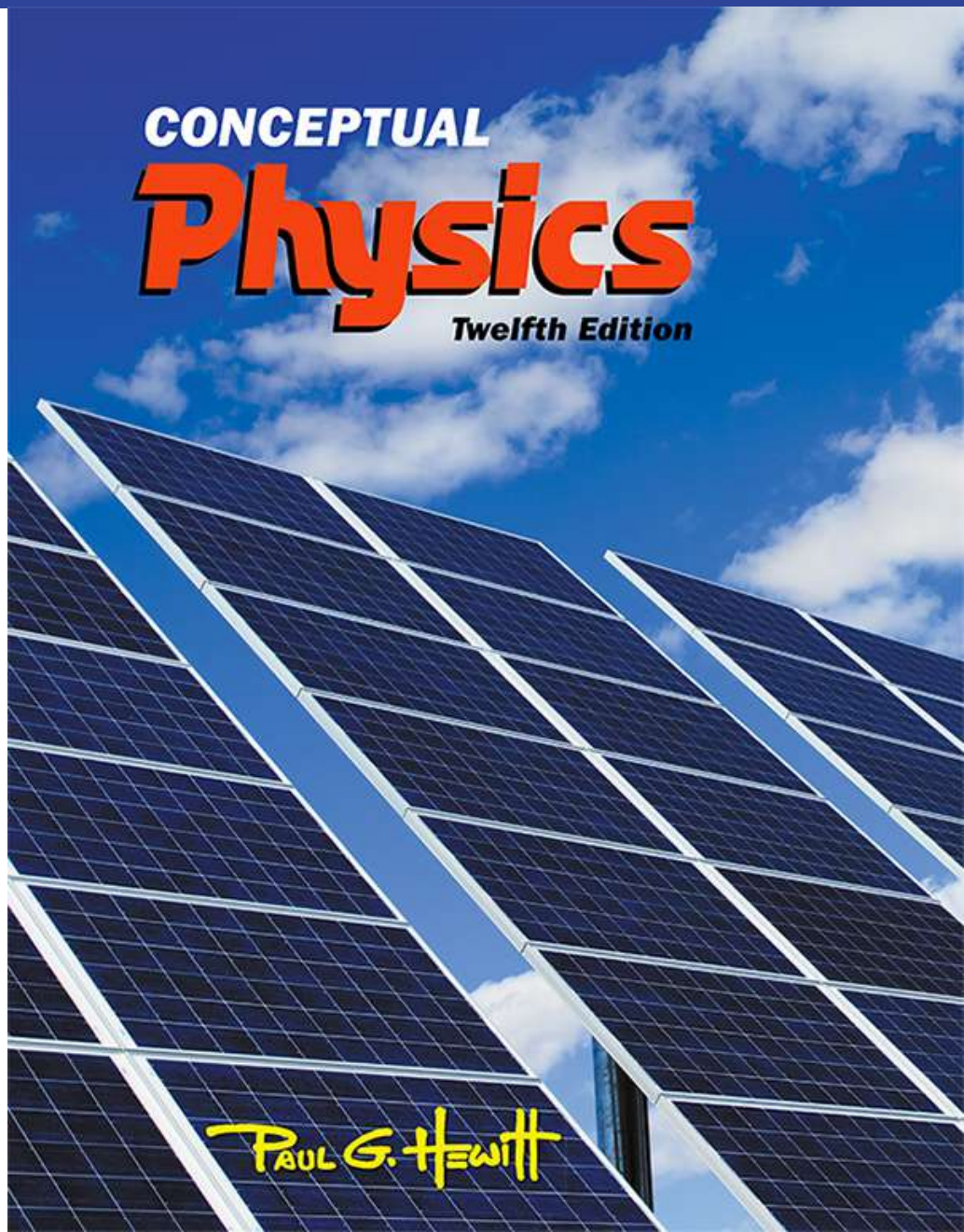
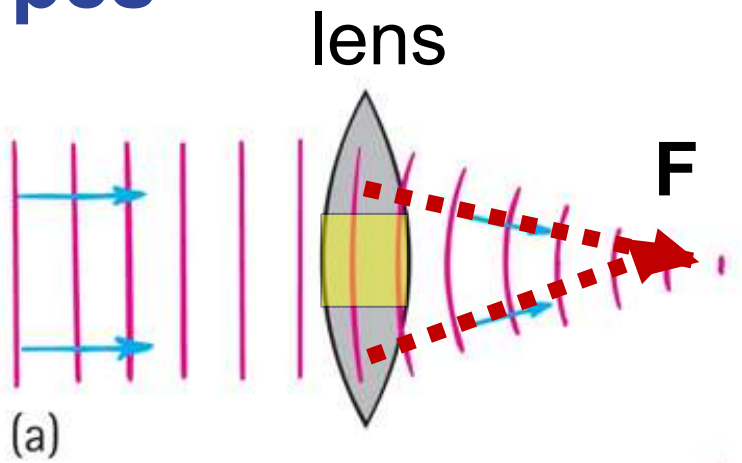
Lecture Outline

Chapter 28: Reflection and Refraction

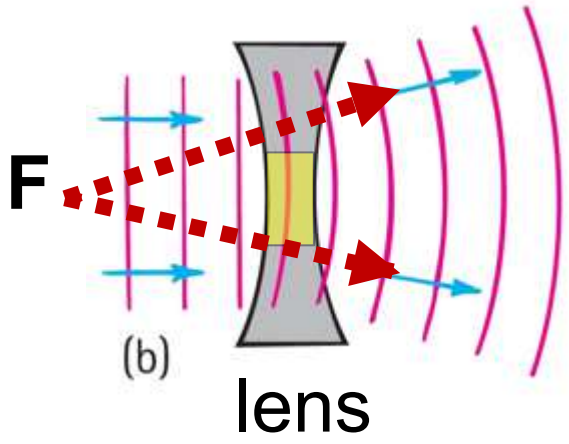


Lenses: Two common types

- **Converging** (convex) lens
- thicker at the center than edges
- converges light at focus F



