Lenses & Optical Devices

SNC2D

Lenses

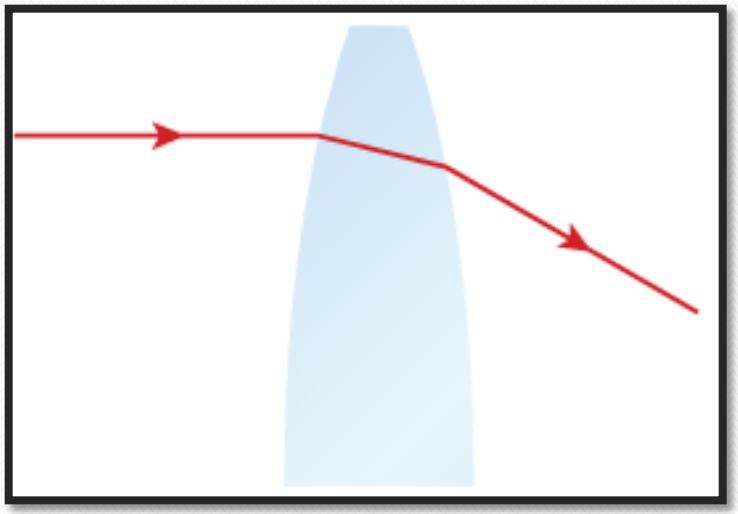
- A transparent object used to change the path of light
- Examples:
  - Human eye
  - Eye glasses
  - Camera
  - Microscope
  - Telescope

Reading stones used by monks, nuns, and scholars ~1000 C.E.

Lenses

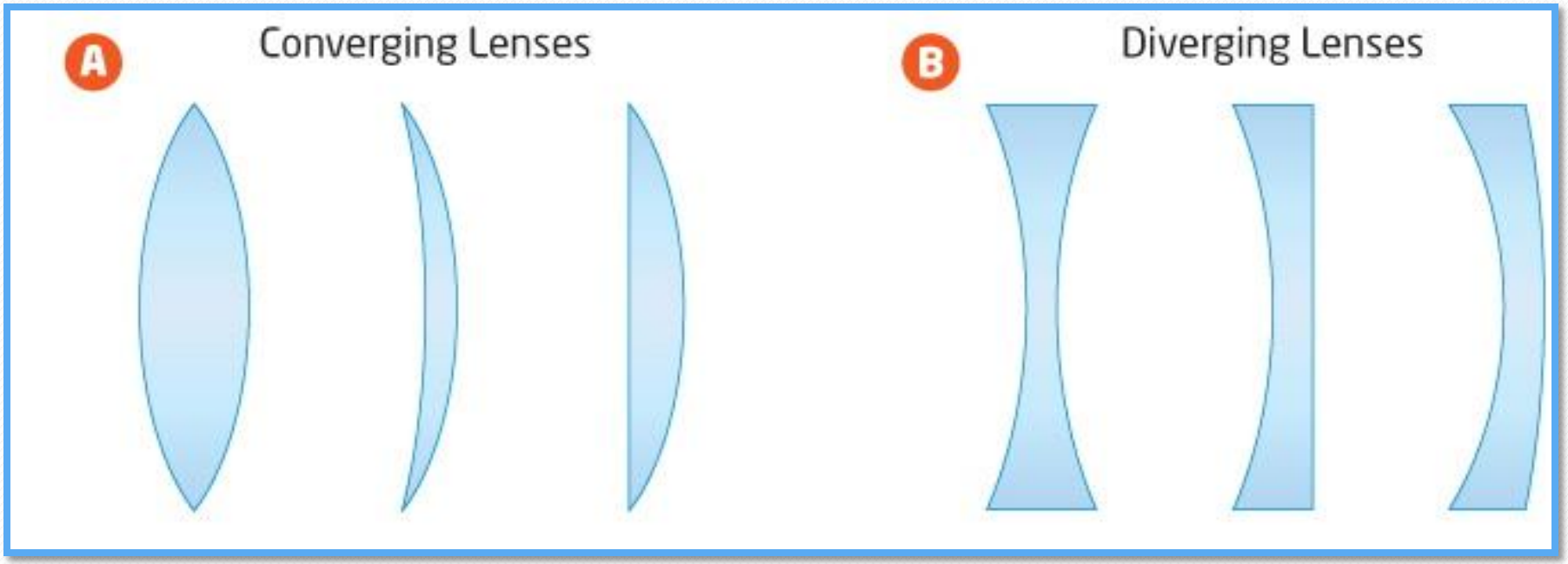
THERE ARE ALWAYS TWO REFRACTIONS IN A LENS

