

# **CS6640** Computational Photography

1. A brief history of photographic technology

# Prehistory



Prehistoric Painting, Lascaux Cave, France ca. 13,000–15,000 B.C.



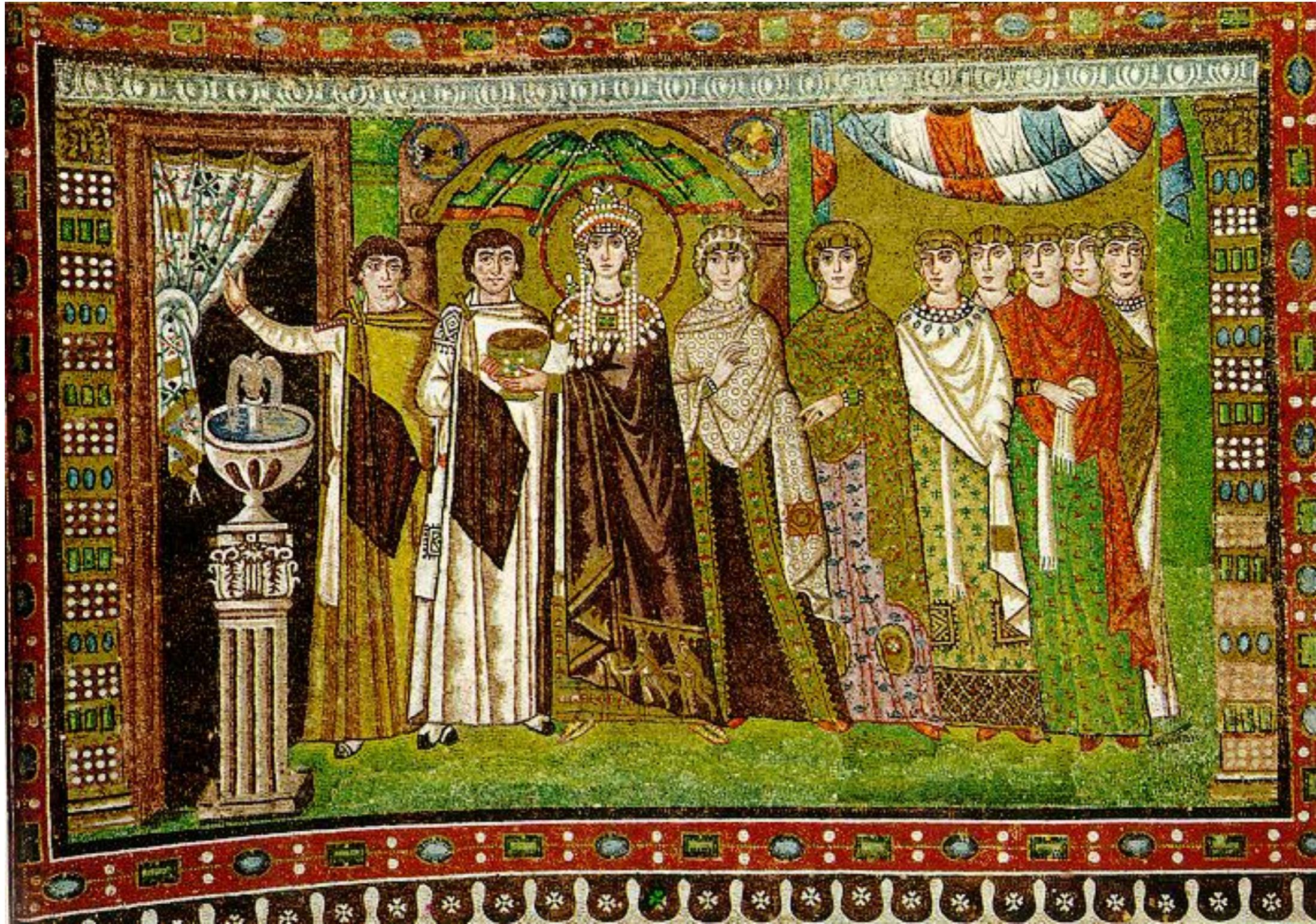
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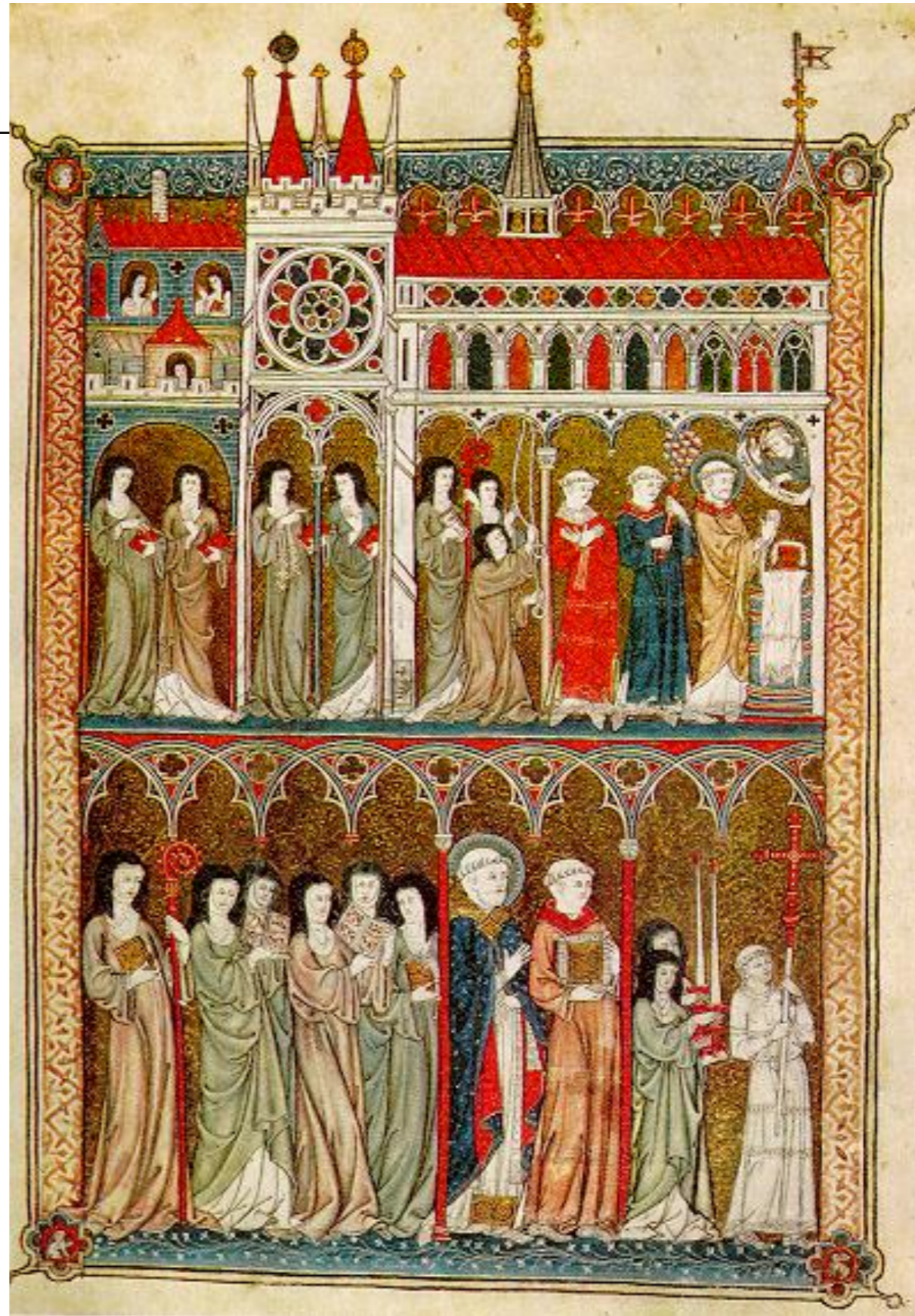
# Middle ages



The Empress Theodora with her court. Ravenna, St. Vitale, 6th century a.d.



# Middle ages



Nuns in Procession. French ms. ca. 1300.



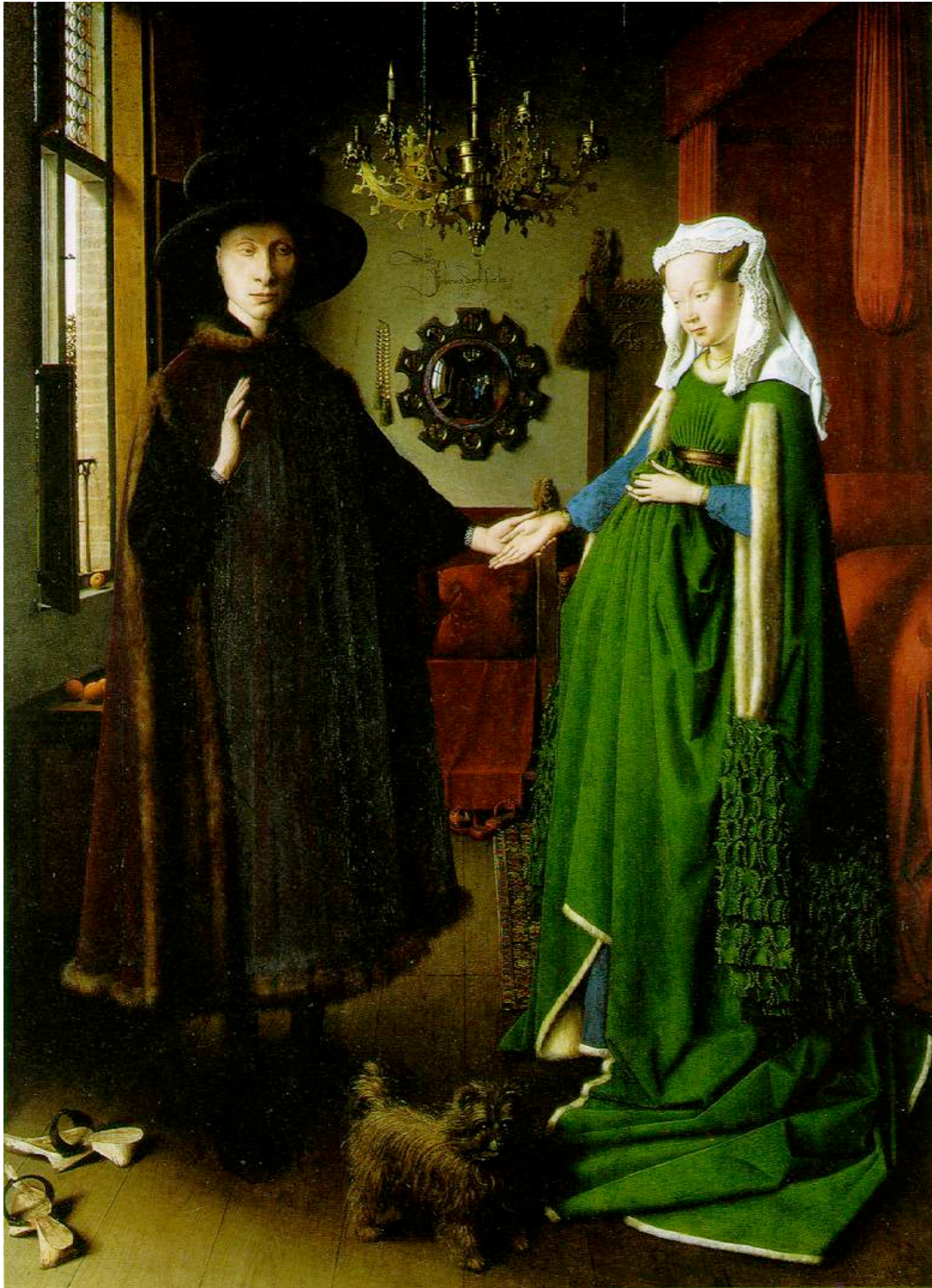
# Renaissance — perspective



*The Flagellation*, Piero della Francesca (c.1469)