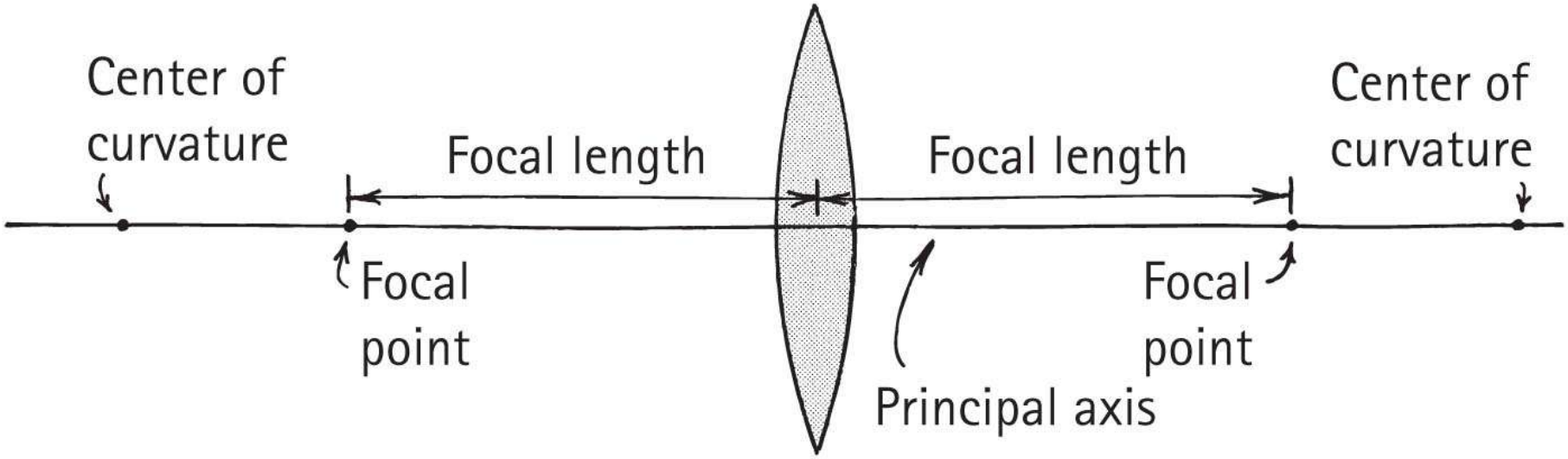
- **Diverging** (concave) lens
- Thinner at the center than edges
- Diverges light, but appear to come from focus F



For both: Most bending (refraction) occurs at edges
→ No bending in middle when lens has little curve

Classwork

25. Distinguish between a converging lens and a diverging lens.



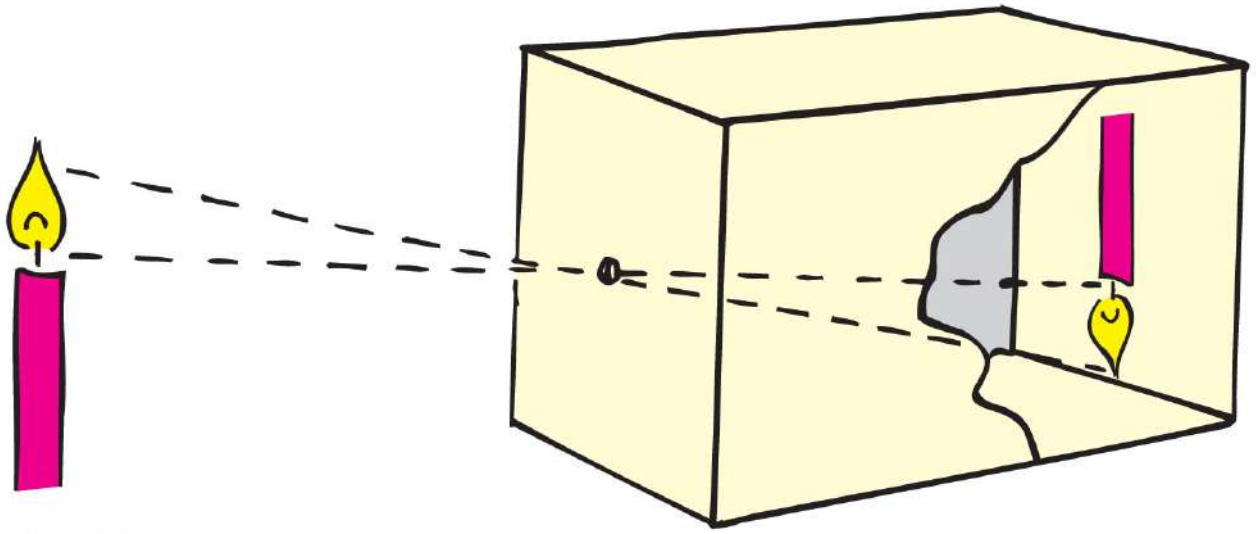
- **Key features of lenses**
  - Principal axis = line through center of lens
  - Center of curvature: center of “lens surface” circle
  - Focal point (focus) = point where all light rays meet
  - Focal length = distance between the center of the lens and either focal point

