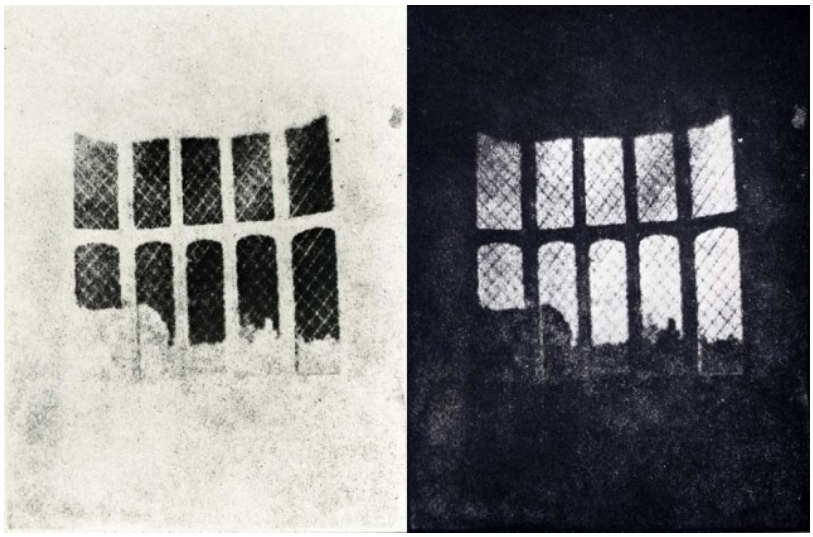
PHOTOGRAPHY IS BORN

The Discovery Of Light Sensitive Material

In 1727 Johann Heinrich Schulze noticed that silver nitrate turned dark when exposed to light. Silver halides became the basis for camera plates and film about 100 year later.



1827: Nicephore Niepce shot the first permanent photograph taken with a camera. The exposure required eight hours. The photo is known as 'View from the Window at Le Gras'. His camera was placed in the upper story window of his house and made a photo of the buildings below. ommons.wikimedia.org)



1835: Latticed window in Lacock Abbey by Henry Fox Talbot. The positive print on the right was made from the oldest negative known to exist, left. Talbot's negative process transformed photography as it allowed multiple copies to be made from one negative and also allowed darkroom developing and exposing techniques to be used to make the final print. (commons.wikimedia.org)

The Fixing Process
While Niepce and Louis Daguerre, another pioneering photographer who collaborated with Niepce and invented the daguerreotype, were able to 'fix' their photographs so that they did not fade -- it was not until 1839 that sodium thiosulfate, known to photographers as 'hypo', became the standard fixing chemical and has been used for that purpose ever since with film photography. Go to this site for a full history and description of photographic chemistry.

A typical studio camera of the 19th century. By about 1840 photographic material was sensitive enough for exposures below 60 seconds, which allowed for stiff but popular portraits. (commons.wikimedia.org)

Astronomy Merges With Photography
Starting as early as 1840, cameras were designed to take photographs with astronomical telescopes. After 1900 large telescopes were optimized for photography rather than for observation -- making them essentially telephoto cameras.

Maxwell, James Clerk
== Contributions To A Scientific Understanding of Light:
In 1865 Maxwell wrote *A Dynamical Theory of the Electromagnetic Field*, a book that united light with other forces. He coined the term 'electromagnetic spectrum' and stated that light was simply part of a continuum from radio waves to x-rays. Finally he asserted that light, therefore, had to be considered a wave and not a particle as Newton had said. (Stay tuned -- as Einstein had the last word on this and what he said was crucial to the invention of digital photography.)