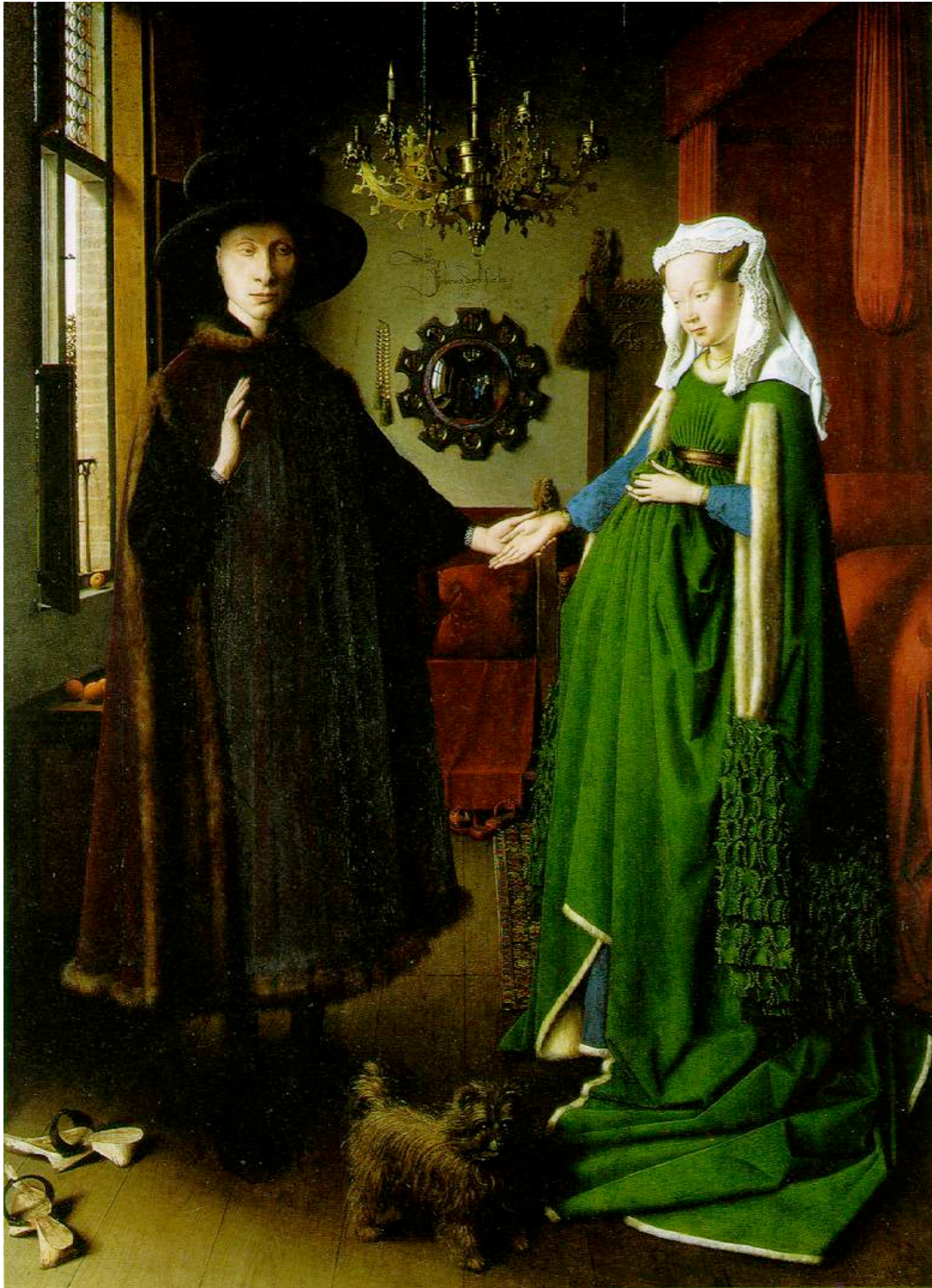
# Renaissance — realism



Jan van Eyck, *The Arnolfini Marriage* (c. 1434)



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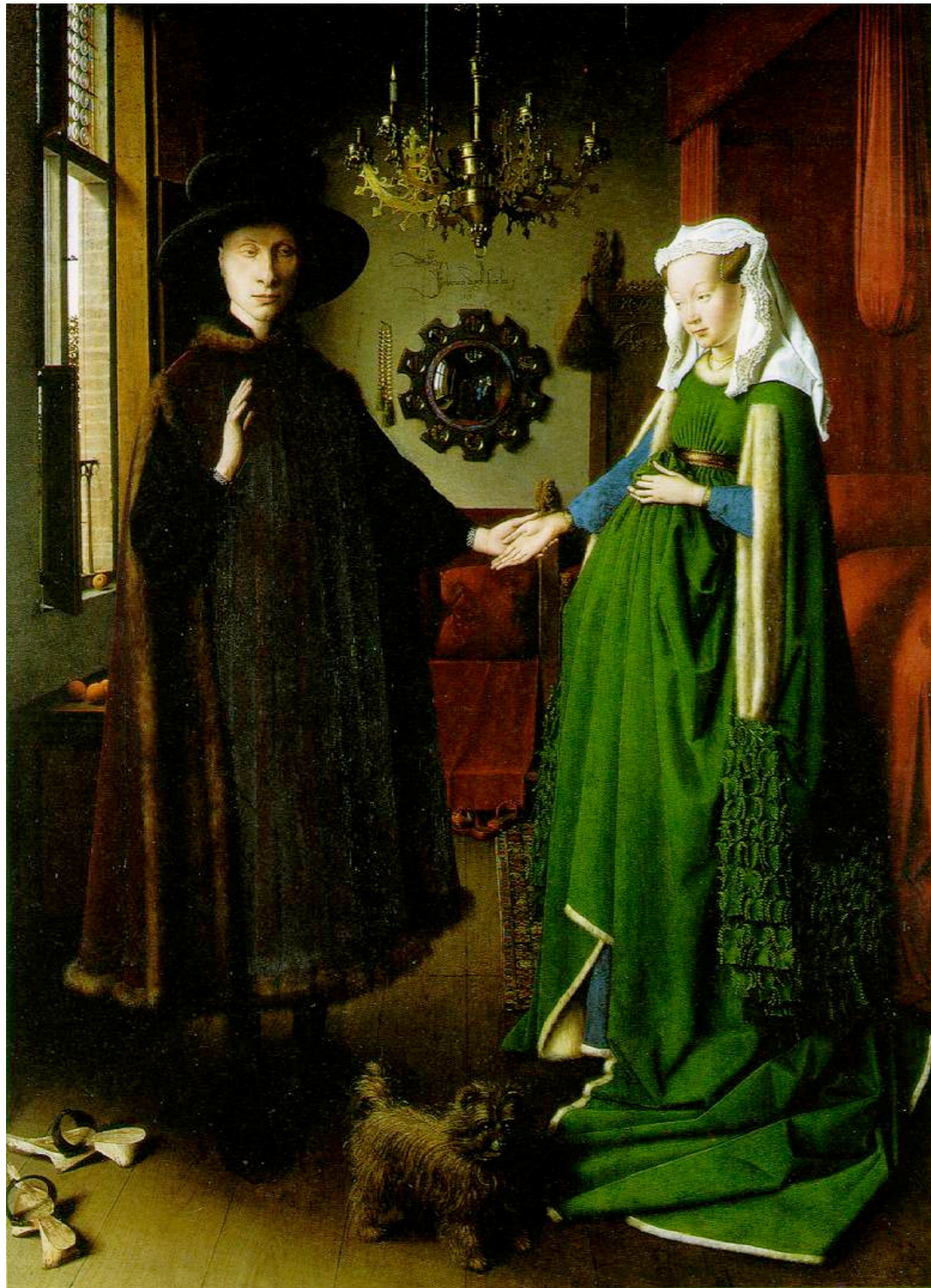


Jan van Eyck, *The Arnolfini Marriage* (c. 1434)

