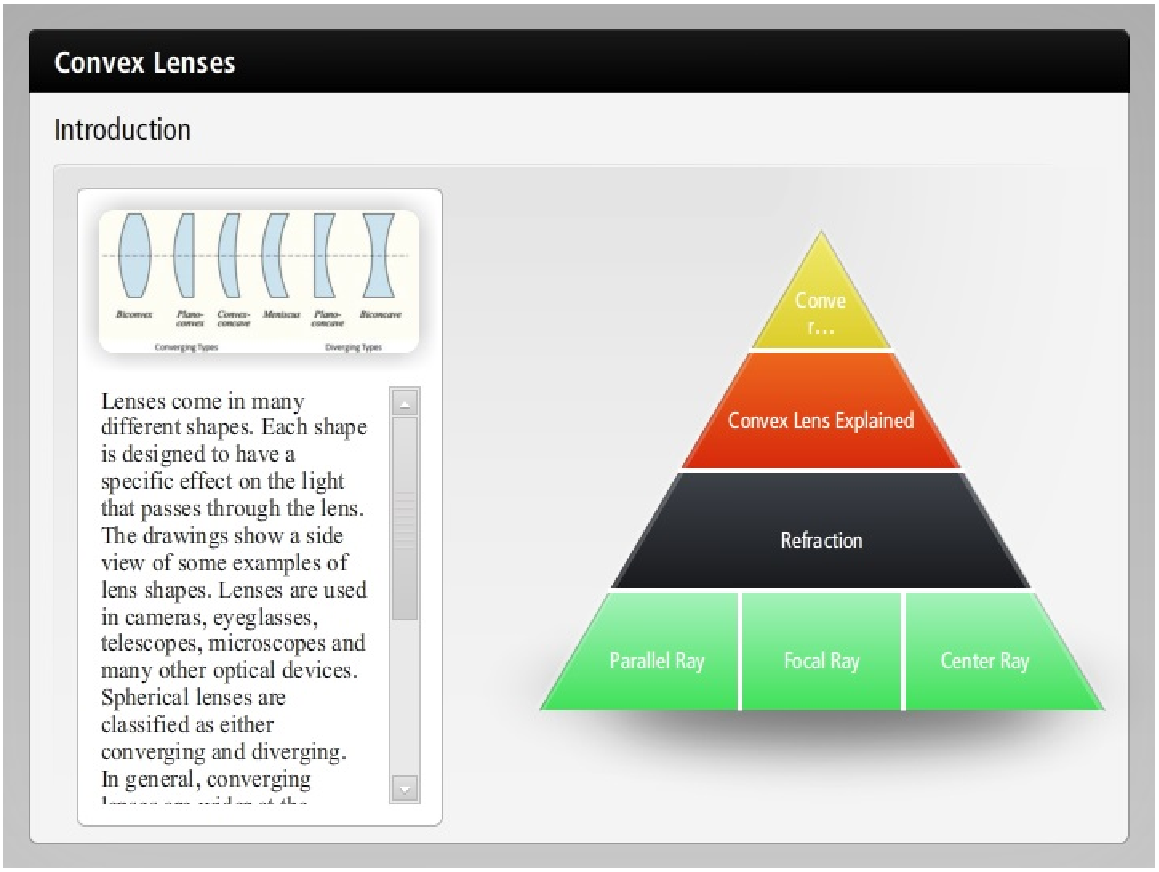
# Module 10: Optics

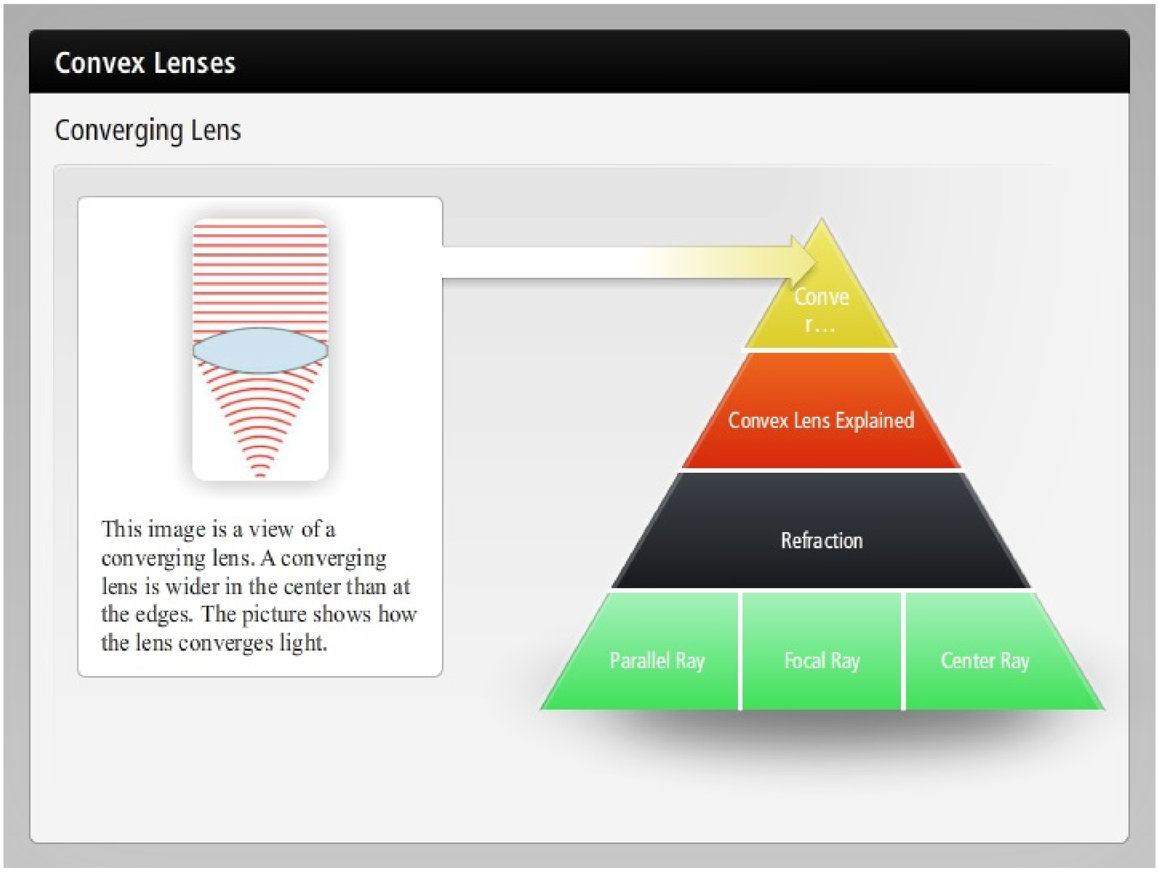
## Topic 4 Content: Spherical Lenses Presentation Notes

### Introduction



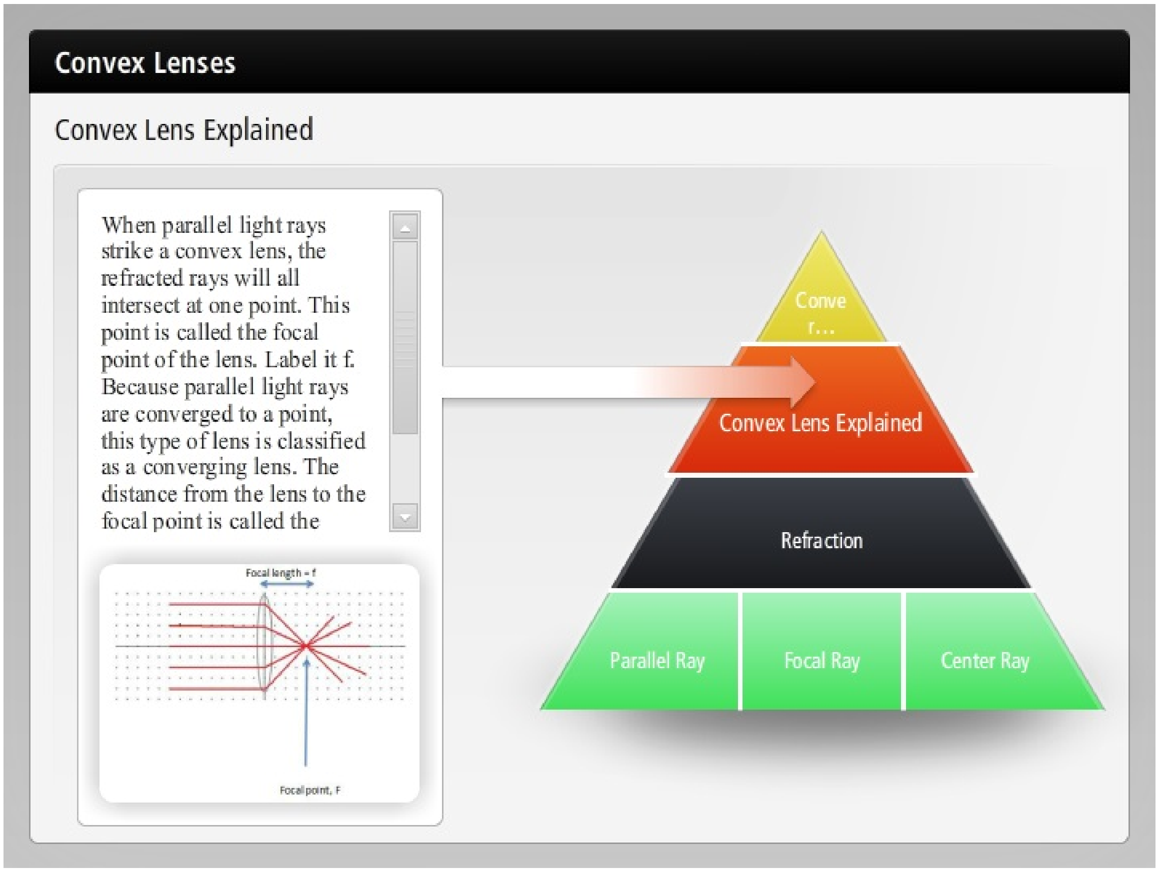

Lenses come in many different shapes. Each shape is designed to have a specific effect on the light that passes through the lens. The drawings show a side view of some examples of lens shapes. Lenses are used in cameras, eyeglasses, telescopes, microscopes and many other optical devices. Spherical lenses are classified as either converging and diverging. In general, converging lenses are wider at the center than at the edges and diverging lenses are wider at the edges than in the center. In this topic, you will learn how each type of lens works. Our studies will focus on the biconvex and biconcave lens shapes. For simplicity we will refer to these two types as simply convex and concave.

### Converging Lens




This image is a view of a converging lens. A converging lens is wider in the center than at the edges. The picture shows how the lens converges light.

## Convex Lens Explained




When parallel light rays strike a convex lens, the refracted rays will all intersect at one point. This point is called the focal point of the lens. Label it f. Because parallel light rays are converged to a point, this type of lens is classified as a converging lens. The distance from the lens to the focal point is called the focal length. It is represented by the letter f. This diagram simplifies the refraction process.

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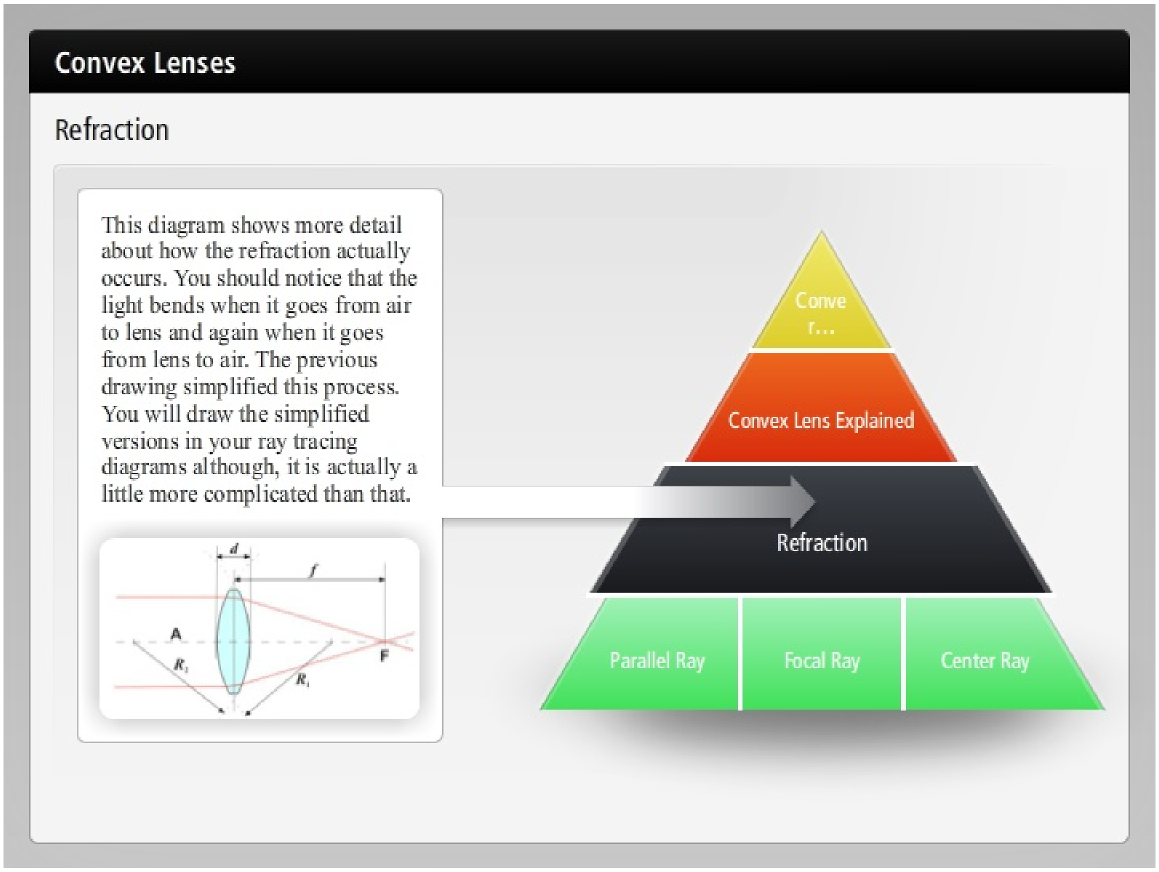
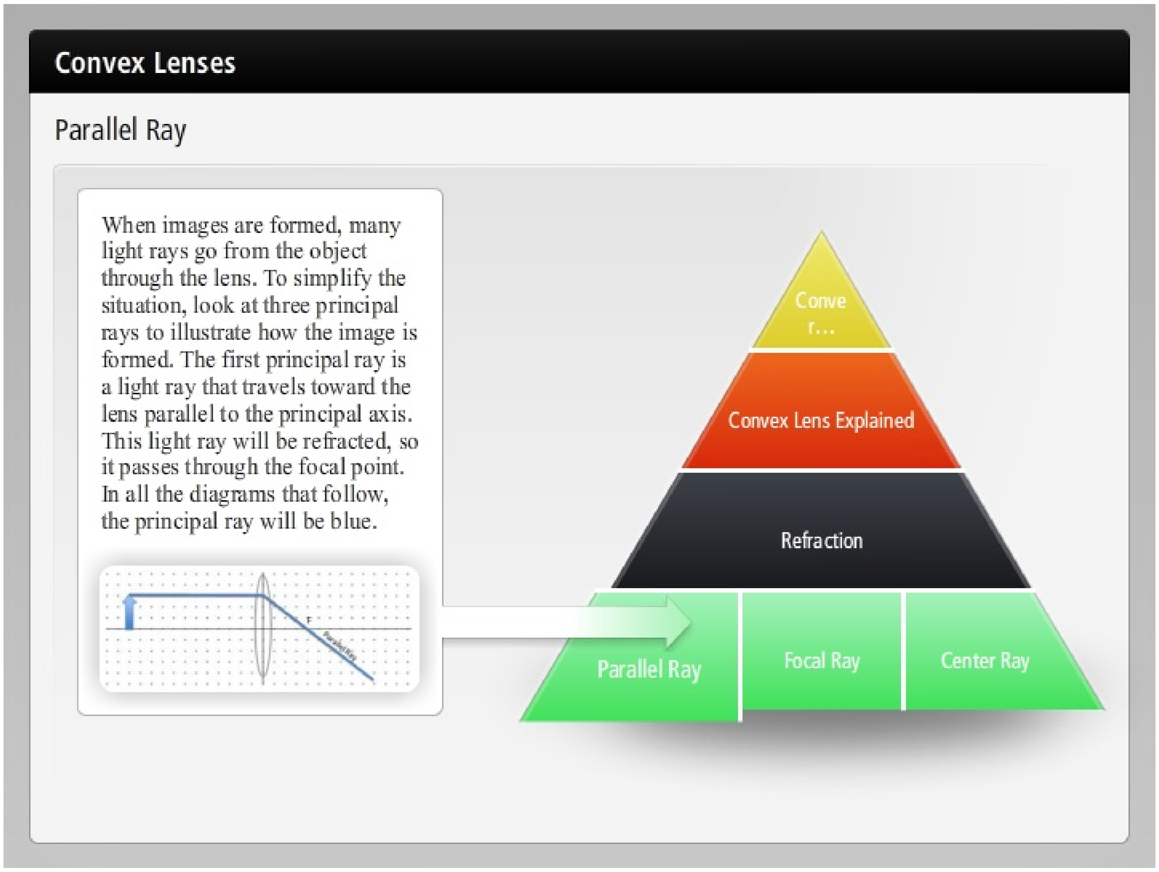
### Refraction