- Light is refracted at the first **air to glass** surface
- Light then travels through the glass of the lens and is refracted again at the **glass to air** surface on the other side



Lenses

- Two basic shapes
  - Converging lens
  - Diverging lens



Lenses

- **Converging lens (aka Convex lens)**

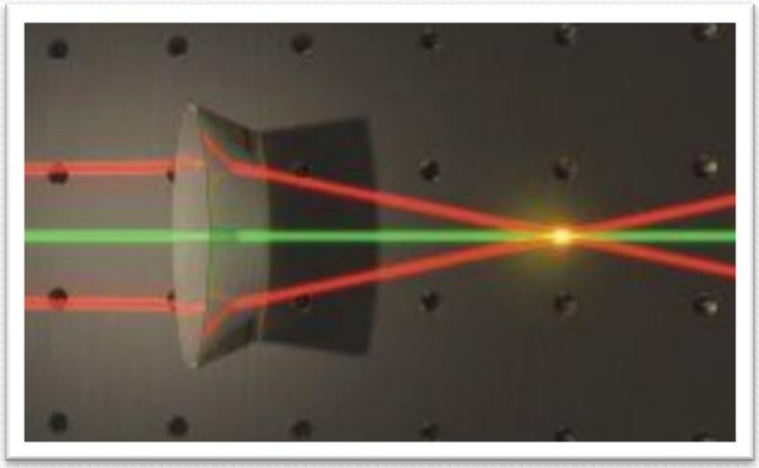
- Thicker in the center than at edges causes parallel light rays to converge (come together) to a single focus point after refraction.

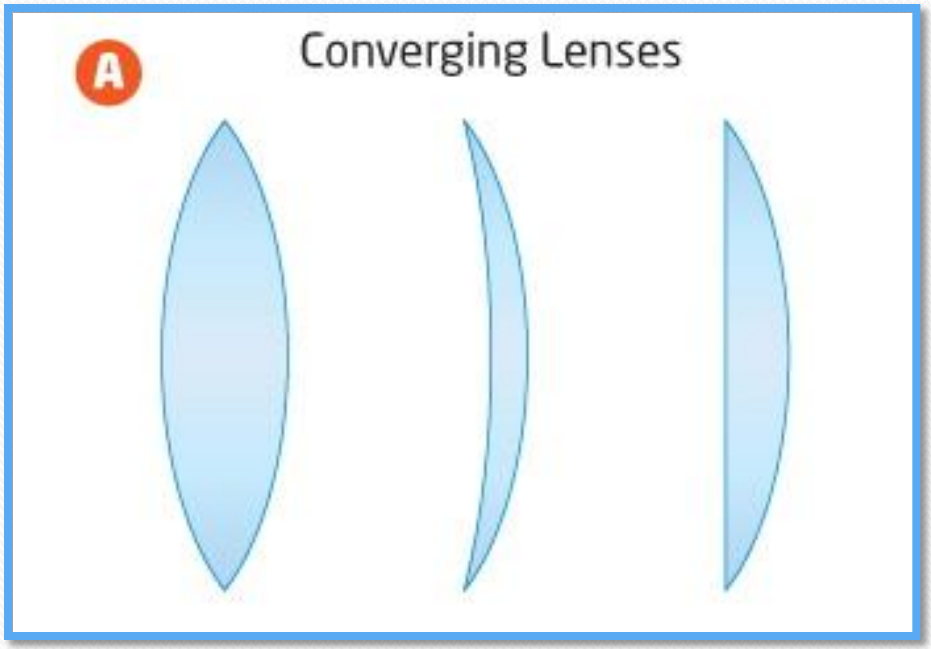
- **Diverging lens (aka Concave lens)**

- Thicker in the edges than at center causes parallel light rays to diverge (spread out) after refraction.