Classwork

26. What is the focal length of a lens?

Lenses, Continued-1

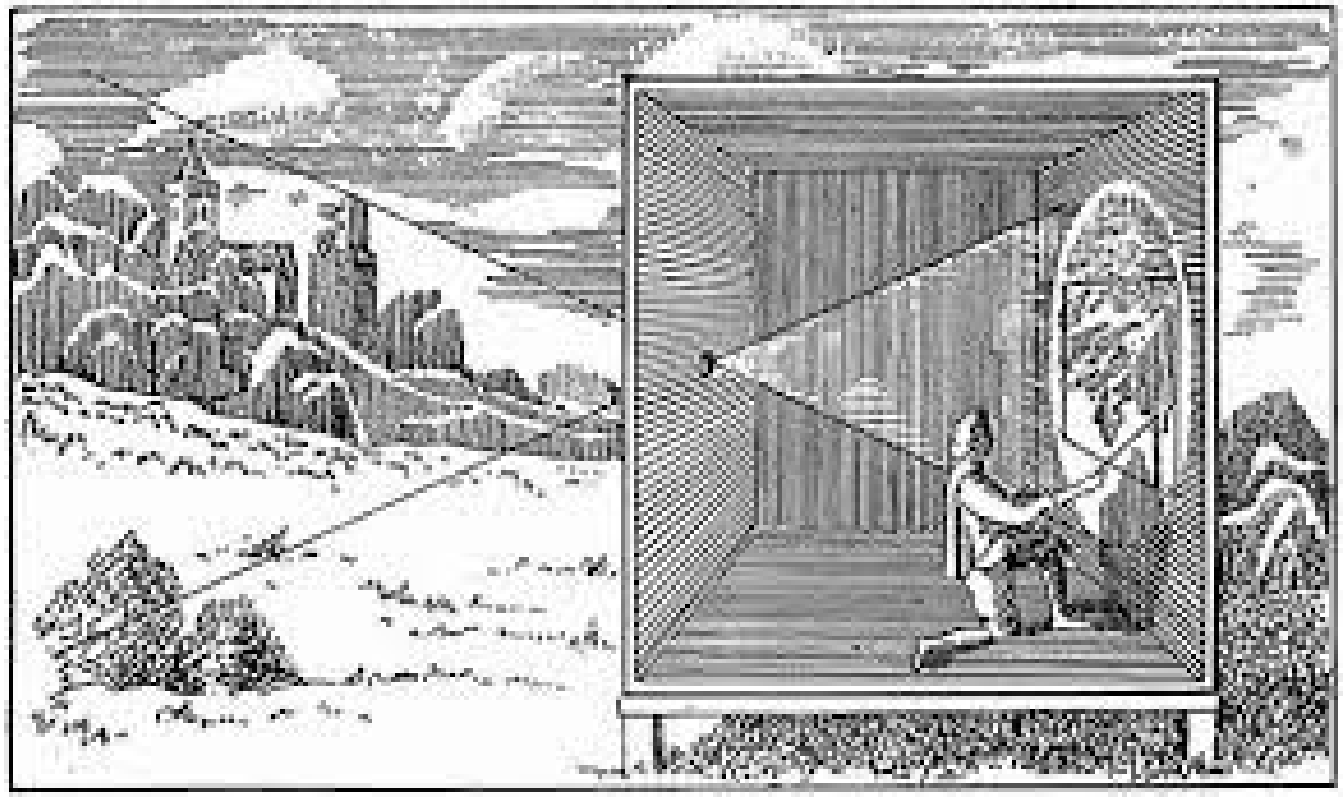
- Image formation is a consequence of light traveling in straight lines.



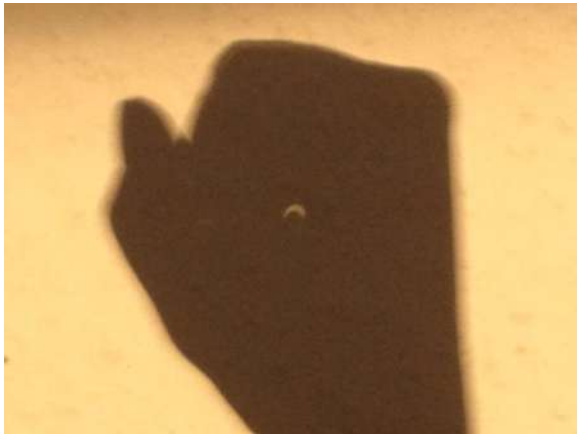
- The first camera—the pinhole camera—illustrates this fact.
- Notice that image is upside down.