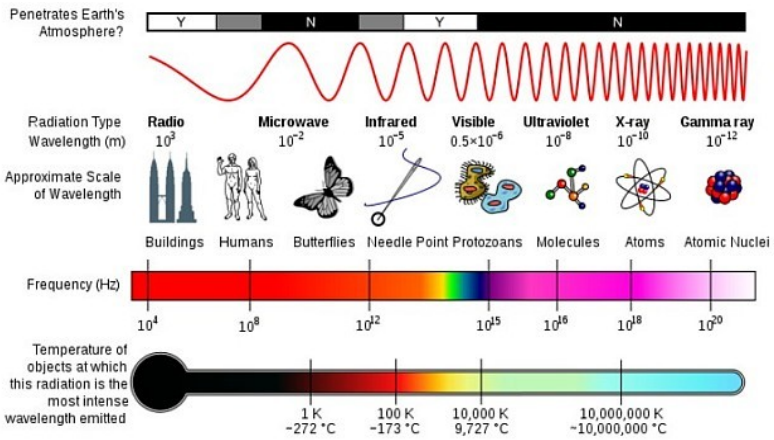
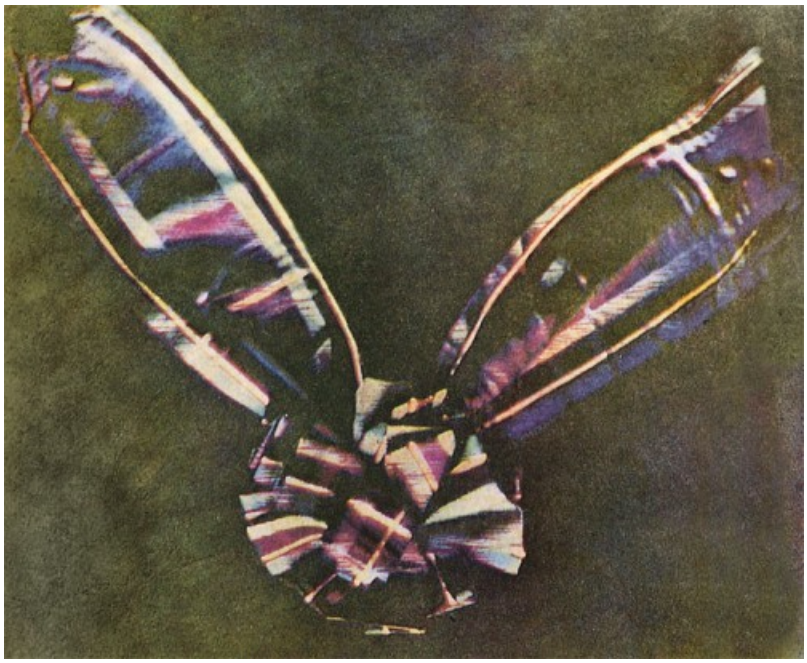


Diagram of the electromagnetic spectrum. (commons.wikimedia.org)

== Maxwell's Contributions To Photography

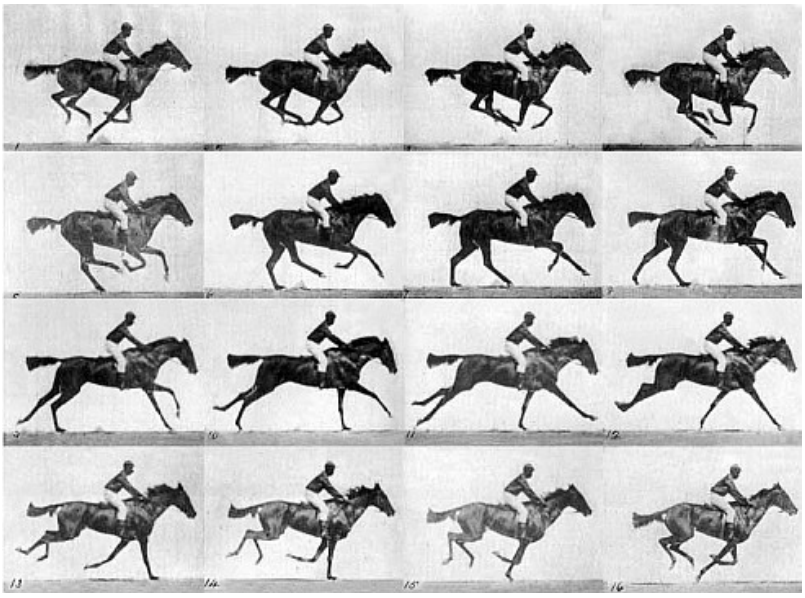
In 1855 Maxwell deduced that if an object were photographed three times on transparent black and white film -- each time with a different filter of red, green and violet -- a full color image would result from the combined photographs when projected together using the corresponding filters.

In 1861 Maxwell made the first color photograph using his method, and it has become the "the basis of nearly all subsequent photochemical and electronic methods of colour photography." (en.wikipedia.org/wiki/James_Clerk_Maxwell)



1861: The first color photograph -- taken by Maxwell and proving what came to be known as his 'principle of three-colour analysis and synthesis'. (commons.wikimedia.org)

== Maxwell's Contributions To Astronomy:
Interested in a wide range of scientific questions, Maxwell wrote a paper *On the Stability of Saturn's Rings* -- which had been a nagging question to astronomers -- and explained how these rings were put together.
== About His Insights:
Although interested in a variety of scientific questions, Maxwell also wrote poetry throughout his lifetime.