Converging Lens

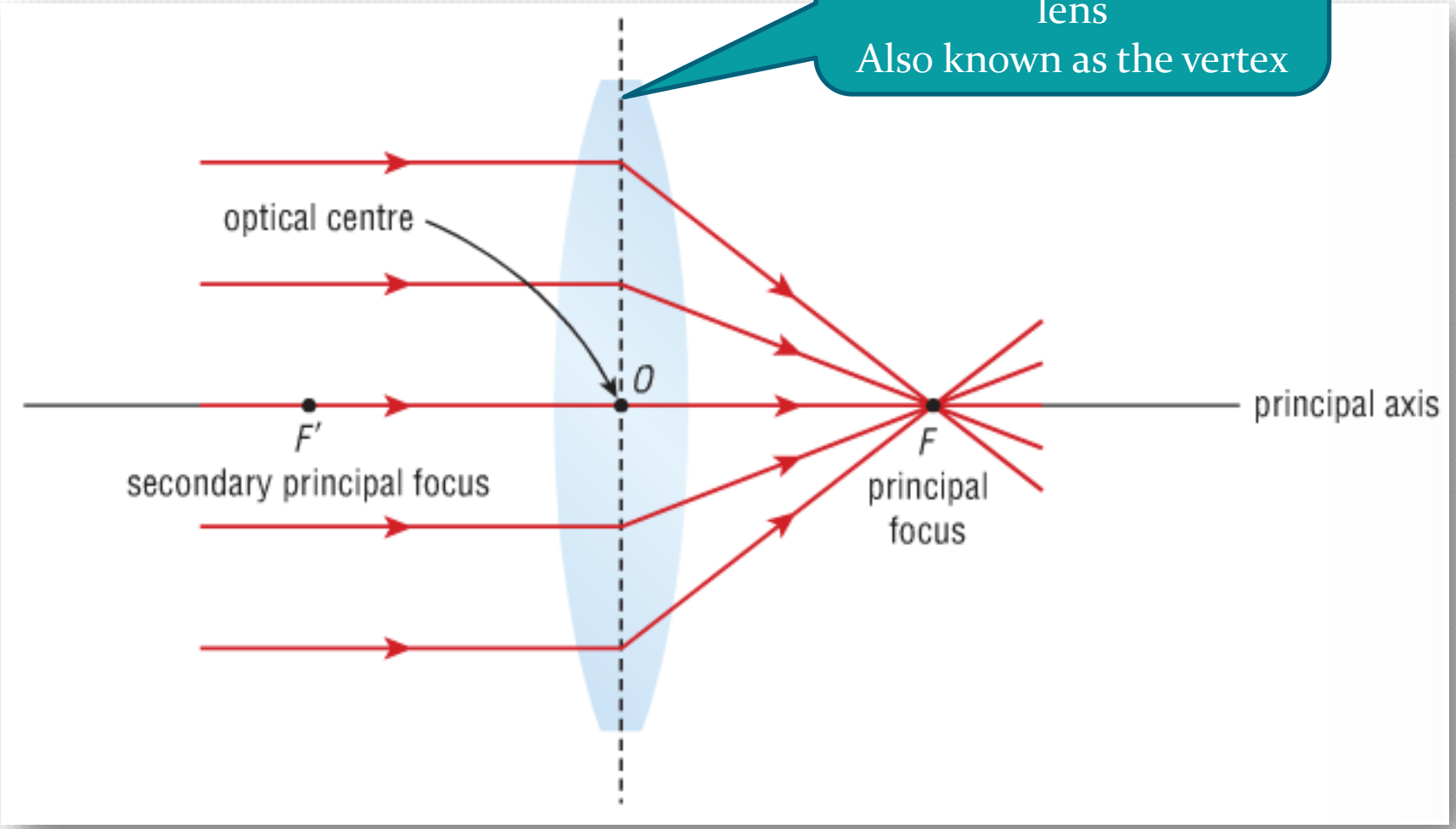
- A lens that has its thickest part in the middle
- Causes all incident parallel rays to converge at a single point after refraction





