

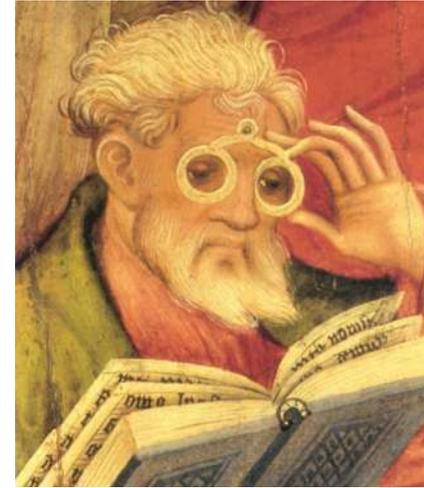


The Prehistory and Cryptozoology of the Telescope

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Far Seeing about Seeing Far

- Assyrian lenses
- Egyptian lenses
- Roman lenses
- 100 Ptolemy's *Optics*
- Viking lenses
- 1000 Ibn al-Haytham's *Kitab al-Manazir*
- Eyeglasses from 1280s



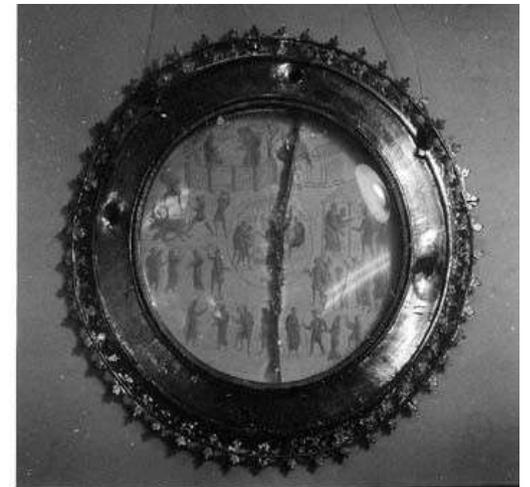
Early Lenses and Magnifying Views

- Oldest lens found is the Nimrud lens, 2700 years old, from Assyria.



Early Lenses and Magnifying Views

- 150 Nero's Monocle
 - Roman Emperor Nero is recorded to have improved his poor vision by viewing events through a "stone".
 - Most historians think this was a cut gem.
 - Was it cut to correct his vision or to magnify?
- 850 The Lothar lens, from a German monastery



Early Lenses and Magnifying Views

- 1000 Viking lens



Single-Lens Viewing

- 1200s Roger Bacon writes that a magnifying lens makes new stars appear where the sky appears empty to the naked eye.
- 1400s Leonardo daVinci writes that a lens makes features on the Moon appear larger.
- Both probably using a convex magnifying lens.
- You can find this today in high school science experiments.
 - But you need young eyes to focus this image.