By 1878 photography had become quite sophisticated allowing for much shorter exposures. For example, Eadweard Muybridge perfected a method for taking sequential photographs of a horse galloping -- at a fast shutter speed of 1/1000 second. (commons.wikimedia.org)

1894: The craft of photography had become so commonplace that an impressionist painter such as Toulouse-Lautrec painted a poster advertising the services of a photographic studio. Some impressionists and other painters even used photography in their work -- such as Degas and Eakins. (commons.wikimedia.org)

PHOTOGRAPHY BECOMES AVAILABLE TO THE GENERAL PUBLIC

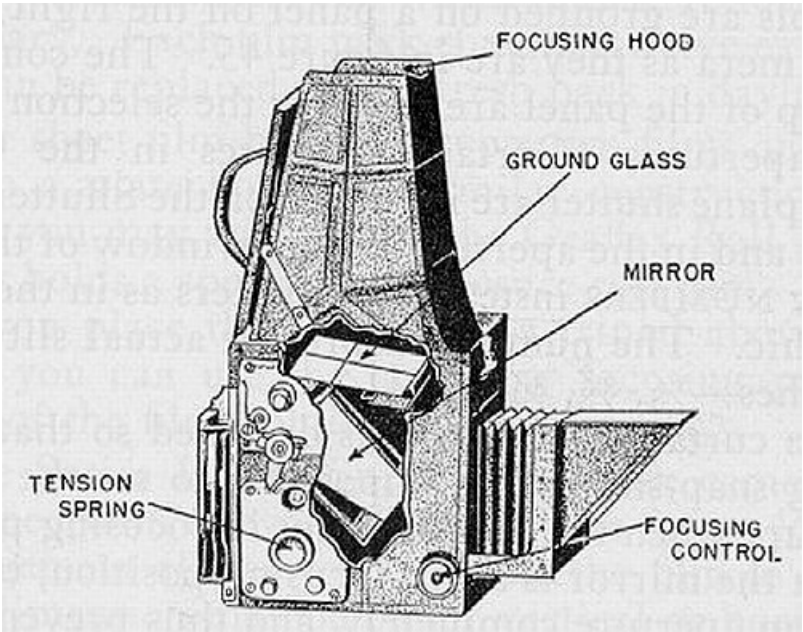
Kodak And The Brownie Camera
Starting in 1878 George Eastman concentrated on making dry plates that were much easier to work with than the former wet plate process that required immediate exposure and development. In 1889 his company, Kodak, produced the first manufactured flexible transparent roll film. In 1900 the company mass produced the Brownie camera. It was easy to use due in part to the simplicity of roll film. Marketed as the everyman camera, it was a device that anyone could get decent snapshots with, as long as they followed Kodak's rather odd directions (see below). Photography then changed from the specialized craft it had been to an activity that was available to the general public.

Quoted From *The Brownie Manual:*
When making snapshots...the subject should be in broad, open sunlight, but the camera must not. The sun should be behind your back or over the shoulder. NOTE: While these instructions guaranteed a properly exposed photo, the bright sunlight also guaranteed the lighting to be harsh and the people probably squinting because the sun was in their eyes. Kodak promoted the word 'snapshot' to market its message of easy quick photography. And snapshots have been getting a bad rap ever since.

Similar to the very first Brownie of 1900, this picture shows the Brownie 2A that was available starting in 1907. (commons.wikimedia.org)

The Cultural Effect Of The Brownie

The Wikipedia article on the Brownie included this fascinating comment: "In 1908, the Austrian architectural critic Joseph August Lux wrote a book called *Kьnstlerische Kodakgeheimnisse (Artistic Secrets of the Kodak)* in which he championed the use of the camera for its cultural potential. ...he argued that the accessibility the camera provided for the amateur meant that people could photograph and document their surroundings and thus produce a type of stability in the ebb and flow of the modern world."