Converging Lens

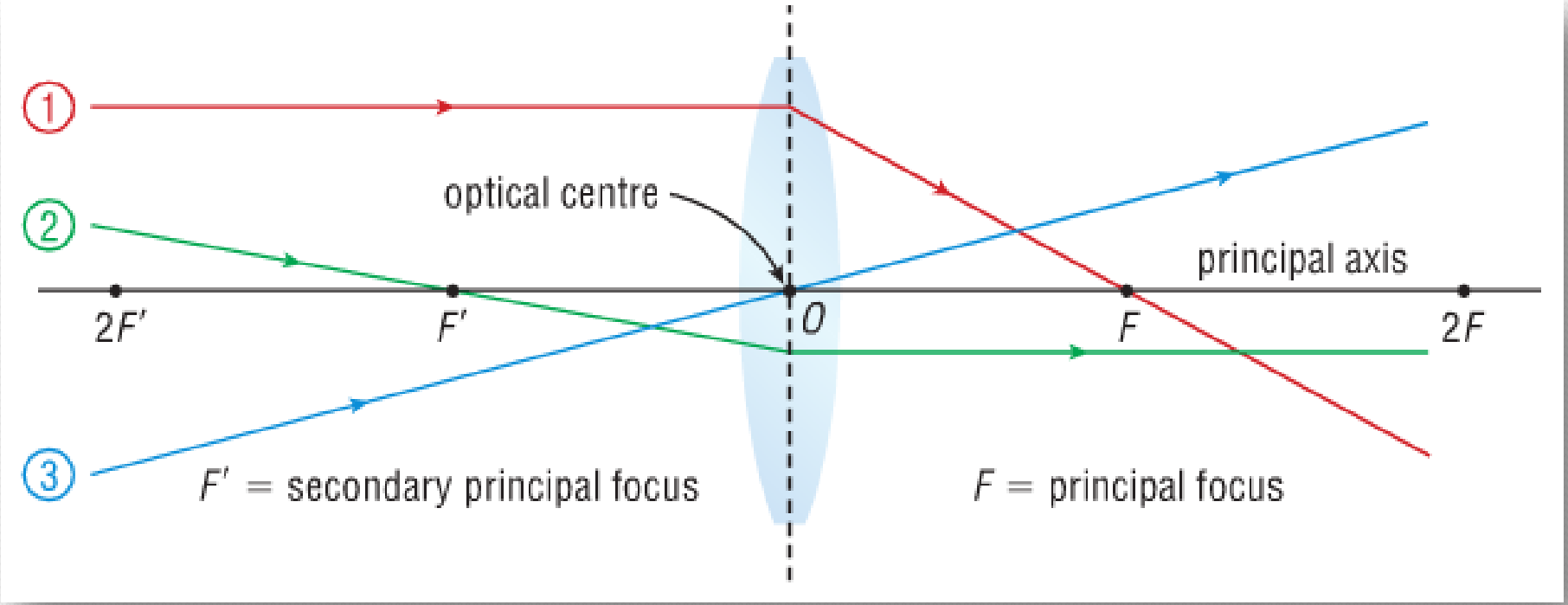
OPTICAL CENTRE:
the exact centre of the lens
Also known as the vertex



Ray diagrams for Converging Lenses

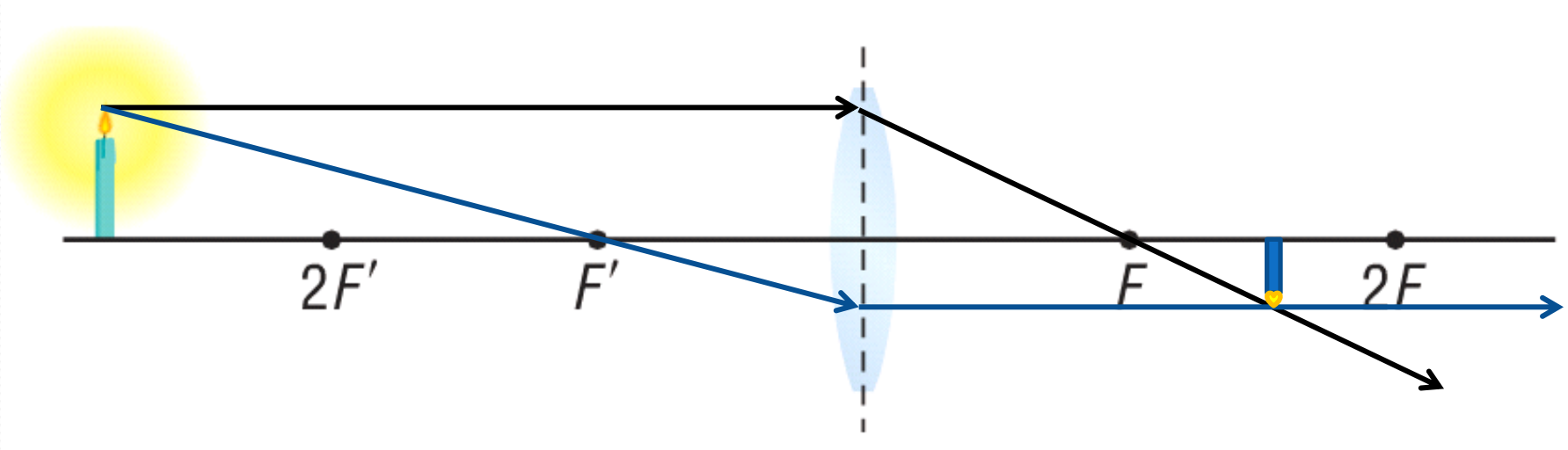
- Rule 1: an incident ray parallel to the principal axis is refracted through F
- Rule 2: an incident ray going through F' will refract parallel to the principal axis
- Rule 3: a ray through the optical center (O) continues straight through without being refracted
  - You can use this line as a check to see if you have placed your first 2 lines accurately

