

<b>Useful Props</b>	<p>Empty plastic milk jug – one gallon size.</p> <p>Small bag of birdseed.</p> <p>A peppercorn</p> <p>The Bucket, fabric, marble, and 8 oz (medium yellow) weight</p> <p>A quarter (25-cent piece)</p> <p>1” marble</p> <p>Play-doh® spaceship (Form the Play-doh® into a spaceship, but don’t let it dry out – it will not stretch properly if it is too dry – knead with a drop or two of water and seal in its container for a few hours to re-soften.)</p>
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### Script for “A Galaxy Full of Black Holes” PowerPoint

SLIDE	SCRIPT
1	<p>To the audience: How many of you have heard about black holes? How many have seen TV shows or movies about them?</p> <p>QUESTIONS TO STIMULATE DISCUSSION (this will help assess the knowledge of your audience):</p> <p>What can you tell me about Black Holes? How do you suppose nature makes black holes? What is a black hole?</p> <p>Our Milky Way Galaxy, as well as the other galaxies in the universe are full of black holes. How are black holes made? Where are they, and how do we find them?</p>
2	<p>Black holes were predicted as a theoretical object about a hundred years ago, long before there was any evidence that they actually existed. Nobody, not even Einstein, believed they could actually exist.</p> <p>Today we have abundant evidence that black holes are distributed throughout our Galaxy and other galaxies.</p>

3	<p>According to Einstein, mass causes space to bend around it. Matter AND light moving near a massive object, like the Earth, are forced to take a curved path around that object.</p> <p>Scientists have accumulated much observational evidence that massive objects actually do bend space, like the bending of starlight around the Sun during an eclipse.</p> <p>DEMO:  (USE BUCKET, STRETCH FABRIC, SMALL MARBLE, AND 8 OZ (medium) WEIGHT)  Have someone roll a marble across the fabric of space with no mass in it, then with the weight in the middle. Compare the paths of the marbles.  For more details see the activity “Gravity and the Fabric of Space”.</p> <p>The Moon orbits the Earth in a curved path. So does a spaceship orbiting the Moon. But we can speed up a spaceship and it will leave the pull of the Moon and come back to Earth.  The more massive the object, the more space bends around it. And the harder it becomes to escape its gravitational pull.  Until you get to the mass of black hole. Black holes in essence wrap space completely around them, trapping everything inside. A black hole will swallow anything that crosses within this distance from the black hole.  (Wrap a tag end of the fabric around a 1” marble.)  --</p> <p>IMAGE and additional info:  The image shows an object like Earth bending space. Think of space as a stretched rubber sheet. When something heavy is placed on the sheet, it causes it to dip. The heavier the object, the deeper the resulting gravitational well. In the words of John Wheeler "matter tells space how to curve". Once one accepts the curvature of space, it is rather easy to see that smaller objects will move along the straightest possible line that they can in that curved space. However, this straightest possible line has different properties than in flat space. In fact, the line itself looks curved, as shown above. Again in the words of Wheeler, the curved space tells the matter how to move. Once space itself is curved, everything moving in it is affected. Thus not only particles, but light too must feel the effects of gravity.</p> <p>Images and text courtesy of Professor Gabor Kunstatter, University of Winnipeg</p>
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4	<p>Here is an artist’s conception of a black hole. What is a black hole?  The density of a black hole is so great it would be like taking the whole Earth and crushing into a volume smaller than a 1” marble.</p> <p>Black holes are called “black” because we cannot see them - no light comes out of them. No light can reflect off them. They swallow all matter and all light that comes too near - within a certain distance called the “event horizon”. If you come within that distance of a black hole, you will be pulled in. Nothing can stop you.</p> <p>We can escape from the surface of Earth in a spaceship if the spaceship is accelerated fast enough (about 11 km/sec).  But black holes are called “holes” because nothing can escape from them - you would need a force that could accelerate your spaceship to faster than the speed light travels to escape from a black hole - and nothing we know of can exceed the speed of light (speed light travels in a vacuum: 300,000 km/sec or 186,000 miles/sec)</p> <p>---</p> <p>Additional information:  Hawking radiation: Theoretically, a very tiny amount of radiation may come from black holes. To read more about this:  <a href="http://casa.colorado.edu/~ajsh/hawk.html">http://casa.colorado.edu/~ajsh/hawk.html</a>  <a href="http://superstringtheory.com/blackh/blackh3.html">http://superstringtheory.com/blackh/blackh3.html</a></p>
5	<p>If we could use a scale like we have on Earth to weigh things elsewhere in the Solar System or the Galaxy, this is what you would weigh. Weight is a measure of the force of gravity.</p> <p>The more massive the object you are standing on (or near) is, the more gravitational force you would feel and the more you’d weigh. Gravitational force is based on the mass of the object and your distance from its center. The Sun has more mass than the Moon. YOUR mass does not change, just the force of gravity. You would still look the same.</p> <p>Let’s pretend that you weigh 150 pounds here on Earth. Can you jump up?  On the moon, would it be easier or harder to jump up?  How about on the Sun?  &lt;CLICK&gt;  But how much harder would it be to jump away from a black hole?</p>
6	<p>Our Milky Way galaxy is over 12 billion years old and the Solar System including Earth has been here over 4-1/2 billion years.</p> <p>How have we existed so long if black holes are so dangerous?  ---</p> <p>Background:  Of the 200 billion stars, 22 billion are similar to our Sun. Currently only 100,000 or so are massive enough(Spectral Type O) to be candidates for future black holes.</p>