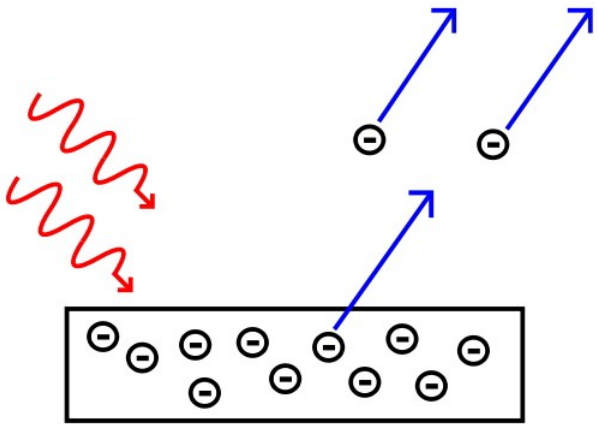
1898: The first single lens reflex, the large format Graflex was bulky and cumbersome, but nevertheless quite portable and a work horse. It was the camera of choice for many professional and famous photographers such as Dorothea Lange and Alfred Stieglitz. (Naval Training Course, Vol. 1)

This picture shows Dorothea Lange with her Graflex finding just the right angle for a shot in the 1930s. (loc.gov)

Einstein, Albert

== Contributions To an Understanding of Light which Lead to Digital Photography:

In 1905 Albert Einstein published a paper explaining the photoelectric effect; this happened when light shown on certain metals causing electrons to be ejected. His explanation became the basis for digital photography and was an important finding that lead to quantum mechanics. In his paper On a Heuristic Viewpoint Concerning the Production and Transformation of Light, he wrote that light acted as both a wave and a particle -- thus agreeing with and contradicting both Maxwell and Newton. When 'light quanta' as he called these wave-packet particles (now called photons) hit certain metals, electrons were ejected based on the intensity and frequency of the light. Einstein won the Nobel prize in part for this explanation which is at the heart of sensors in digital cameras today. See this article for a good explanation.



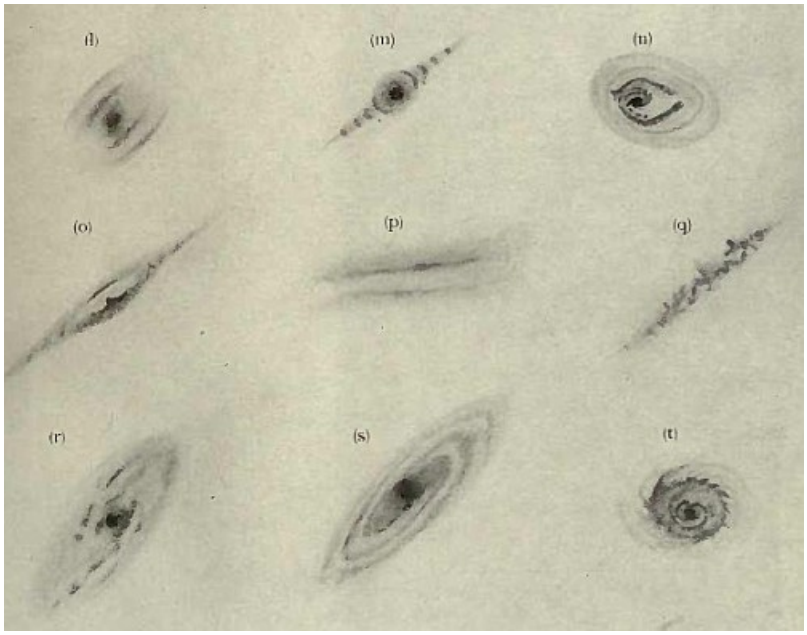
Quoted from Wikipedia: 'The photoelectric effect. Incoming photons on the left strike a metal plate (bottom), and eject electrons, depicted as flying off to the right.' (en.wikipedia.org/wiki/Albert_Einstein)

== Einstein's Contributions to Astronomy:
Einstein redefined the universe as a space-time continuum. And he redefined gravity as a warp in space. In addition he asserted that time itself was relative. In short he completely changed the accepted views of the physical laws of nature. == About His Insights:
When Einstein was 16 he played an imagination game in which he was chasing a beam of light -- other accounts say that he imagined riding a beam of light -- and that this game he had played with himself had an important role in his development of his theory of relativity. Considered a "thought experiment" it is now seen as one of the greatest imaginative endeavors by any scientist. This was only one of a number of thought experiments, in which he was able to visualize and see a series of events due to the imaginative circumstances that he had placed himself in. Like Newton, it was Einstein's intuition that guided him to the right results, not rigid scientific methodology.