Ray diagrams for Converging Lenses



Images through Converging Lenses

- Let's practice



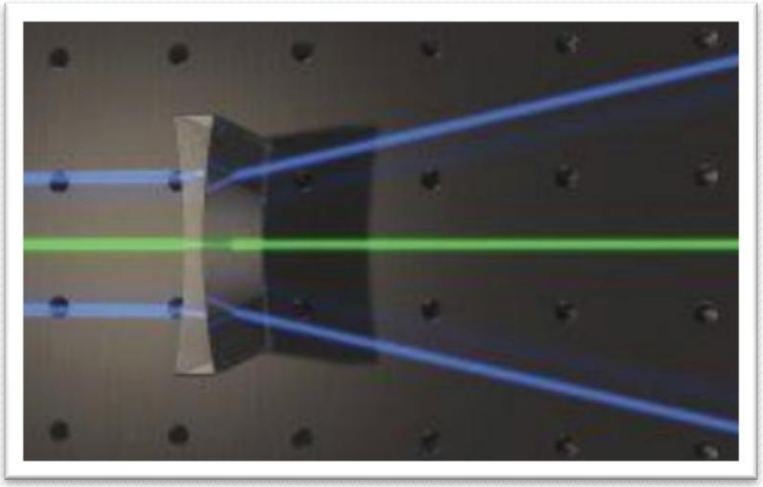
Converging Lenses

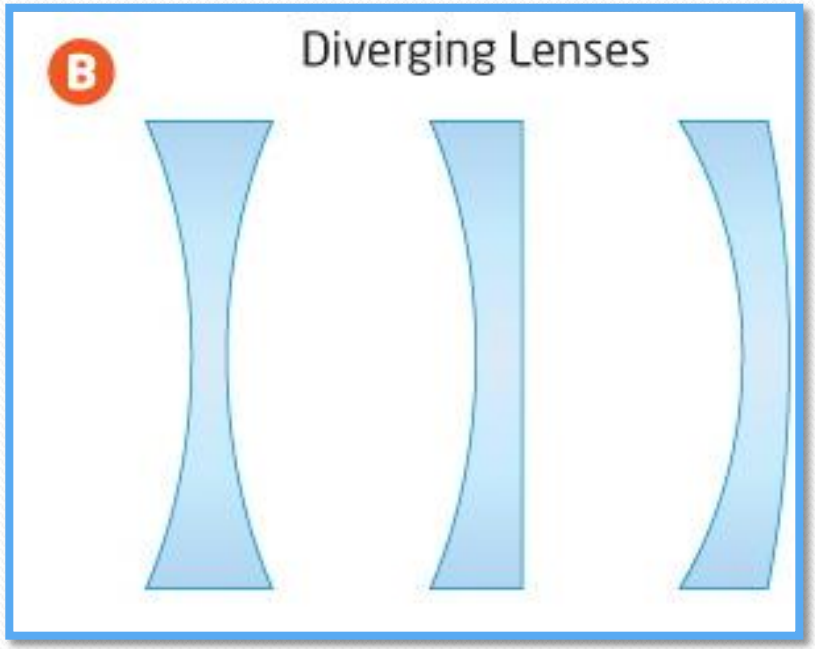
- Can produce real and virtual images
- The size and attitude will vary depending on the location of the object
- Many uses including to correct for far-sightedness

Object	Image ----------			
Location	**Size**	**Attitude**	**Location**	**Type**
Beyond 2F'	Smaller	Inverted	Behind	Real
At 2F'	Same	Inverted	Behind	Real
Between 2F' and F'	Larger	inverted	Behind	Real
At F'	No clear image			
Inside F'	larger	upright	In front	Virtual

