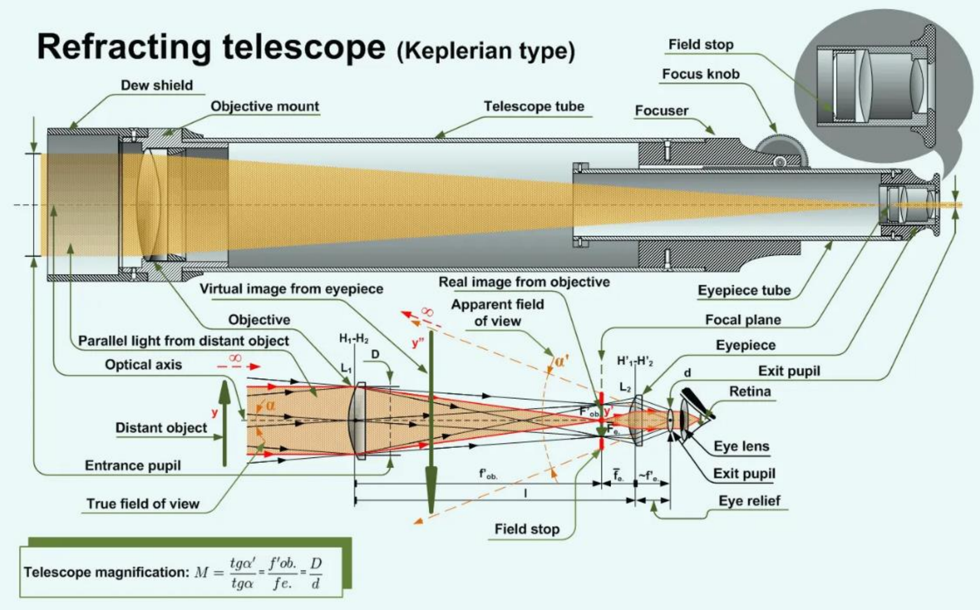
ABOUT TELESCOPES



The most familiar type of telescope is the refractor. It uses two lenses: one to collect the light and form an image, called the objective, and another to magnify it, called the eyepiece.

These are the instruments we used for looking at wildlife, looking out to sea and for backyard skywatching. A pair of binoculars is two refractor telescopes fastened together. This type of telescope is heavily used for backyard astronomy, but when probing deeper and deeper into the cosmos, looking at fainter and fainter objects, they run into a serious problem.

Distant cosmic objects are very faint, so to observe them we need to collect as much light as possible. This means we need large objective lenses on our telescopes. It turned out that the largest objective lens we could put on a telescope has a diameter of about a metre. This is due to two things. Firstly, to form an image a lens has to be convex, thicker in the middle than at the edges. This means that supporting the weight of a potentially very heavy lens is left to the thin glass at the edges.

Picture of the Vatican university refractor Yerkes Observatory, WIsconsin

Installing a support structure across the body of the lens would solve this. However, since the light has to pass through it, with the minimum of loss or impediment, that is not an attractive option.

Fortunately, way back in 1668 Isaac Newton had come up with a solution that made modern astronomy possible. Newton came up with the idea of instead of using a convex lens to form the image, a concave mirror could be used.

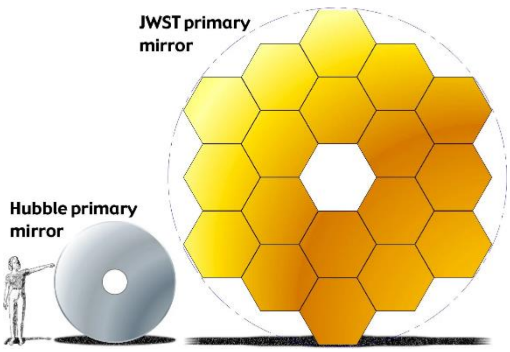
The great benefit from this is that since a mirror does not require light to pass through it, it can be supported from behind, which in turn makes it possible to make the mirrors much larger than we can make lenses. From an engineering standpoint, it is a huge advantage to have the heaviest single component of the telescope at the bottom end of the instrument near the ground, rather than perched on top.

Photo – A replica of Newton's second reflecting telescope.