NOTE ABOUT GENIUS: Both Newton and Einstein intuitively settled on light as an area of fruitful study, not knowing where their investigations would take them. While their discoveries required methodical and scientific inquiry, the decision to concentrate on light was an intuitive one. Genius often senses which areas are the most promising. In a modern day example, Stephen Hawking focused on black holes which were not thought to be important and considered just an oddity in the universe. Decades later it was discovered that super massive black holes are at the center of most galaxies and are what, in fact, holds them together.

The intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honors the servant and has forgotten the gift.
Albert Einstein

Hubble, Edwin
== Hubble's Critical Use of Photography in Astronomy:
In 1917 Hubble's Ph.D. dissertation, *Photographic Investigations of Faint Nebulae*, the furthest light ever recorded on film became the foundation for his later photographic research of the heavens. Up until then it was assumed that the Milky Way galaxy was the entire universe. Hubble showed that other galaxies existed outside the Milky Way and that the universe was expanding. Eventually this would lead to photographs of thousands of galaxies and the discovery that there were billions of other galaxies. In addition it became clear that the general expansion could be traced back to a single event, the Big Bang.



In 1917 Hubble included these photographs in his Ph.D. dissertation of different types of nebulae that he had identified. (archive.org)

35MM BECOMES THE STANDARD FORMAT

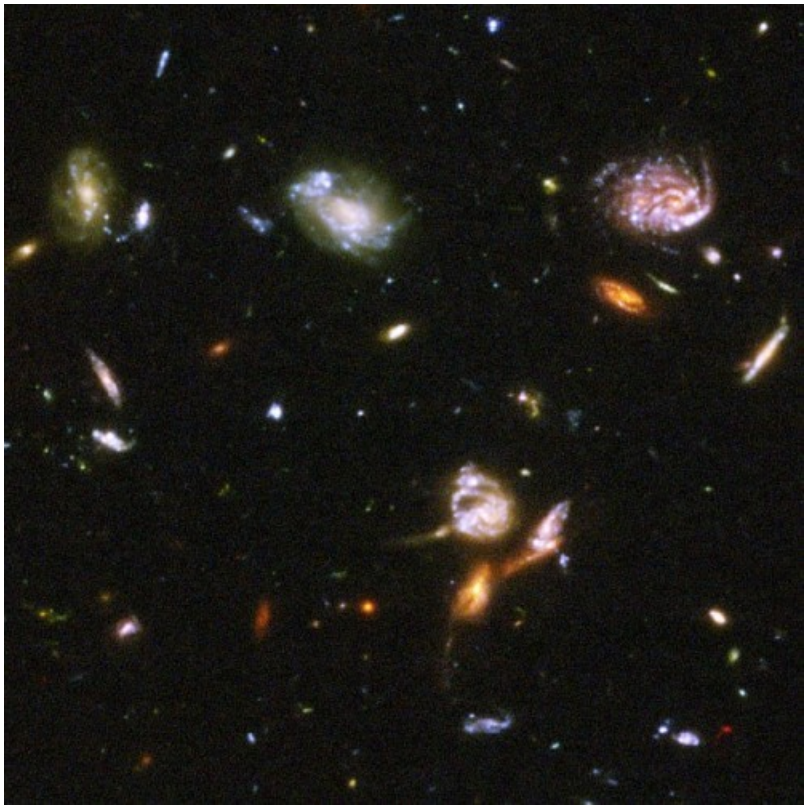
1925 Leica A: Leica introduced this first successful 35mm camera; compact and easy to carry, it still produced quality photos. Shortly after this the 35mm format became the standard. (commons.wikimedia.org)

In 1949 Contax produced the first 35mm pentaprism SLR which allowed eye-level viewing. The small easily hand-holdable SLR design became the camera of choice for photographers for the next fifty years. (commons.wikimedia.org)

DIGITAL PHOTOGRAPHY BECOMES AVAILABLE

1995, Casio QV-10: This was first digital camera with a LCD monitor. It also served as the viewfinder. The monitor gave a real time viewing of a scene before the shot and then immediately showed the resulting photo. Even though it was relatively expensive compared to a film camera and had poor resolution, it became instantly popular. Get the manual for the Casio QV-10: support.casio.com/pdf/001/qv10e.pdf (commons.wikimedia.org)

1998: Self portrait of the author (Rick Doble)with an early Casio -- showing the LCD monitor -- this shot was taken using a mirror.