7	<p>“Let’s discuss these questions about black holes.”</p> <p>Discuss these displayed questions with your audience. This will help you generally assess their level of knowledge about black holes.</p>
8	<p>So where do the millions of black holes come from?</p> <p>Scientists have discovered and classified black holes into three categories. What does “stellar” mean? Yes, star-like. These black holes have masses comparable to the mass of stars.</p> <p>Supermassive: millions to billions of times the mass of the Sun  And, the creatively named, “mid-mass”: between these two extremes.  Where do we find each kind?</p> <p>---</p> <p>Additional information:  <a href="http://chandra.harvard.edu/chronicle/0403/dark/">http://chandra.harvard.edu/chronicle/0403/dark/</a>  Your audience may ask about mini (or primordial) black holes. Mini black holes are theoretical only. In 1971 Stephen Hawking suggested that there might be "mini" black holes created by the Big Bang explosion, when our universe was created. There is as yet no evidence for these.  <a href="http://imagine.gsfc.nasa.gov/docs/features/news/14may04.html">http://imagine.gsfc.nasa.gov/docs/features/news/14may04.html</a></p>
9	<p>Most of the black holes are stellar-mass. How do they form?</p> <p>Are people born? Do we live our lives and then die?  How about stars? Are stars born? Do they live their lives and die?  There are two ways that a star might die.</p> <p>Stars around the mass of our Sun and smaller die, throw off much of its atmosphere as a nebula (planetary nebula) and the core becomes white dwarf. Stars with much more mass – about 8 times or more mass than the Sun die in a supernova explosion and leave a neutron star or what? Yes, a black hole!</p> <p>The millions of stellar-mass black holes spread throughout our galaxy are the corpses of massive stars.</p> <p>---</p> <p>Additional Info:  A star of 8 solar masses or larger will go supernova at the end of its life. If the REMAINING mass (the core mass not blown off the star during the supernova) is greater than 3 solar masses, the end object will become a black hole. Less than that and it will become a neutron star.</p> <p><b>Another analogy:</b>  You may instead want to communicate the “life” of stars to the length of their lives. The large, hot stars (stellar type: O) live very short lives, burning their fuel at a very rapid rate – these are roughly 50 times the mass of our Sun. A large commercial jet airplane (representing these large, hot stars) will burn 50 gallons of fuel in less than a minute during take-off. A small economy car (representing our Sun), traveling at 20 mph, can easily run for a couple of hours on just one gallon of fuel. O-type stars typically live only a few million years, whereas our Sun will continue for about 10 billion years.</p>