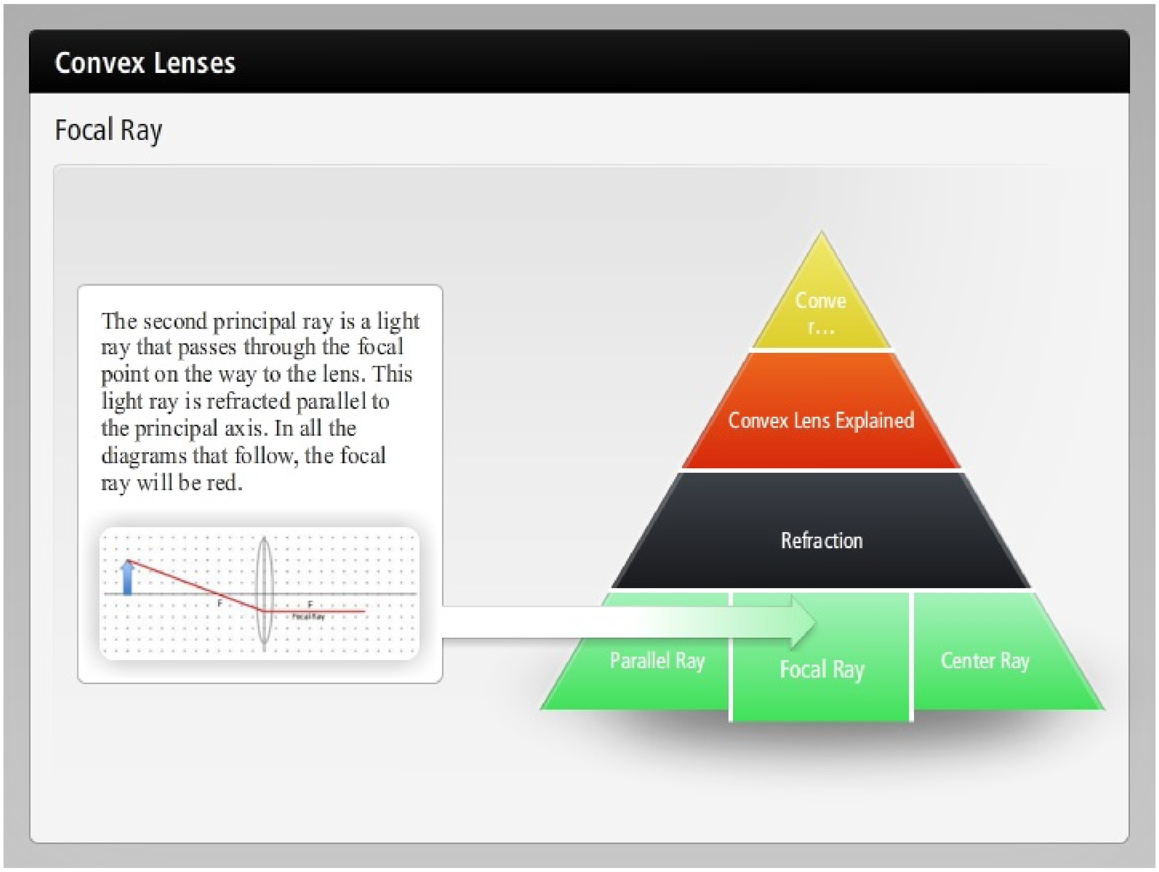

This diagram shows more detail about how the refraction actually occurs. You should notice that the light bends when it goes from air to lens and again when it goes from lens to air. The previous drawing simplified this process. You will draw the simplified versions in your ray tracing diagrams although, it is actually a little more complicated than that.

### Parallel Ray



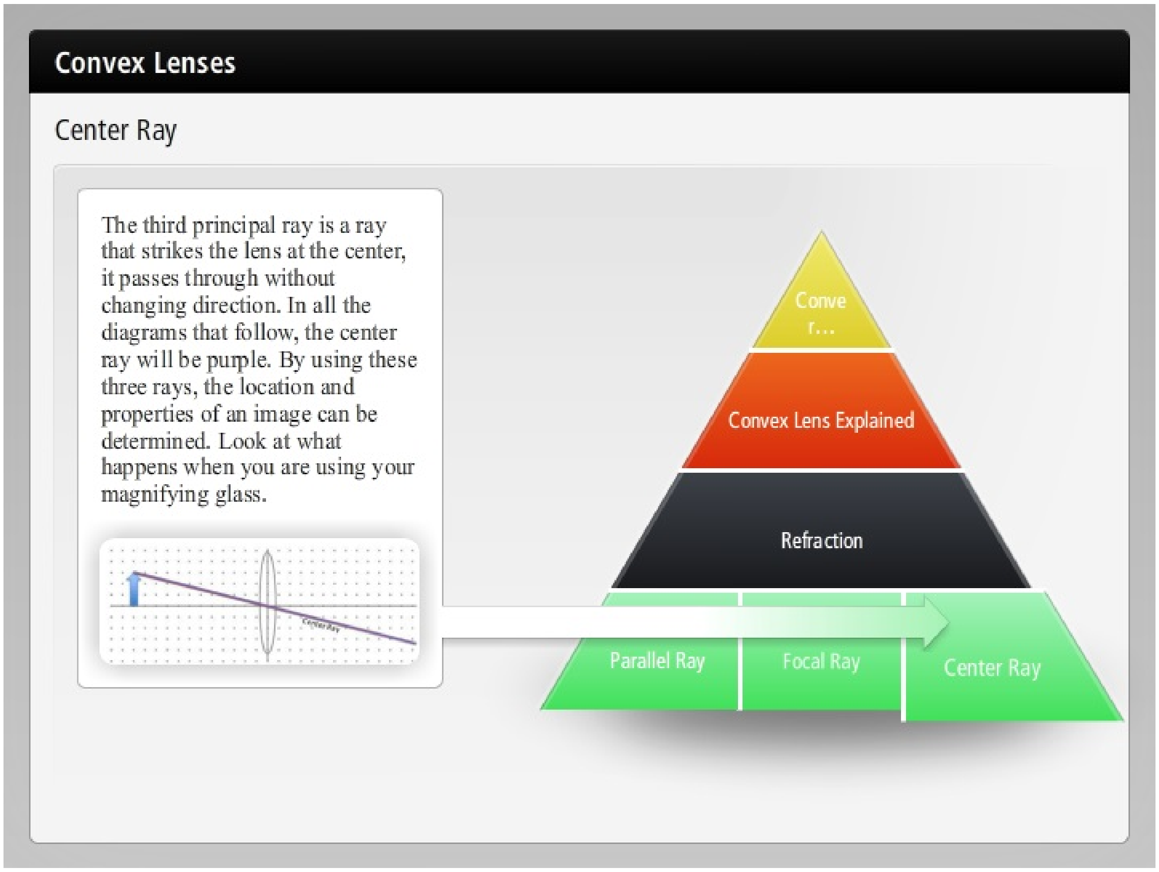

When images are formed, many light rays go from the object through the lens. To simplify the situation, look at three principal rays to illustrate how the image is formed. The first principal ray is a light ray that travels toward the lens parallel to the principal axis. This light ray will be refracted, so it passes through the focal point. In all the diagrams that follow, the principal ray will be blue. In all the diagrams that follow the principal ray will be blue.

### Focal Ray




The second principal ray is a light ray that passes through the focal point on the way to the lens. This light ray is refracted parallel to the principal axis. In all the diagrams that follow, the focal ray will be red.

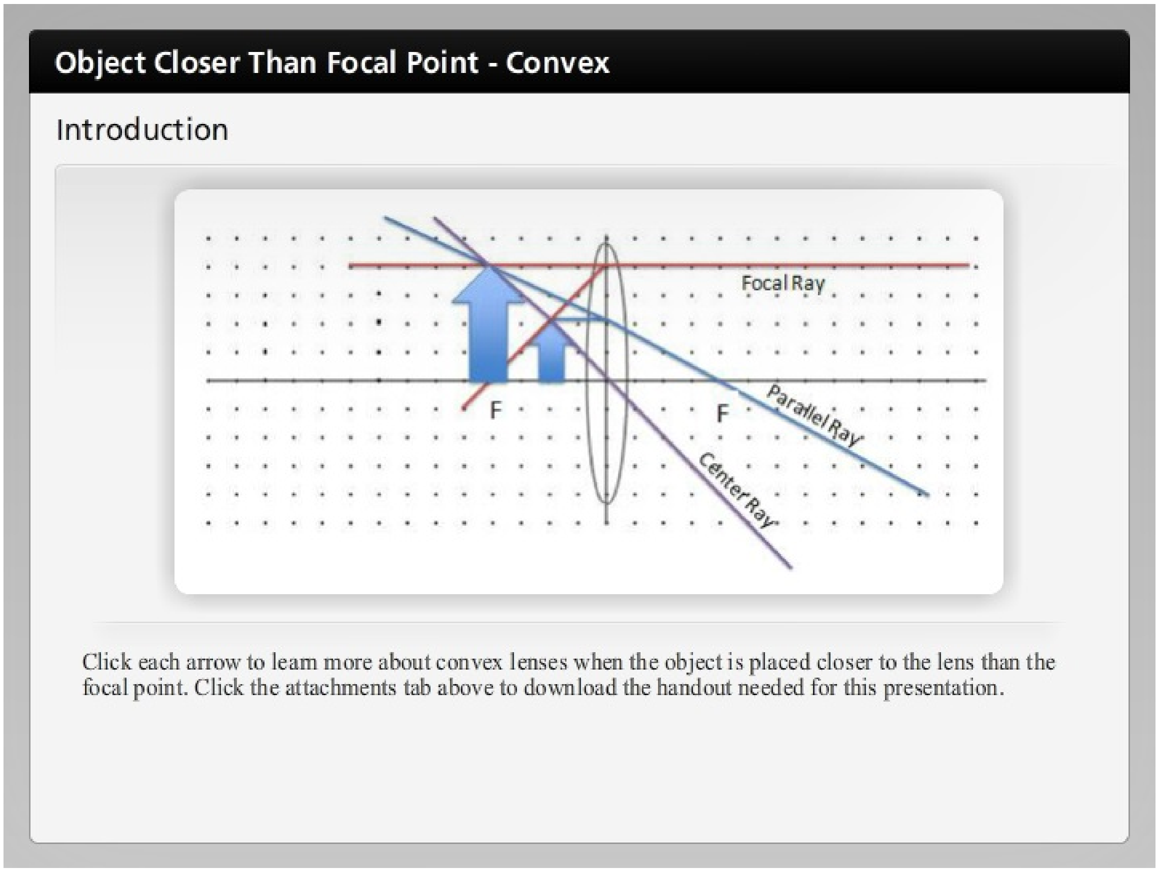
### Center Ray




The third principal ray is a ray that strikes the lens at the center, it passes through without changing direction. In all the diagrams that follow, the center ray will be purple. By using these three rays, the location and properties of an image can be determined. Look at what happens when you are using your magnifying glass.

