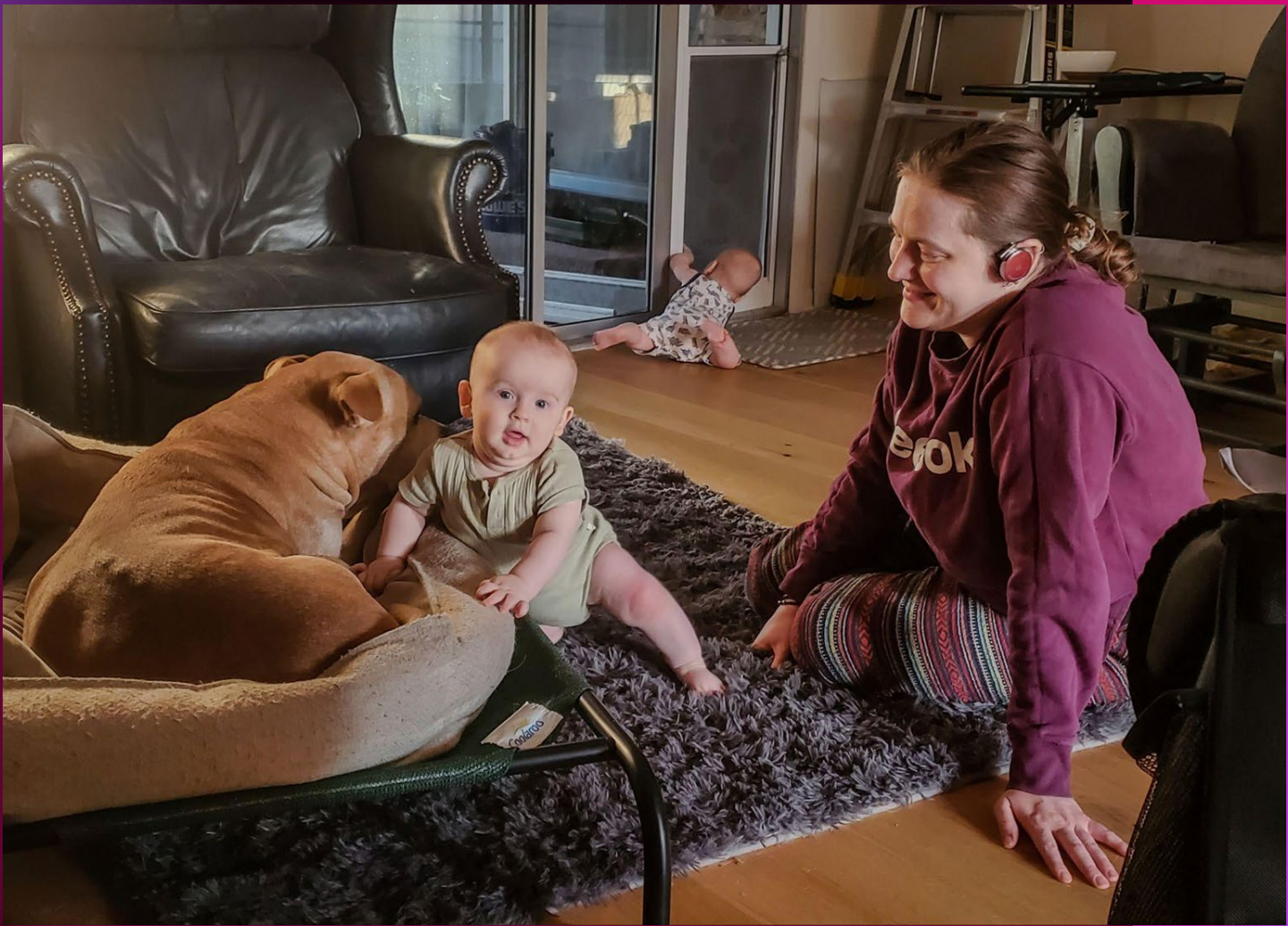


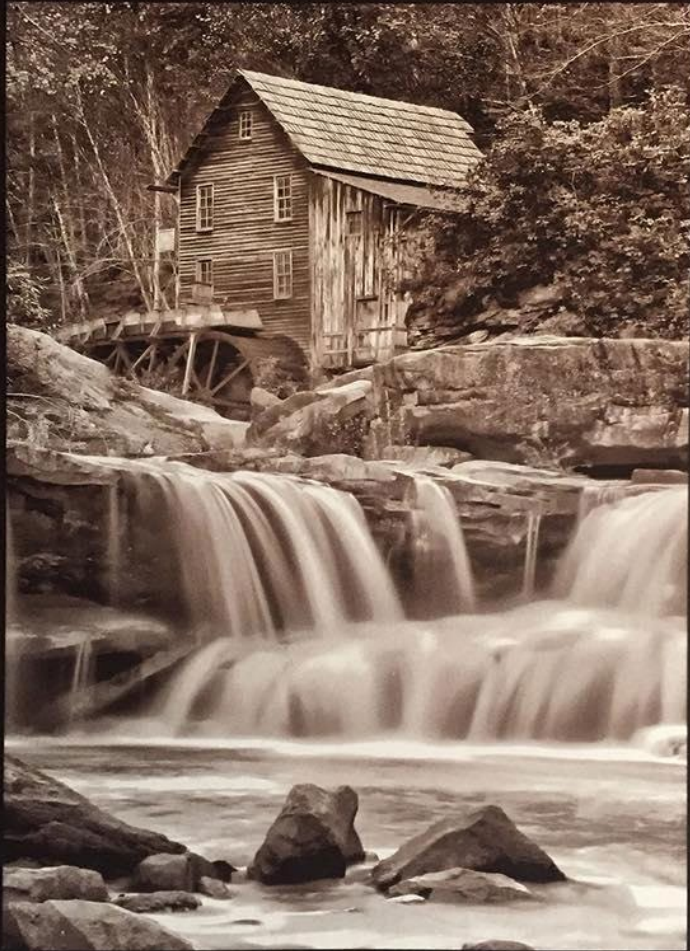


The Math and Science of Photography

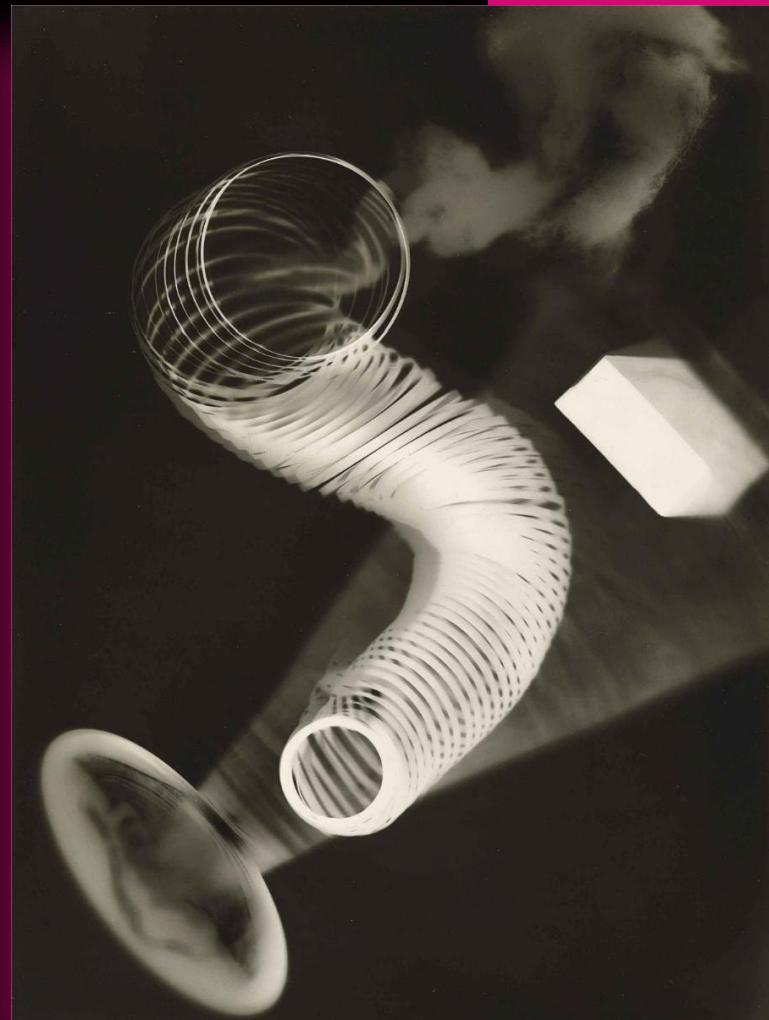
What is Photography?