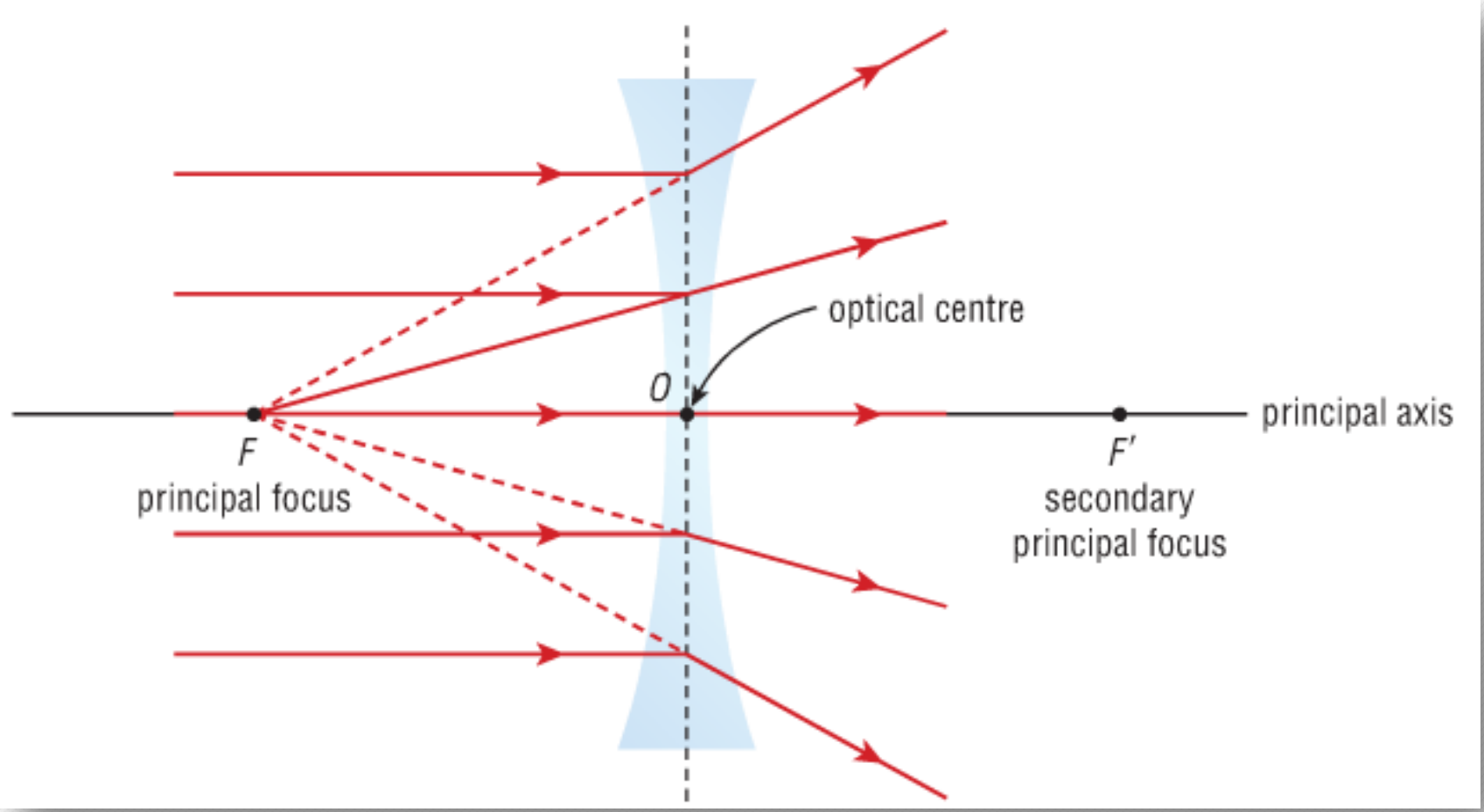
Diverging Lens

- A lens that has its thinnest part in the middle
- Causes all incident parallel light rays to spread apart after refraction