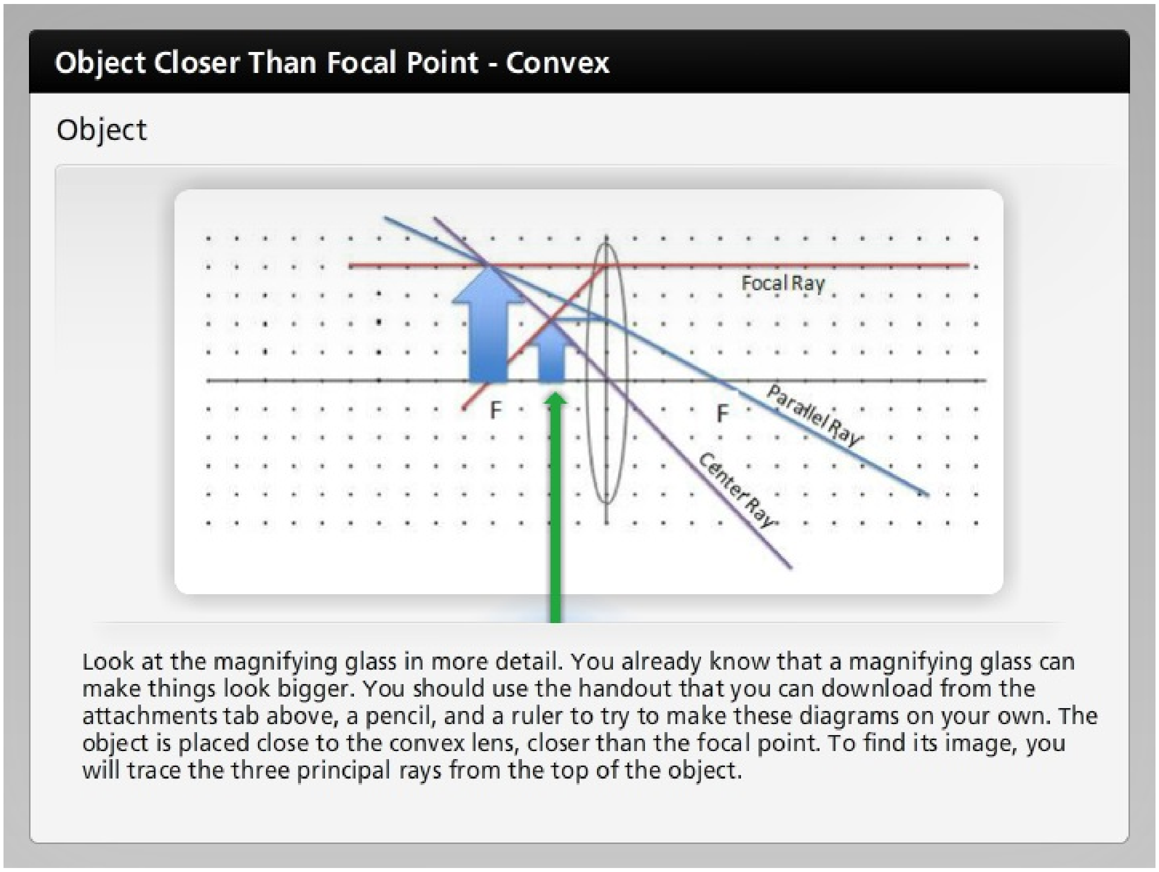
### Object Closer Than Focal Point – Convex

### Introduction



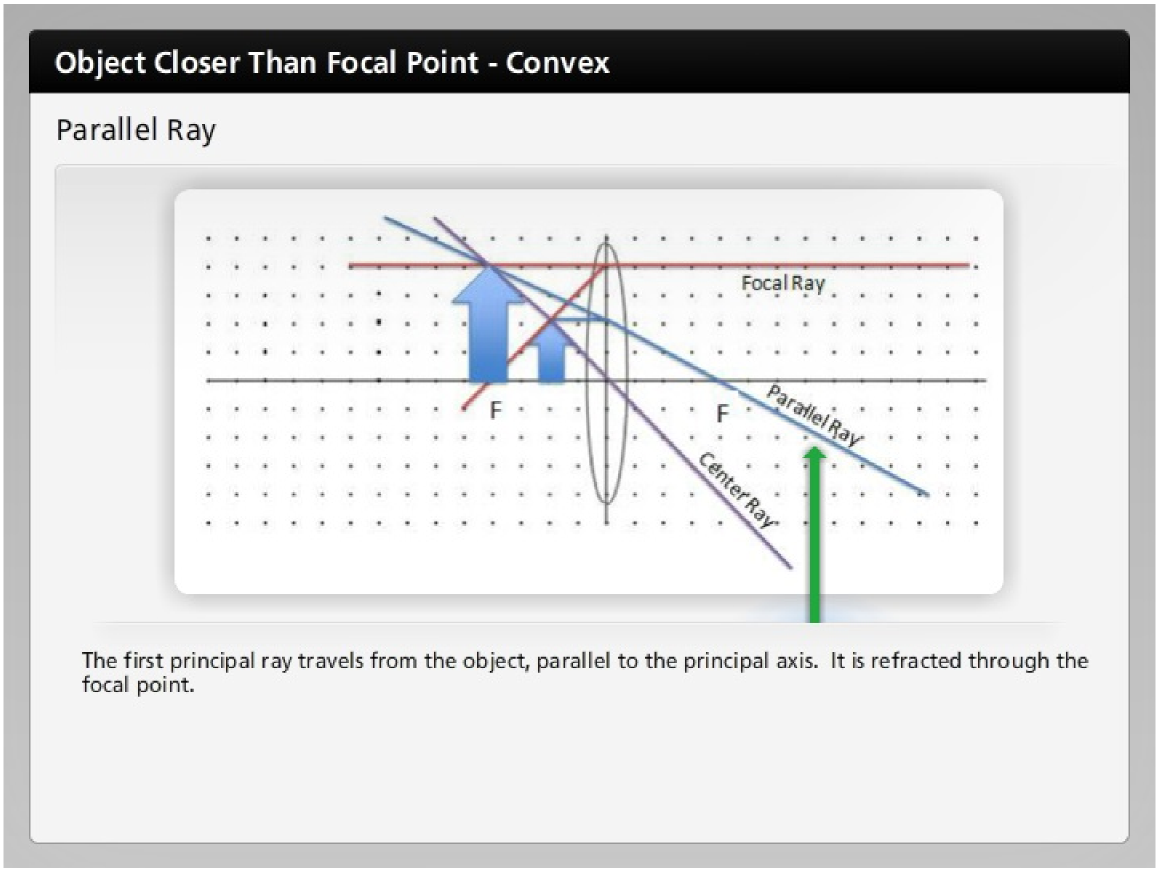

Click each arrow to learn more about convex lenses when the object is placed closer to the lens than the focal point. Click the attachments tab above to download the handout needed for this presentation.

### Object



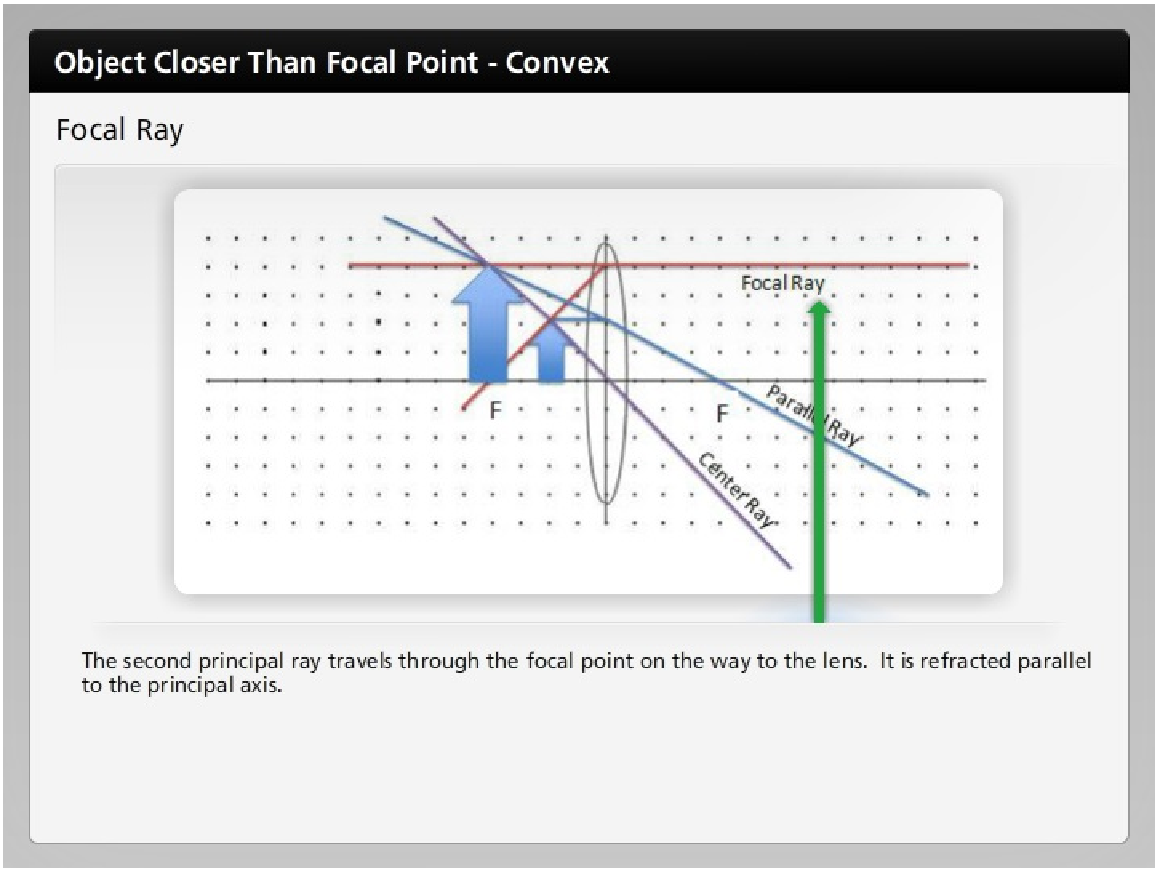

Look at the magnifying glass in more detail. You already know that a magnifying glass can make things look bigger. You should use the handout that you can download from the attachments tab above, a pencil, and a ruler to try to make these diagrams on your own. The object is placed close to the convex lens, closer than the focal point. To find its image, you will trace the three principal rays from the top of the object.

### Parallel Ray



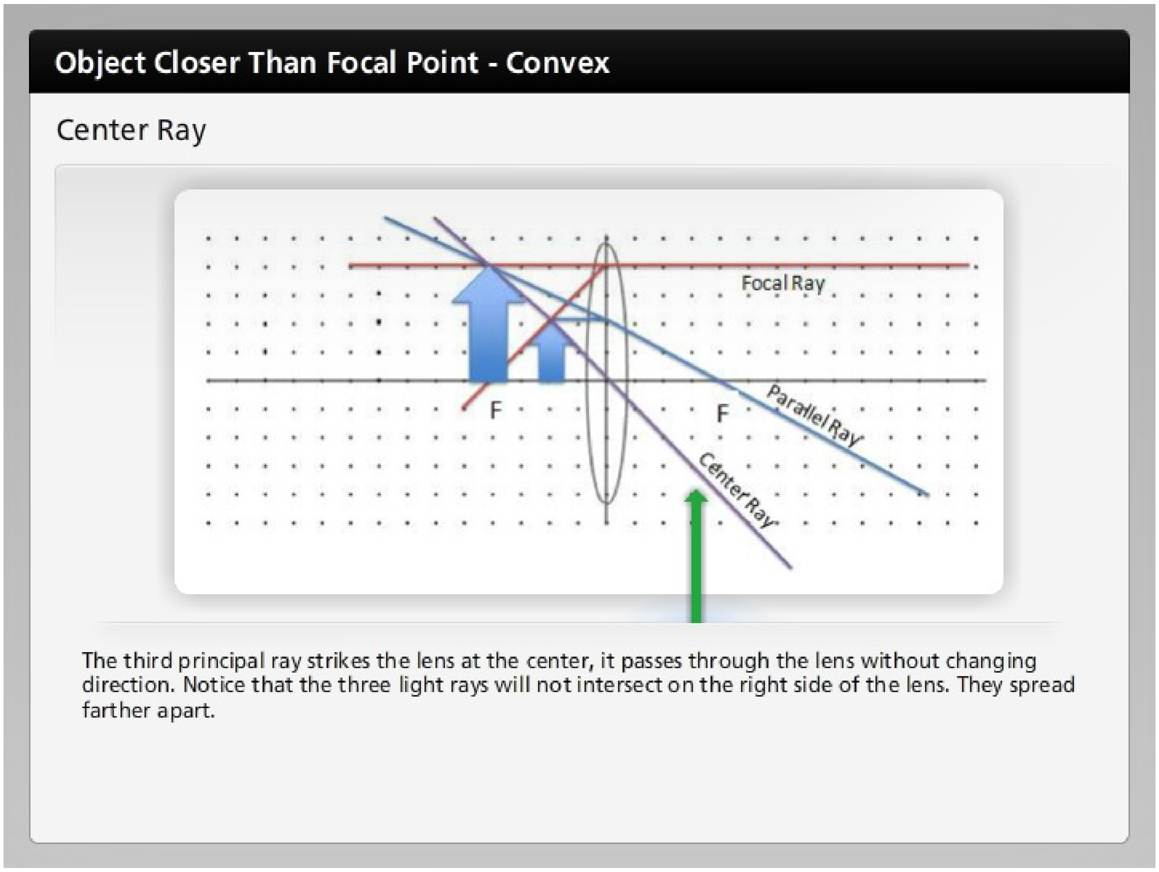

The first principal ray travels from the object, parallel to the principal axis. It is refracted through the focal point.