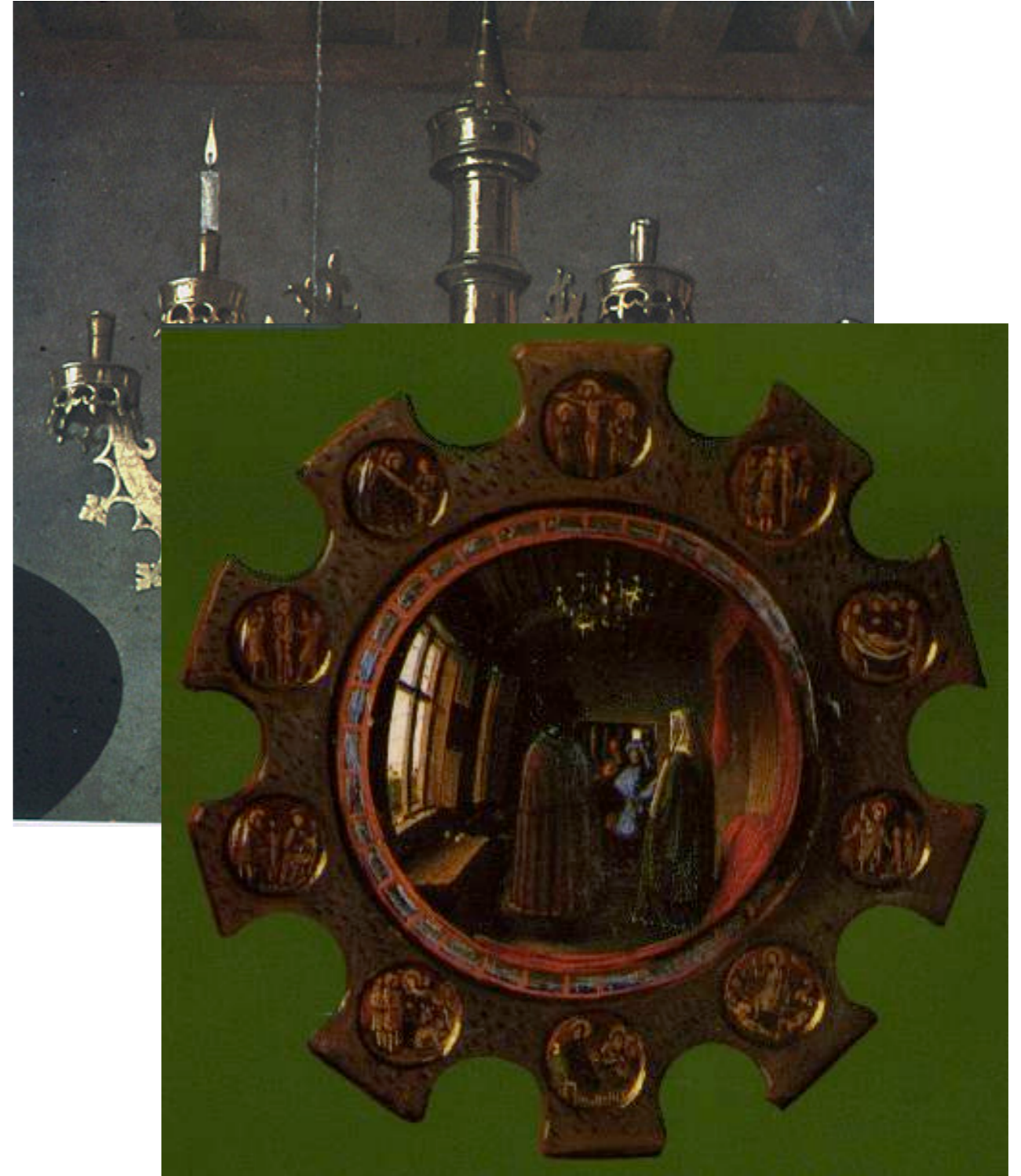




# Renaissance — realism



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# Camera obscura

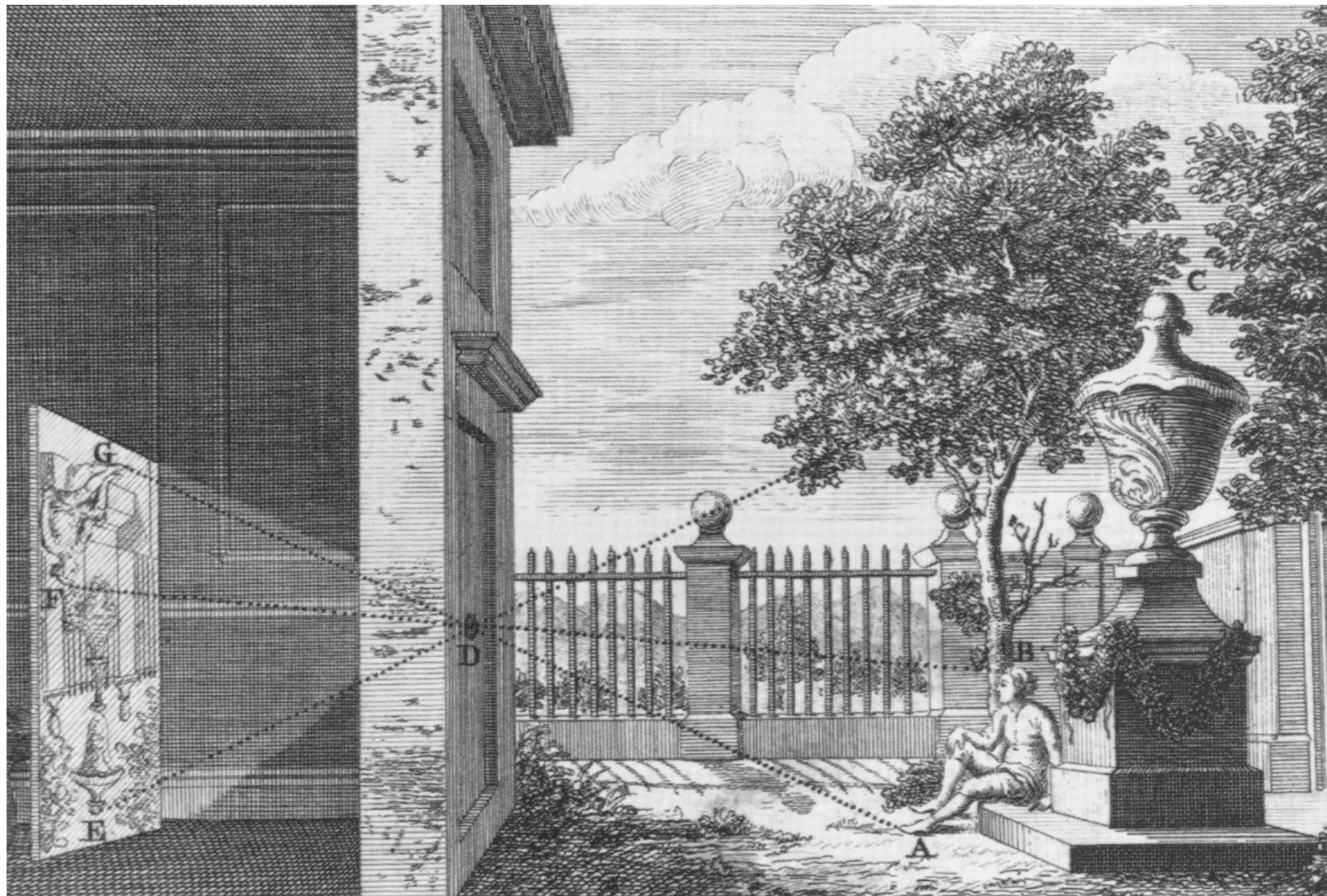
- **A camera-like device for automating perspective drawing**

- **Key elements of camera already present**

Image formation—small hole projects image into room

Image recording—artists stands there and traces

- **Stand in a camera obscura at the Ithaca Sciencenter!**











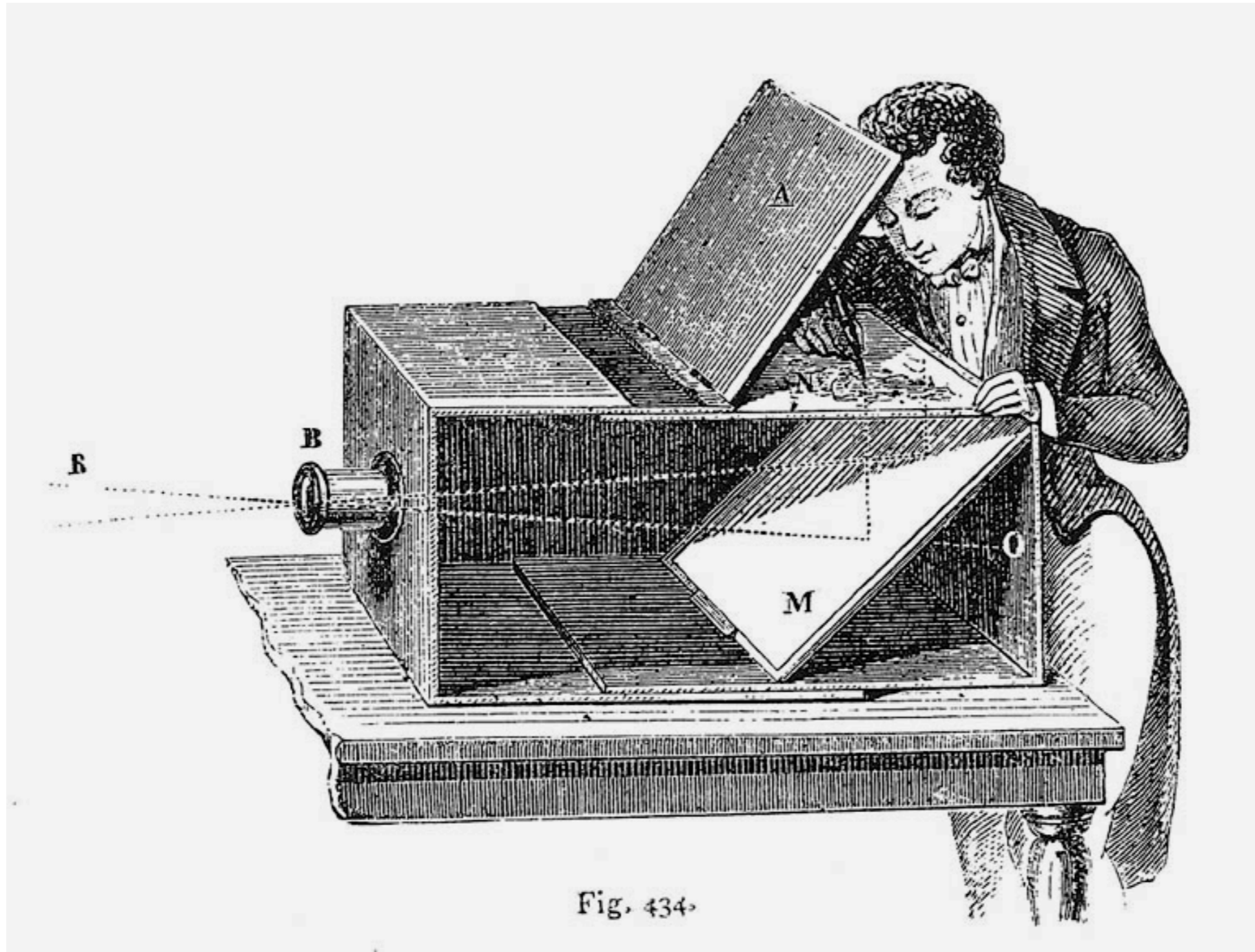






# Forming better images

- **Lenses increase sharpness and brightness**



Lens Based Camera Obscura, 1568



# Recording images better



Still Life, Louis Jaques Mande Daguerre, 1837





John Plumbe. Half plate daguerreotype, ca. 1846.