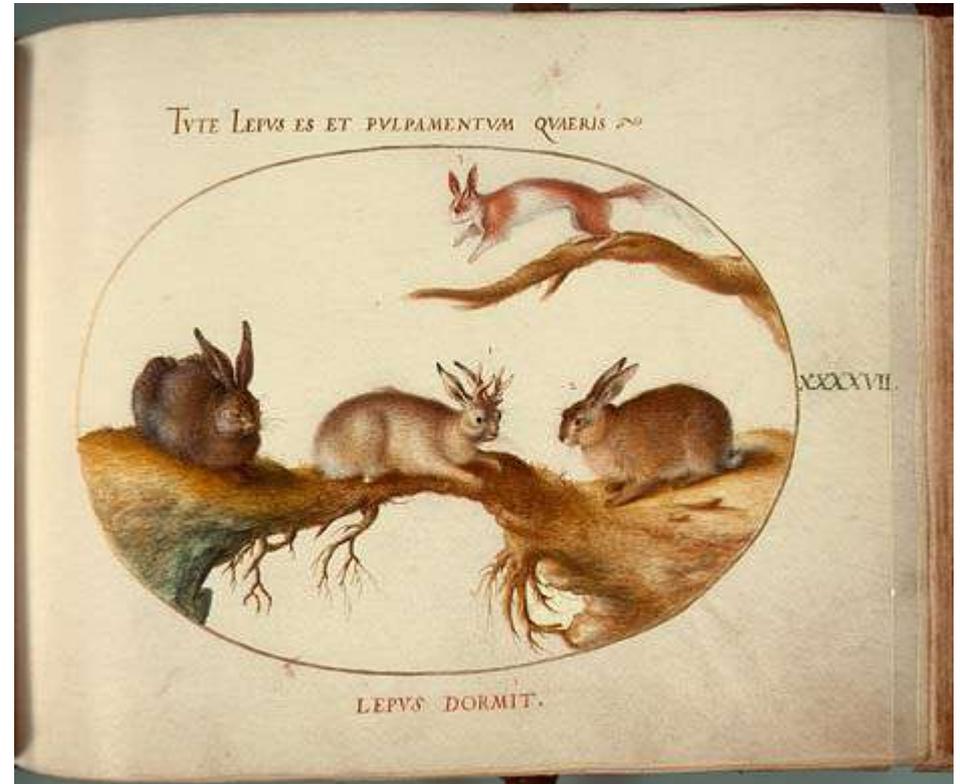
The Camera Obscura

- An Ancestor of the Telescope.
- Pinhole or lens projects image onto opposite wall of a room.
- First built by al-Haytham ~ 1000.
- Widely adopted by artists in the Renaissance.
 - Assisted drawing in the new perspective style.

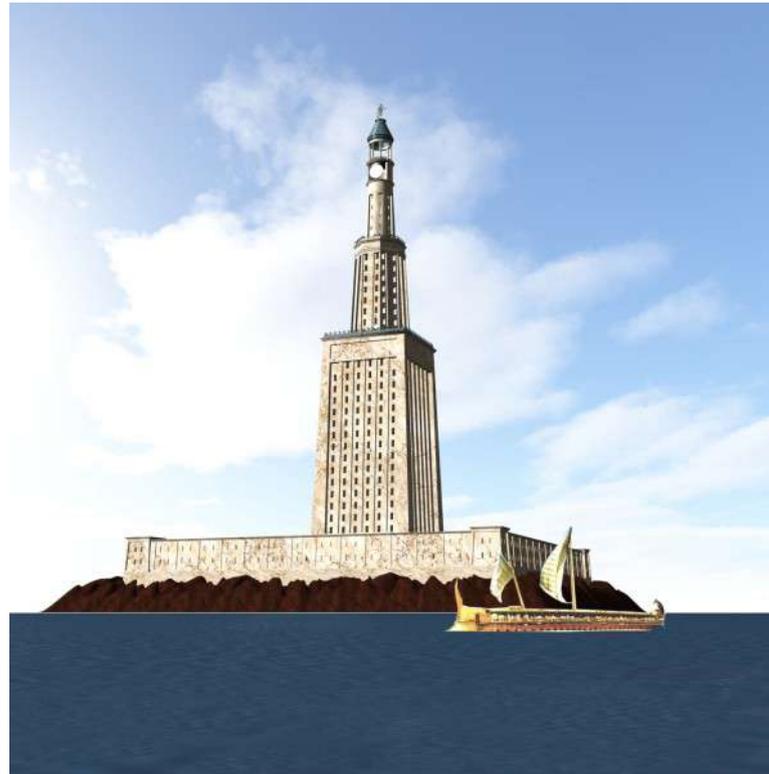


Cryptozoology: Mystery Beasts that Never Were (or were they?)