### Focal Ray



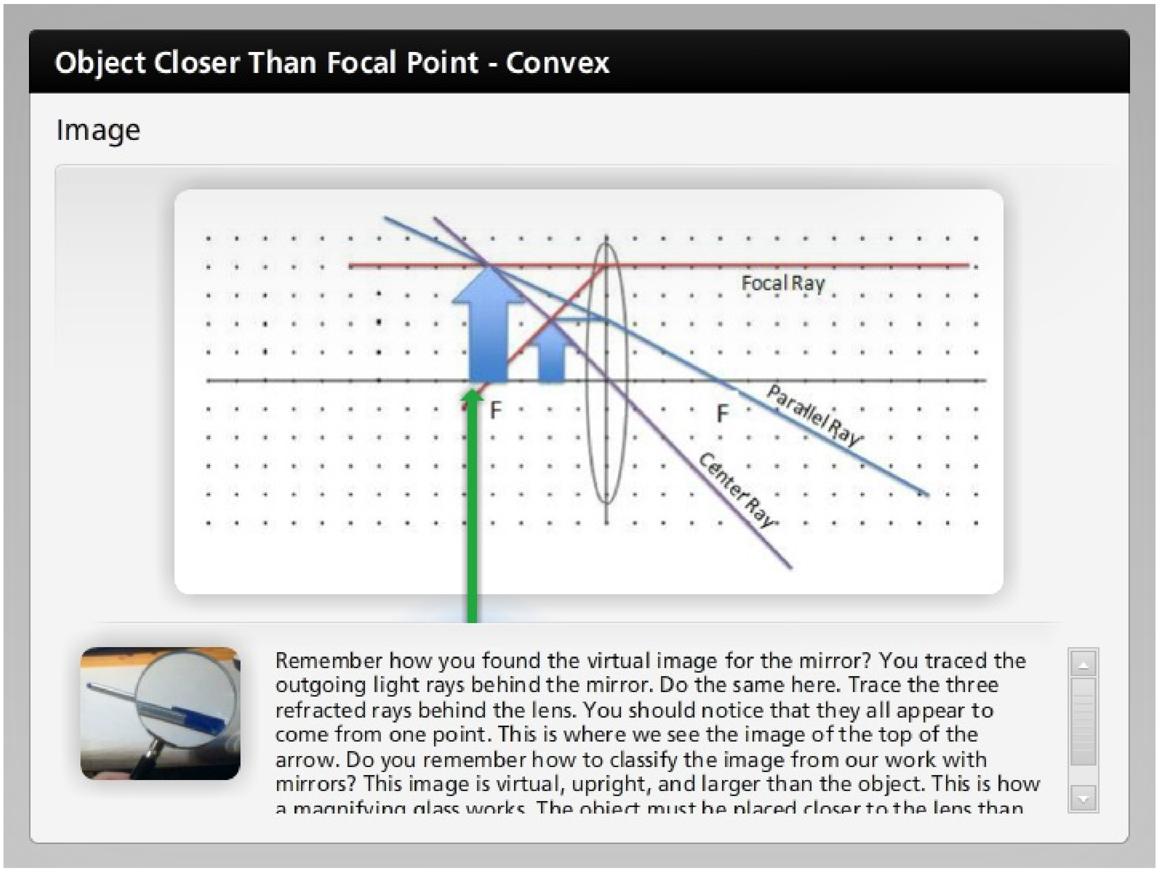

The second principal ray travels through the focal point on the way to the lens. It is refracted parallel to the principal axis.

### Center Ray



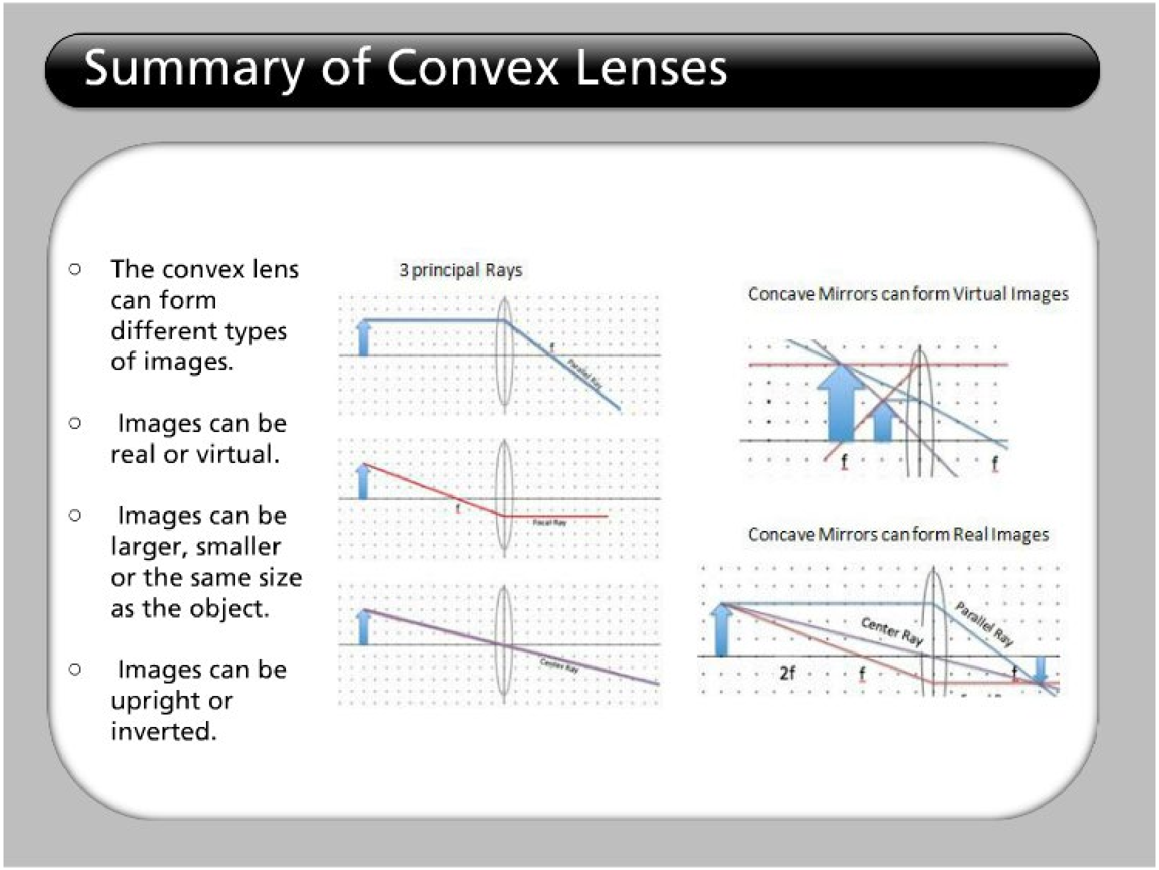

The third principal ray strikes the lens at the center, it passes through the lens without changing direction. Notice that the three light rays will not intersect on the right side of the lens. They spread farther apart.

### Image




Remember how you found the virtual image for the mirror? You traced the outgoing light rays behind the mirror. Do the same here. Trace the three refracted rays behind the lens. You should notice that they all appear to come from one point. This is where we see the image of the top of the arrow. Do you remember how to classify the image from our work with mirrors? This image is virtual, upright, and larger than the object. This is how a magnifying glass works. The object must be placed closer to the lens than its focal point.

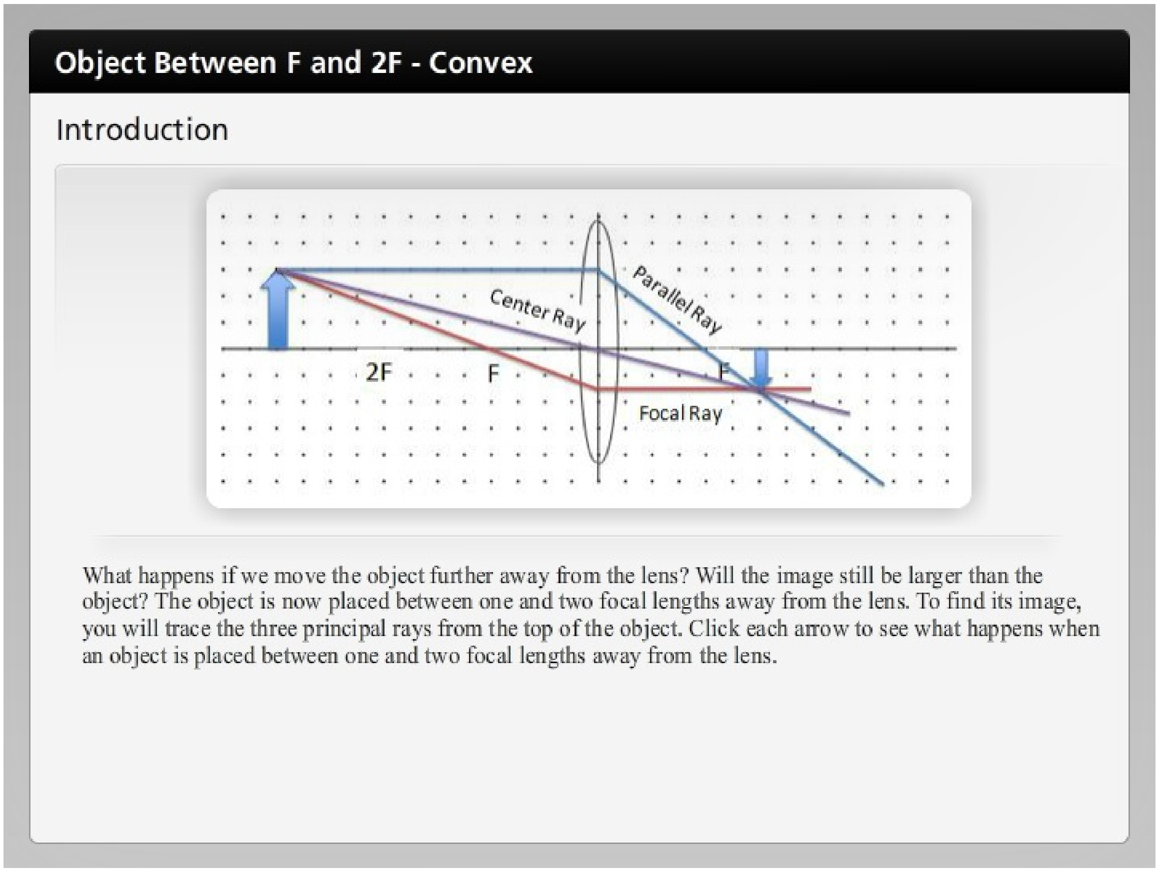
## *Summary of Convex Lenses*




- The convex lens can form different types of images.
- Images can be real or virtual.
- Images can be larger, smaller or the same size as the object.
- Images can be upright or inverted.

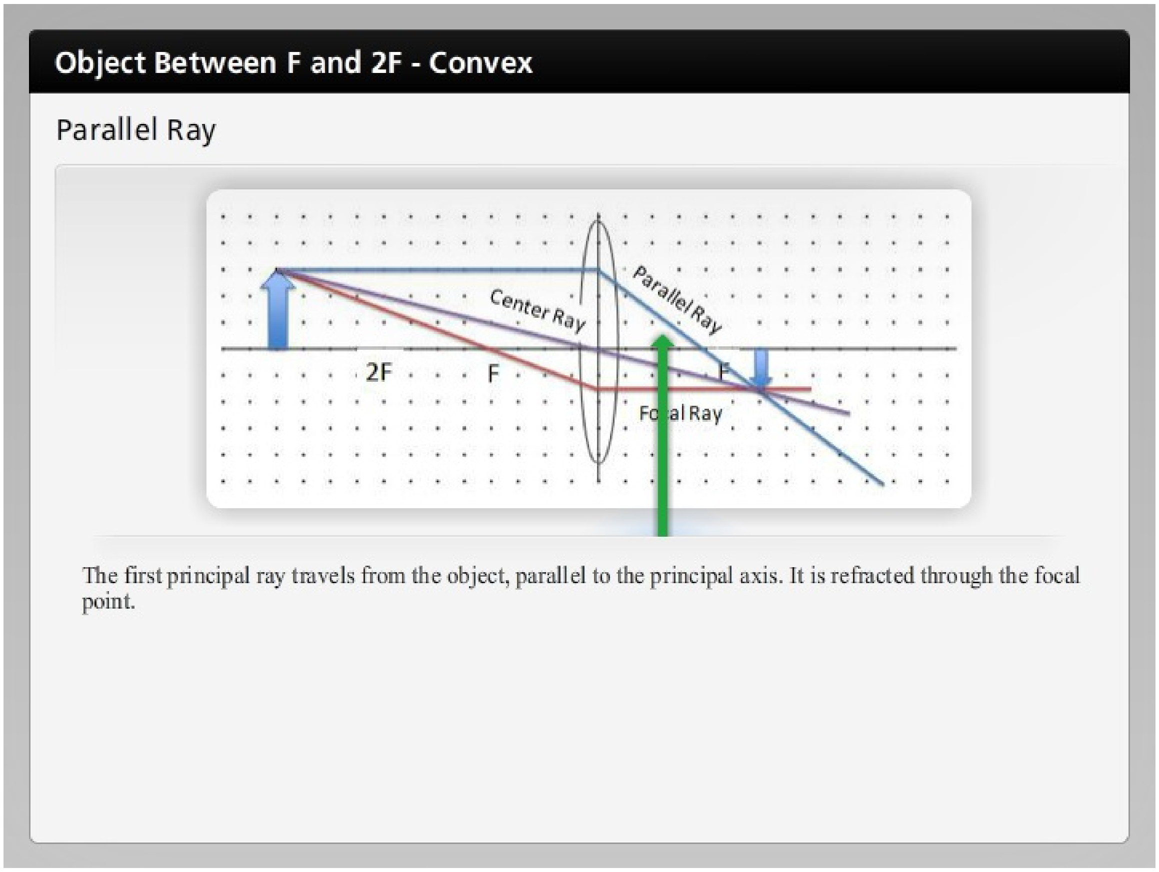
### Object Between F and 2F - Convex

### Introduction



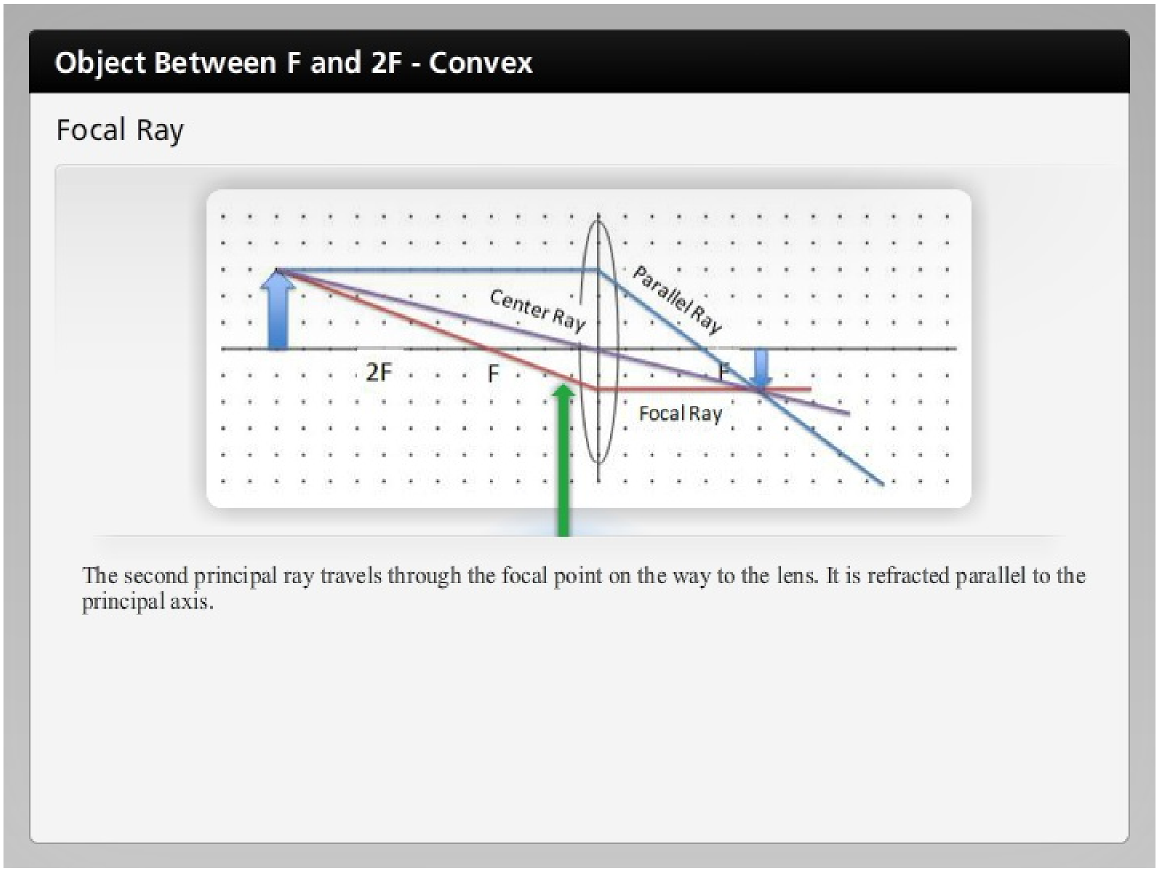

What happens if we move the object further away from the lens? Will the image still be larger than the object? The object is now placed between one and two focal lengths away from the lens. To find its image, you will trace the three principal rays from the top of the object. Click each arrow to see what happens when an object is placed between one and two focal lengths away from the lens.