- Photo = light, Graph = line or drawing
- Camera Based Art
- Lens Based Medium
- Mechanical or Chemical Based
- Handless (“hand of the artist”) Based Art

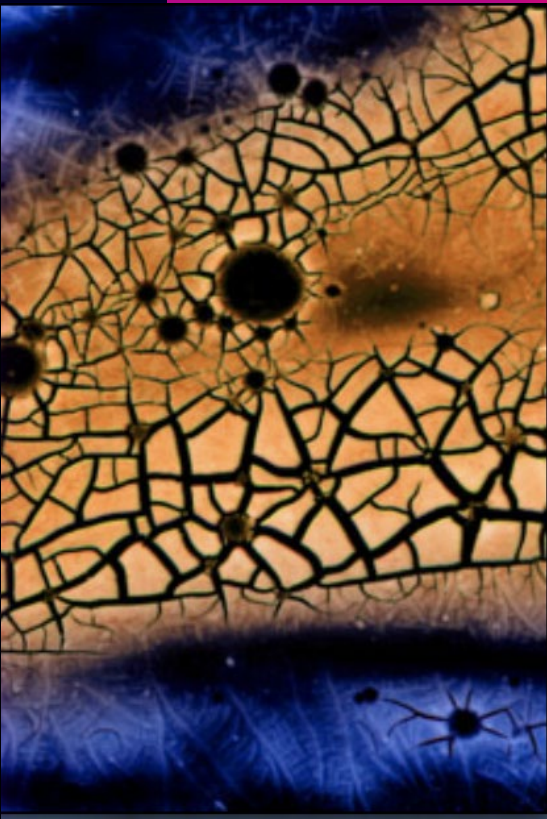
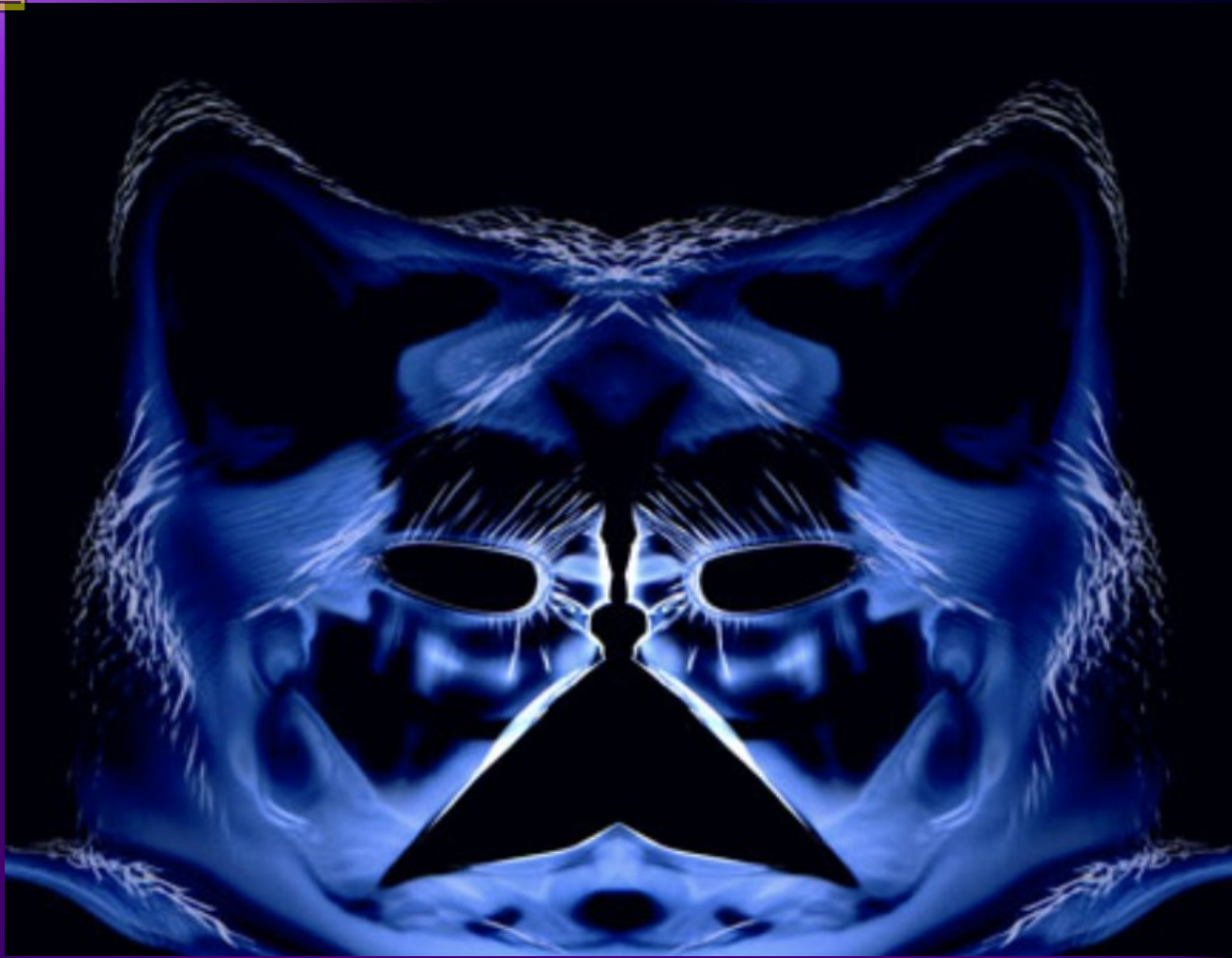