- Giant Mirrors
- The Perspective Trunk
- The 16" reflector
- Prototelescopes



The Harbor Mirror of Alexandria

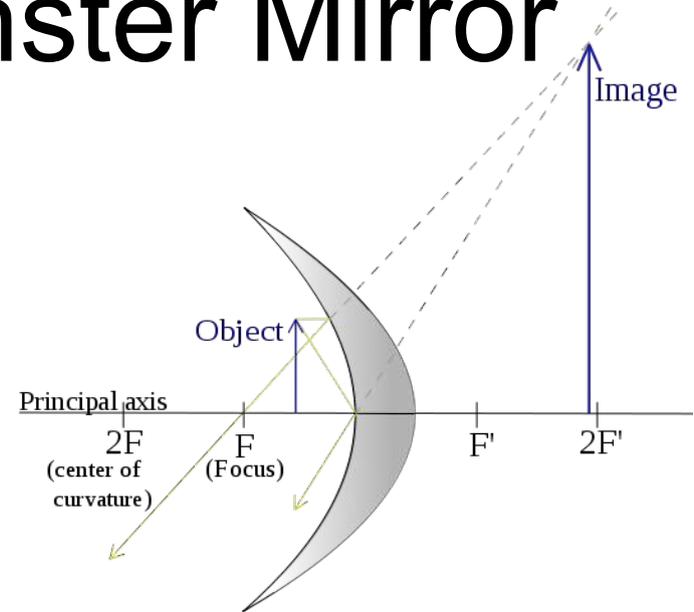
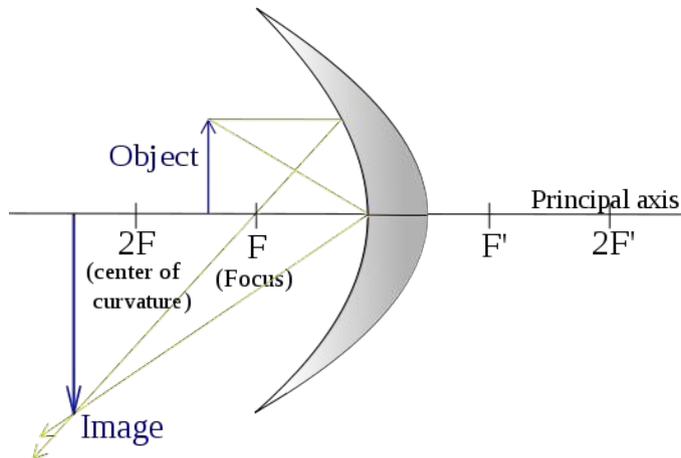


- Pharos Lighthouse at Alexandria.
- Romans added a mirror to reflect sunlight by day and fire by night.
- One of the 7 Wonders of the Ancient World.

The Myth of the Mirror

- Claims by European writers in the Middle Ages that a giant magnifying mirror enabled an inspector to stand before the mirror and examine ships as they approached port.
- There are claims that other harbors had these devices.
- The people who built the mirror at Alexandria never claimed it had these superpowers.

The Mythical Monster Mirror



- A concave mirror only magnifies an object closer than its center of curvature.
- To put the center of curvature at the distance of a ship would require a mirror many meters tall.
- In this period mirror makers were producing accurate curves on the order of centimeters, not meters.

Leonard Digges and his Amazing Perspective Trunk

- Digges was a prominent architect, surveyor, and landed gentleman of the reign of Henry VIII.
- The Perspective Trunk was a portable camera obscura for surveying use.
- Projected the image onto a parchment screen to observe from outside the trunk.

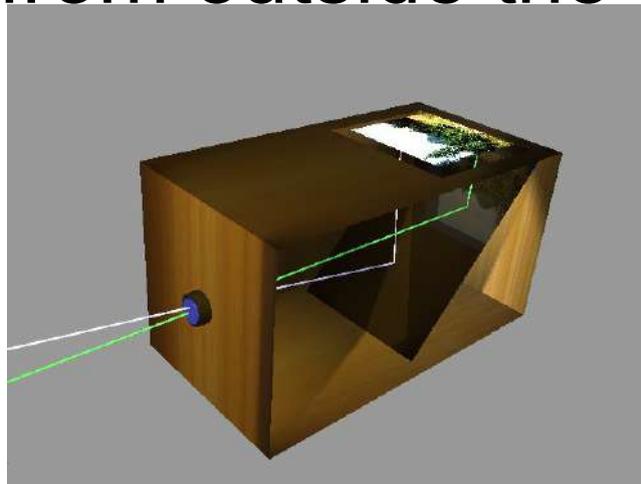


Illustration is of a 19th century descendant

Leonard Digges and his Amazing Perspective Trunk

- 1571 Leonard's son Thomas Digges writes that he could magnify that image and read a broadside posted 2 miles away.
 - He said he was writing a paper on this.
- Thomas Digges became England's first modern astronomer, the first to promote the Copernican model in England, and tried to develop a telescope.