### Parallel Ray



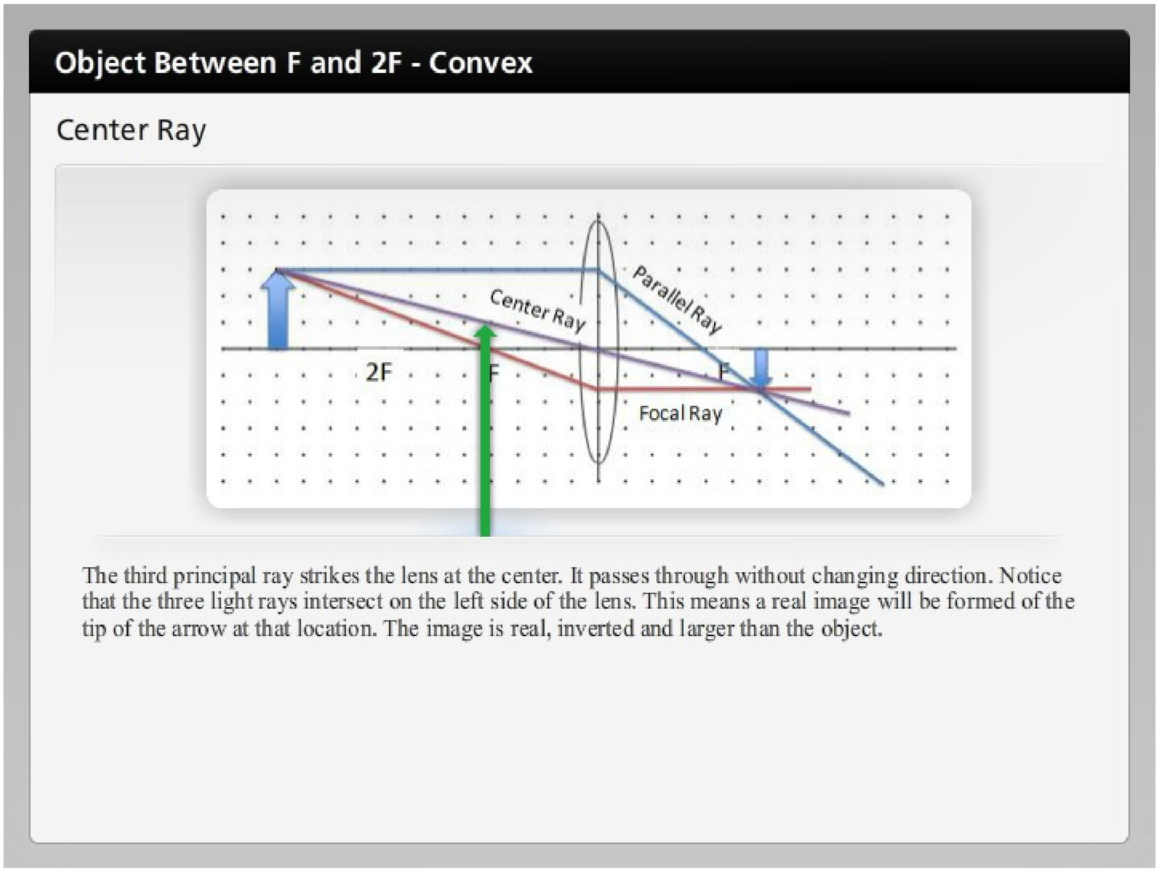

The first principal ray travels from the object, parallel to the principal axis. It is refracted through the focal point.

## Focal Ray




The second principal ray travels through the focal point on the way to the lens. It is refracted parallel to the principal axis.

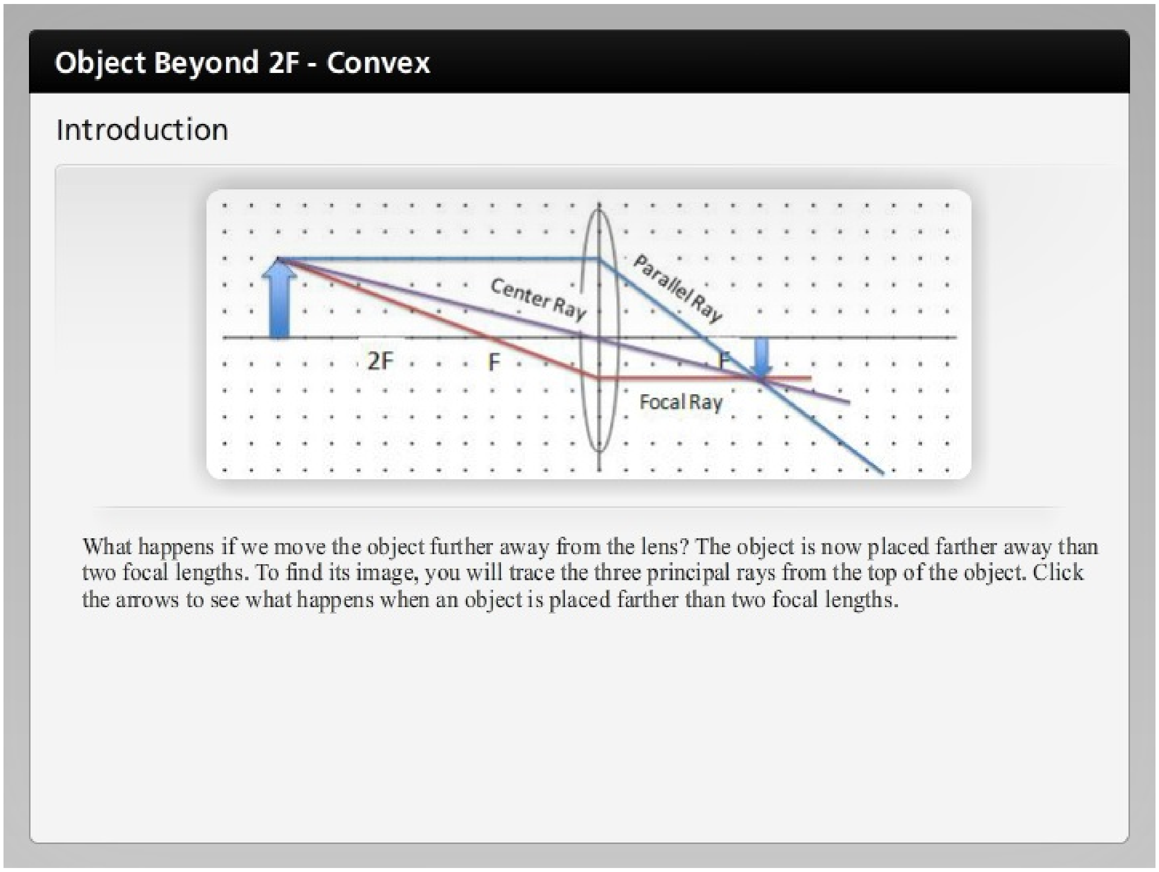
### Center Ray




The third principal ray strikes the lens at the center. It passes through without changing direction. Notice that the three light rays intersect on the left side of the lens. This means a real image will be formed of the tip of the arrow at that location. The image is real, inverted and larger than the object.

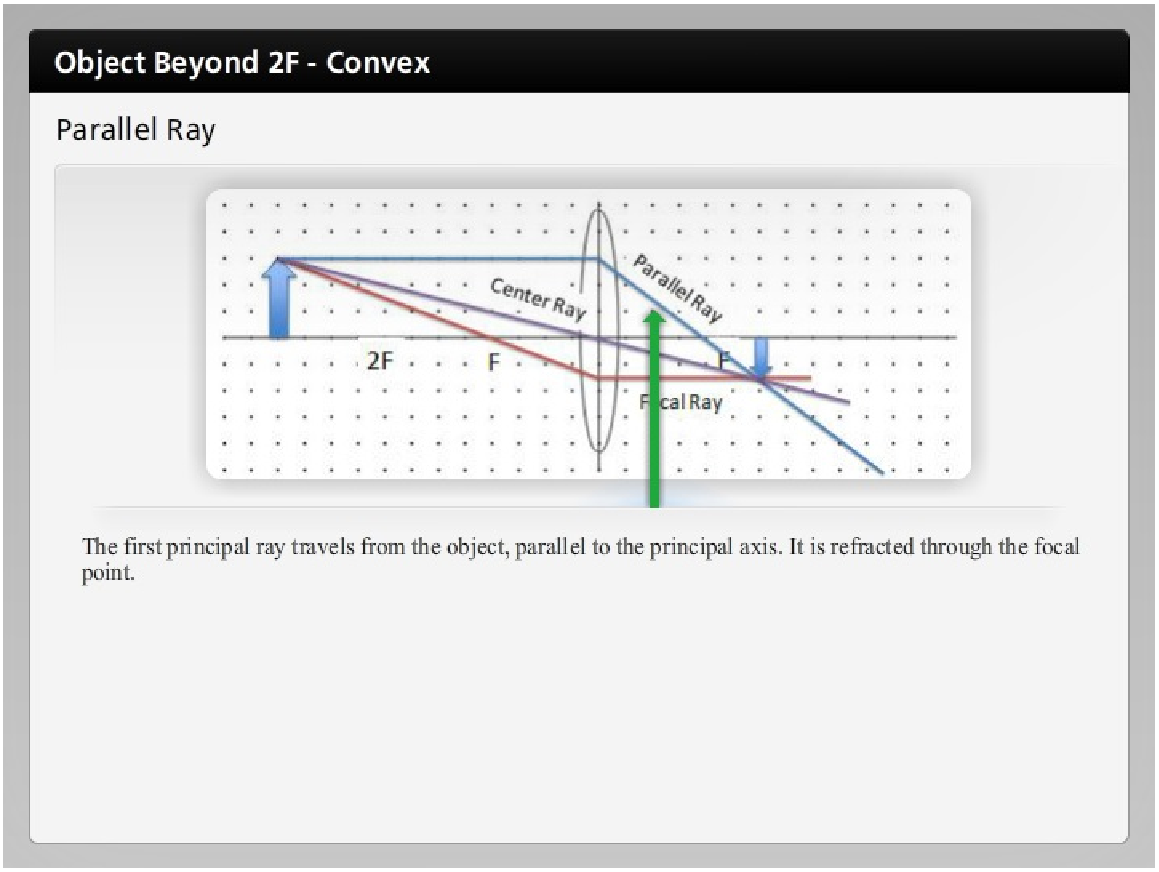
## Object Beyond 2F - Convex

### Introduction



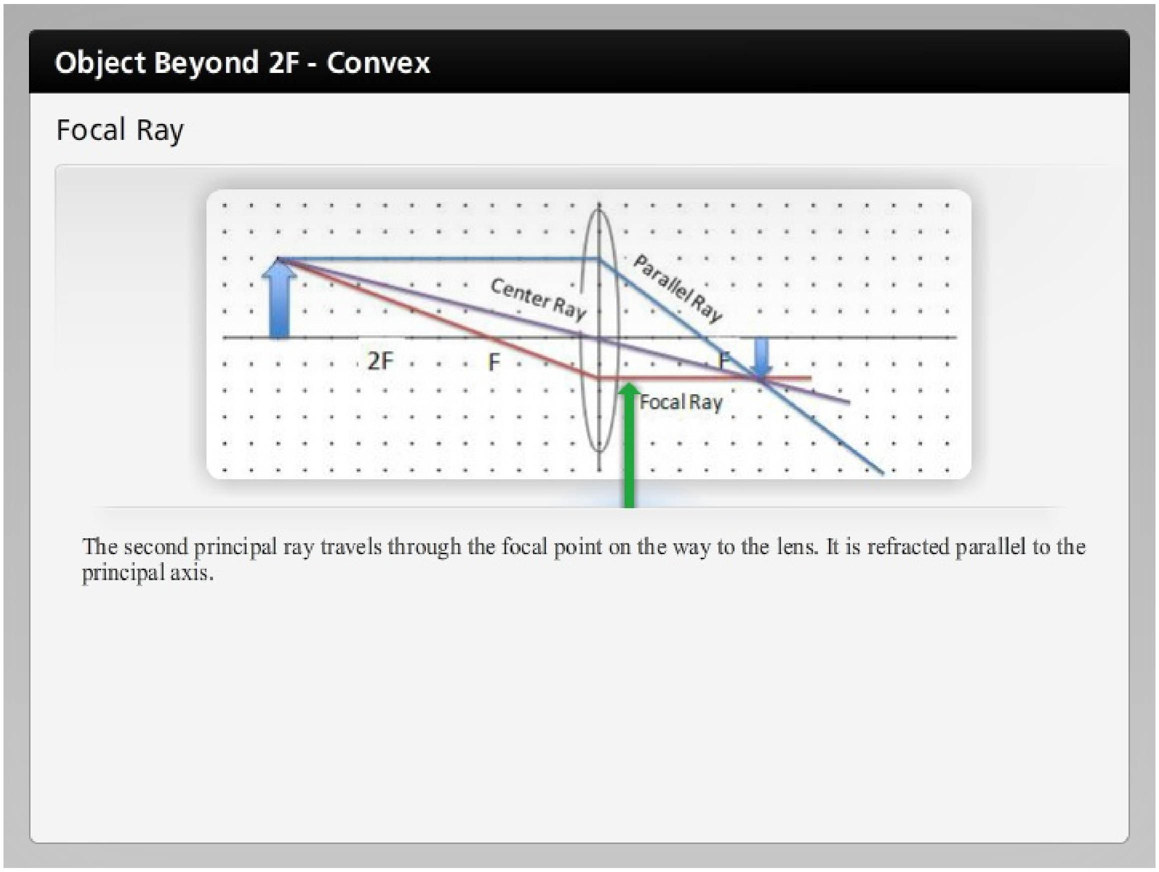

What happens if we move the object further away from the lens? The object is now placed farther away than two focal lengths. To find its image, you will trace the three principal rays from the top of the object. Click the arrows to see what happens when an object is placed farther than two focal lengths.