Camera obscura = dark room

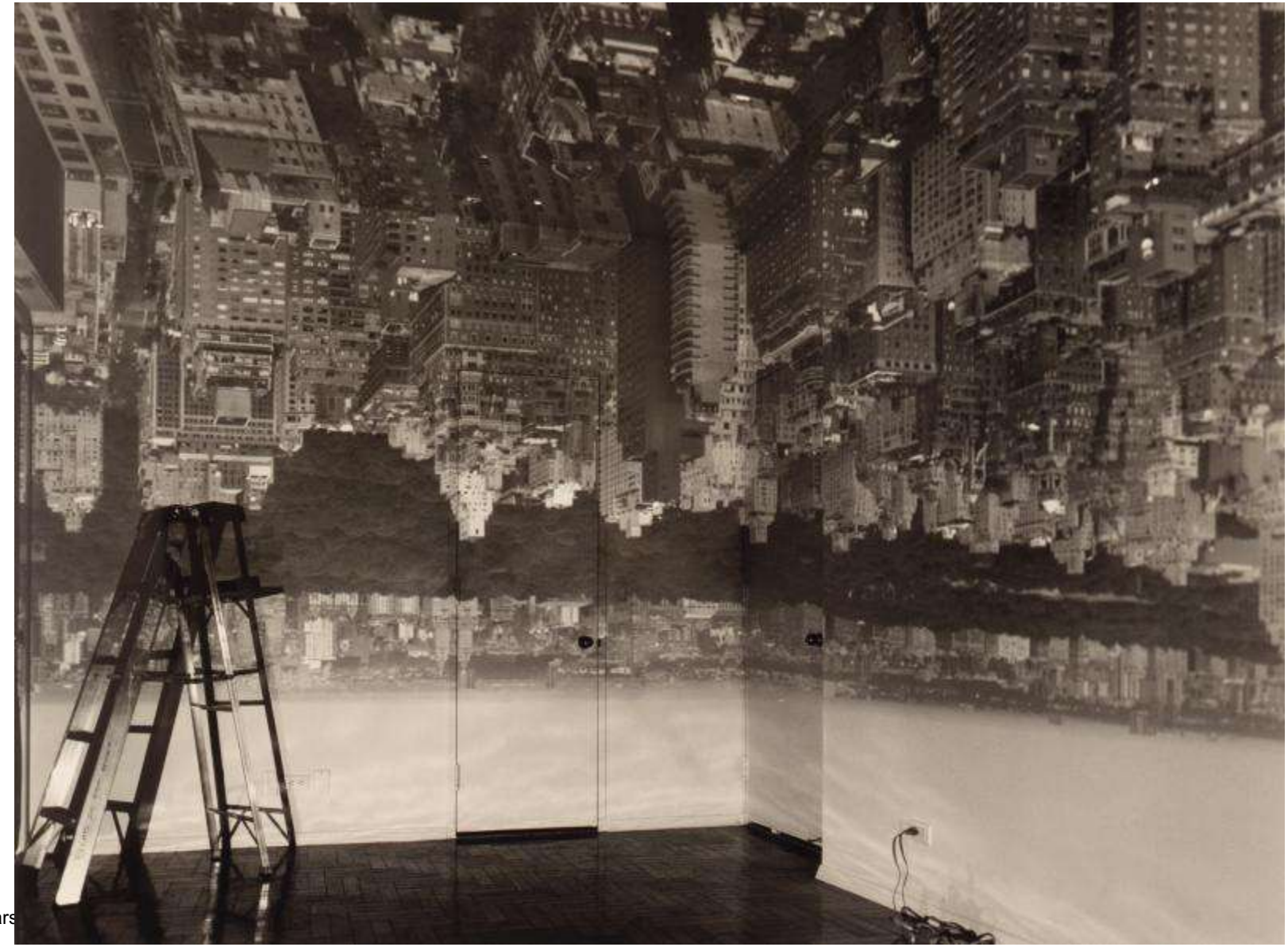
Early painters used a dark room to project upside down images on a wall—then paint them.



- Pinhole images are caused by small openings in the leaves above.



Manhattan on a wall:



Why lenses are better than pinholes:

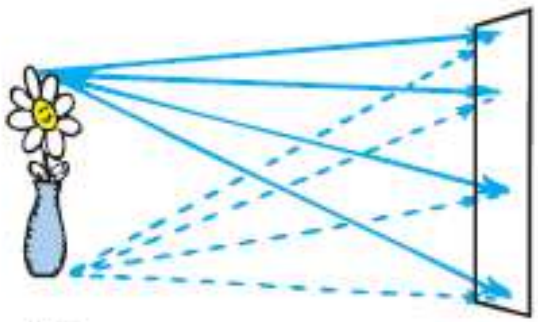
No clear image. Light from all parts hits all surfaces. So, images overlap.

Image.

Light from each part only hits one part of surface so faint image.

Image.

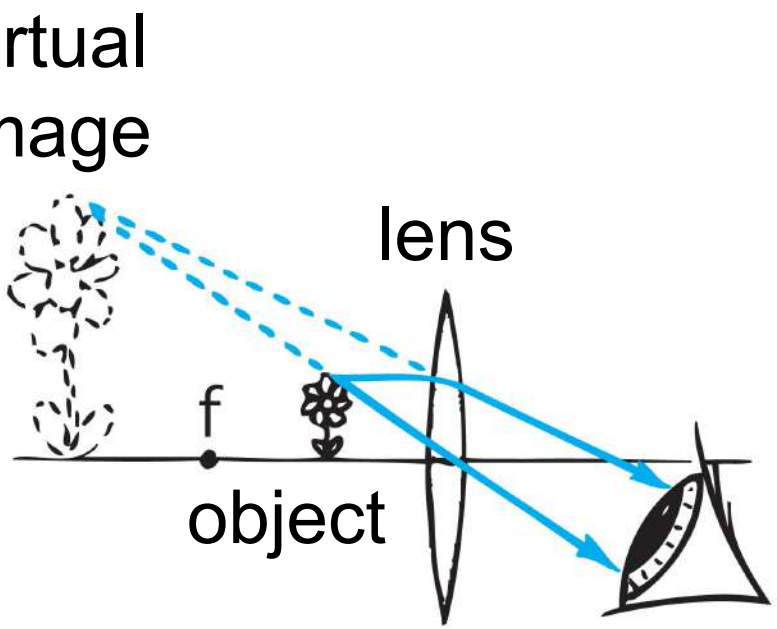
Light from each part is focused to one point so bright image.



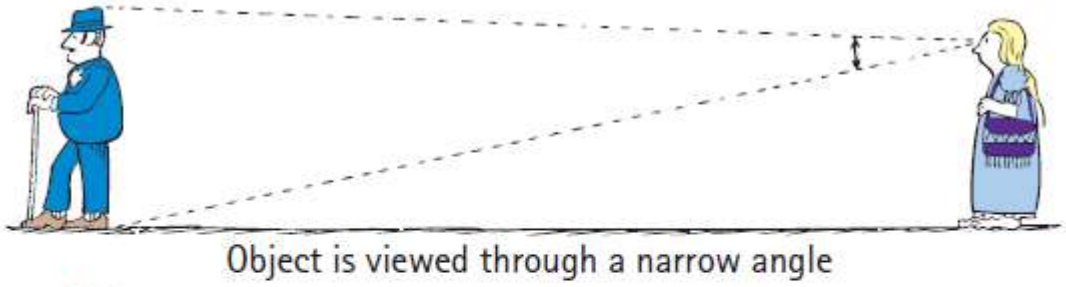
(a)

Magnifying lens

- Image is magnified because converging lens allows you to get closer to object and see clear image.

