What is a Black Hole?

A region of space so dense and compact that the speed a particle would need to escape its gravitational pull would be greater than the speed of light. While theorized in 1783, only recently (from 1971, Cygnus X-1) have gravitational interactions of candidates been observed in nature. It is now thought that almost all galaxies contain massive black holes in their centers about which stars quickly orbit (e.g. Andromeda Galaxy M31, Sombrero Galaxy M104).

Cygnus X-1 binary system
a black hole eating a star.

How do black holes form?

When a sufficiently massive star (about 25 solar masses) begins to run out of fuel, it collapses because there is no longer any outward pressure from the burning core to keep stellar material from falling under gravity. The increase in pressure causes the heavier elements to ignite (rather than burn through fusion) and blow the star's matter outward in shock waves. If the collapsing part of the star is massive enough, it will become a black hole. Like everything else, black holes move through space and may come into contact with other objects allowing us to observe the interaction.

Any amount of mass can be theorized in black hole dimensions. The largest, *supermassive* black holes, can form at the same time as their parent galaxy, having millions or even billions of times the mass of the Sun and a radius up to 10 AU. An intermediate-mass black hole would be a thousand solar masses in the size of the Earth. A *stellar-mass* black hole would have a few solar masses compressed into the size of a city. A *micro black hole* would have the mass of the Moon smashed into an area smaller than a dust mite.

$$r_{\mathrm{sh}} = \frac{2GM}{c^2}$$

Three properties of a black hole are visible from the outside: mass, charge, and angular momentum. The simplest black holes theorized have no charge and do not rotate, but the black holes we observe in space do.

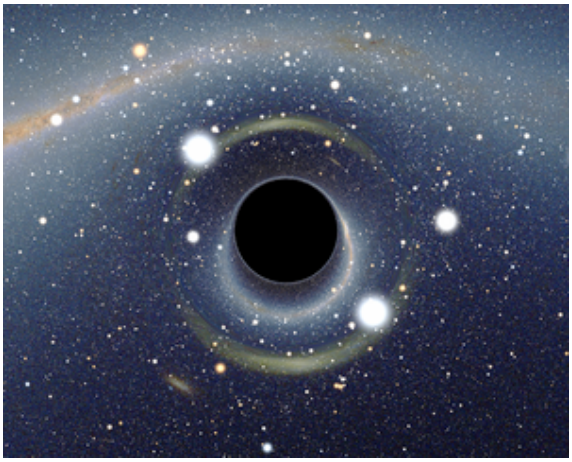
Black holes have short reach

The *event horizon* of a black hole is the point of no return for matter and energy nearby. If the Sun was replaced with a black hole that had the same mass as the Sun, the event horizon would be 3 km (compared to the Sun's radius of nearly 700K km). Hence the Earth would have to get very close to get sucked into a black hole at the center of our Solar System.

Black holes can be very bright

Infalling material can get hot enough to glow. Sometimes black holes are so bright they can outshine an entire galaxy. Supermassive black holes can be so luminous we can

see them from distances of billions of light years. The birth of a stellar-mass black hole produces a flash of radiation so bright it can outshine entire galaxies, and be seen clear across the observable Universe!



Simulated view of a black hole (center) in front of the Large Magellanic Cloud.

Wormholes

Black holes twist space and time, in a sense punching a hole in the fabric of the Universe. There is a theory that if this happens, a black hole can form a tunnel in space called a *wormhole*. While wormholes appear to be possible mathematically, they would be violently unstable, or need to be made of theoretical forms of matter which may not occur in nature.

Spaghettification can occur as an object approaches a stellar-mass black hole, the force of gravity on the mass farther from the center of gravity can be thousands of times stronger than the force closer to it. This has the effect of stretching an object apart like taffy in a matter of milliseconds.

Blazars are a voracious supermassive black hole inside a galaxy with a jet that happens to be pointed right toward Earth. These objects are rare and hard to find, but astronomers have discovered that they can use infrared images to uncover new ones. So far, researchers have found more than 200 new *blazars* and we have the potential to find many more.

Further reading: Black Hole, Black Holes in fiction, Black hole information paradox, Cygnus X-1, Event horizon, General Relativity, List of black holes, Schwarzschild radius, Wormhole.

- *A Brief History of Time* (1988) by Stephen Hawking 212pp
- *Black Holes and Time Warps* (1994) by Kip S. Thorne 624pp
- *The Search for Black Holes*, Scientific American, Dec 1974, pages 32-43.

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