### Parallel Ray



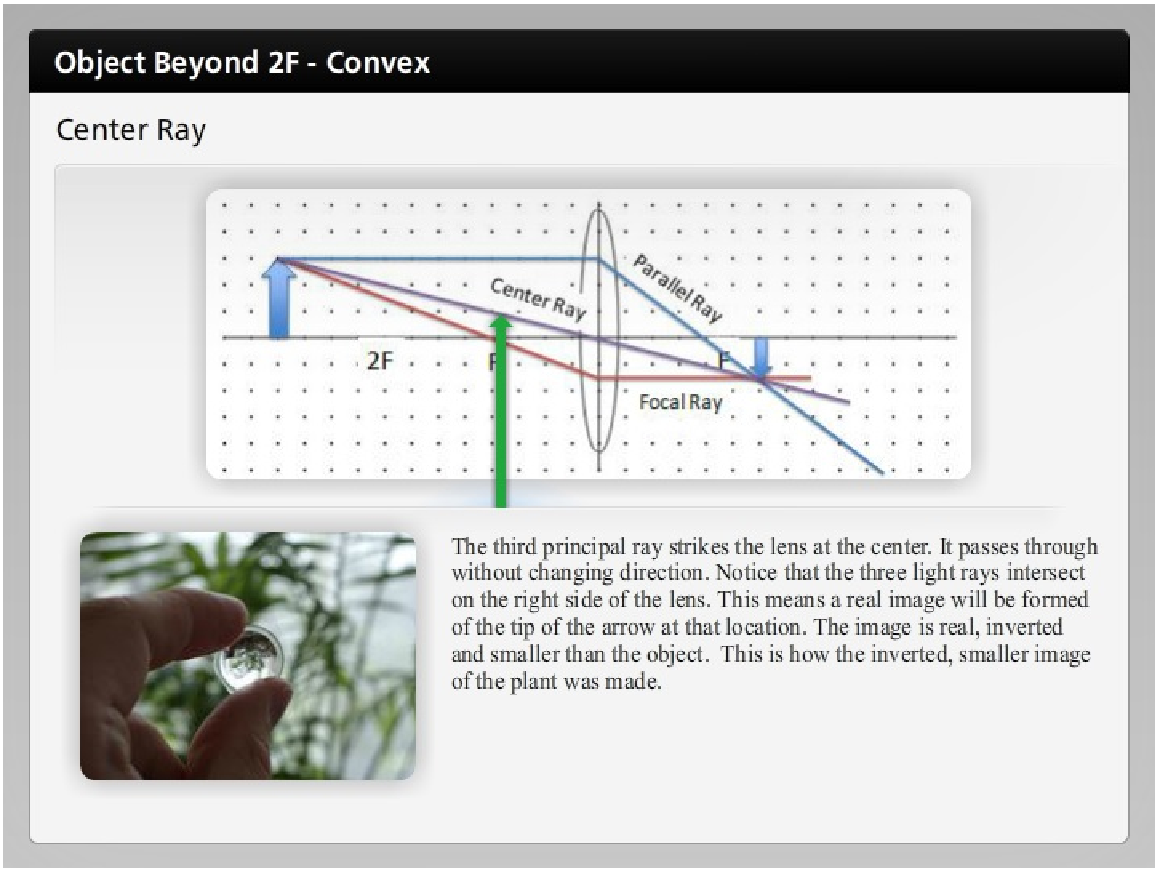

The first principal ray travels from the object, parallel to the principal axis. It is refracted through the focal point.

### Focal Ray




The second principal ray travels through the focal point on the way to the lens. It is refracted parallel to the principal axis.

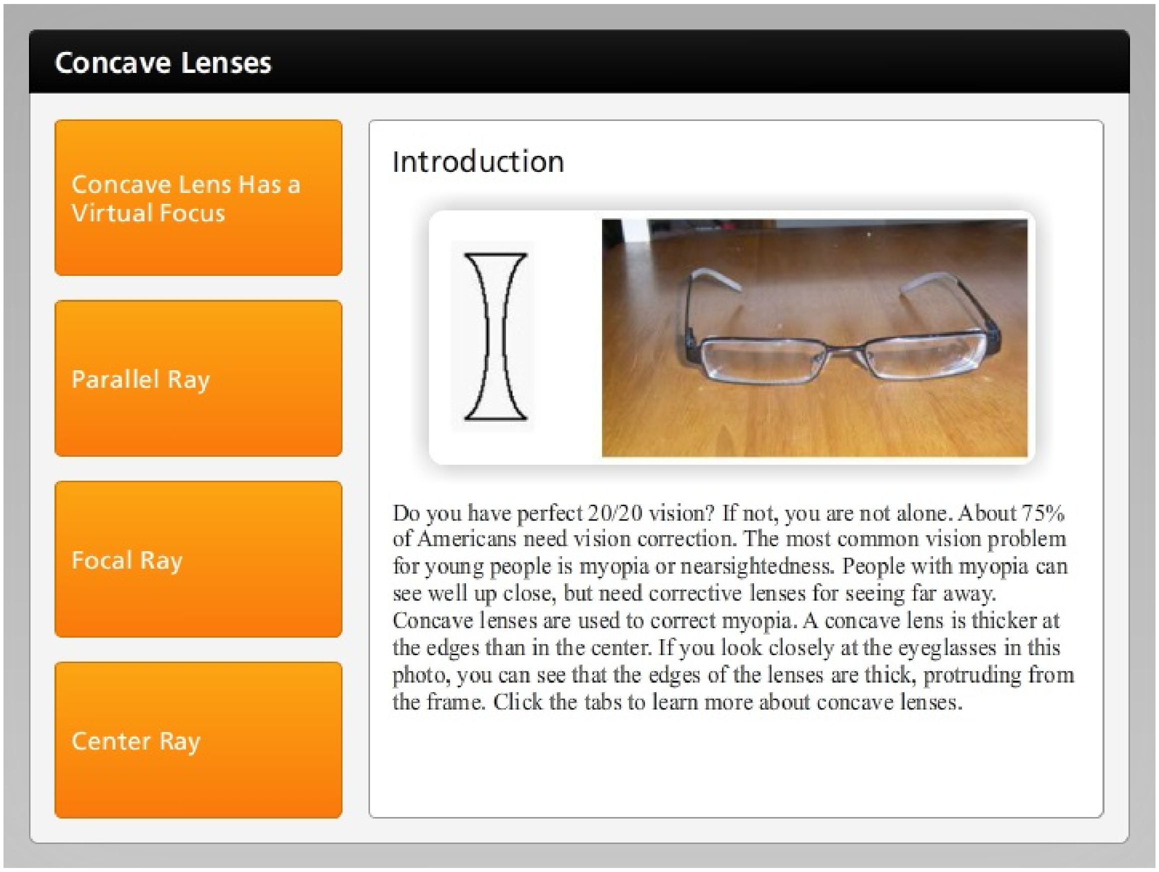
## Center Ray




The third principal ray strikes the lens at the center. It passes through without changing direction. Notice that the three light rays intersect on the right side of the lens. This means a real image will be formed of the tip of the arrow at that location. The image is real, inverted and smaller than the object. This is how the inverted, smaller image of the plant was made.

### Concave Lenses

### Introduction




Do you have perfect 20/20 vision? If not, you are not alone. About 75% of Americans need vision correction. The most common vision problem for young people is myopia or nearsightedness. People with myopia can see well up close, but need corrective lenses for seeing far away. Concave lenses are used to correct myopia. A concave lens is thicker at the edges than in the center. If you look closely at the eyeglasses in this photo, you can see that the edges of the lenses are thick, protruding from the frame. Click the tabs to learn more about concave lenses.

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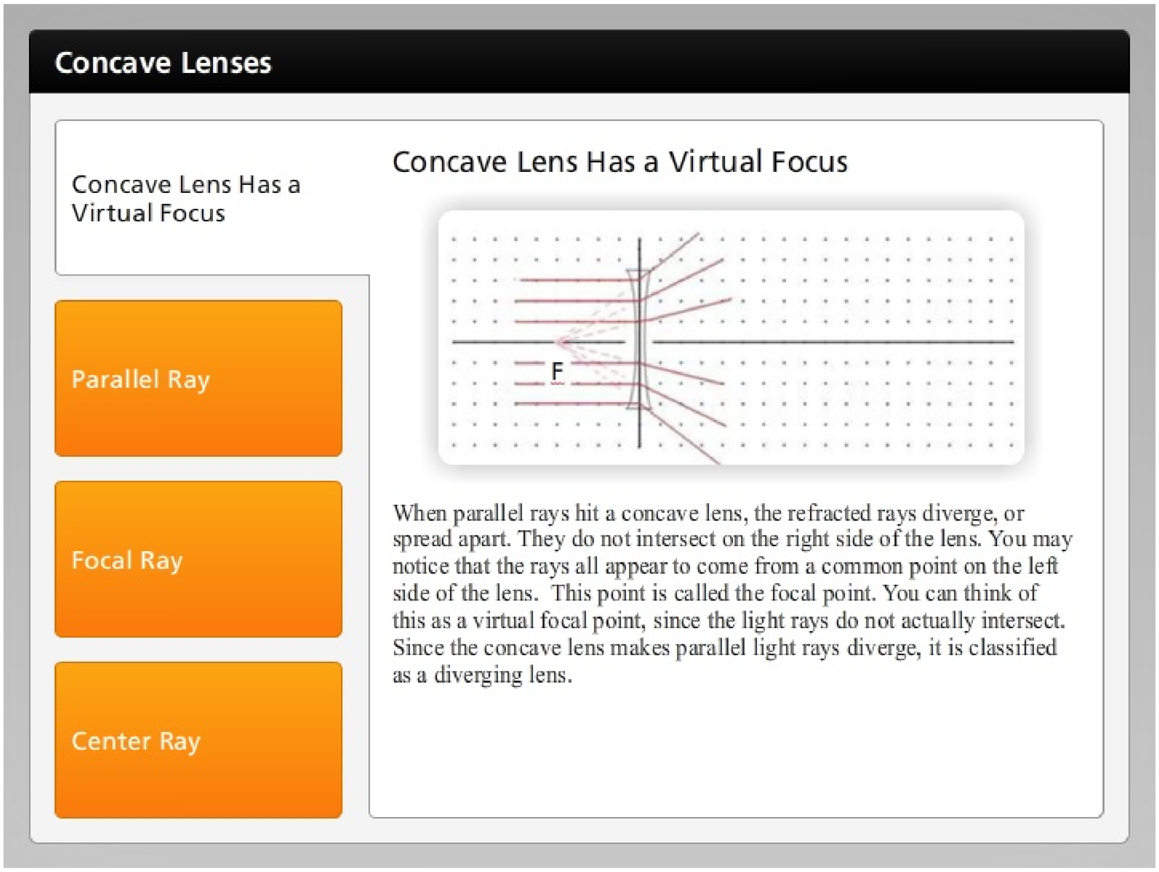
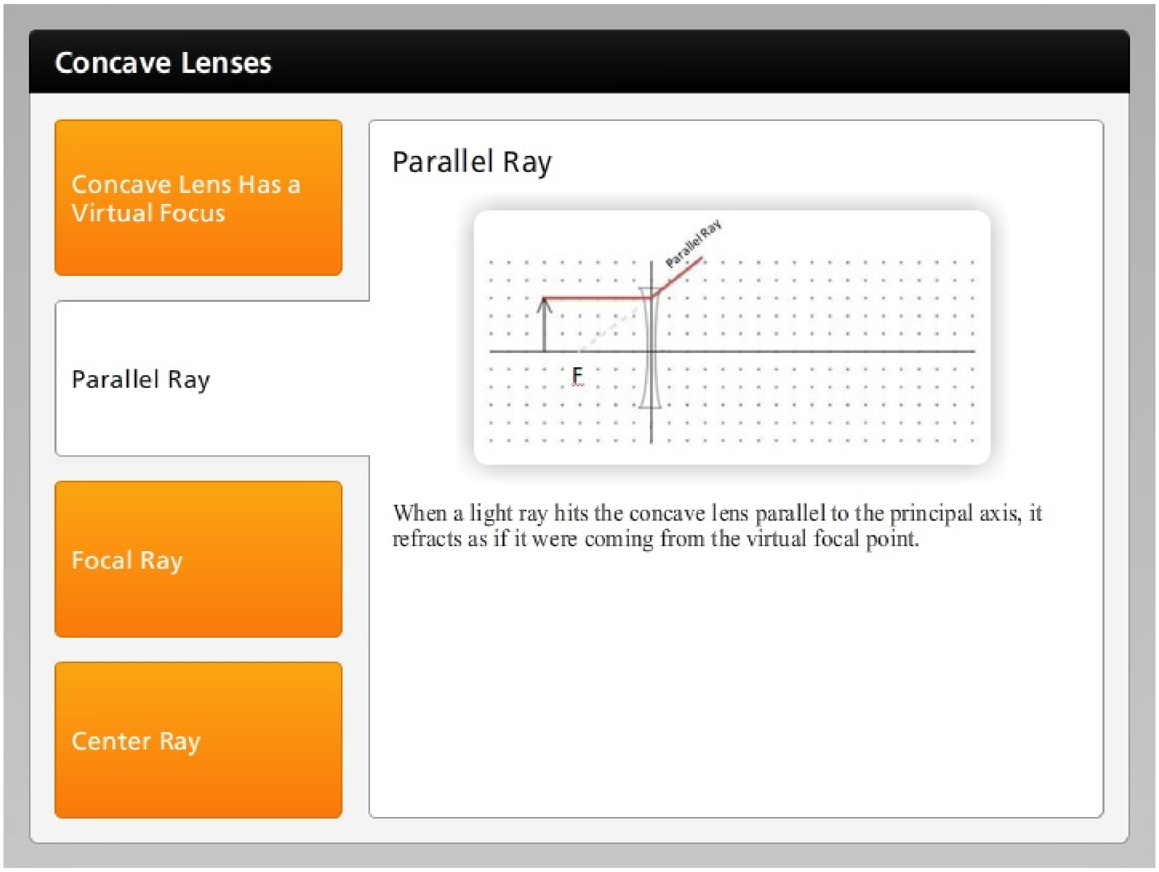
### Concave Lens Has A Virtual Focus




When parallel rays hit a concave lens, the refracted rays diverge, or spread apart. They do not intersect on the right side of the lens. You may notice that the rays all appear to come from a common point on the left side of the lens. This point is called the focal point. You can think of this as a virtual focal point, since the light rays do not actually intersect. Since the concave lens makes parallel light rays diverge, it is classified as a diverging lens.