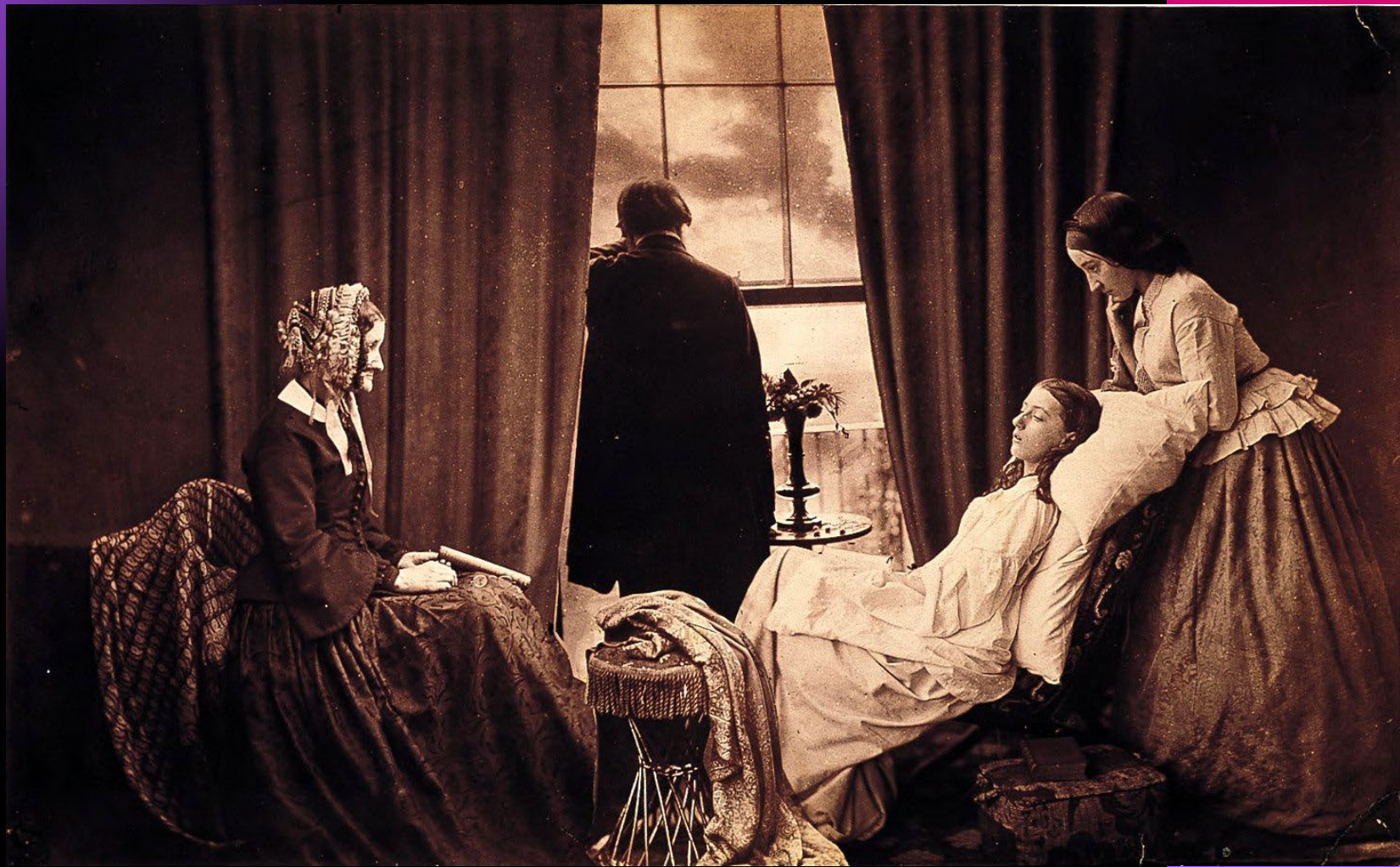






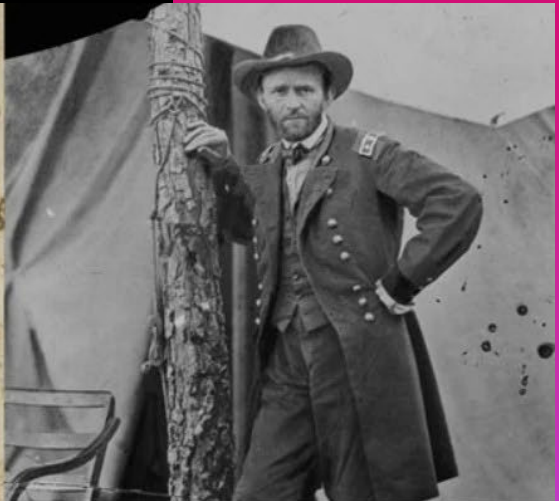




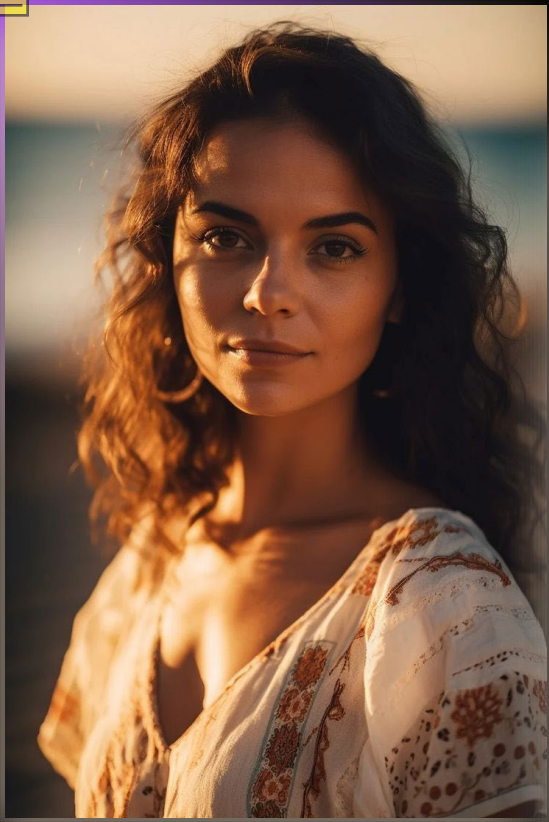




WRIGHT 1904
BY
HANDY











What about this slide?

*The projector is using light to make an image.

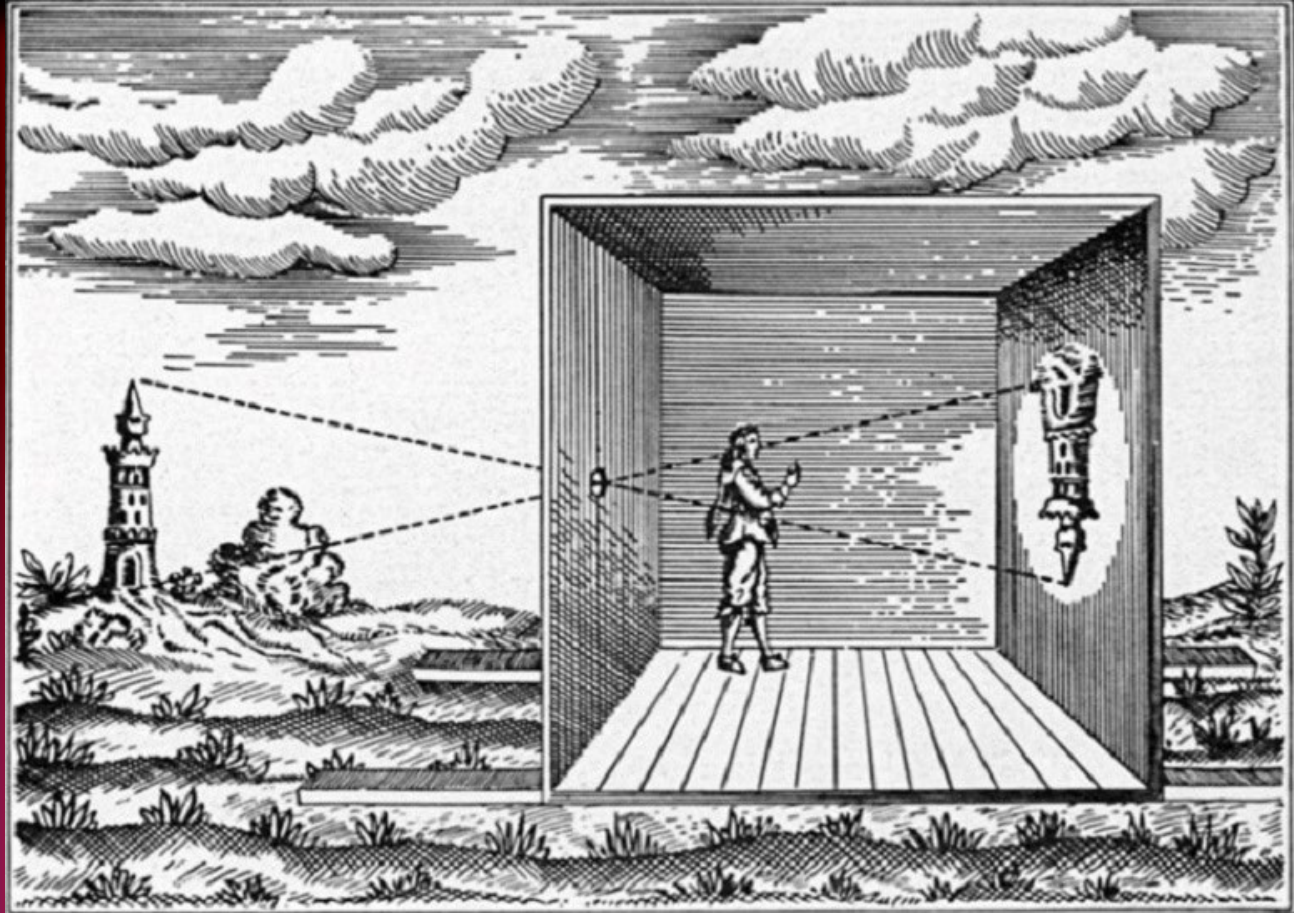
Camera Obscura

-First documented account in 4th Century BCE by Chinese philosopher Mozi.

-Mathematician and architect Anthemius of Tralles was the first to study the effect in the 6th Century CE.

-Roger Bacon used one to falsely claim light traveled in circles. (1267)

-Studied and used extensively by Leonardo da Vinci (1452-1519).