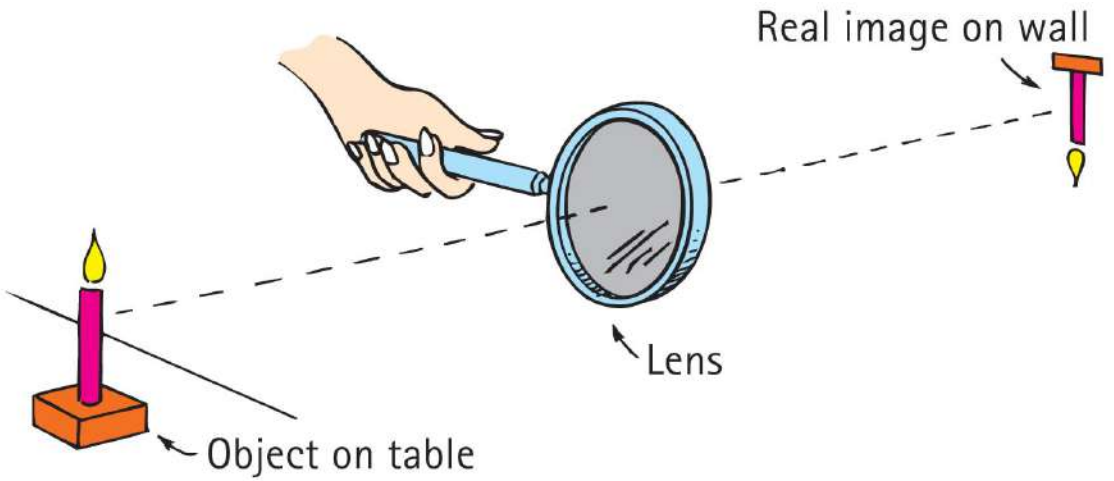


- Getting closer makes image appear bigger, or magnified.

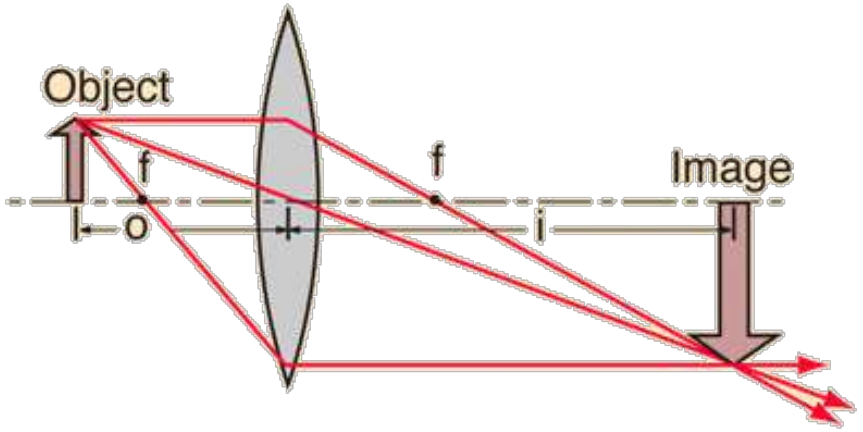


More Converging lenses:

- A converging lens can project a real image.

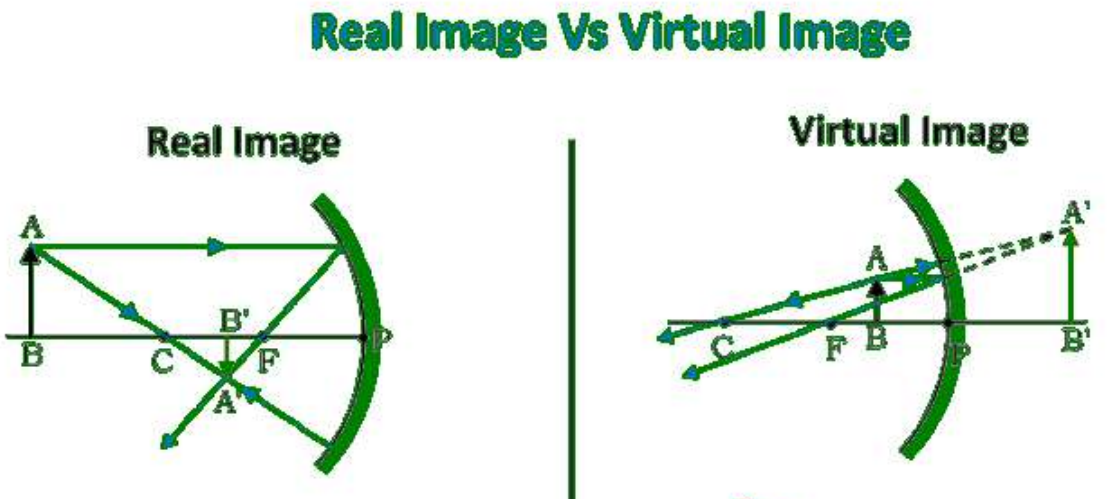


Lens diagrams show how rays travel through lens and form image.