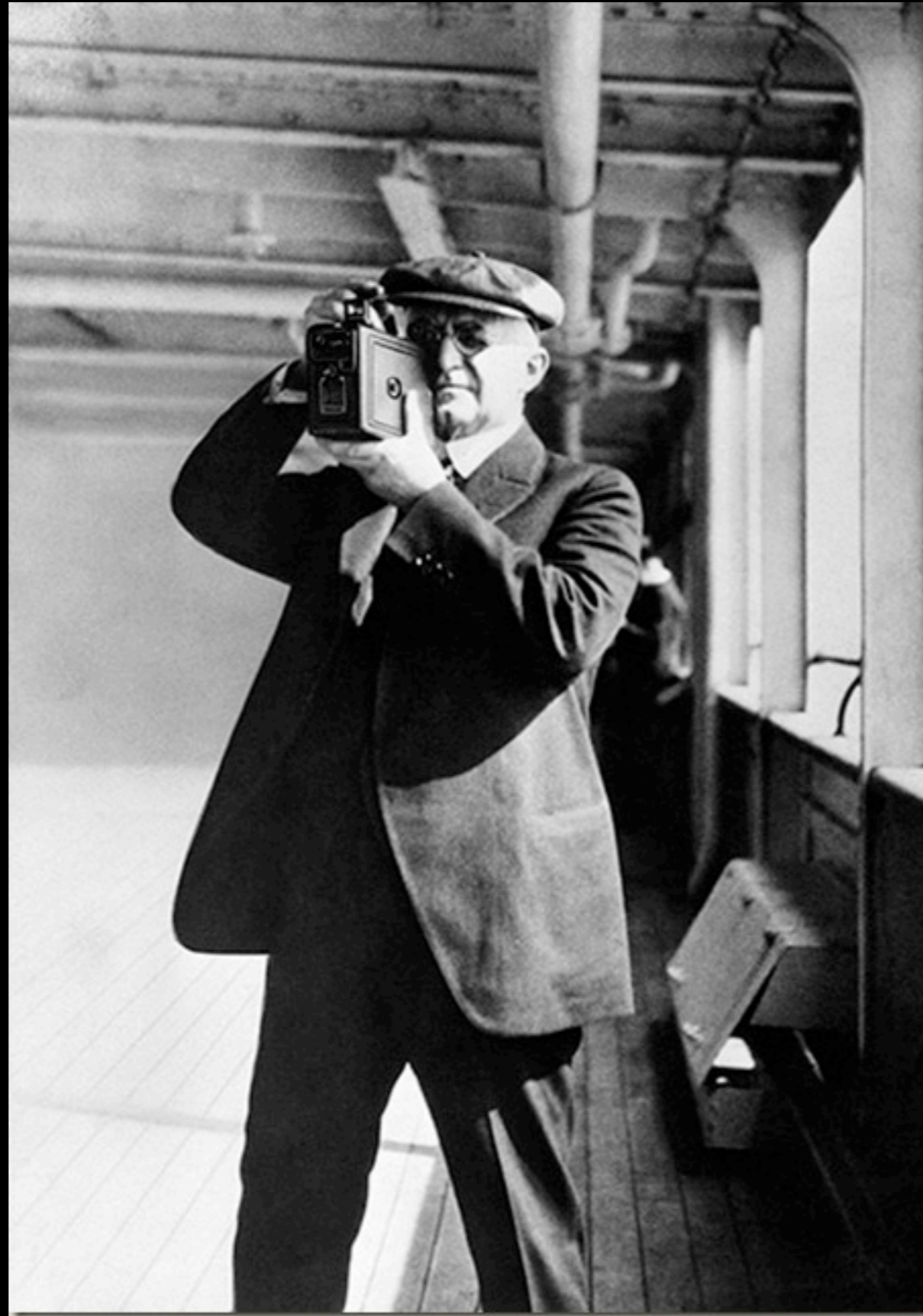


# Recording images automatically

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- **Silver halide (AgCl, AgBr, AgI) salts are light sensitive**  
absorbed photons in halide ions cause free electrons  
electrons combine with  $\text{Ag}^+$ , producing metallic silver
- **Daguerre: first practical and permanent photographic plate**  
Hg vapor (yikes!) combines with Ag to produce reflective amalgam  
Daguerrotypes were widely popular
- **Indirect negative-plate processes**  
negative images on paper, glass allowed multiple copies to be printed
- **Roll film: silver halide grains in gelatin on celluloid**  
introduced by Eastman in 1880s  
portable, convenient, practical  
sensitive (“fast”) enough for moving subjects in daylight





George Eastman with his Kodak camera



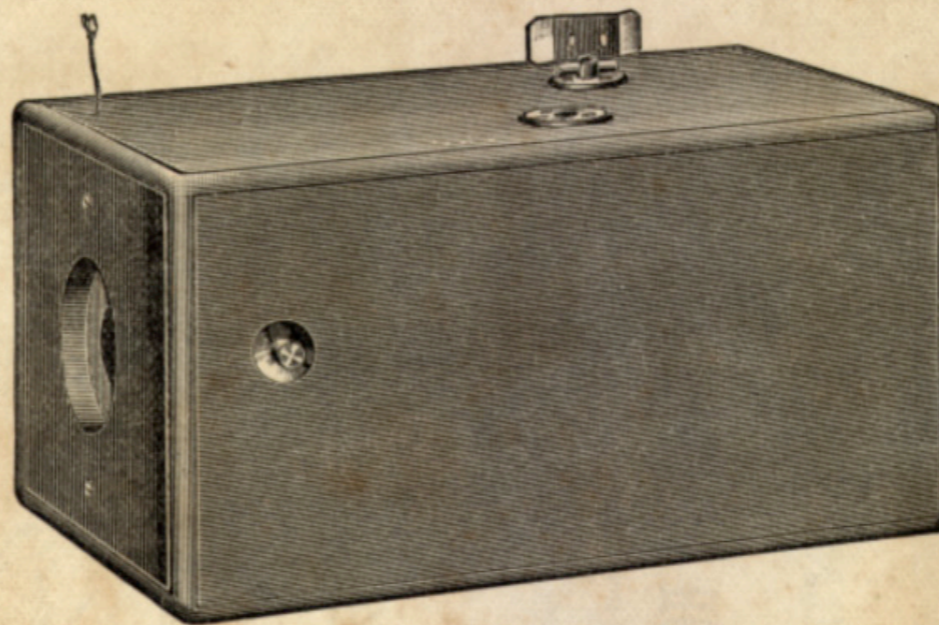
Size:  
3¼ x 3¼ x 6½ inches.

Weight:  
1 lb., 10 oz.

PRICE, \$25.00.

Loaded for 100 pictures, including Sole Leather Carrying Case with Strap.

Size of Picture:  
2½ inches diameter.



ONE-HALF LENGTH.

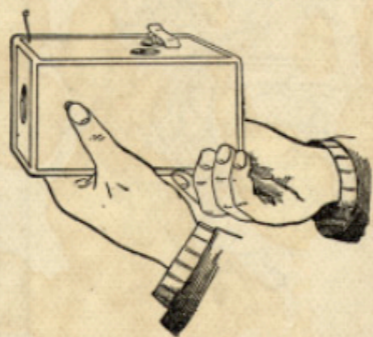
## THE KODAK CAMERA.

ANYBODY who can wind a watch can use the Kodak Camera. It is a magazine camera, and will make one hundred pictures without reloading. The operation of taking the picture is simply to point the camera and press a button. The picture is taken instantaneously on a strip of sensitive film, which is moved into position by turning a key.

A DIVISION OF LABOR. After the one hundred pictures have been taken, the strip of film (which is wound on a spool) may be removed, and sent by mail to the factory to have the pictures finished. Any amateur can finish his own pictures, and any number of duplicates can be made of each picture. A spool of film to reload the camera for one hundred pictures costs only two dollars.

No tripod is required, no focusing, no adjustment whatever. Rapid rectilinear lens. The Kodak will photograph anything, still or moving, indoors or out.

A PICTURESQUE DIARY of your trip to Europe, to the mountains, or the sea-shore, may be obtained without trouble with a Kodak Camera, that will be worth a hundred times its cost in after years.



A BEAUTIFUL INSTRUMENT is the Kodak, covered with dark Turkey morocco, nickel and lacquered brass trimmings, enclosed in a neat sole leather carrying case with shoulder-strap—about the size of a large field-glass.

Send for a copy of the KODAK PRIMER with Kodak photograph.

### THE EASTMAN DRY PLATE AND FILM CO.,

Branch: 115 Oxford St., London.

ROCHESTER, N. Y.