Angelo Sala (1576-1637)

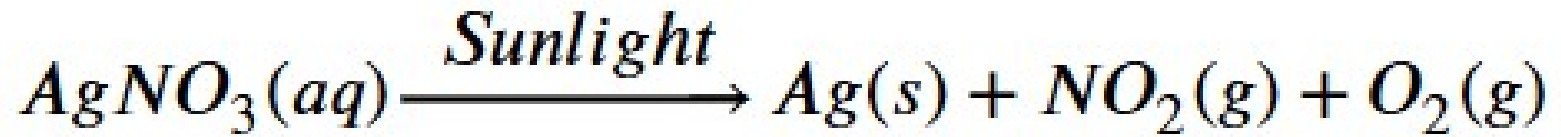


-Medical Doctor and “Chemist”.

-While wrong about many things, and the cause of many more, he showed ideas that would later be seen in the scientific revolution.

-First to discover that light would cause powdered silver nitrate to blacken in 1610.

-Wrote up his findings but at the time it was seen as a minor curiosity and no further research took place.



- Sunlight, especially UV light, provides the energy to break the bonds in silver nitrate.
- Silver ions are reduced to elemental silver atoms.
- Other products formed include nitrogen dioxide and oxygen.

Johann Heinrich Schulze (1687-1744)

-German Professor who studied medicine, chemistry, philosophy and theology.

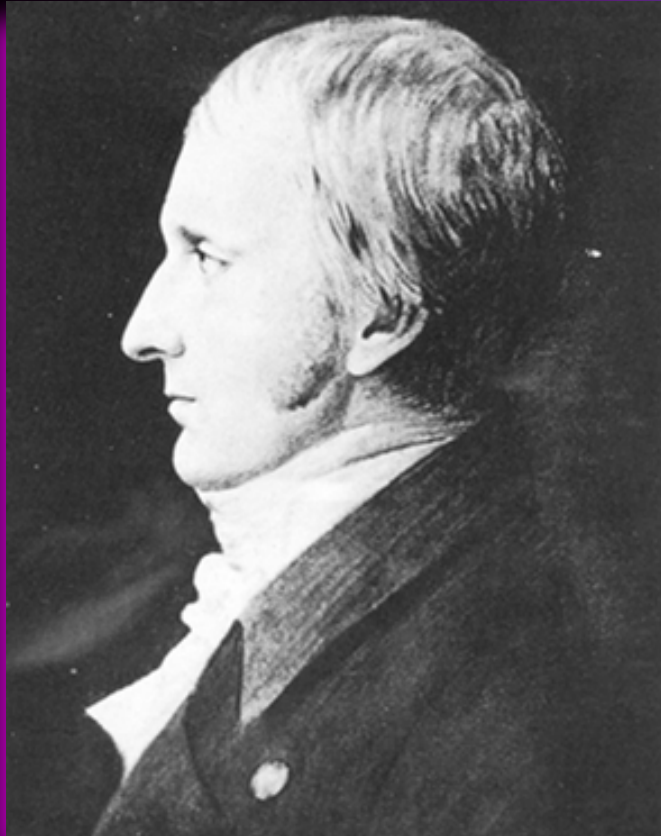
-One of a handful of people who are credited as the inventor of photography.

-In 1717 he dissolved silver nitrate and chalk into nitric acid in a bottle, put a stencil over it and exposed it to sunlight.

-Many people after Sala believed heat caused the silver to blacken, Schulze is credited as confirming it was light not heat.



Thomas Wedgwood (1771-1805)



-Inventor, chemist, and studied education in young children and infants.

-Uncle of Charles Darwin.

-First person to have been documented as to making something we today would understand as a photograph. Though they were not lightfast and could only be viewed for a short time by candle light. (1790-1799)

-Every once in a while it is claimed someone has found an original photo from Wedgwood.

Sir Humphry Davy (1778-1829)

-Baronet, President of the Royal Society, Member of the Royal Irish Academy, a founder member and Fellow of the Geological Society of London, poet, painter, chemist, inventor...

-Was the first to isolate potassium, sodium, calcium, strontium, barium, magnesium and boron.

-Coined the term “laughing gas” and was the first to consider it for anaesthetic uses.

-Worked with Wedgwood and many believe it was Davy who did most the work.



Carl Wilhelm Scheele (1742-1786)

-Discovered oxygen, molybdenum, tungsten, barium, nitrogen, and chlorine. He was also the first to identify several acids.

-Was not well known or widely published. This led to a lot of his work being unknown or later “discoveries” being attributed to others.

-First to discover the mechanism of silver based photography (silver salts \rightarrow elemental silver) and also discovered a way to fix the image.

-Ammonia would dissolve the silver chloride but leave the elemental silver untouched. This discovery went unnoticed and would take nearly 60 years to be rediscovered.



Sir David Brewster (1781-1868)



-Entered college at age 12 and had a masters degree by 18.

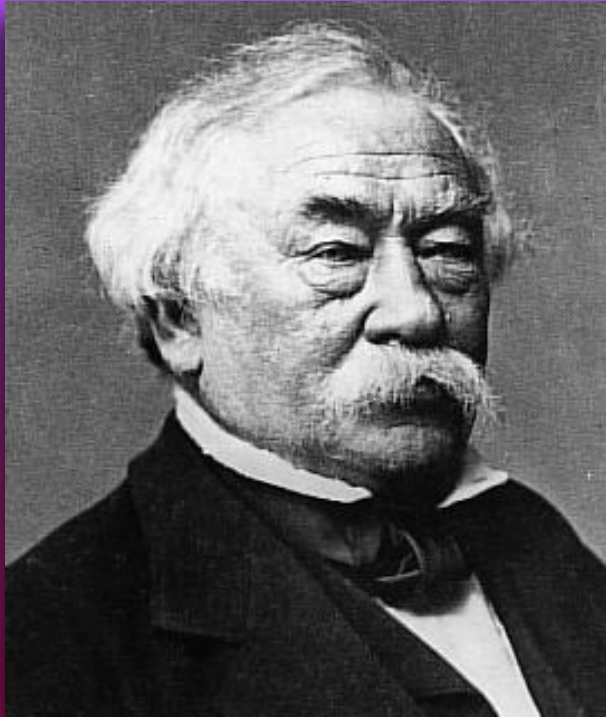
-Studied physics, mathematics, astronomy and theology.

-Founding member and first president of the Photographic Society of Scotland.

-Invented the stereoscope that allowed for a portable 3D image viewer.

-His work with optics would later lead to purpose built photography lenses.

Joseph Petzval (1807-1891)



-PhD in Physics, primarily known in his time as a mathematician and engineer.

-Professor of Physics and Mathematics. Was head of the math department at the University of Vienna.

-Discovered the Laplace Transform but like many other times in history did not get the credit for it and it was named after someone else later.

-Built the first truly purpose built photography lenses.

-A rival of his broke into his home and stole or destroyed all of his work. That company is still around today.

Elizabeth Fulhame

-Chemist

-Known for inventing the concept of a catalysis and the first female chemist.

-In 1794 wrote about the effects of light on silver salts.

-She never tried to make images or work on fixing the results she saw. Her work was purely related to the chemistry of the reactions themselves. Her work later influenced people who were trying to make images.



And then...

Nothing happened for about 30 years.

And then...

A lot happened very fast.

Nicéphore Niépce (1765-1833)



-French politician, chemist, and inventor.

-Invented one of the first internal combustion engines and the first to power a vehicle with one (a boat).

-Seen as the inventor of photography by most art historians and photographers.

-Made the oldest surviving and oldest known fixed image. (1826)





Louis Daguerre (1787-1851)

-Scientist and artist.

-If 95% of people credit Niépce as the inventor of photography the other 5% credit Daguarre (unless they are English.)

-Worked with Niépce to further develop both of their processes.

-Took the first image of a human.

-Released the process free of charge, unless you were English.

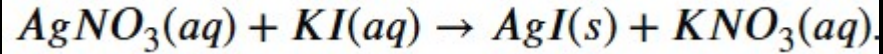


Daguerreotype Process

-Take a sheet of copper and plate it with silver.

-Polish it to a mirror like shine.

-Expose the plate to iodine vapor. The elemental silver and the iodine bond creating a thin coating of silver iodide.