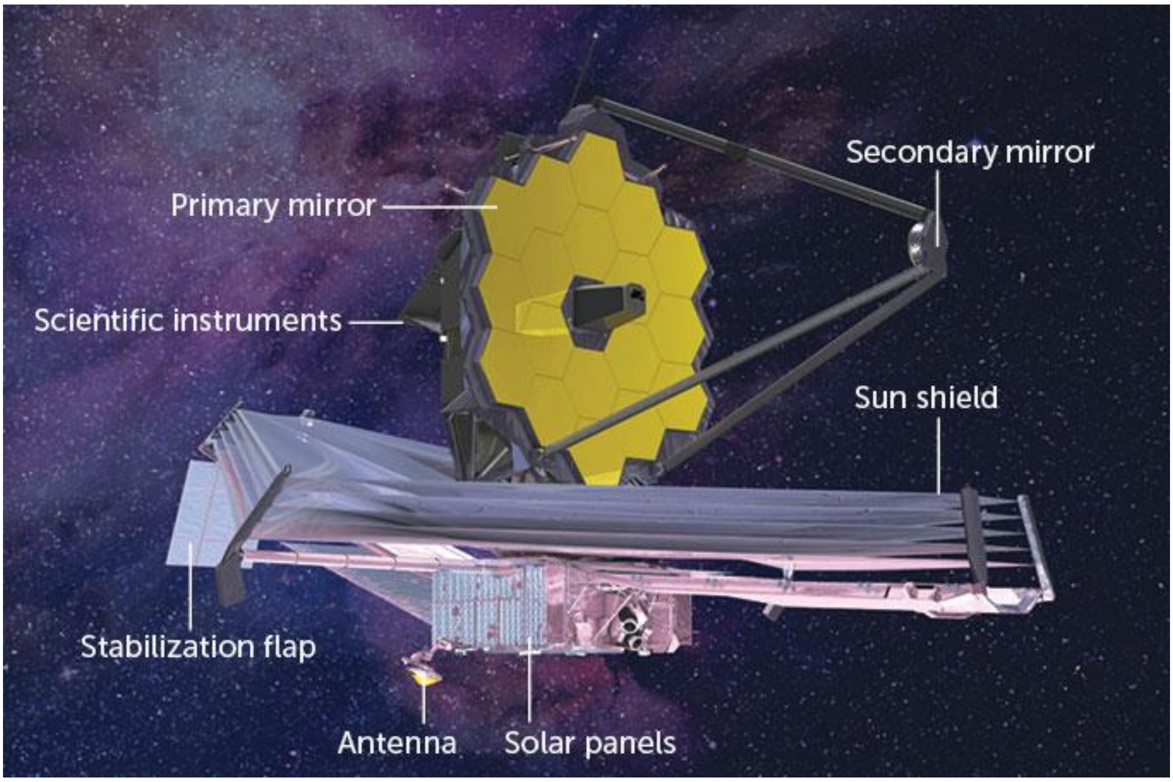
To be effective, errors in the shape of the lens or mirror have to be much smaller than the wavelength of light; that is, accurate to around a tenth of a millionth of a metre. This is easier to achieve with mirrors because they can be made thick to stay in shape. The Hale Telescope, which started operation on Mount Palomar in 1949, has a mirror 200 inches (about 5 metres) in diameter, and weighing in at 18 tons. Over the following decades the need grew for telescopes with even larger mirrors. However, larger versions of the Hale Telescope mirror were not practical. They would bend out of shape under their own weight and be impossible to support properly.

The solution was made possible by the advent of cheap and powerful computer systems. The mirror can be made huge, thin and relatively light, and kept in shape as the telescope moves around the sky by a large number of computer-controlled actuators, which push at the mirror from behind, keeping it in shape. Even then, making big, one-piece mirrors, even thin ones, is very hard, which led to telescope mirrors being made of a number of hexagonal panels, all kept in position and in the right shape by computer-controlled actuators.

This technique eventually led to one of the most fascinating telescopes ever, the James Webb Space Telescope, currently observing the cosmos from a location 1.5 million kilometres out in space. It has a 6.5 metre diameter mirror, made out of 18 hexagonal sub-mirrors. This was so the mirror could be folded up to fit into the launch vehicle. The fact that it unfolded and deployed with all the mirror sections in the right



place to within fractions of a millionth of a metre, says a lot about the quality of the engineering. The observations this telescope is making are revolutionizing our ideas of how the universe works.



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