### Parallel Ray




When a light ray hits the concave lens parallel to the principal axis, it refracts as if it were coming from the virtual focal point.

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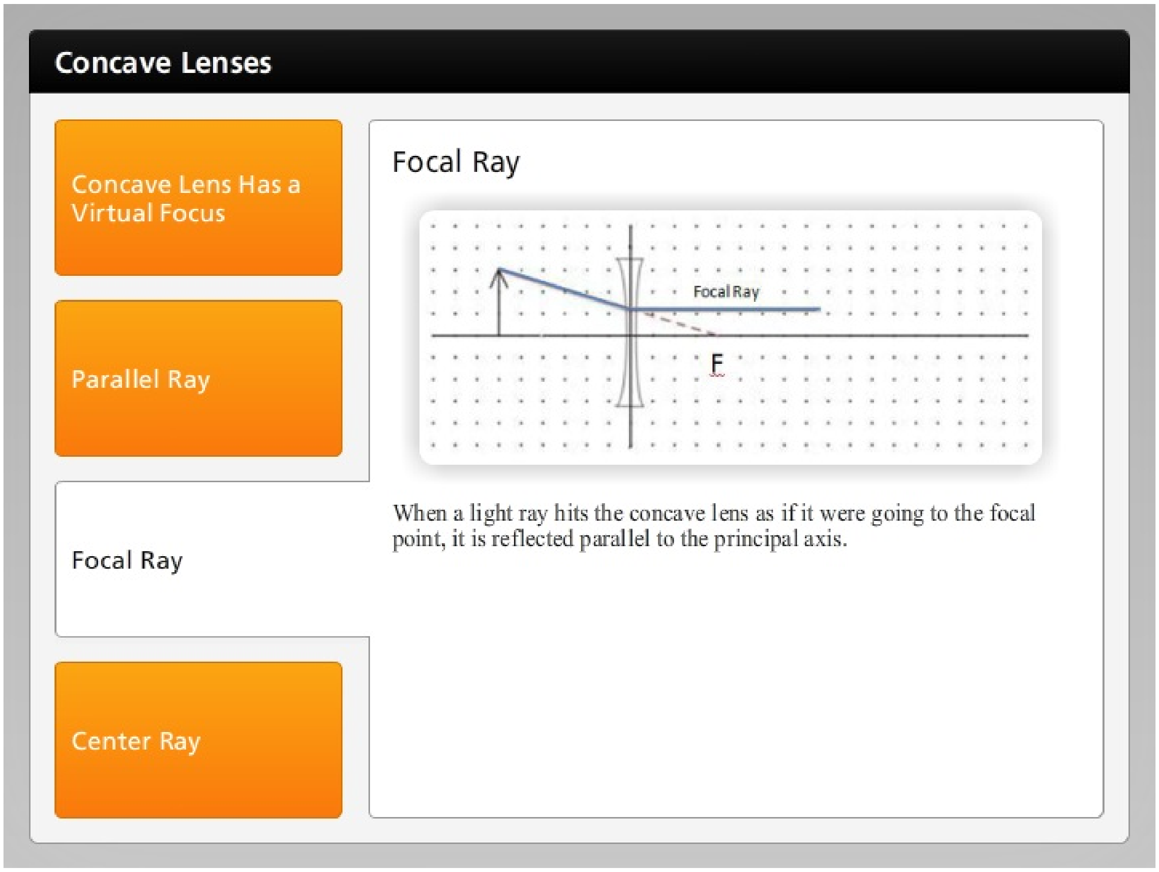
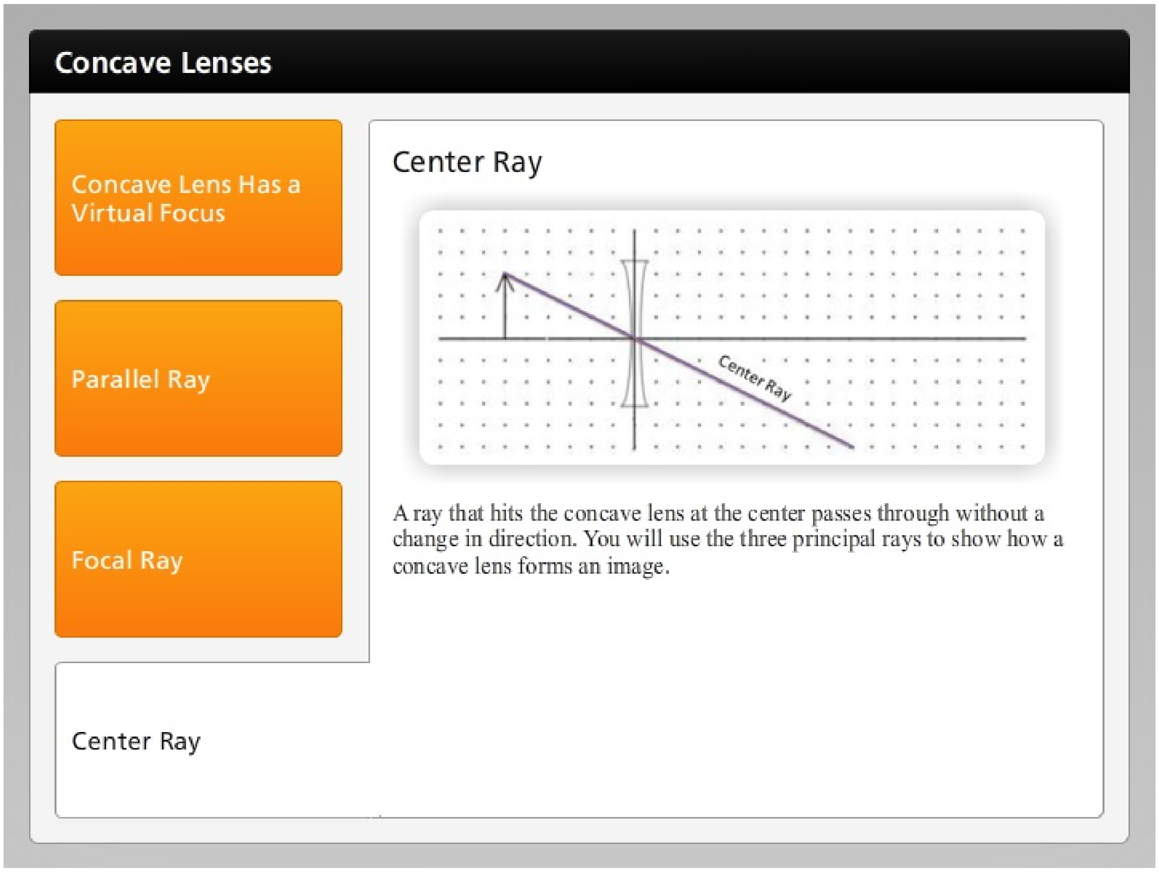
### Focal Ray




When a light ray hits the concave lens as if it were going to the focal point, it is reflected parallel to the principal axis.

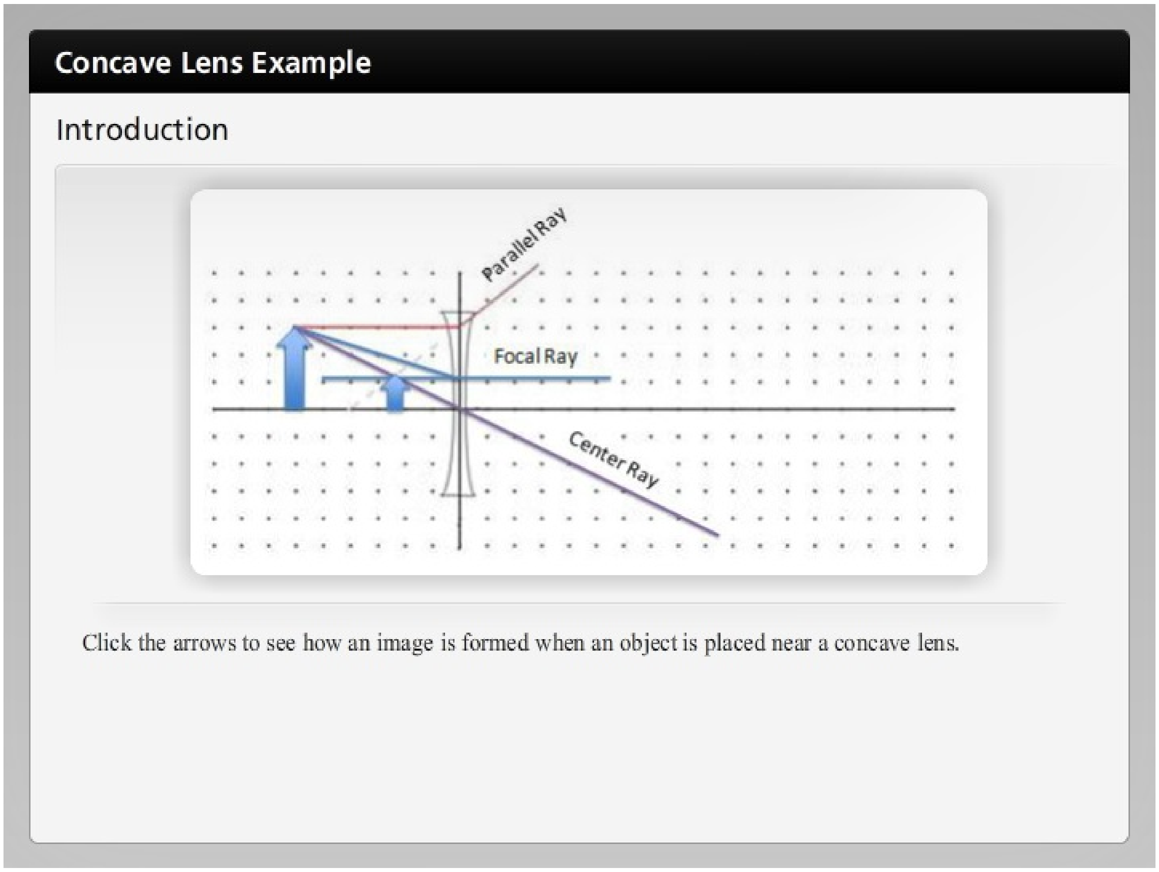
## Center Ray




A ray that hits the concave lens at the center passes through without a change in direction. You will use the three principal rays to show how a concave lens forms an image.