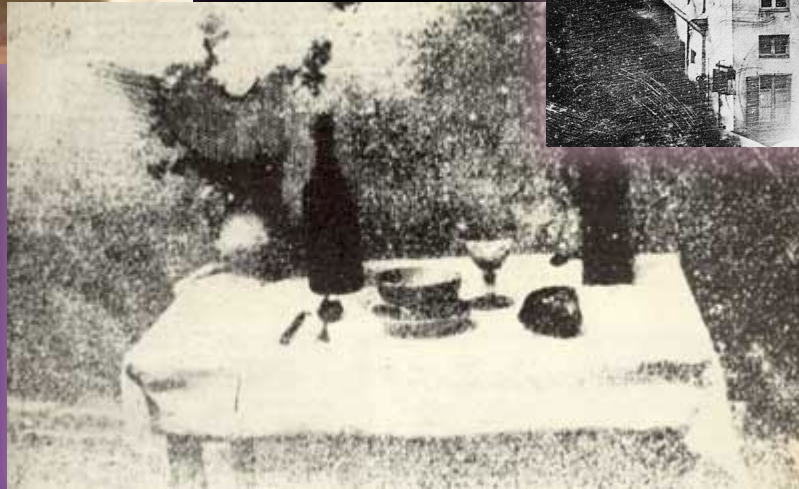
-Expose the plate to mercury vapor.

-The plate is then fixed by washing it in sodium thiosulfate to dissolve any undeveloped iodide.

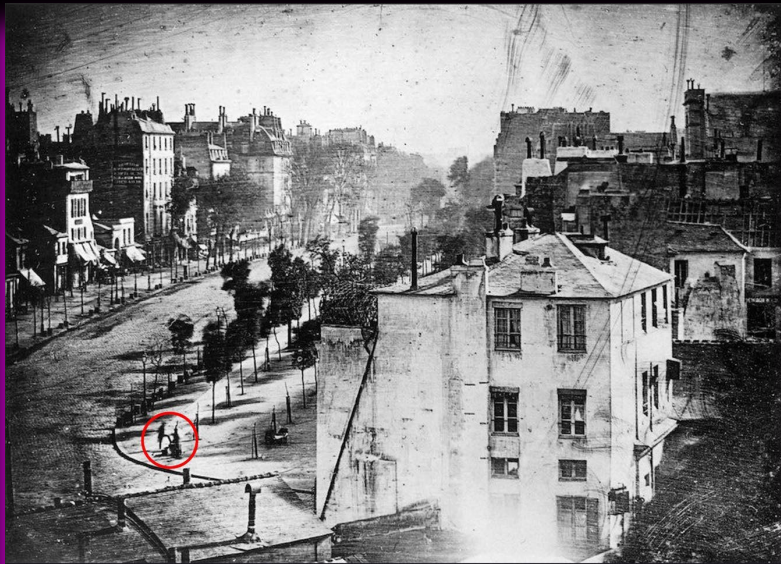
-Wash the plate to remove the sodium thiosulfate.



Within 10 years photography went from..



First photograph of a human.



Henry Fox Talbot (1800-1877)



-Inventor, chemist, and scientist.

-The last person to be brought up as the inventor of photography.

-Invented the first negative/ positive system and the first to be able to make multiple of the same image.

-Used silver chloride and writing paper.

-Patented and would not let others use it.

Salted Paper and Calotype Process

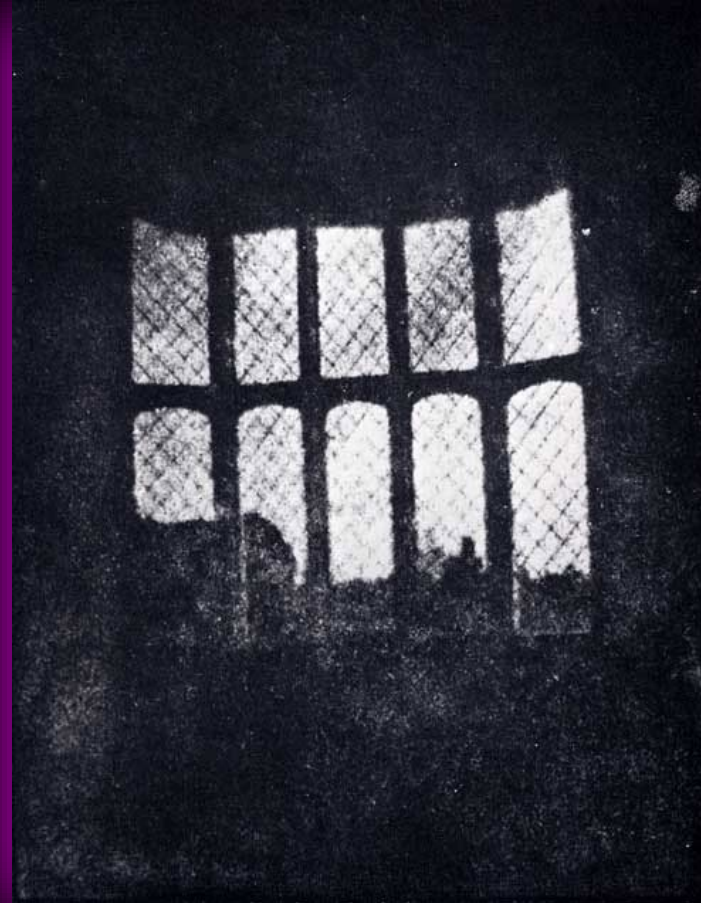
-Submerge paper in salt water (table salt/ sodium chloride). Later this would be potassium iodide for the calotype process.

-Let dry and then coat one side with silver nitrate. This would produce silver chloride or silver iodide depending on the process.

-For the salted print the image would then needs hours to develop. The final image would appear in a printing-out process. I.e. the image would be visible without the need to be developed.

-For the Calotype the exposure could be much shorter but would need to be developed.

-The final step in either process would be to fix the image.





Pros

- Reproducible.
- Cheaper to produce.
- Could be enlarged.
- Left/ right correct (words are readable).
- MUCH safer to make.
- Did not need specialized equipment.

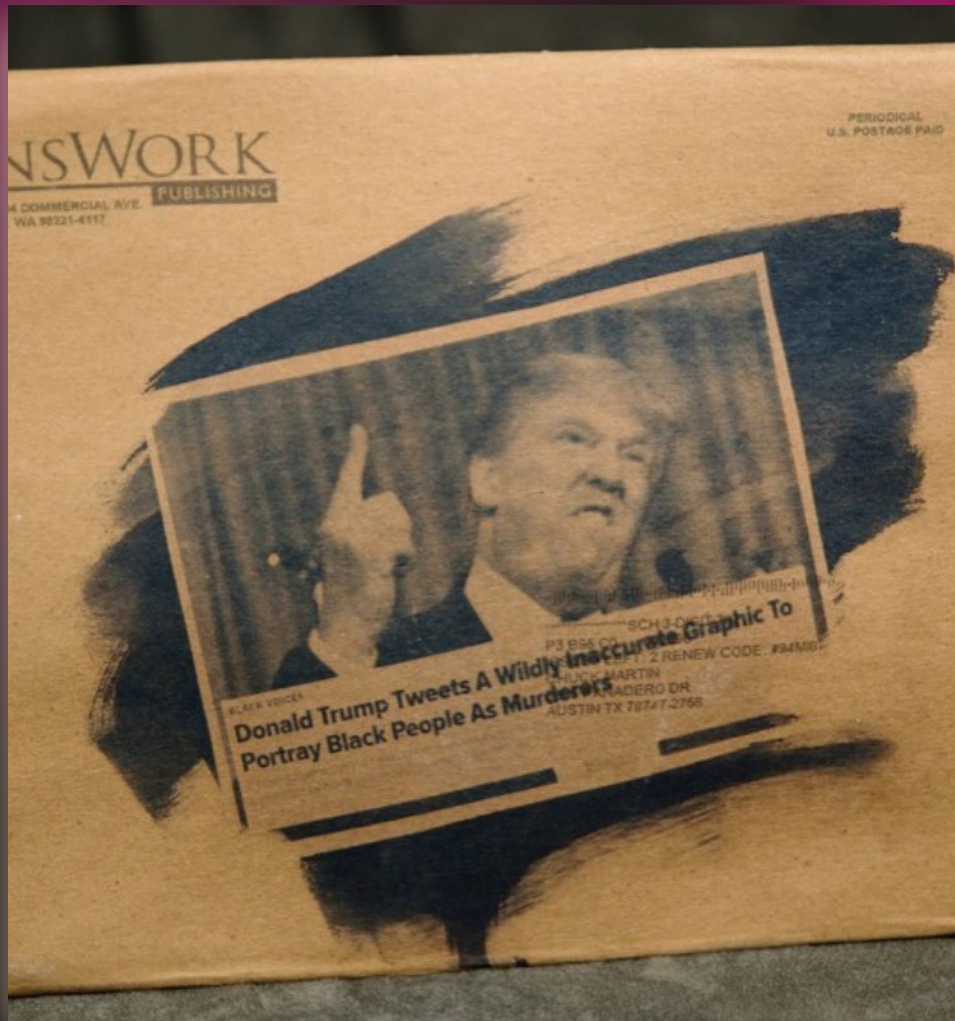
Cons

- Had a fee to produce.
- Because of the fibers in paper in both the negative and the print it has a noticeable loss of detail.
- Later to announce his work and took even longer to finalize his process.