Real vs Virtual Images

Mirrors:



Lenses:

Real rays converge

Can be projected

Real rays diverge

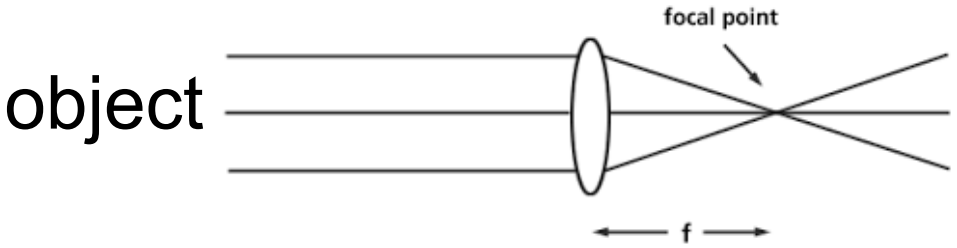
Cannot be projected

Classwork

27. Distinguish between a virtual image and a real image.

Converging lenses are versatile:

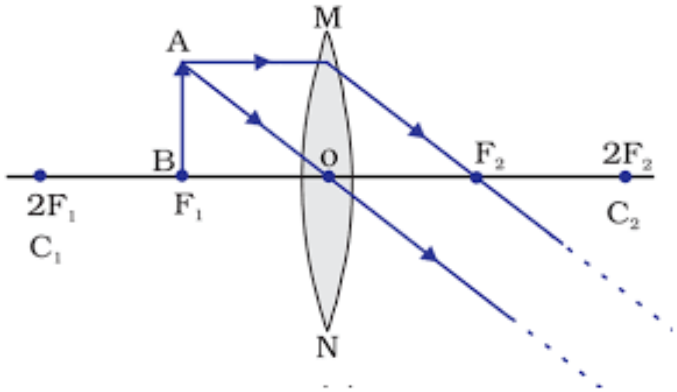
Object at infinity → Image at focal point



If Sun is the object

Object at focal point:
Image at infinity.

Lighthouses do this.



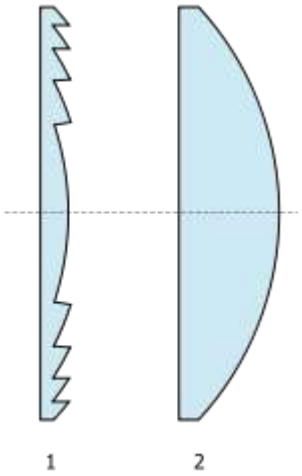
Fresnel lens

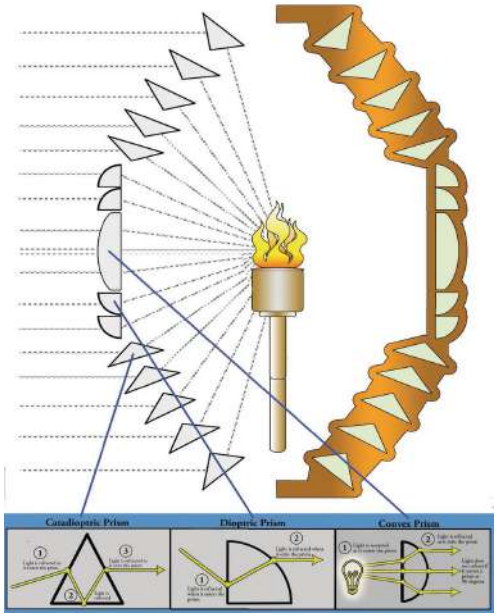
Only uses curved part of lens

Cuts out middle.

Much lighter.

Used in lighthouses.





Lens and the images they make:

Converging lens:

Real or virtual images

Diverging lens:

Virtual image only

Classwork

28. What kind of lens can be used to produce a real image? A virtual image?

Lenses
CHECK YOUR NEIGHBOR

The action of lenses depends mainly on

A. reflection.
B. refraction.
C. Both A and B.
D. Neither A nor B.

Lenses
CHECK YOUR ANSWER

The action of lenses depends mainly on

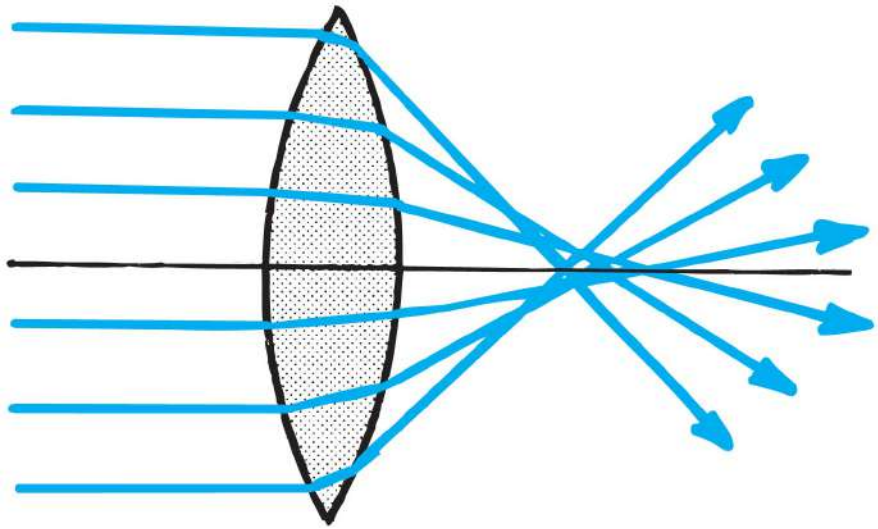
B. refraction.

Lens Defects

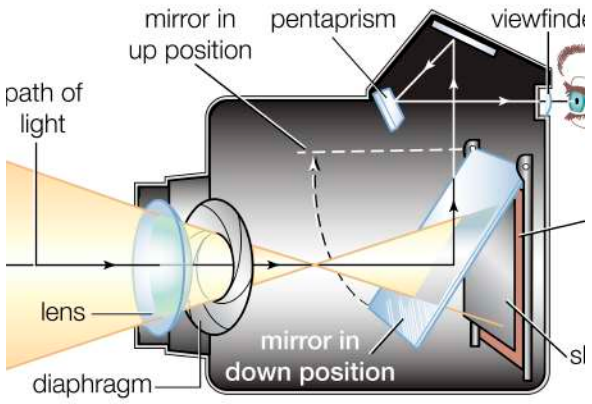
- Aberration - distortion in an image

Spherical aberration:

Light passing through the edges of lens focus at slightly different place than the light passing through the center of the lens.