10	<p>Now, let's look at the second classification of black holes: Supermassive. Found in the centers of most (and maybe all!) galaxies. Do we live in a galaxy? Yes, our Sun is one star in our Milky Way Galaxy of billions of stars. Are there many galaxies in the universe?</p> <p>Astronomers have found evidence for black holes that contain millions to billions of times the mass of our Sun at the centers of many galaxies. But we're not sure how they formed in the first place – did the black hole form first and the Galaxy formed around it or did the black hole form after the galaxy was born?</p> <p>This is one of the questions NASA scientists are investigating.</p> <p>IMAGE: Central light year of the Milky Way taken in infrared light. Stars at the very center of this frame are orbiting the central black hole. (Credit: European Southern Observatory (ESO) - Very Large Telescope).</p>
11	<p>Finally, astronomers have found some black holes with masses between stellar-mass and supermassive, creatively named “mid-mass” black holes. These appear to be found in the centers of large, dense star clusters. But, once again, scientists are not sure of the mechanism of how they formed.</p> <p>IMAGE: M15 - one globular cluster with a suspected black hole at its center.</p>
12 - 15	<p>(NOTE: THIS IS A SERIES OF 4 SLIDES - THE TEXT COVERS ALL FOUR SLIDES)</p> <p>Let's say you decide to travel to a stellar-mass black hole in a rocket ship (this could take a several hundred thousand years, though, so it would be your descendents arriving). Starting several thousand miles from the black hole, you just turn off your rockets and coast in.</p> <p>This image is not to scale. The black hole's event horizon would be about 35 miles in diameter (about 60 km), so the spaceship would have to be lot smaller. (Take a piece of Play-Doh® and make a 3” spaceship) About like this little spaceship compared to a sphere that fits inside a baseball stadium.</p> <p>At first, you don't feel any gravitational forces at all. Since you're in free fall, every part of your body and your spaceship is being pulled in the same way, and so you feel weightless. (This is exactly the same thing that happens to astronauts in Earth orbit: even though both astronauts and space shuttle are being pulled by the Earth's gravity, they don't feel any gravitational force because everything is being pulled in exactly the same way.)</p> <p>SLIDE 12</p> <p>As you get closer and closer to the black hole, within about 10,000 km (6000 miles – or within about 20 miles of the stadium in the small model), you start to feel "tidal" gravitational forces. The gravitational pull gets stronger as you get closer so the front of your spaceship is being pulled more strongly than the back of the spaceship. (Start stretching the Play-Doh® spaceship)</p>

12-15	<p>SLIDE 13</p> <p>As a result you and your spaceship feel "stretched." (This force is called a tidal force because it is exactly like the forces that cause tides on earth.) (Stretch the Play-Doh® spaceship even farther)</p> <p>SLIDE 14</p> <p>These forces get more and more intense as you get closer to the black hole, and eventually they will rip your spaceship apart and the pieces will be pulled into the black hole (Pull the Play-Doh® spaceship apart into small pieces). The material pulled in will be compressed beyond recognition into the tiniest of its component particles and merge with the mass of the central black hole. (smash the pieces of the spaceship into a table or onto the weight on the bucket)</p> <p>The whole process, from the time you shut off your engines, takes just a few minutes.</p> <p>There is some speculation that a black hole is a portal to another part of the Universe (wormholes). Unfortunately neither you nor your spaceship would ever survive intact to find out. (peel the smashed spaceship off the table and hold it up)</p> <p>NOTE TO PRESENTER: The public is very curious about what would happen if they fell into a black hole. To find out more:  <a href="http://cosmology.berkeley.edu/Education/BHfaq.html">http://cosmology.berkeley.edu/Education/BHfaq.html</a></p>
16	<p>So our galaxy is full of black holes. But there are two things in our favor: the great distances between the stars and all the stars are orbiting the center of the Galaxy.</p> <p>Despite the number of black holes in the galaxy, we are quite safe. The many black holes are spread through the huge disk of the Milky Way, where the separation of stars, and of all the black holes, is immense.</p> <p>If the distance from the Sun to Pluto was represented by the distance across a quarter, our Milky Way Galaxy would span North America.  If the 200 billion stars in our Galaxy were represented by birdseed, a football field piled 4 feet deep in birdseed would represent those 200 billion stars.  Distribute those birdseed from the football field all over North America, about 25 miles deep – Are the stars pretty far apart?  Yes, you can imagine that the stars (and the black holes) are VERY far apart.</p> <p>The mass of the central black hole in our Galaxy is over 3 million times the mass of the Sun.  If the mass of the Sun was represented by the mass of one birdseed, the mass of the central Black Hole would be represented by about 22 one-gallon milk containers of bird seed. But all that bird seed would be stuffed inside a volume of a peppercorn. Black holes are VERY dense!  (Hold up the 1-gallon milk jug and the peppercorn)</p> <p>Credit: M74 Photo Credit: NOAO/AURA/NSF</p>