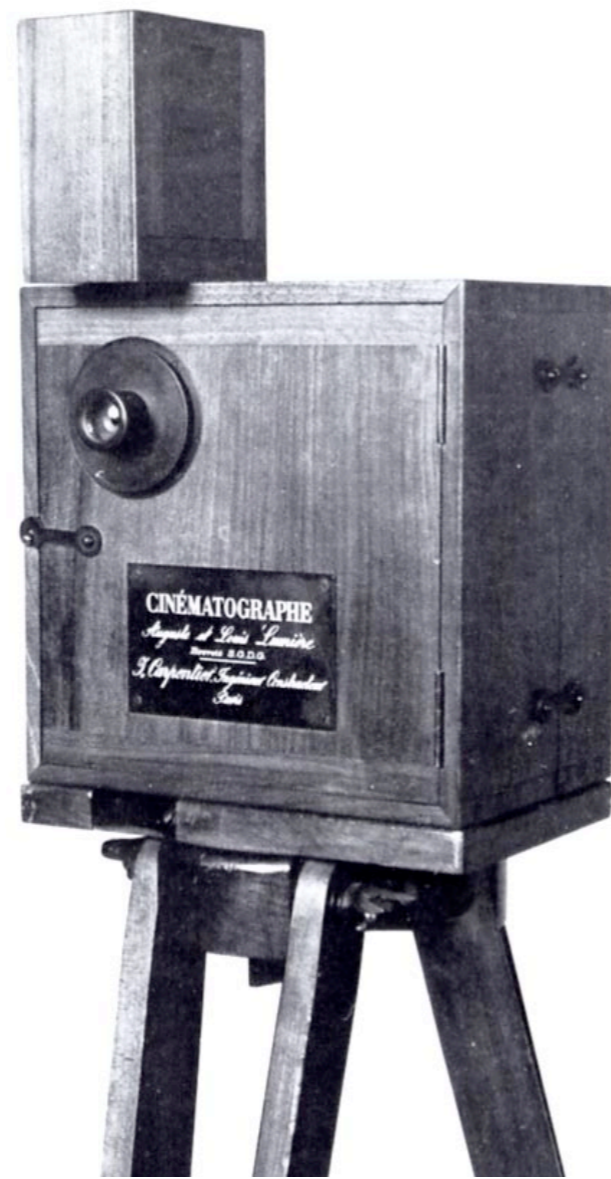


# Motion pictures

- **Sensitive roll film enables sampling in time**
- **1890s – several cameras**

Lumière brothers' Cinématographe  
Edison's Kinescope

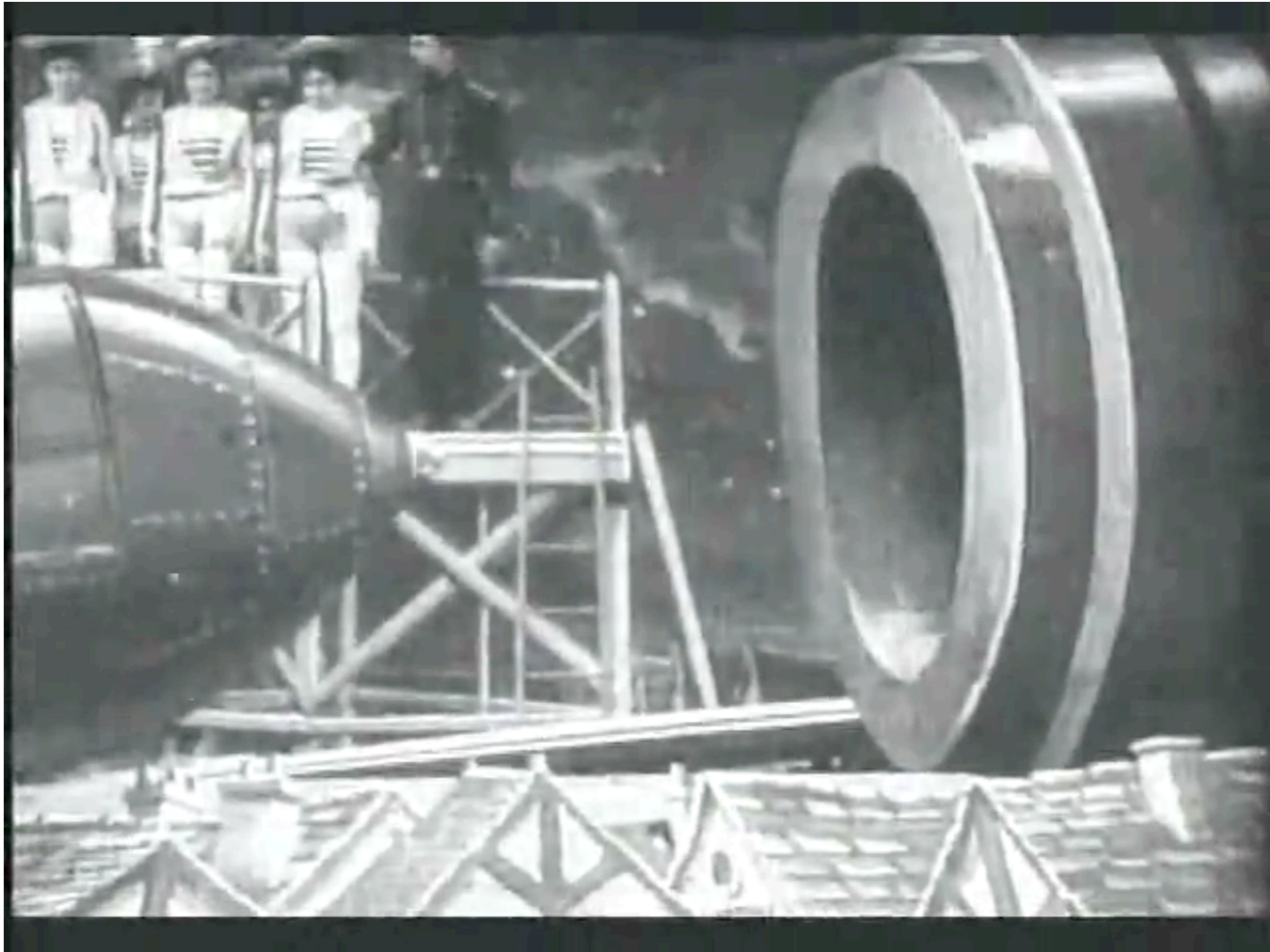
Cinématographe  
[Wikimedia commons]