Thomas Digges' Telescope and the Spanish Armada

- 1570s Digges sends to his patron Baron Burghley a design for a telescope using an objective lens and a mirror focuser.
- Burghley sends it to Royal Navy cannon inventor William Bourne.
- Bourne proposes swapping the elements: a primary mirror and a lens to magnify and focus.
- 1580 Bourne proposes a new design with 2 lenses.

Did the English Navy have a Digges Telescope?

- After defeating the Spanish Armada, Queen Elizabeth rewards Digges with land and money for unspecified services to the Crown.
- But Digges' design could not be built with state of the art Elizabethan technology.
 - Researchers have built it using modern technology.
- Digges probably demonstrated the Perspective Trunk at a Navy lookout post.
- Part of a larger program of secret weapons.
 - E.g., the backstaff (predecessor of the sextant).



Why Couldn't Digges Build His Telescope?

- Digges designed his telescope from the math and theory available at the time.
- Working From Bacon's *Optics*,
 - Limited restatement of Ptolemy, no refraction.
 - Just one chapter in Bacon's *Opus Magnus*.
- Digges computed that he needed a 12" to 16" lens and mirror.
 - The largest usable lens at this time was 2".
- Meanwhile, the lensmakers experimented till they converged on a small lens that worked.

Why Did Newton Succeed Where Digges Failed?

- 1668 Newton builds his reflecting telescope.
 - Newton was trying to solve the problem of chromatic aberration (which he explained for refractors).
- Newton had an additional century of development of theory and technology.
 - Not least, his own contributions to optics.
- As President of the Royal Society, Newton had the older papers about Digges' attempt.

The Difficult Labor and Fuzzy Claims to the First Telescope

- From the *Optics* of Bacon and, after 1604, Kepler, many scientists recognized the telescope was possible.
- Galileo: "Everybody knew it should work, it was only a question of discovering what arrangement of lenses was needed."
- Patent application for first Dutch telescope was denied because "Everybody is building these. We can't enforce the patent monopoly."
- All through the 1500s people in many countries tried to build one.

The Many Pretenders to the Throne of First Telescope

- 1538 Fracastoro in Italy writes about using 2 lenses to make objects appear larger and closer.
- 1570 John Dee in England writes about military uses for the perspective glass.
- 1580 Digges' and Bourne's designs in England.
- 1598 Della Porta in Italy places a mirror + lens in a Camera Obscura to enlarge the image.
- 1604 Kepler's *Optics*. Still no refraction.
 - Galileo: "Kepler's *Optics* is so complicated nobody understands it, not even Kepler."

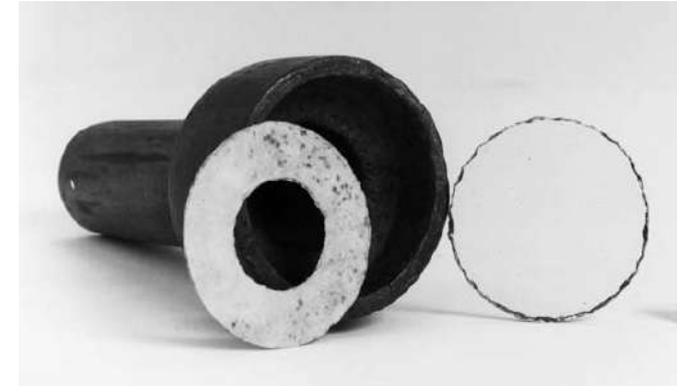
The Many Pretenders to the Throne of First Telescope

- 1608 Hans Lipperhey in Holland demonstrates a telescope and applies for a patent on it.
- 1608 a telescope for sale at Frankfurt Book Fair.
- 1609 telescopes for sale on the streets of Paris.
- August 2 1609 Thomas Harriott in England observed the Moon through a Dutch telescope.
 - Publishes sketches of the Moon before Galileo.
 - Develops the first theory of refraction.