Sir John Herschel (1791-1871)

- Mathematician, chemist, astronomer, inventor, and discovered several moons of Saturn and Uranus.
- Son of William Herschel, (discovered Uranus in 1781)
- Discovered the use of sodium thiosulphate (formerly called hyposulphite) in 1819. The name hypo is still the generic term used for any fix today.
- Coined the terms photography, negative and positive.
- Discovered the first non-silver based chemical reactions. Chrysotype/ gold. Cyanotype/ Iron (aka blueprints). platinotype/ platinum.



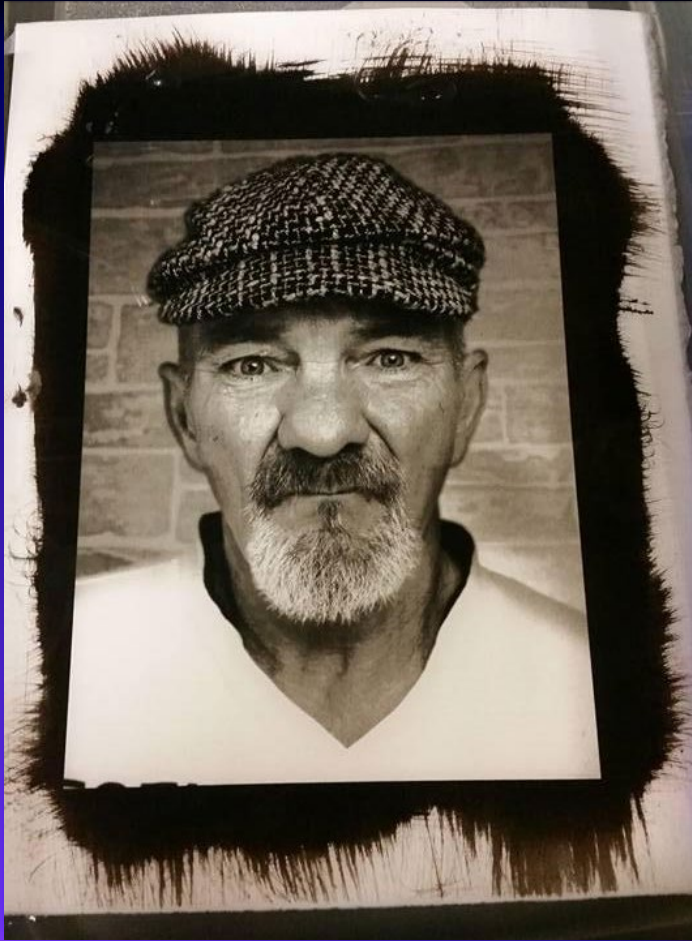


Coffee

Black Tea

Myrobalan

Acorn Dye

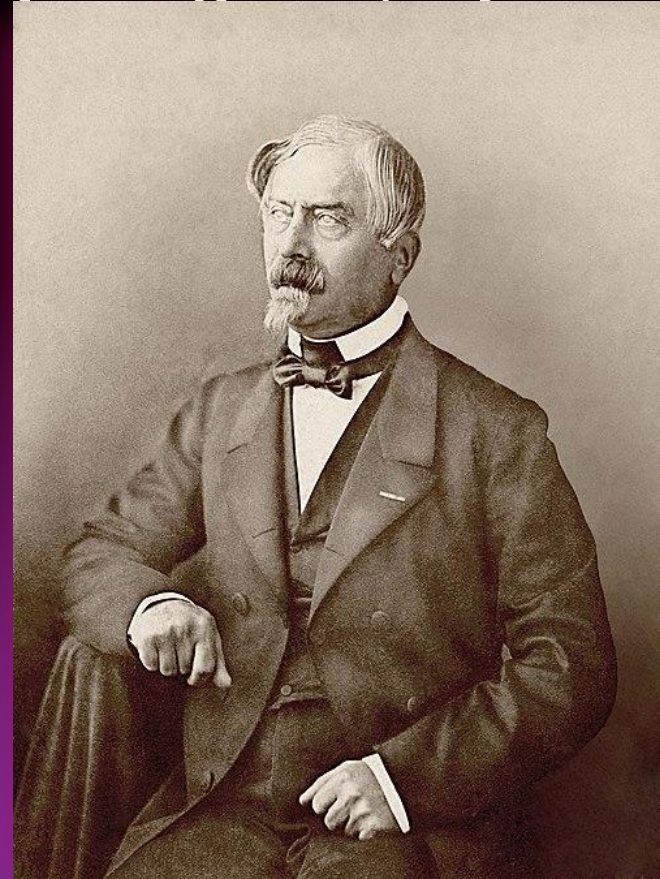


Abel Niépce de Saint-Victor (1805-1870)

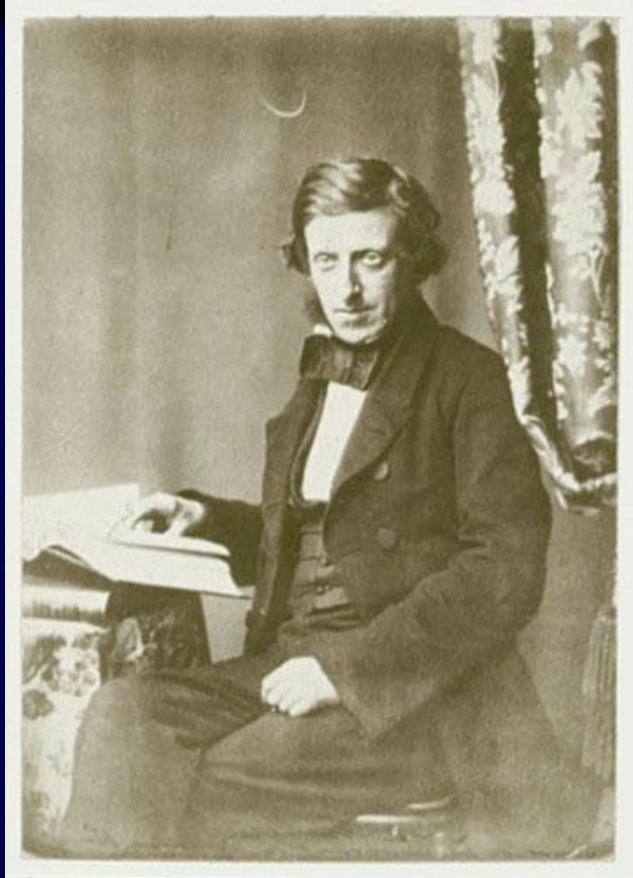
-Inventor, chemist, and some argue he was the one to discover radioactivity.

-Invented the photogravure process which was the first mechanical process of reproducing photographs and other highly detailed work. It would remain the basis for all other methods for over 50 years and still sees use today in the art world.

-Invented the albumen print. Uses egg whites to coat glass with silver nitrate. Replaced the processes that replaced the daguerreotype and became so popular that parts of Europe had a shortage of eggs.



Frederick Scott Archer (1814-1857)



-Chemist, inventor, and sculptor.

-Invented the collodion process, more commonly known as the wet plate process.

-This invention made photography accessible to the masses. A Daguerreotype could be had for a few dollars but a tintype could be had for a few cents.

-If you know what any of your family members looked like before around 1910 it is most likely because of this man.

-Died poor because he did not patent his invention and allowed anyone to use it.

Adolphe-Alexandre Martin (1824-1896)



-PhD and Professor in Physics. Chemist and inventor.

-Used the process from Archer to improve on it and invent the Tintype. I can't emphasize enough how important the tin-type was to photography or how massive a leap forward it was.

-Imagine if in a time of car phones where they didn't work well, were heavy, and expensive someone invented the iPhone and they only cost \$5.00.