George Eastman and Thomas Edison in 1928



# George Méliès

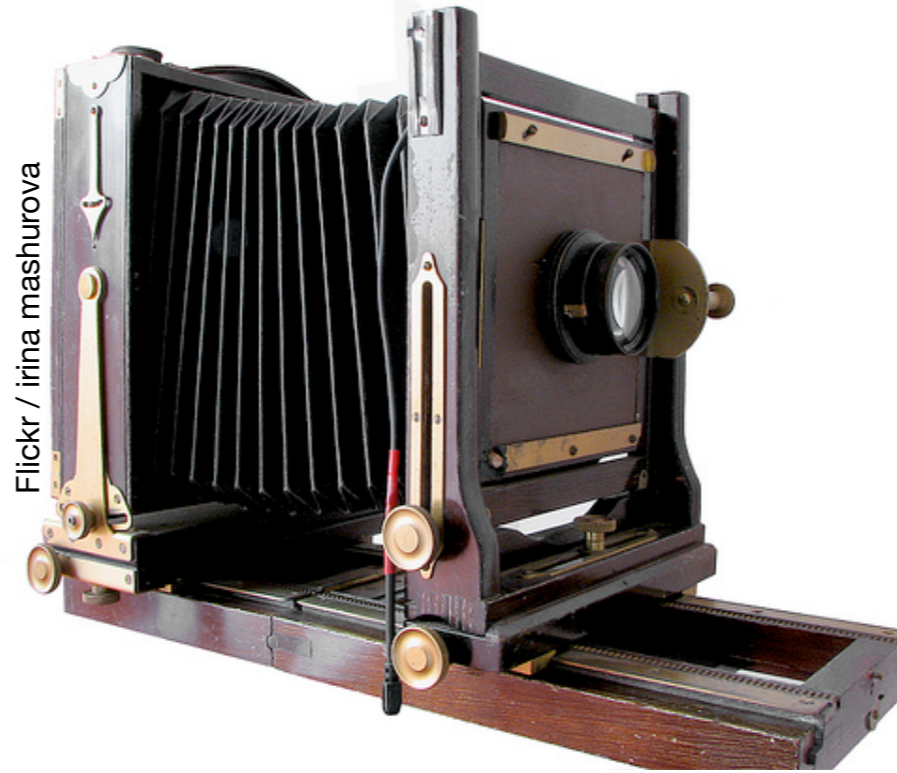


Georges Méliès, *A Trip to the Moon*, 1902



# Improvements in cameras

- **Size and portability**
- **Ease of use**
- **Automation**

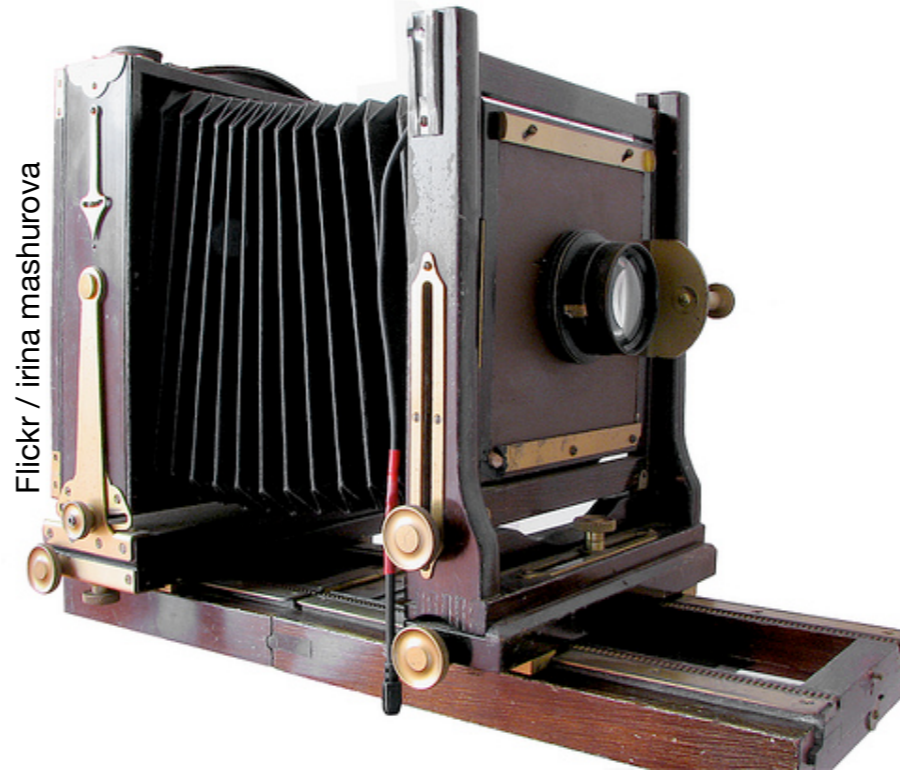


Flickr / irina mashurova



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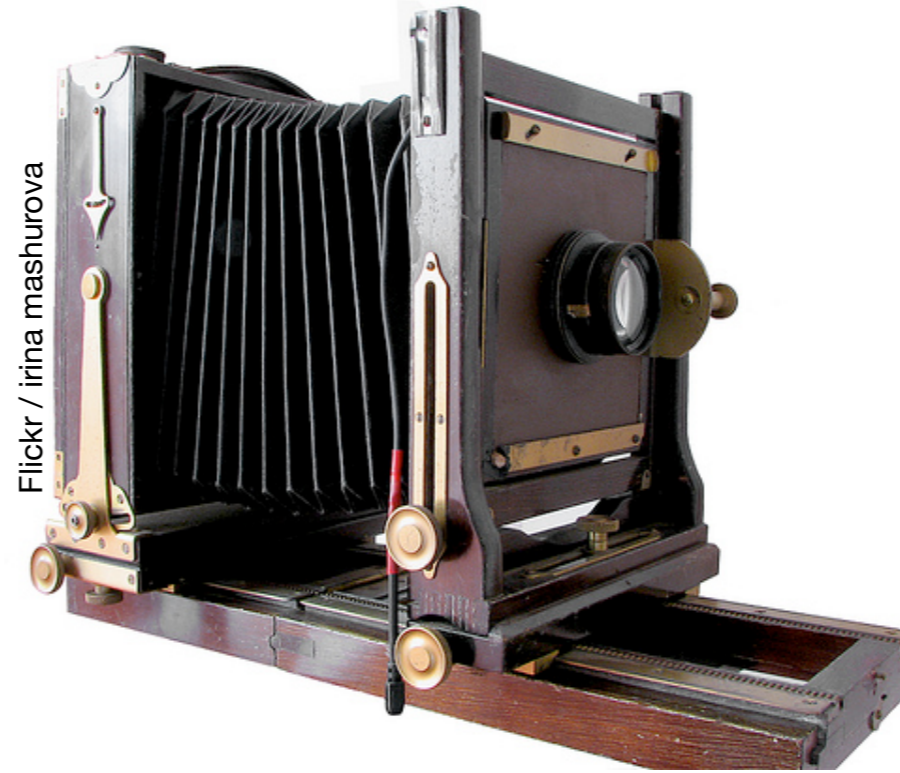
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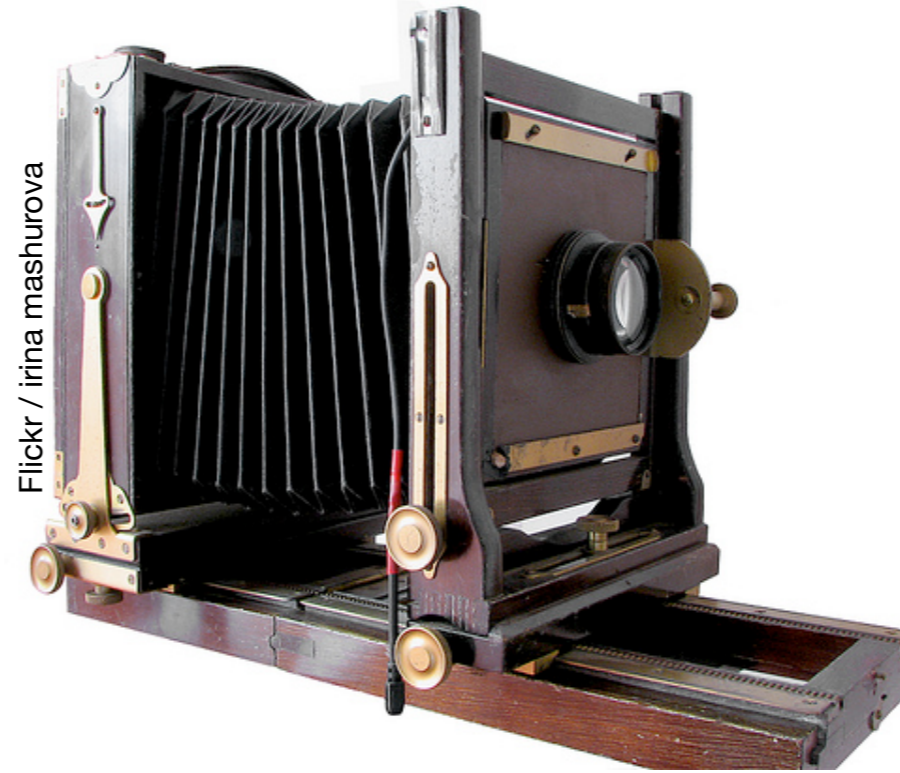
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# Improvements in film

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- **Sensitivity**

enables photographs of faster subjects — “faster” film

- **Dynamic range**

higher quality images with detail in highlights and shadows  
expanded “latitude” to mess up the exposure

- **Resolution**

enables smaller format cameras



# Television

- **Practical around 1927 (Farnsworth)**
- **Camera basically the same**  
imaging lens plus planar image sensor
- **Recording is electronic**  
various early schemes  
early winner: CRT image sensors  
(Orthicon, Vidicon, ...)
- **Initially seems quite different from photography/cinematography**  
ephemeral output signal—live viewing only  
low resolution, low dynamic range images



Philo Farnsworth, c. 1935

Farnsworth Archives



# Recording video signals

- **Kinescope (1940s)**
  - photograph onto motion picture film
  - re-photograph the film for replay
- **Videotape (1956)**
  - record signal on magnetic tape
  - very high head velocities required
  - transverse or helical scanning



A Kinescope, c. 1950–55

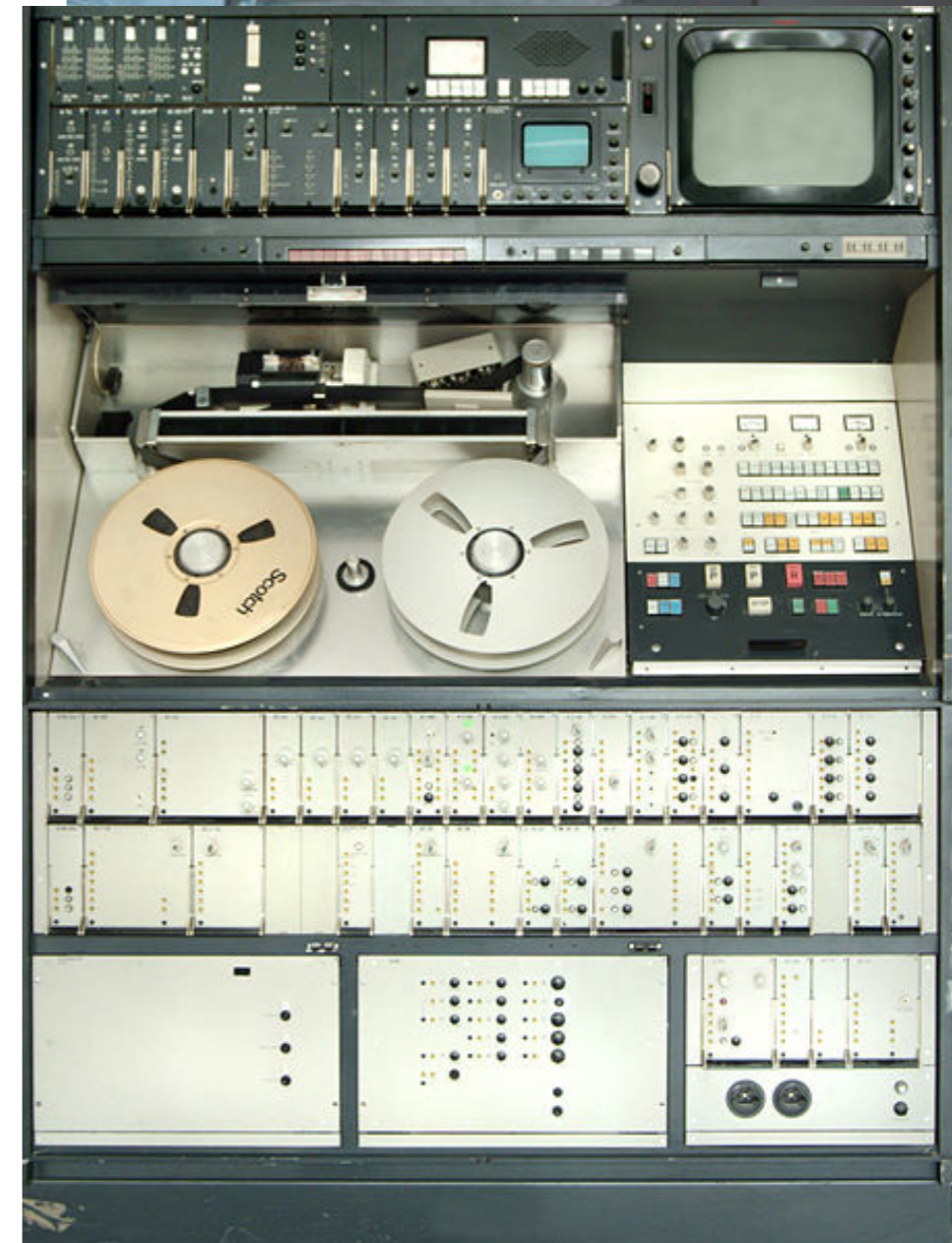


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Peter Lindell, Canada Science and Technology Museum



Wikipedia

A 2-inch video tape recorder c.1970



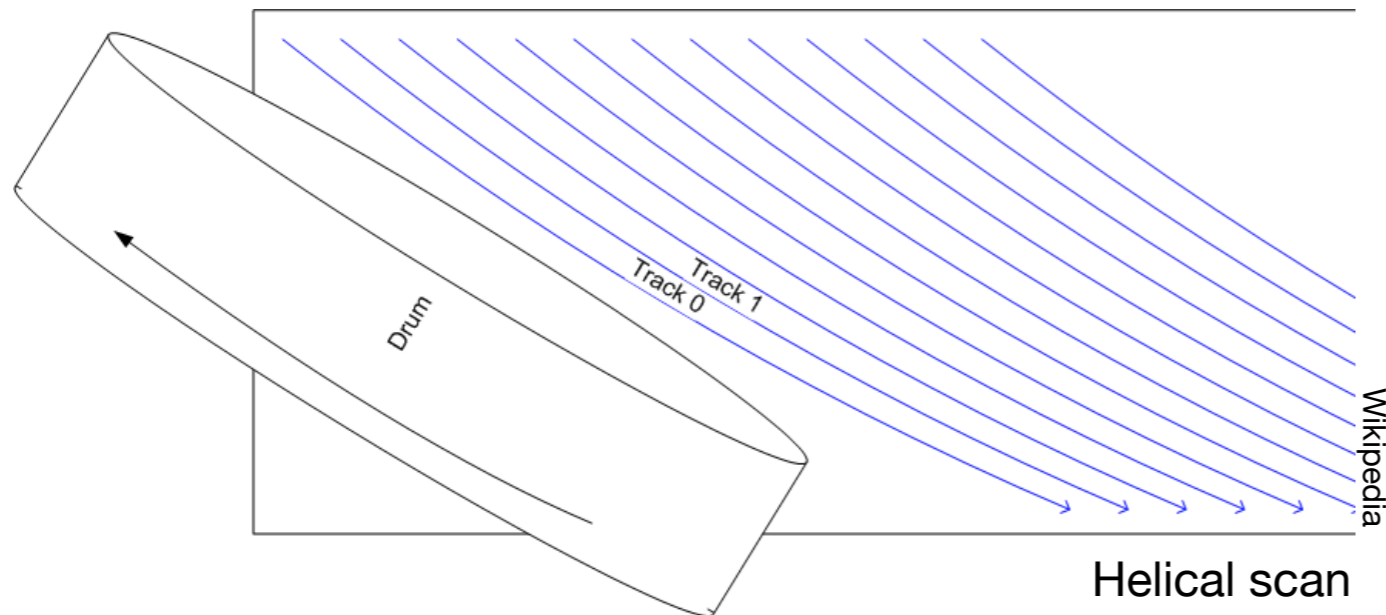
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A 2-inch video tape recorder c.1970



# Imaging around 1950s–70s

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- **Technology improves incrementally**

  - Film emulsions improve; very high quality attainable in large formats

  - Video technology improves; but standards keep resolution fixed

  - Lens designs improve, cameras become much more usable

- **Usage is refined**

  - Photography an established art form, widespread hobby

  - Cinematography develops as a storytelling medium

  - Television becomes dominant mass communication medium



# Meanwhile...

- **Invention of CCD (1969)**

- solid-state, fundamentally discrete image sensor

- quickly established in astronomy, space by mid-80s, displaces tubes in video cameras (as drop-in replacement)