The Many Pretenders to the Throne of First Telescope

- July-August 1609 Galileo copies a Dutch telescope.
 - But quickly improves the design.
 - March 1610 publishes his first observations.
- 1609 Juan Roget (Spaniard working in Genoa) claims to have invented the telescope.
- 1611 The word "telescope" invented by a poet honoring Galileo.
- 1610s Dutch sources claim other inventors.

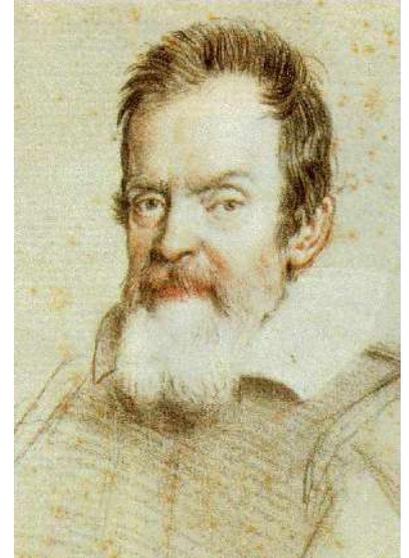


Galileo's second telescope. The aperture stop was Lipperhey's technological innovation.

Galileo's Job Search

Or, how he inflated his account of his first telescope to impress his patrons

- Galileo: "It is too bad that I had heard a telescope already existed. Otherwise you would be even more impressed at how I arrived at the design by pure reason."



Did Galileo Reason His Way Past Digges' Mistakes?

Digges	Galileo
Using Bacon's <i>Optics</i>	Using Kepler's <i>Optics</i>
Had no theory of refraction	Still had no theory of refraction
So computed mathematically a reflecting design	So computed mathematically a reflecting design
Concluded he needed a mirror larger than any that could be made with good optical qualities	Concluded he needed a mirror larger than any that could be made with good optical qualities
Canvassed England for someone who could make a 14" mirror	Commissioned a shop to try to make a 6" mirror

- Galileo made all the same mistakes Digges did.
- He said "it was only a question of discovering what arrangement of lenses was needed" *after* he saw the Dutch telescopes that used lenses rather than mirrors.

How Did Galileo Invent His Telescope?

Galileo's Account

Galileo visits Venice to discuss reports of the Dutch telescopes

A foreigner comes to Padua with a telescope

Galileo rushes home to Padua to see it

But misses the foreigner, who is now in Venice and tries to sell it to the city

Venice city council gives it to Sarpi (a friend of Galileo) to evaluate

Sarpi sends a letter to notify Galileo

In a fit of logic and creativity, Galileo builds his first telescope overnight

Galileo tells Sarpi he has the secret

Sarpi tells the city the foreigner's telescope is too expensive

Galileo shows his own telescope at Venice

What Historical Documents Support

Agree with Galileo's account ...

Galileo was probably in Venice for part of the 2 weeks Sarpi took for his evaluation

Galileo may have had the foreign telescope on the table in front of him when he built his

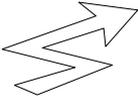
Galileo on the Shoulders of Giants

- Taught himself lensmaking.
- Soon was producing the largest, best quality lenses known in early telescopes.
- Developed better telescopes specifically for planetary observations.
 - During his career his telescopes advanced from 10mm (stopped) aperture, 3x to 60mm aperture, 33x.
- Recognized that his observations were experimental evidence supporting the Copernican model.

Summary: How Did We Get the Telescope?

Real
Ancestors
of the
Telescope

Imaginary
Ancestors
of the
Telescope


inspiration

It was a magical time...

Not just
one, but
many
telescopes

- Lots of people were doing lots of work.
- "Genius is 1% inspiration and 99% perspiration" – Edison
- "The telescope itself fails to be invented" – Van Helden

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