2004: Ultra Deep Field digital photograph of distant galaxies taken by the Hubble space telescope: this shot of about 10 thousand galaxies more than 10 billion light years away was recorded using a 1 million second exposure, photographing the faintest light ever. Photography had now taken us to the edge of the universe in space and almost to the beginning of the formation of the universe, the Big Bang, in time. (nasa.gov)

Note About Our Changing Understanding Of The Universe
From Kepler to Galileo to Newton to Hubble, the perceived position of humans in the cosmos was radically diminished. No longer at the center of the universe, instead humans were on a small planet that orbited one of 100 billion stars in the Milky Way Galaxy. And to make matters worse, the universe contained a 100 billion other galaxies. Indeed we discovered we were just a tiny part of things. Yet the same technology which had revealed this -- and in which photography had played a crucial role -- also gave us unprecedented power over our lives and our world.

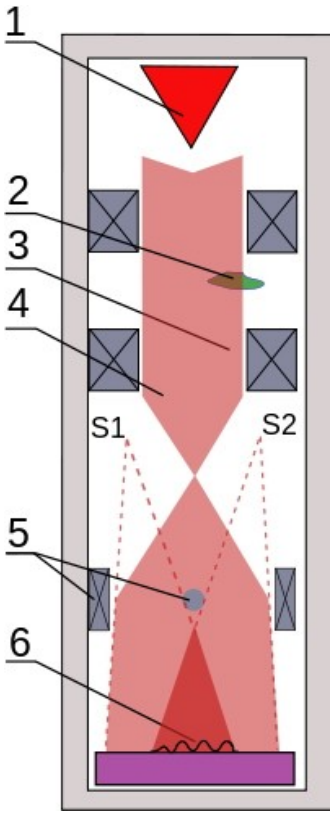
The Effect Of Photography On Contemporary Culture
Whenever I see a story on the local news about a house fire, the family always comments on whether they were able to save the family photo album -- the one thing perhaps that was irreplaceable. Before photography time simply passed with no record. Today photography has transformed our perception of time and created an experience of the passing years which is unique to modern life. Now we can see how we looked last Christmas or a decade ago. And as we age, we are amazed that we ever looked so young. Photography is so precise that a well focused snapshot will show us details that we had forgotten like the pattern on a tie or a raggedy doll in a child's arms. Time is now not something that slips by out of reach, but that we can hold onto just a bit.

THE FUTURE OF PHOTOGRAPHY

So Is Digital Photography The End Of Photography's Development?
Far from it -- photography has been changing from the very beginning. While there have been periods of relative stability such as 35mm and the single lens reflex, there have been other periods of rapid change. We are in one of those periods right now. A good example is the Lytro light-field camera that was just introduced this year -- using state of the art technology. Instead of taking a picture, it photographs 'light field data'. A photographer can go back later and decide where to put the focus. And while the advertised advantage of such a camera is today: "shoot now, focus later," I suspect that many other techniques will come about as a result of this technology.
“Light field photography was once only possible with 100 cameras tethered to a supercomputer in a lab. Today it’s accessible to everyone in a camera that’s small and powerful, but incredibly easy to use. Our goal is to forever change the way people take and experience pictures...” said Professor Ng of theLytro light field camera.

What Is In The Future?

2050? We can only speculate, of course, but an obvious leap in technology would be an easily usable, cheap holographic system.



Holographic Photography? -- This diagram is a 'Schema of electron holography: 1-electron source; 2-specimen; 3-object wave; 4-reference wave; 5-electron biprism; 6-hologram.' (picture and text from commons.wikimedia.org) BTW doesn't this look an awful lot like those early camera obscura diagrams in my previous blogs in this series? (commons.wikimedia.org)

More Ideas For Cameras Of The Future

== As an experimental photographer, my own wish-list includes an LCD monitor that would show me how a picture was 'building' in real time during a long exposure of 4 seconds, for example. Right now the monitor blacks out and I have to take an educated guess.

== Expect that photons, the particles of light, will be better understood at the subatomic and quantum level and that the resulting nanotechnology will again make major changes in photography. For example, today's digital cameras must translate voltage at a photosite (the point where light hits in a camera and that equals one pixel) using an analog to digital conversion. In the future this could be a purely digital task that would count the number of electrons that had been ejected when light hit -- and which could lead to an extended tonal range never before seen in photography.