- **Computing and computer graphics**

- sufficient memory to store images becomes available

- first framebuffers developed 1972–74

- **Digital signal transmission and processing**

- used for audio and telephone

- **These set the stage for the next revolution**



Photo: Alcatel-Lucent/Bell Labs

George Smith and Willard Boyle in 1970



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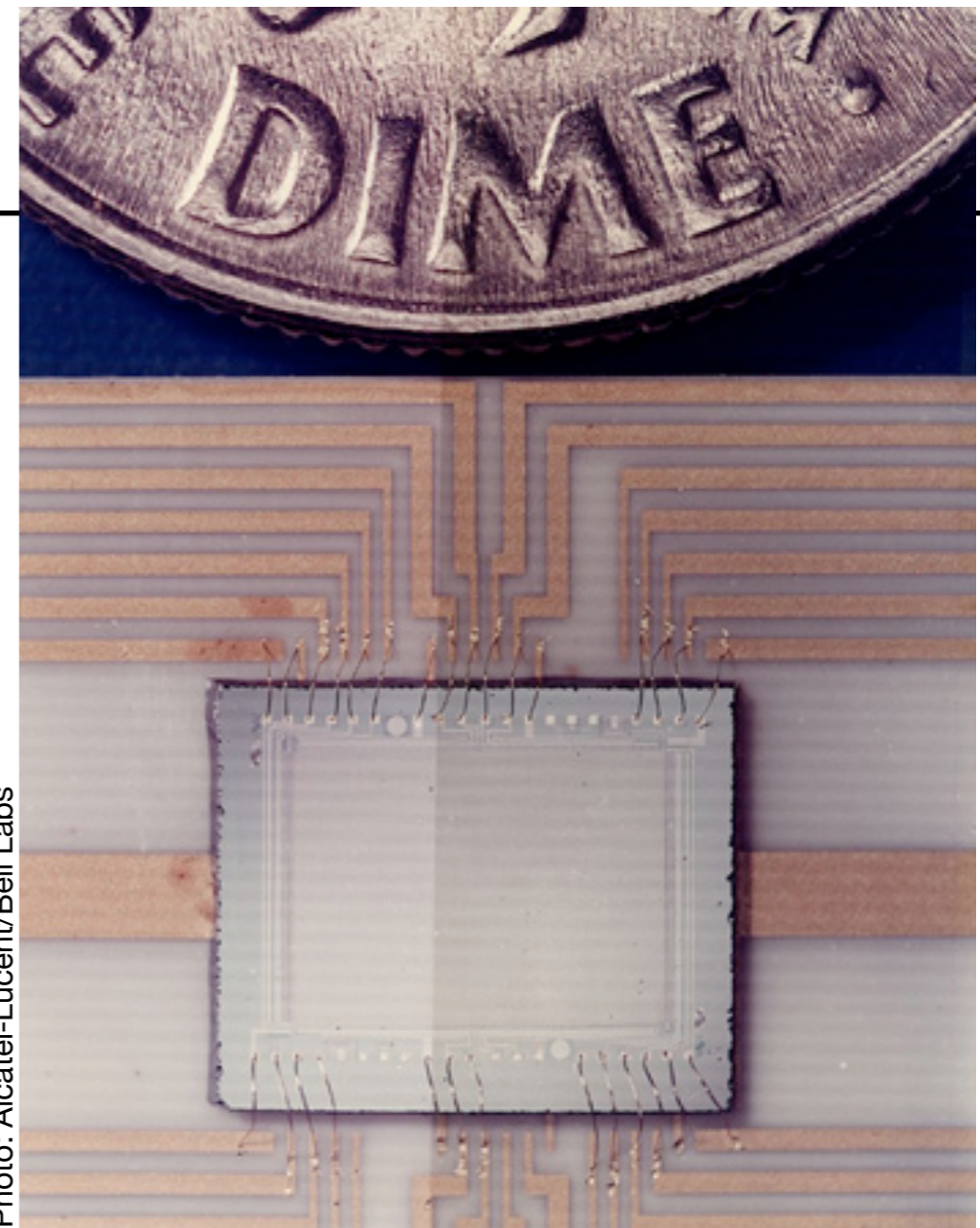
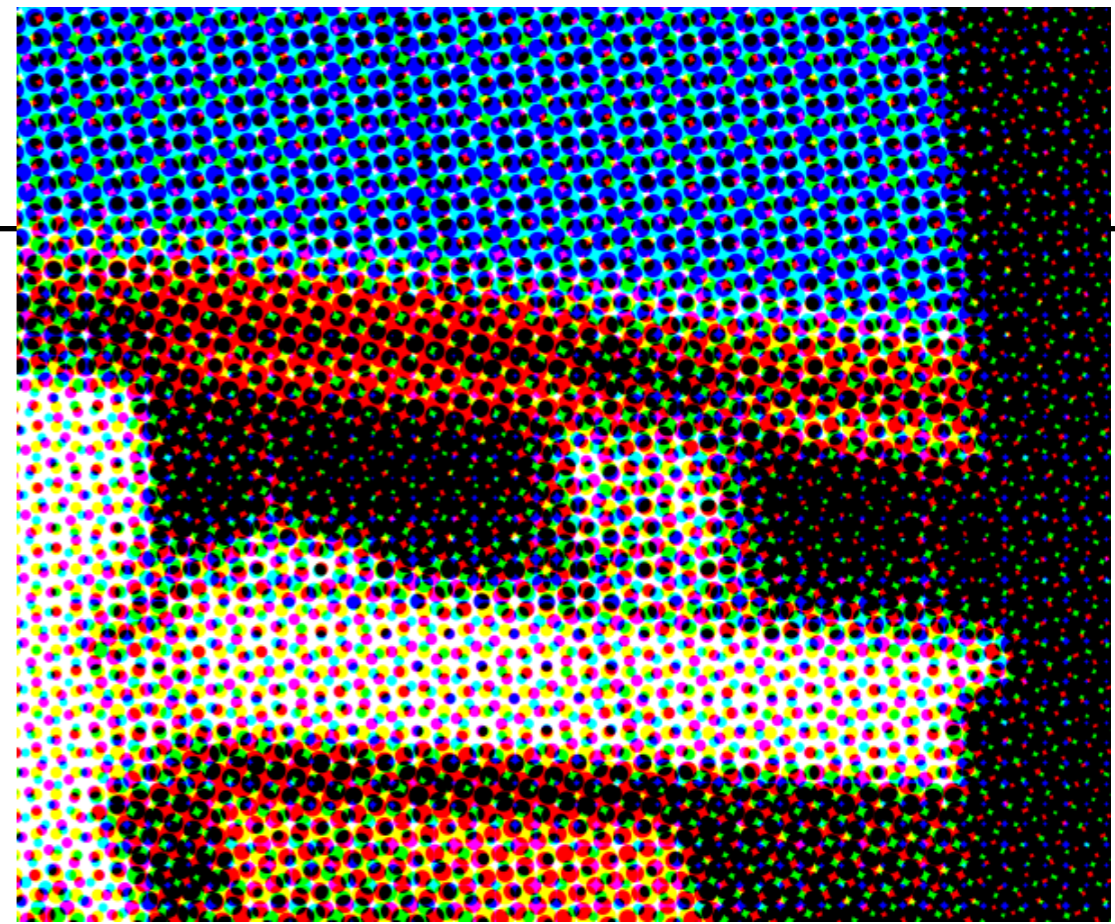


Photo: Alcatel-Lucent/Bell Labs

Early CCD array



# Digital imaging



- **Halftone printing of images**

halftone process around for a while  
complex, delicate optical procedure  
moving images from place to place  
requires moving film or paper

- **Digital imaging**

scan images from film or paper  
transmit images by phone  
do processing (e.g. halftone separation) by computing  
print images using laser printer or laser film recorder

- **Image editing**

1990—Adobe Photoshop 1.0

- **Image compression algorithms**

make image storage, transmission more practical



# Digital photography

- **Digital images are established**  
people can make use of them directly

- **CCD sensors improve**

Moore's law makes pixels smaller  
video cameras already recording  
images electronically

digital image capture used in scientific applications

- **Analog electronic still camera (aka. still video camera)**

is just a video camera that takes one frame at a time  
several manufacturers made them

but high image quality expectations for stills delays acceptance



Canon RC-701 still video camera, 1986



# Early digital cameras

- **Important limitations**

- low image quality (relative to film)
  - slow camera performance
  - large, heavy, clunky
  - limited, expensive image storage

- **Important advantages**

- immediate availability of images
  - zero (well...) marginal cost per exposure

- **First adopters: photojournalists**

- **Kodak DCS series**

- based on film camera bodies
  - early commercial success
  - storage: PCMCIA hard disks (mid 90s)



Kodak DCS-100, 1991



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Kodak DCS-420, 1996

eBay seller lbmfairth



# Digital rivals film

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- **Key improvements**

- cameras become more compact
  - resolution and dynamic range improve
  - LCD displays for immediate image review
  - costs drop

- **Meanwhile**

- computers with high-quality color displays become pervasive

- **User experience**

- image review is a big change for users
  - sharing of digital images suddenly becomes easier than prints

# Digital video

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- **Initially: improved recording medium**
  - record the same old signal, but digitally
  - best-quality medium for professional use
- **Improvements**
  - storage and bandwidth improve by orders of magnitude
  - video compression algorithms advance
  - digital formats become simpler/better than analog-derived
  - flexibility finally unlocks video resolution
- **Digital recording becomes standard for video**
  - basic experience similar
  - cost and quality greatly improved