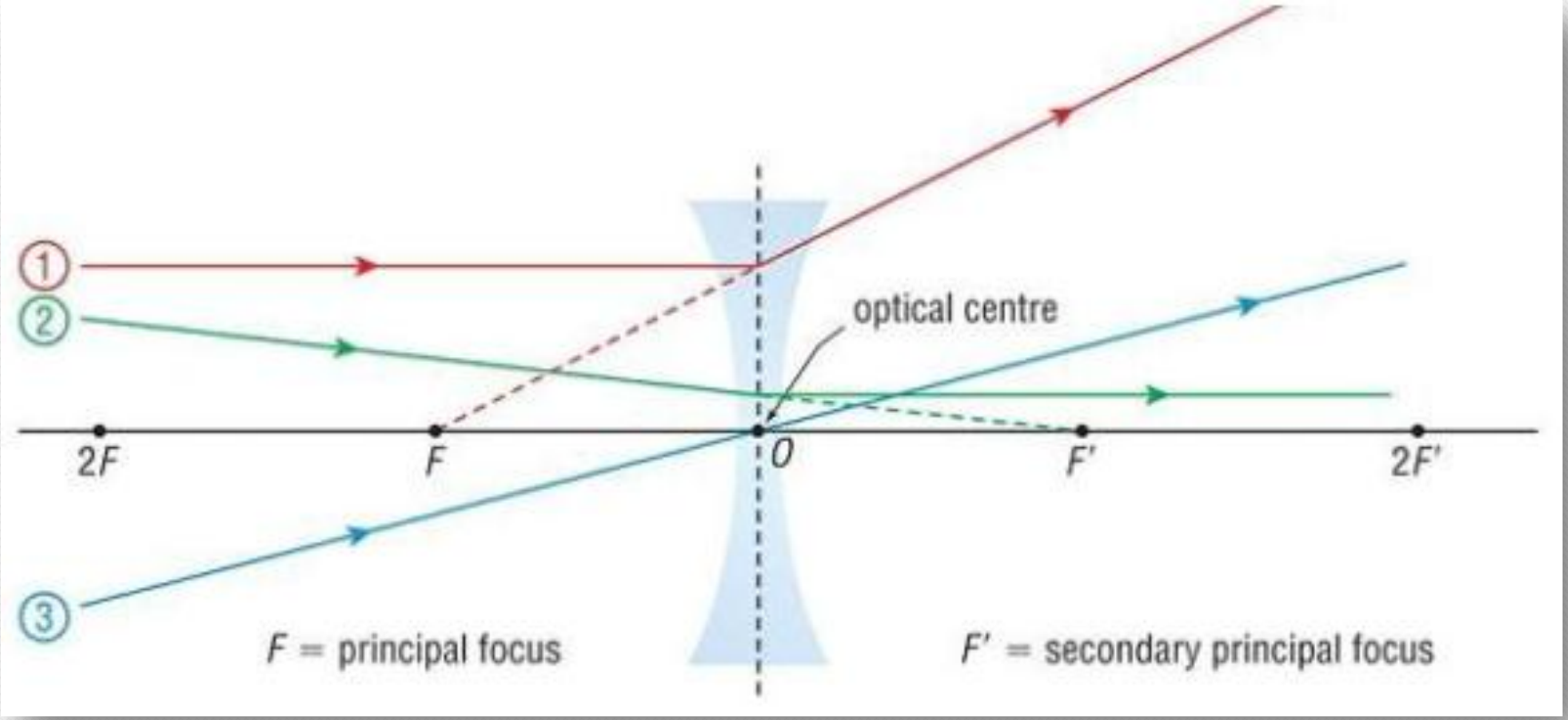
Diverging Lens



Ray diagrams for Diverging Lenses

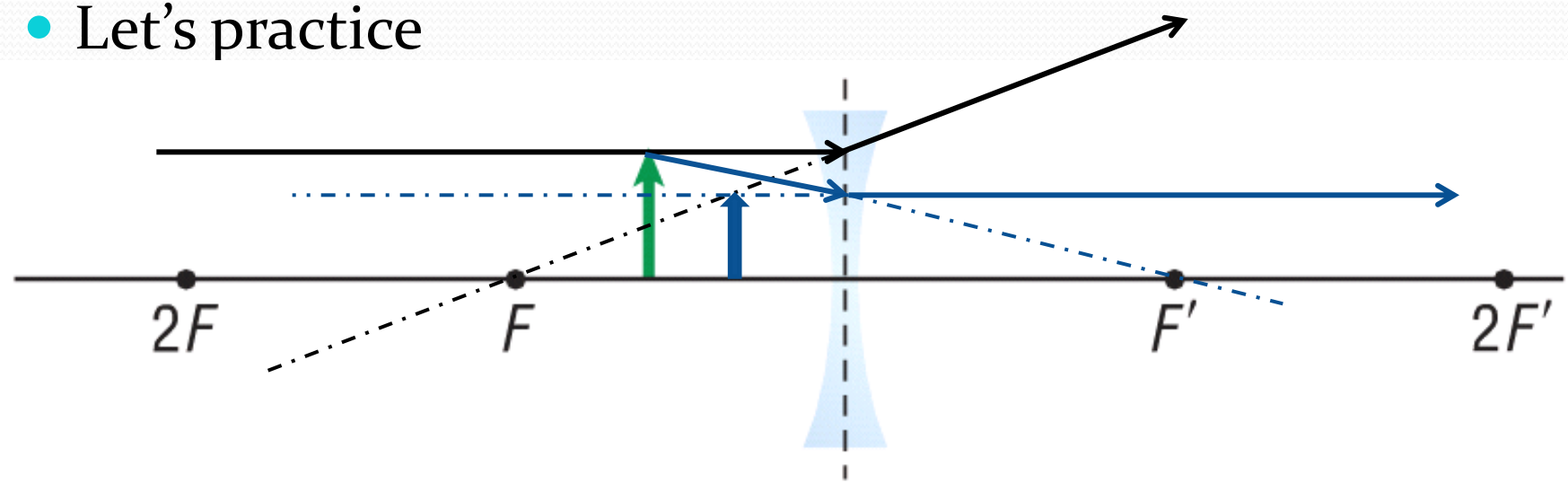
- Rule 1: an incident ray parallel to the principal axis is refracted as if it had come through F
- Rule 2: an incident ray that appears to pass through F' will refract parallel to the principal axis
- Rule 3: a ray through the optical center (O) continues straight through without being refracted.
  - You can use this line as a check to see if you have placed your first 2 lines accurately

