Why Refracting Telescopes Reached Their Maximum Practical Size with the Yerkes 40-inch Refractor in 1897:

Refractors use lenses, which refract, or bend light. They also split light into its component colors, much as prisms do: this is called chromatic aberration.

To minimize chromatic aberration, refractors often have long focal lengths.

This means that refractor tubes are very long, with no way to fold them up, as with reflectors.

This means that refractors often have:

- Long tubes (Yerkes 40-inch's tube is 80 feet long!)
- Tall piers (Yerkes: 40 feet high)
- Domes like great cathedrals
- HUGE COSTS.

Refractors also often have bad “dome-effect” seeing, from their huge domes trapping lots of air, which escapes turbulently out the dome slit.

Other problems with refractors are that:

- Lenses bend out of shape over time, due to their own weight.
Mirrors don’t, since they can be supported from the back.

- Glass from which lenses are made must be PERFECT, with no bubbles or cracks, and perfectly transparent.

- Mirrors are more forgiving. Only one surface matters.

- Mirrors only need to be polished and aluminized on one side. Lenses need at least two sides, and so are at least twice as expensive.

The Campus Observatory’s 16-inch telescope is a catadioptric telescope, or a combination refractor/reflector. Its Schmidt-Cassegrain optical design has a spherical mirror (the objective) in back, and a corrector plate (lens) in front. Schmidt-Cassegrain telescopes are economical to mass-produce, and can be portable (for smaller models).

The Campus Observatory also has two refractors, mounted piggyback on the 16-inch telescope: the 70-mm guide scope and a 50-mm finder scope.

Required Reading

Telescopes: Have essentially two parts:

Magnification = $f_{objective}$ / $f_{eyepiece}$ = focal length of objective / focal length of eyepiece.

The Campus Observatory's 16-inch telescope has $f_{objective}$ = 4064 mm.

When used with the large, 55-mm eyepiece, it therefore gets:

> Magnification = 4064 mm / 55 mm = 74 x, or "74 power."

For the 26-mm eyepiece, Magnification = 4064/26 = 156 x.

> BUT: the 26-mm eyepiece covers a field of view of 55/156 $\approx$ 1/3 of that of the 55-mm eyepiece (10 arcminutes for the 26-mm, versus 30 arcminutes for the 55-mm).

→ Higher magnification isn't always better: as you increase the magnification, you decrease the field of view, or how much of the sky you can see.

Therefore, use low power to find things, since you can see a wide area of the sky. Only after you find what you're looking for can you switch to high power, for a close-up view.

Magnification is not the same as resolution. Magnification is how big the image is.
Resolution is how clear the image is

It is perfectly possible to have a large, unclear image. (I'll demonstrate w/ the overhead.) Therefore, don't buy a telescope because of the magnification it can attain!

> BEWARE of cheap, junky, "department store" telescopes,
> with plastic lenses and spindly, shaky little mounts!

Buy from a reputable dealer, e.g. Orion, Meade, Celestron, Boot's Camera.

The properties of astronomical telescopes, in order of importance:

Most important:
(1) Collecting area, which sets how much light a telescope gathers:

This depends on aperture: a telescope with larger aperture (or diameter) can gather more light.

More precisely, collecting area is the area of the objective:

$$\text{Area} = \pi\,(\text{Aperture}/2)^2$$

Example: a 5-m telescope (with a diameter of 5 meters) gathers $5^2 = 25$ times more light than a 1-m telescope.

(2) Resolution, also called resolving power, or image resolution: is how clear the images are.

How small is the smallest detail visible? It depends on the quality of the telescope optics, and the observing site. Telescopes on tall mountains are above much of Earth's atmosphere, and are less affected by its obscuring effects.

(2a) For amateurs: Portability!
Large telescopes have more aperture, but if they're too heavy to pick up, they don't get used much. How steady the telescope's mount is, and how easy it is to point, are also important.

Least important:

(3) Magnification: one can change the magnification easily, just by changing eyepieces. High magnification often just as much of a hindrance as it is a help: it's hard to find things at high magnification.

More on resolution (how clearly a telescope can see):

Practically, telescopes on Earth are limited by the **seeing**, or turbulence in Earth’s atmosphere, which blurs the images—and causes the stars to twinkle, as you’ve no doubt seen.

Seeing:	3-4”	Typical backyard (“poor seeing”)
	1”	Typical mountaintop observatory
	0.2”	Best for any ground-based telescope (or telescope on Earth, and not in space like *Hubble*)
	0.0455”	*Hubble Space Telescope* (which is above Earth’s atmosphere, and so is limited only by diffraction in its optics).

The diffraction limit is an absolute physical limit to the resolving power any telescope can deliver, imposed by the wave nature of light. It is:

Diffraction limit (arcseconds)

$$= 2.5 \times 10^5 \lambda \text{ (meters)} / \text{Aperture (meters)},$$

so the diffraction limits depends on aperture, and the wavelength of light used.

Two technological tricks are now used to improve on this:

(1) Adaptive optics: We can now reach the diffraction limit with ground-based optical telescopes, by taking the twinkle out of starlight by computer control. (This is a former military technology.)

(2) Interferometers: can get images more detailed than the diffraction limit allows by connecting multiple, widely separated, telescopes together. An example of this is the Very Large Array (VLA) radio telescope array, in New Mexico.