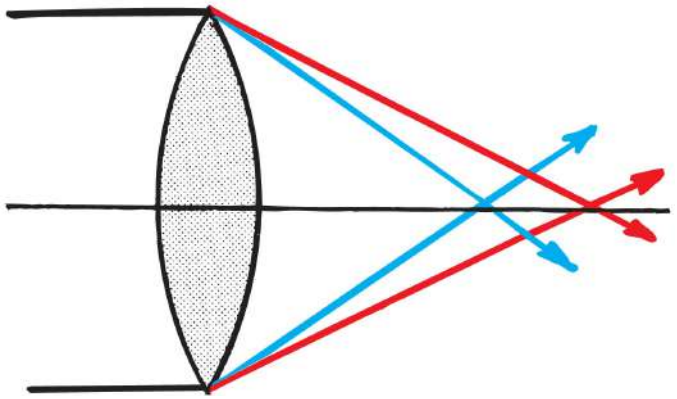
In a camera, this is fixed by covering the edges with a *diagram* or by using a combination of lenses.



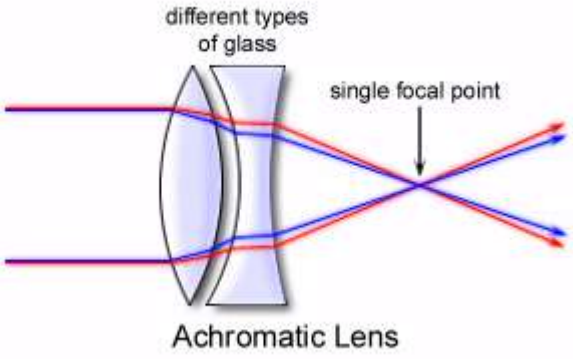
- **Chromatic aberration**

Different colors have different speeds and refract differently.

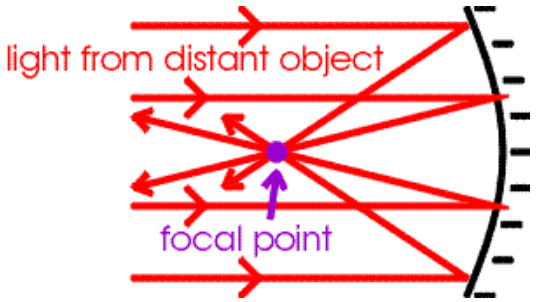
So they focus at different distances.



Fixed by having lenses made of two (or more) different glasses



Or use a mirror instead of a lens to make the image:

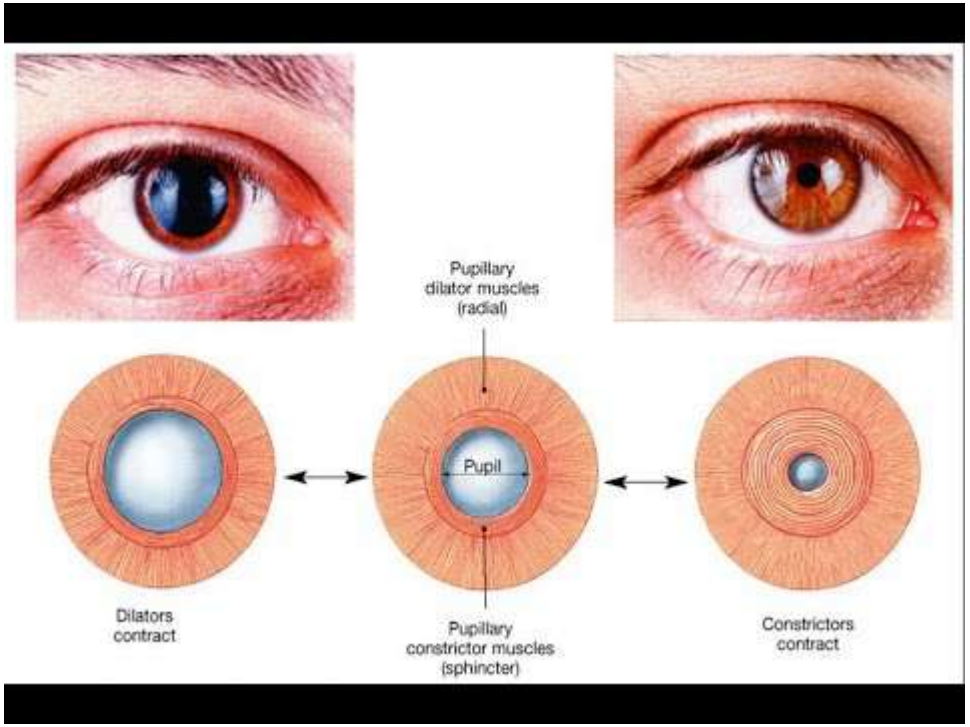


All colors reflect the same and focus at same point.

Smaller pupils are better!

When your pupils are smaller, *light is forced to pass through the middle of your lens.*

Result: less spherical and chromatic aberrations!