-Before Martin people had heard of photography, they may even have seen one, but the vast majority of people could never afford to get their photo taken. Then all of a sudden for the price of a candy bar they could.

Wilhelm Röntgen (1845-1923)

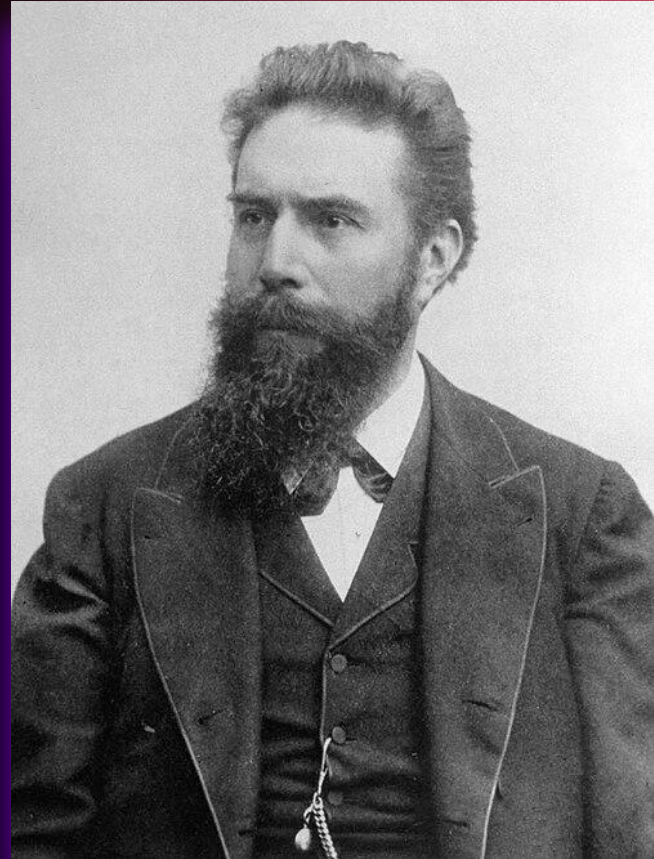
-Ph.D in Physics

-Spent most of his life as a professor and researcher.

-Discovered x-ray radiation.

-Produced the first x-ray image and seen as the father of modern medical imaging. (1895)

-Received the first ever Nobel Prize in Physics in 1901.





Russell Kirsch (1929-2020)

-Engineer and Computer Scientist

-Ph.D from MIT in 1952

-In 1951 was on the team that invented the first stored-program computer.

-His work was used on the Apollo moon landing and also lead to the CAT scan.

-Invented the first digital image scanner and digital line detection. (1957)

-Made the first even digital image by combining multiple scans of his son.



Willard Boyle (1924-2011)



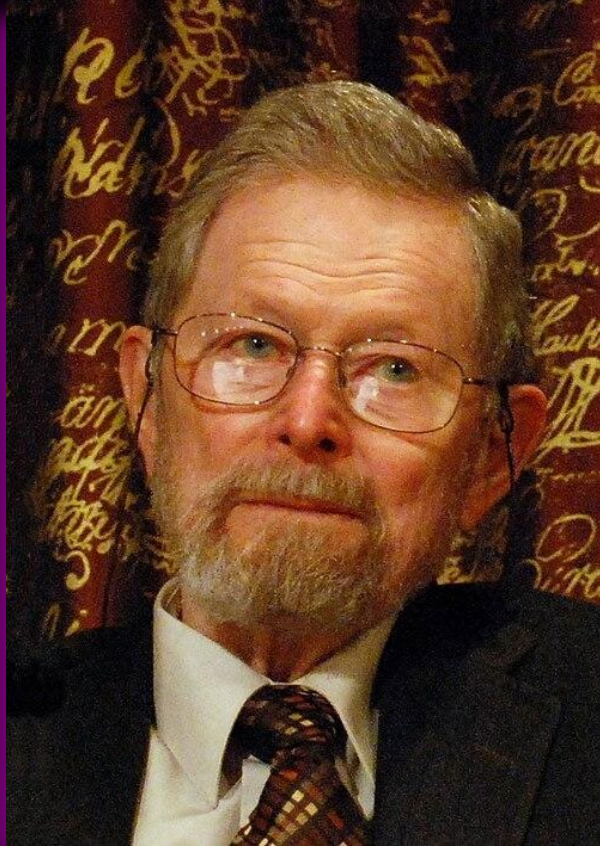
-Ph.D in Applied Physics in 1950 (BSc 1947, MSc in 1948)

-Co-invented the semiconductor ruby laser.

-2009 Nobel Prize in Physics

-In 1969 co-invented the charge-coupled device (CCD). The first electronic light sensor.

George E. Smith (1930-2025)



-Ph.D in 1959 in Physics

-2009 Nobel Prize in Physics

-In 1969 co-invented the charge-coupled device (CCD). The first electronic light sensor.

Steven Sasson



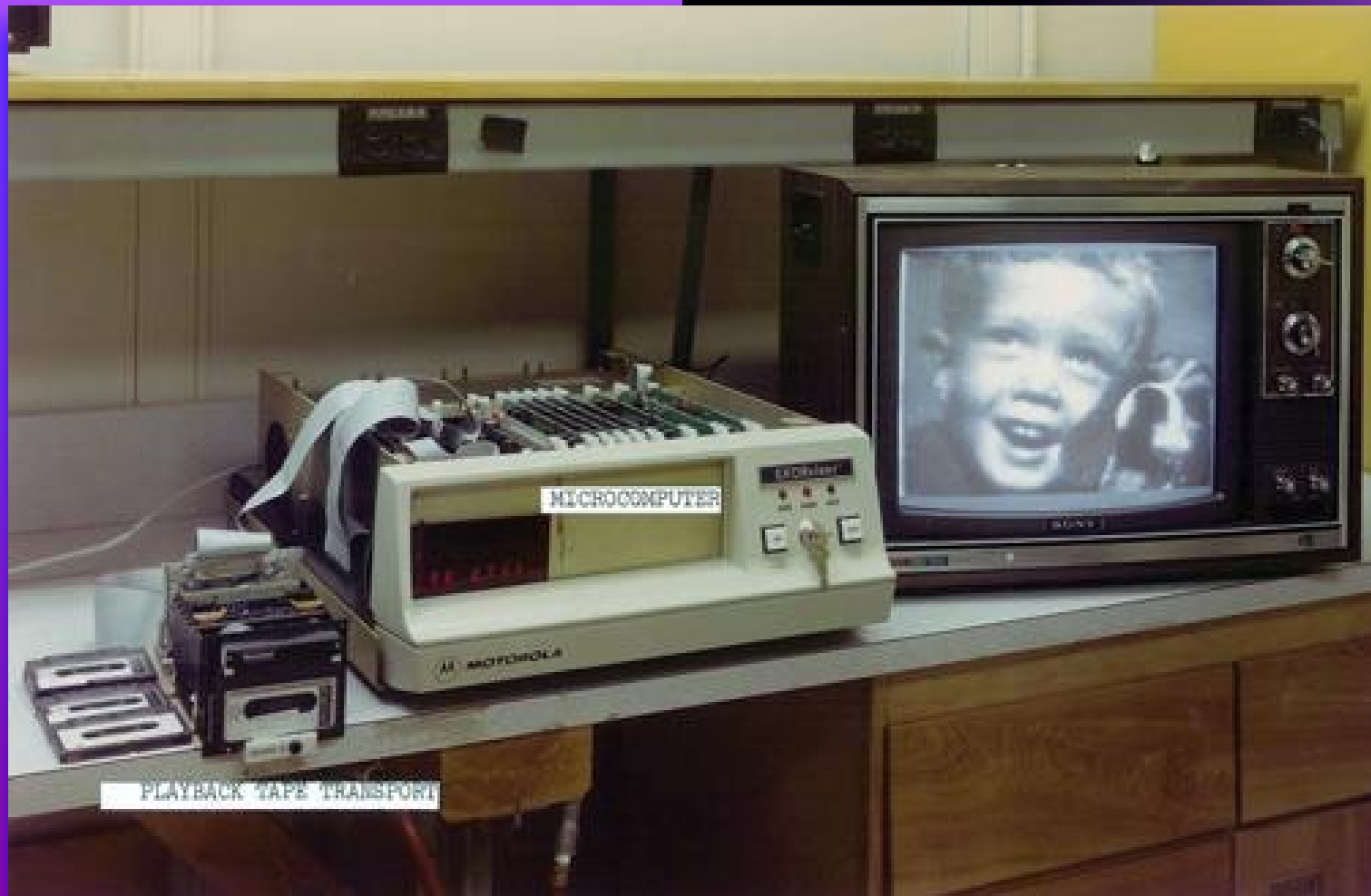
-Engineer and inventor.