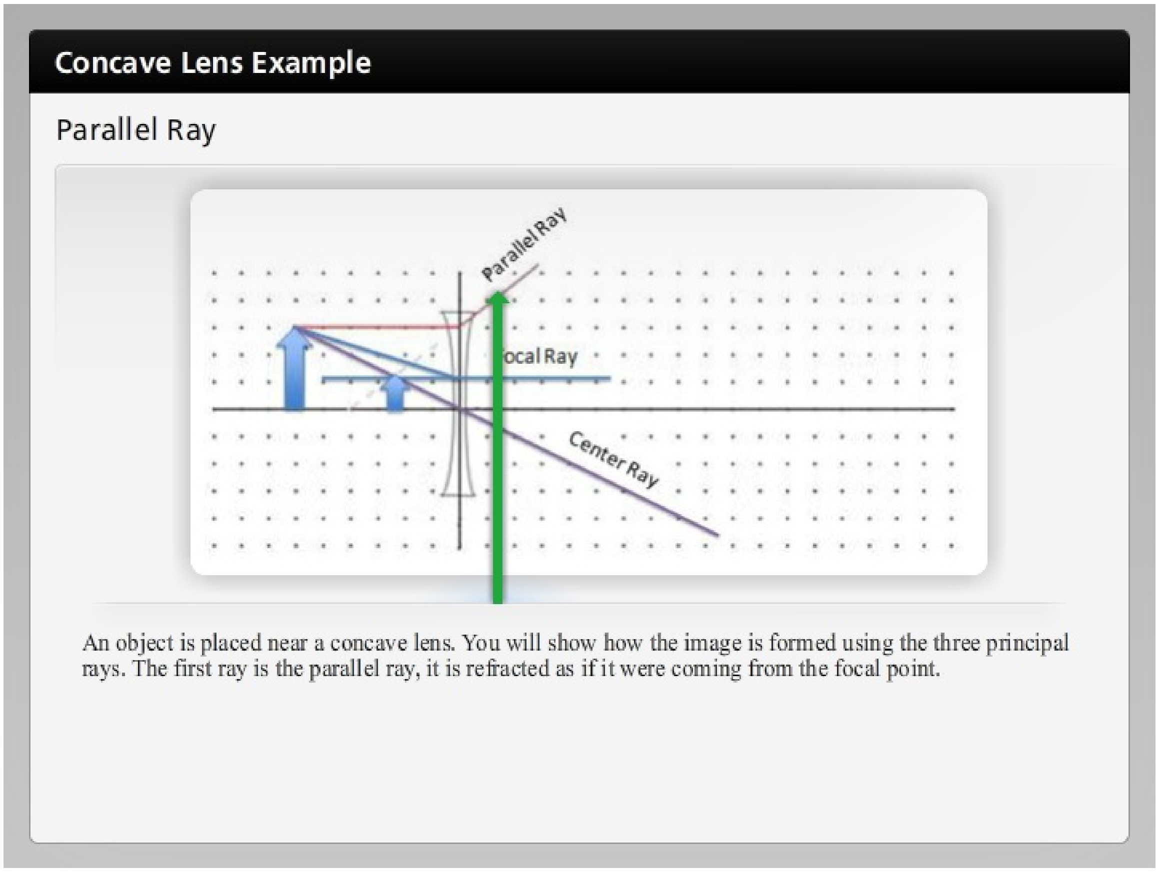
### Concave Lens Example

### Introduction



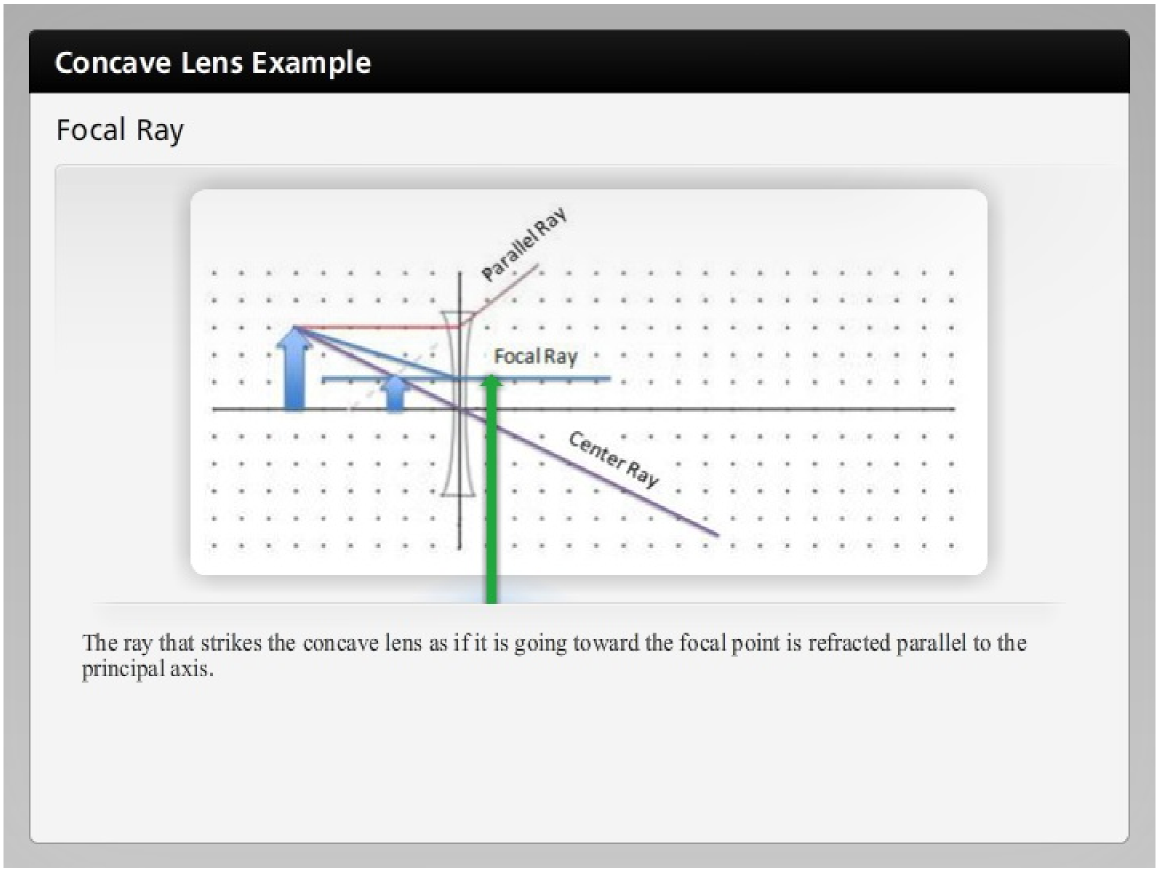

Click the arrows to see how an image is formed when an object is placed near a concave lens.

### Parallel Ray



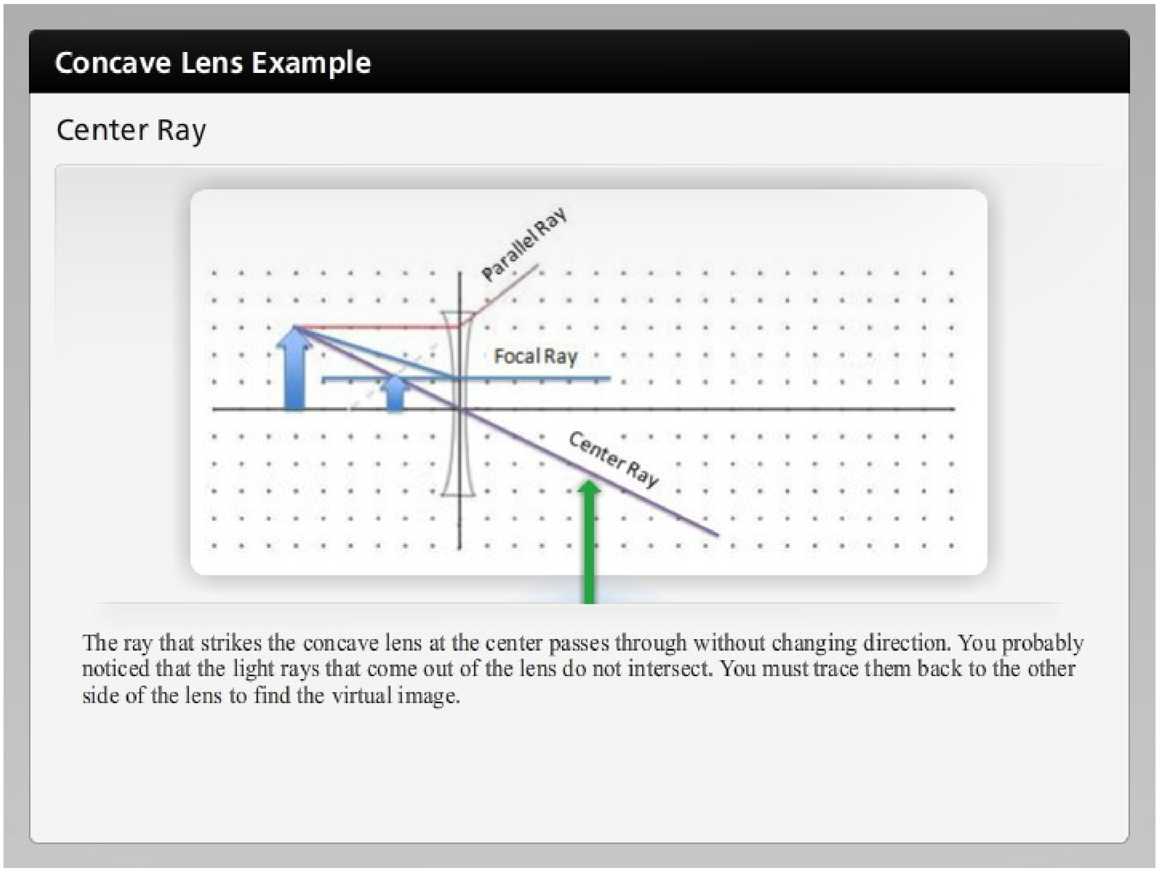

An object is placed near a concave lens. You will show how the image is formed using the three principal rays. The first ray is the parallel ray, it is refracted as if it were coming from the focal point.

## Focal Ray



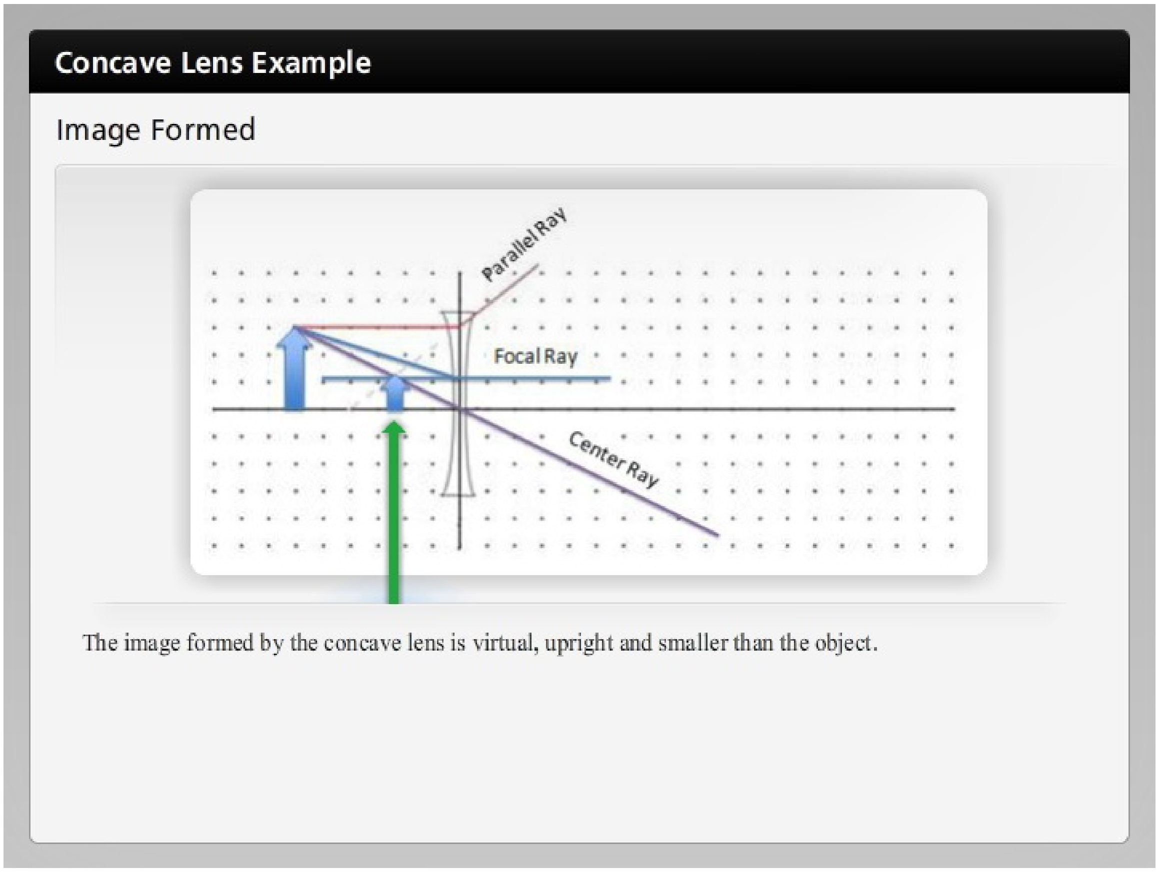

The ray that strikes the concave lens as if it is going toward the focal point is refracted parallel to the principal axis.

### Center Ray



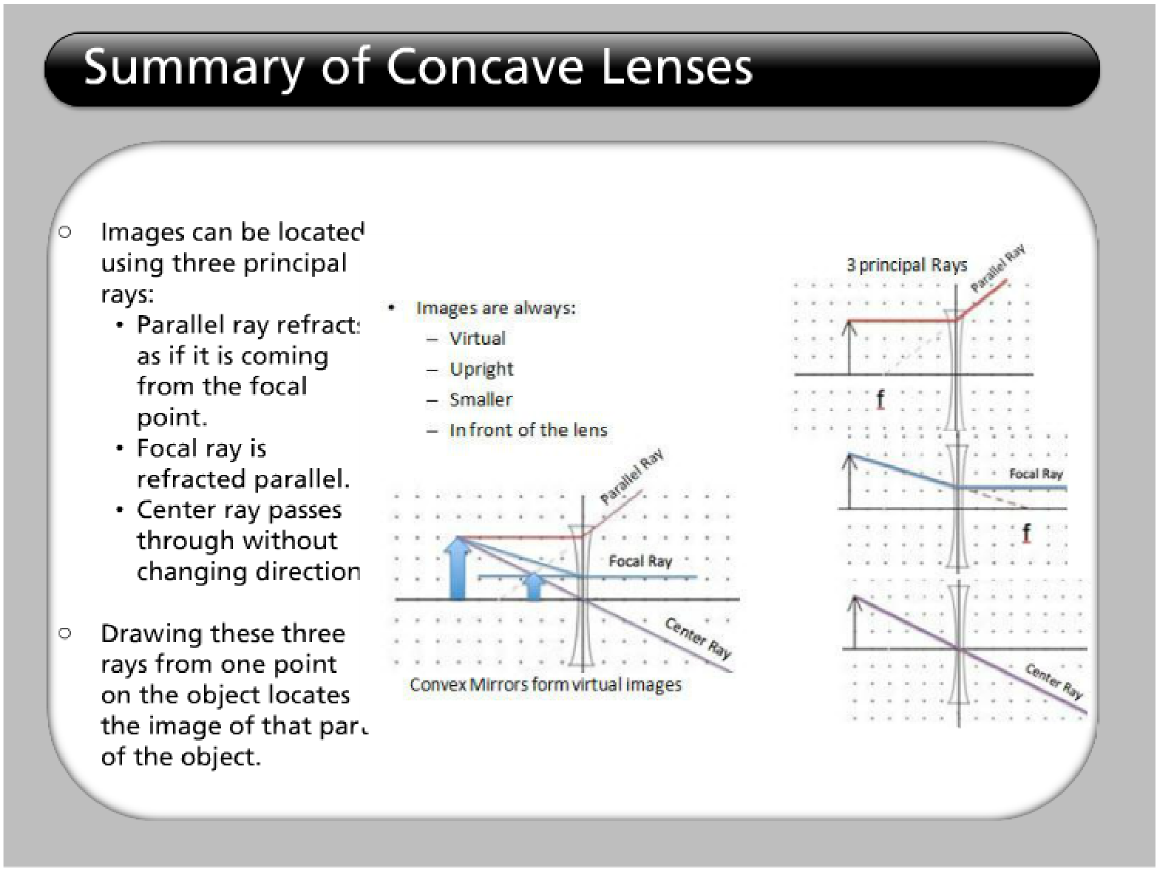

The ray that strikes the concave lens at the center passes through without changing direction. You probably noticed that the light rays that come out of the lens do not intersect. You must trace them back to the other side of the lens to find the virtual image.

### Image Formed




The image formed by the concave lens is virtual, upright and smaller than the object.

## Summary of Concave Lenses




- Images can be located using three principal rays:
  - Parallel ray refracts as if it is coming from the focal point.
  - Focal ray is refracted parallel.
  - Center ray passes through without changing direction.
  - Drawing these three rays from one point on the object locates the image of that part of the object.