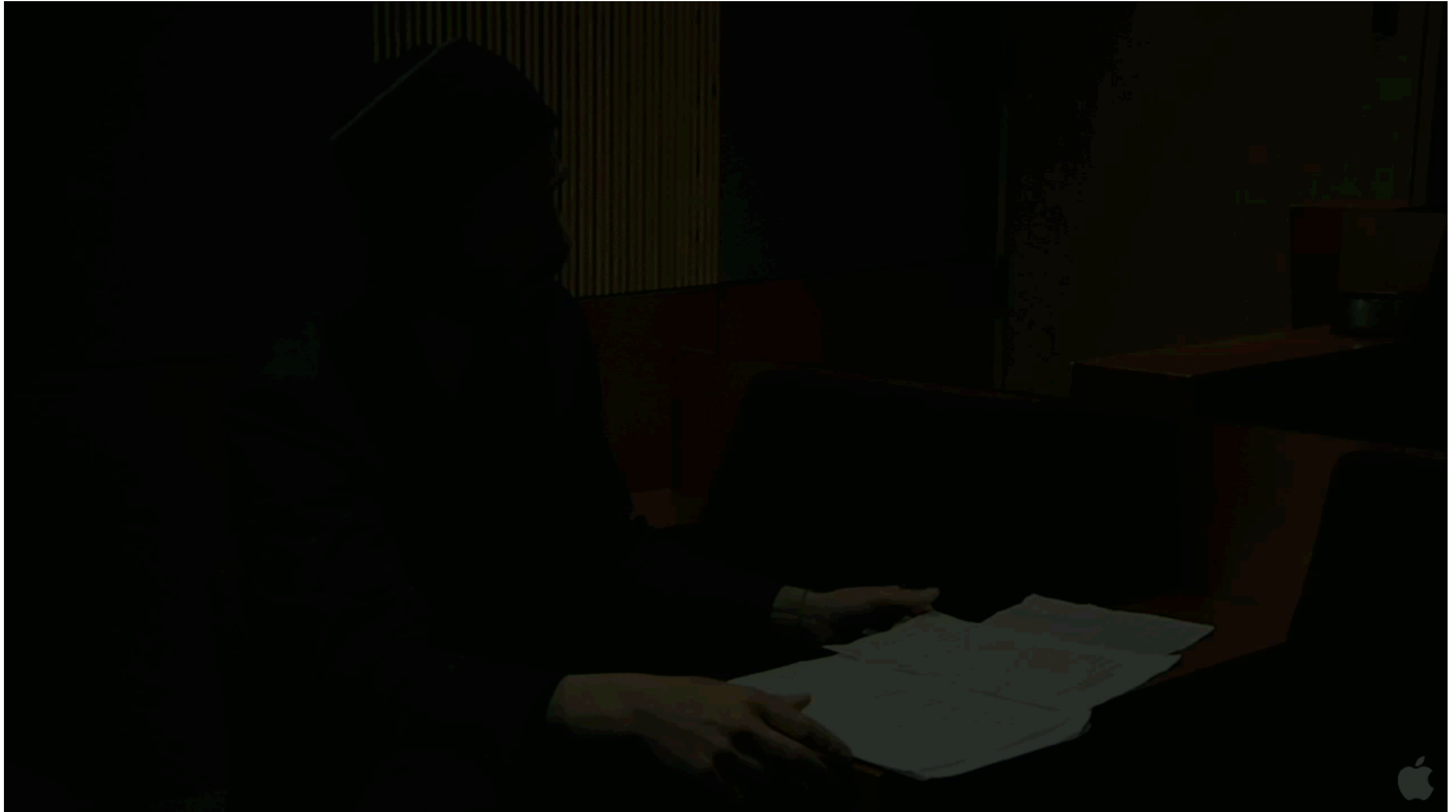


# Digital displaces film and video

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- **Move from convenience vs. quality to convenience and quality**
- **Digital slowly takes over for basically all users**
  - advances in storage/transmission and compression algorithms
  - ecosystem for online sharing of photos, videos
  - declining use of printed images
- **Last bastion: cinematography**
  - delay: quality standards plus tradition
  - first took over low end because of film costs
  - now taking over high end because of superior quality/usability

# Digital cinema



Excerpt from preview of documentary *Side by Side* (2012)—director David Lynch interviewed by Keanu Reeves



# Digital cameras today

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high-end product for  
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medium resolution for low-end film and high-end TV production





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smaller high-end cameras with electronic viewfinding



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inexpensive, auto-everything for day-to-day usage





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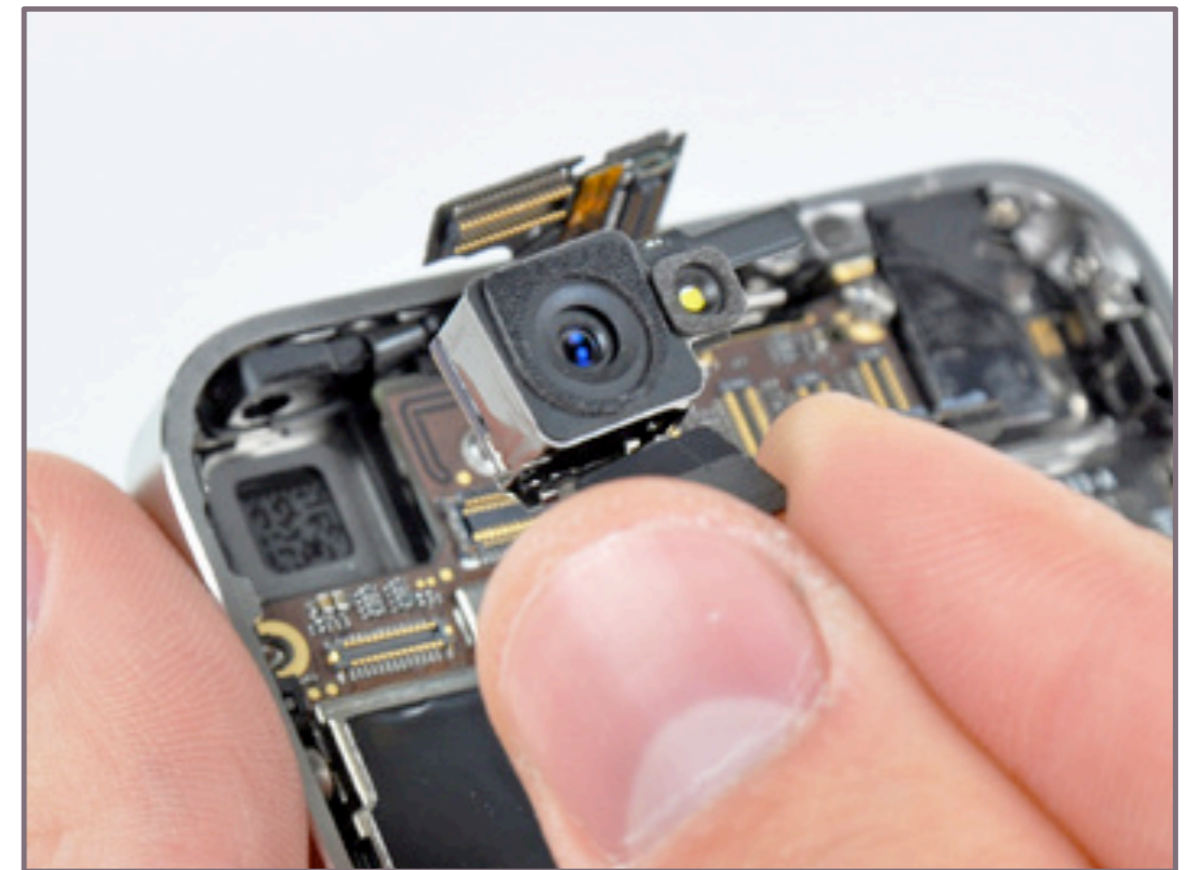
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iFixit

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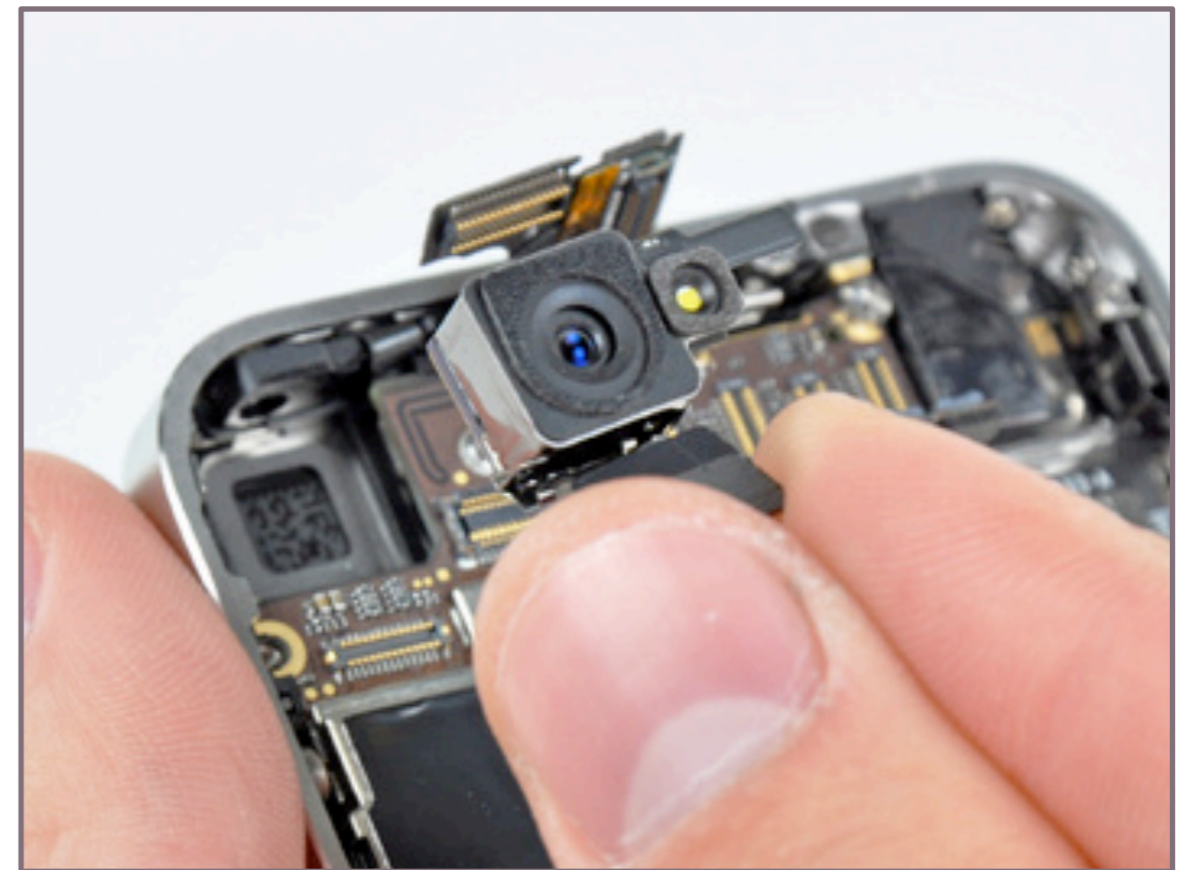
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- **Video, photography, and cinema have converged**
  - all using the same basic technology
  - all modern still cameras do video too (and many vice versa)
- **Cameras becoming completely pervasive**
  - film-equivalent quality possible in  $<1 \text{ cm}^3$
  - mobile applications driving much sensor/lens development
  - mobile cameras eating compact digicam market
- **Computing power still rapidly advancing**
  - more and more computation being done on images

# Some sources

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- **London et al. *Photography*, Prentice-Hall.**
- **digicamhistory.com**
- **dpreview.com—lots of data on digicam models over time**
- **Canon camera museum** <http://www.canon.com/camera-museum/>
- **Sony history site** <http://www.sony.net/SonyInfo/CorporateInfo/History/sonyhistory.html>
- **Nikon pictorial history** <http://www.mir.com.my/rb/photography/companies/nikon/>
- **many Wikipedia articles**