is at the rim, shown in **Figure 5(b),** is an example of a *diverging* lens. The light rays show why the names *converging* and *diverging* are applied to these lenses.

Focal length is the image distance for an infinite object distance

As with mirrors, it is convenient to define a point called the *focal point* for a lens. Note that light rays from an object far away are nearly parallel. The focal point of a converging lens is the location where the image of an object at an infinite distance from the lens is focused. For example, in **Figure 6(a)** a group of rays parallel to the principal axis passes through a focal point, *F*, after being bent inward by the lens. Unlike mirrors, every lens has a focal point on each side of the lens because light can pass through the lens from either side, as illustrated in **Figure 6.** The distance from the focal point to the center of the lens is called the *focal length, f.* The focal length is the image distance that corresponds to an infinite object distance.

Rays parallel to the principal axis diverge after passing through a diverging lens, as shown in **Figure 6(b).** In this case, the focal point is defined as the point from which the diverged rays appear to originate. Again, the focal length is defined as the distance from the center of the lens to the focal point.

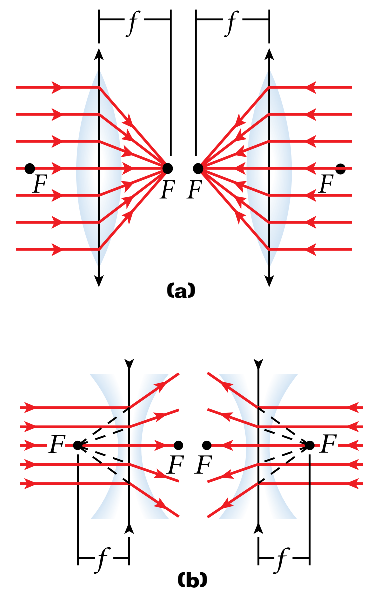

Figure 6
Both **(a)** converging lenses and **(b)** diverging lenses have two focal points but only one focal length.

Ray diagrams of thin-lens systems help identify image height and location

In the chapter on light and reflection, we used a set of standard rays and a ray diagram to predict the characteristics of images formed by spherical mirrors. A similar approach can be used for lenses.

We know, as shown in **Figure 5,** that refraction occurs at a boundary between two materials with different indexes of refraction. However, for *thin lenses* (lenses for which the thickness of the lens is small compared to the radius of curvature of the lens or the distance of the object from the lens), we can represent the front and back boundaries of the lens as a line segment passing through the center of the lens. To draw ray diagrams in the thin-lens approximation, we will use a line segment with arrow ends to indicate a converging lens, as in **Figure 6(a).** To show a diverging lens, we will draw a line segment with "upside-down" arrow ends, as illustrated in **Figure 6(b).** We can then draw ray diagrams using the set of rules outlined in **Table 2.**

Table 2 Rules for Drawing Reference Rays

Ray	From object to lens	From *converging* lens to image	From *diverging* lens to image
Parallel ray	parallel to principal axis	passes through focal point, *F*	directed away from focal point, *F*
Central ray	to the center of the lens	from the center of the lens	from the center of the lens
Focal ray	passes through focal point, *F*	parallel to principal axis	parallel to principal axis