17	<p>So one reason we survive having all these black holes in our Galaxy is the vast distances between the stars.  The other reason is that everything is orbiting!  If Sun and the rest of the stars in our Galaxy were not orbiting, we'd all eventually get pulled in to central black hole and the closer we got, the faster we'd be pulled.  (Place a marble at the edge of the bucket with a weight in the middle and release it – it falls in)  But we ARE orbiting. (Push marble into orbit around the weight) – And we're moving fast enough to keep from getting pulled in.  Everything is orbiting something. Orbits are stable UNLESS something outside the system perturbs the object.</p> <p>Yes, someday the Solar System might approach a black hole in space (stellar mass), but we would have to approach over 1000 times closer than our closest star to be significantly affected.  Birdseed galaxy: Quarter as solar system, nearest star is currently about 600 feet (2 football fields) – a black hole would have to approach closer than a few inches, but this would be true for ANY star we approached.</p>
18	<p>Now let's talk about what would happen if the Sun was replaced by a black hole of the small mass.  What do you suppose would happen to Earth and the other planets?</p>
19	<p>If the Sun was replaced by a black hole of the same mass as the Sun, the Earth and all the planets would continue in their current orbits unaffected.  Of course, there wouldn't be any daylight - we would certainly get VERY cold!  Gravitational force is based on 2 things: the mass of the object you are near and your distance from its center of mass. Did the mass of the object at the center of the Solar System change? No! Did the Earth's distance from the center of the object change? No! So, the gravitational force does not change and we would continue orbiting as before.</p>
20	<p>So how do we find black holes?  If we were to approach a black hole in space, since we can't see the black hole itself, how would we know it was there?  ---  <b>IMAGE:</b>  The central bright star, HD226868 is also known as Cygnus X-1. Unlike every other star in this frame, it is pouring out X-radiation. Known as an X-ray binary, Cygnus X-1 is an ordinary star in a tight orbit with a black hole. Cygnus X-1 is about 7,000 light years away.  (Palomar Observatory POSS)  Credit: Palomar Observatory - Space Telescope Science Institute</p> <p>Although not too different in mass from the black hole it is orbiting, the star HD226868 would fill the space inside the Earth's orbit around the Sun. The black hole would span Manhattan Island.</p>

<p>21</p>	<p>(An artist’s impression of an X-Ray binary system, the best way to detect a stellar-mass black hole)  There are three ways scientists can detect the presence of a black hole.</p> <ol style="list-style-type: none"> <li>1. If we see a star or stars orbiting an “unseen” object, this might be a binary (double) star system - that unseen object could be the remains of a massive star that used to be the companion star of the visible star - the companion died in a supernova explosion and now all that’s left is a black hole which the visible star is still orbiting.</li> <li>2. As a black hole pulls material from a closely orbiting companion star, the material heats up as it forms a swiftly rotating disk around the black hole. As it heats up, it gives off hot radiation in the form of x-rays.</li> <li>3. And sometimes hot jets of gas shoot out from the black hole. Very hot objects like the disk and the jets emit X-rays which we can detect with special telescopes out in space, like the orbiting Chandra X-Ray observatory.</li> </ol> <p>Let’s look at some real examples of all three ways to detect a black hole.  ---  Additional information:  <a href="http://cfa-www.harvard.edu/seuforum/bh_reallyexist.htm">http://cfa-www.harvard.edu/seuforum/bh_reallyexist.htm</a>  NOTE:  The perspective on this illustration is misleading: the star is a red giant, with a radius of order 1 AU. The black hole is about 30 km radius, with the gas disc (called an accretion disc) about 100 times larger, say 3000 km</p>
<p>22</p>	<p>This is a series of actual images showing the orbits of stars very close to the center of our galaxy over a period of 14 years: from 1992 through 2004 and projected to 2006 (watch the counter in the upper left corner)  The red cross in the center marks the location of the invisible supermassive black hole in the center of our galaxy called Sagittarius A-star (Sgr A*).</p> <p>If we go back to our North America model of our Galaxy, The area we’re looking at would <b>span about seven feet</b> (a little over 2 meters) on a side around that central peppercorn black hole.  See how fast the stars are moving as they pass by central black hole.  Near the center of our galaxy, stars are much denser than out here where the Sun is. More interactions and deflections – easier for a star to get too close to black hole and have some of its material pulled into black hole.</p> <p>Let’s see what it looks like when gas is pulled into the central black hole.  ---  Additional Information:  At closest approach, stars sweep around the black hole at 5000 kilometers per second! By contrast, the Sun orbits the center of our Galaxy at a relatively slow 220 km/sec - but we’re 26,000 light years from the center – roughly 650 miles on the quarter-North America scale.  © Infrared and Submillimeter Astronomy Group at MPE Used with permission  (Max-Planck-Institut für extraterrestrische Physik)  To find out more: <a href="http://www.mpe.mpg.de/ir/GC/index.php">http://www.mpe.mpg.de/ir/GC/index.php</a></p>