Ray diagrams for Diverging Lenses



Images through Diverging Lenses

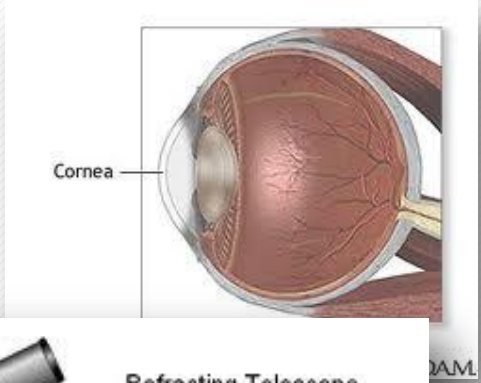
- Let's practice

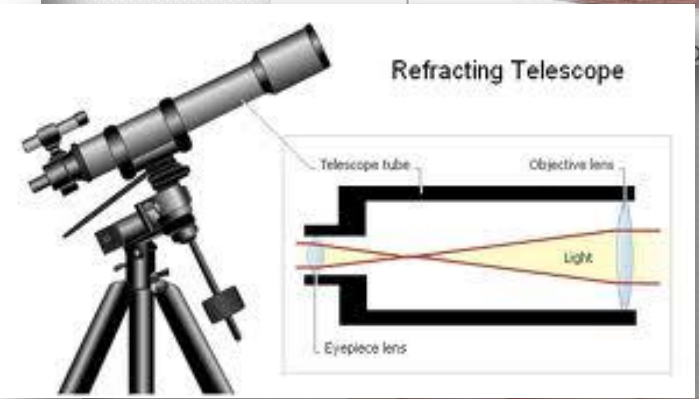


Diverging Lenses

- Only produce virtual images that are always smaller, upright and in front of the lens
- Used to correct near-sightedness (can see objects close up)

Applications of Lenses



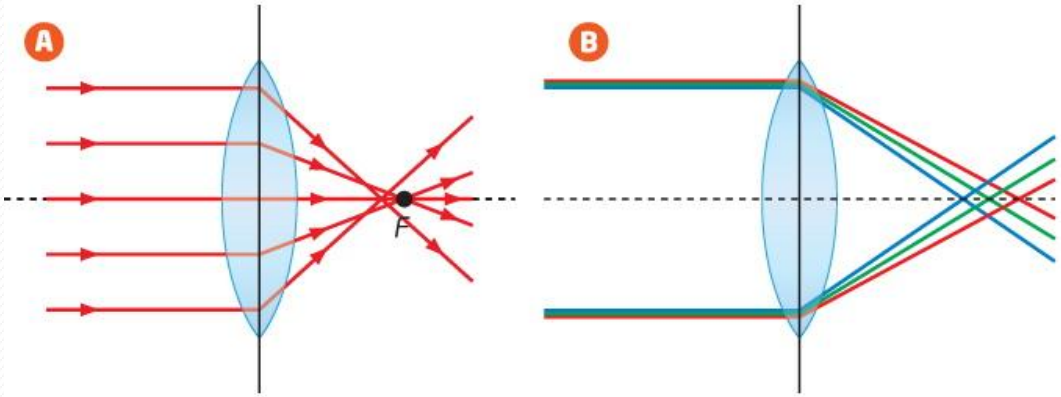


Fun with lenses

- A fish-eye lens:
  - **Thick lens**
  - Short focal length
  - Causes "**spherical aberrations**"
- Only light rays that pass through the lens near the principal axis meet at the focal point and give a sharp image
- Brings larger area into view

Chromatic Aberration

- When all colours of light do not come to focus at the same point
- Because of dispersion (prisms, rainbows), violet light refracts more than red light




c
chromatic
aberration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Correction

- Spherical & chromatic aberrations can be “corrected”
- High quality lenses for expensive cameras use a combination of *many* lenses to reduce aberration as much as possible