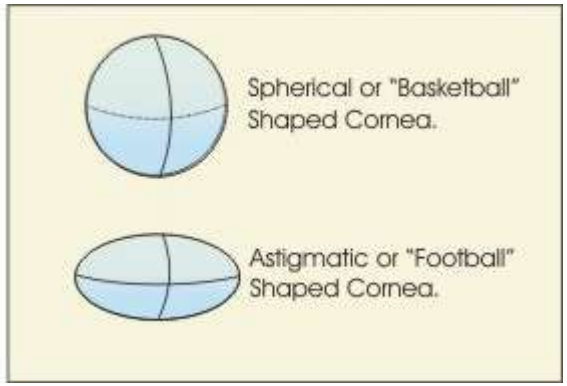


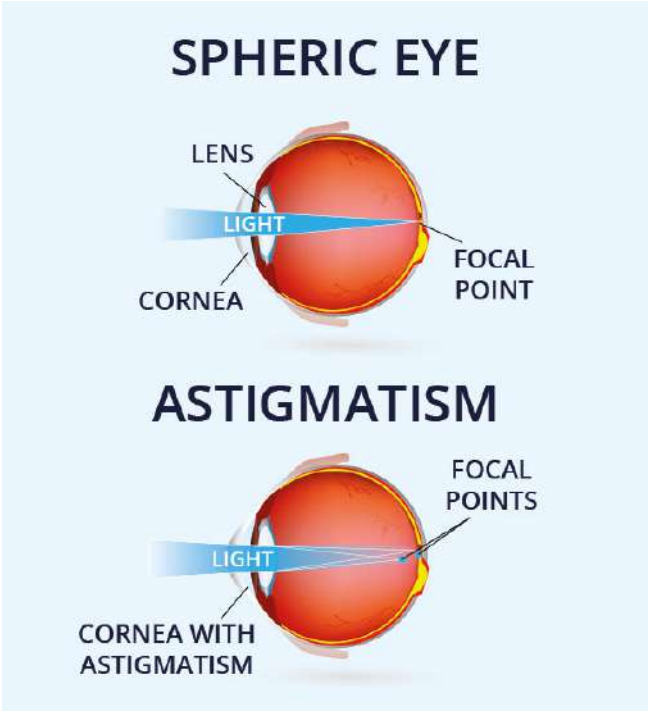
Classwork:

29. Why is vision sharpest when the pupils of the eye are very small?

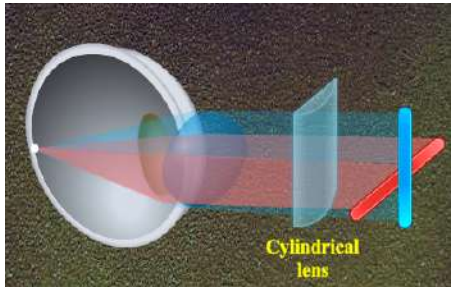
Astigmatism

- Cornea is unequally curved





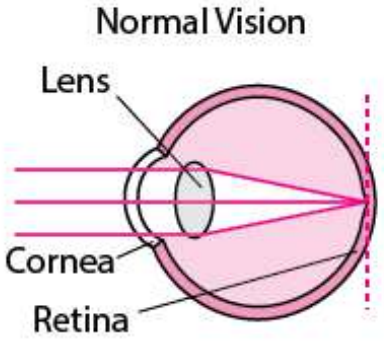
- Fix with barrel shaped lens:



Classwork

30. What is astigmatism, and how can it be corrected?

Correcting vision with lenses:

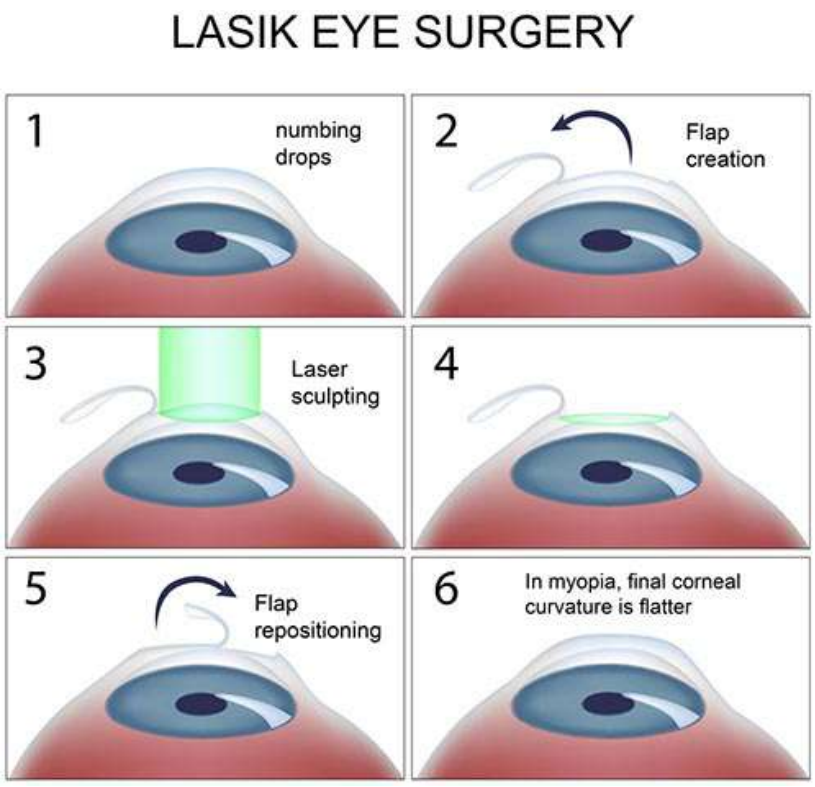


Other options:

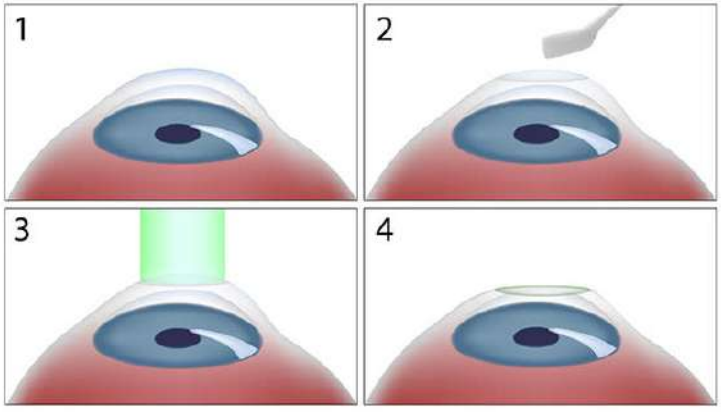
Cut flap

Shape cornea,

Put flap back:



If you have a thin cornea or might bump the flap, try:



Photorefractive Keratectomy (PRK)

Or stick one of these in your eyes:

fyi

- Or pump water in to make lens more curved (more focusing) or flatter (less focusing).