-MS in 1973.

-Invented the handheld digital camera in 1975.

-Wanted it to have no moving parts and came very close.

-Used a CCD sensor.



MICROCOMPUTER

PLAYBACK TAPE TRANSPORT

Eric Fossum (1957)



-Ph.D from Yale in Electrical Engineering

-Queen Elizabeth Prize for Engineering (Nobel or Fields level prize for Engineering)

-Invented the CMOS sensor. It allowed digital cameras to be practical.

-Digital sensors before the CMOS needed a lot of power to run and required bright light to work properly.

-More photo have been taken on a CMOS sensor then every other format (analog and digital) put together.

Fields of mathematics used in developing photography.

- Geometry
- Optical Mathematics
- Trigonometry
- Linear Algebra
- Logarithms
- Calculus
- Discrete Mathematics
- Topology
- Statistics
- Probability

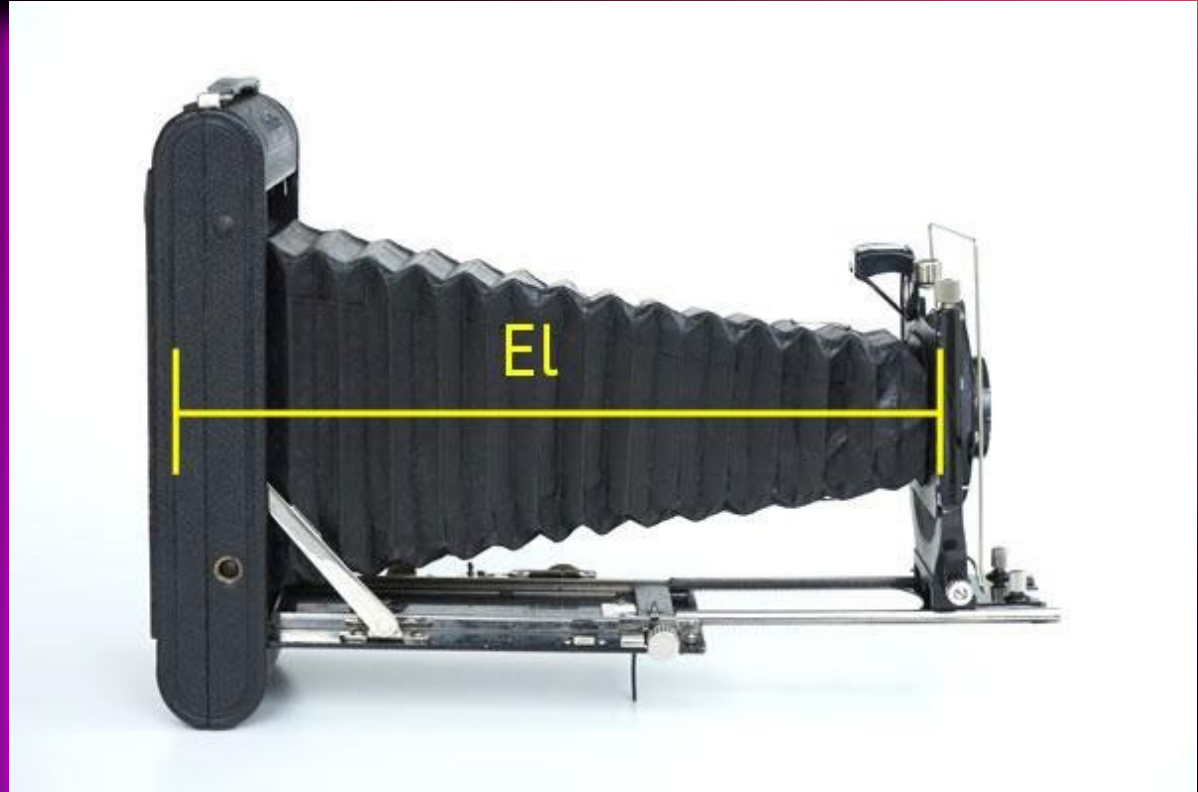


Using math in creating a photograph.

- ISO
- Aperture
- Shutter Speed

- Light intensity
- Light location
- Light duration
- Light timing

- Bellows Extension
- Film Reciprocity



Characteristic Curves for Black & White and Color Negative Films

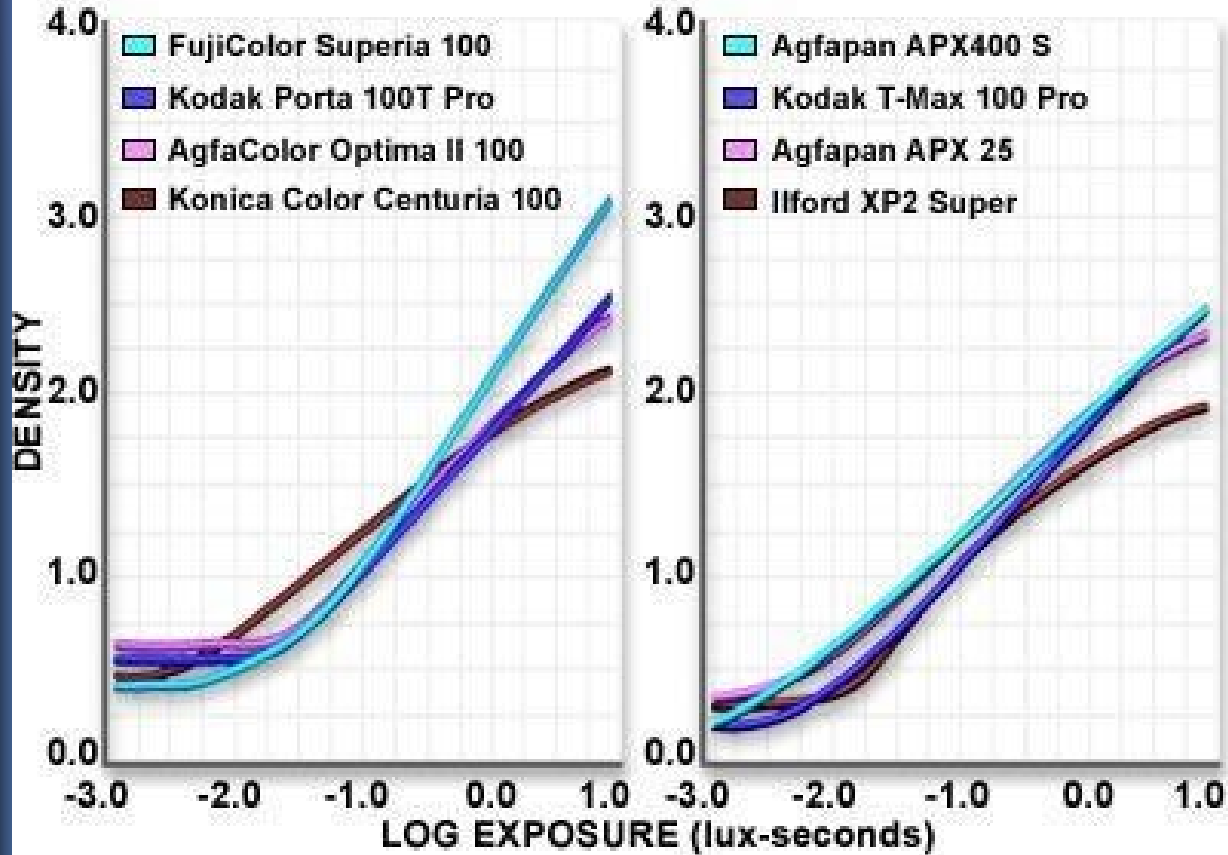


Figure 5



Hiroshi Sugimoto

$$x = a \sinh v \cos u$$

$$y = a \sinh v \sin u$$

$$z = \int_0^v \sqrt{1 - a^2 \cosh^2 t} dt$$

$$(0 < a < 1, 0 \leq u < 2\pi)$$



THANK YOU

Any questions?