23	<p>Watch the flare at the center - next to the red arrow. That's a hot flare marking gaseous material being pulled in by the central black hole in our galaxy.</p> <p>The time elapsed in <b>minutes</b> is shown in the lower right corner. These images were taken in July 2004. This could happen to a star that wanders too near the center. Hot gases can be detected by infrared telescopes, like this image, and by X-ray telescopes, like NASA's Chandra X-Ray telescope. Chandra can detect these high temperature X-rays emanating from a small area of space.</p> <p>The S- numbers next to a few of the stars are their astronomical designations. Star S2 is the same as the star in the previous movie with the smallest orbit shown around Sgr A*</p> <p>Now let's look at the third way of detecting black holes: jets! ---</p> <p>Additional information: <a href="http://www.mpe.mpg.de/ir/GC/index.php">http://www.mpe.mpg.de/ir/GC/index.php</a> © Infrared and Submillimeter Astronomy Group at MPE – Used with permission <b>(Max-Planck-Institut für extraterrestrische Physik)</b> NOTE: This is an infrared image rather than an X-Ray image, but the effect would be essentially the same.</p>
24	<p>A radio telescope image of jets from a stellar-mass black hole in our Galaxy - about 40,000 light years from us. The movie was made from a series of images taken over a period of <b>just one month</b>. The image is about <b>30 light days</b> top to bottom. If we go back to our North America model of our Galaxy, the area we're looking at would <b>span about eleven feet</b> with the black hole smaller than the tiniest grain of dust in the middle and each jet shooting about four feet in opposite directions.</p> <p>NASA's Hubble Space Telescope and Chandra X-Ray telescope have detected these powerful jets. ---</p> <p>Additional information: <a href="http://home.achilles.net/~ypvsj/news/GRS1915n105.html">http://home.achilles.net/~ypvsj/news/GRS1915n105.html</a> The images were taken over a period of 1 month and the speed of the jet material is 92% the speed of light. This object is also on our black hole list for "Where are the Black Holes?" star maps as V1487 Aql A lot of jets have a knotty structure, especially at the high resolution you get with radio telescopes. There is an analogy with the spiral density waves in spiral galaxies - you are seeing a high pressure wave moving up through the jet.</p>
25	<p>Have you found out a lot about black holes? Let's look back at the questions we had at the beginning. (Review these questions with your audience - how much did your audience understand?)</p>

26	<p>What are scientists still exploring?</p> <p>NASA missions continue to search for and study black holes, in our galaxy and in other galaxies, determining the fate of matter as it falls into black holes, how powerful jets form, and what role black holes played in the formation of the early universe.</p> <p>IMAGES:</p> <p>1. <a href="http://chandra.harvard.edu/photo/2005/bhlock/">http://chandra.harvard.edu/photo/2005/bhlock/</a> X-ray: NASA/CXC/U. Wisconsin/A.Barger et al.; Illustrations: NASA/CXC/M.Weiss <i>The Chandra mosaic of a region of the sky known as the Lockman Hole (named after astronomer Felix Lockman, who discovered that this region of the Galaxy is almost free of absorption by neutral hydrogen gas) shows hundreds of X-ray sources. The high spatial resolution of Chandra allowed for the identification of many supermassive black holes in this image.</i></p> <p>The Lockman Hole data and two other surveys with Chandra and the Hubble Space Telescope have provided a reasonably accurate census of supermassive black holes in the Universe. Astronomers have used this census to study the rate at which these enormous black holes grow by pulling in gas from their surroundings.</p> <p>2. <a href="http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/35/image/b">http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/35/image/b</a> This is an artist's impression of how the very early universe (less than 1 billion years old) might have looked when it went through a voracious onset of star formation, converting primordial hydrogen into myriad stars at an unprecedented rate.</p>
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We hope that this has given you enough background so that the next time you see a TV show or movie about black holes, you have a better understanding of how they form, where they are, and how we detect them.

Thank you!

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Additional Information:

What NASA is trying to find out about Black Holes:

[http://cfa-www.harvard.edu/seuforum/bh\\_findout.htm](http://cfa-www.harvard.edu/seuforum/bh_findout.htm)

NASA Missions:

<http://cfa-www.harvard.edu/seuforum/missions.htm>

IMAGE:

Cluster of galaxies HCG 87. All the galaxies in this cluster possess central black holes. It seems that the central black hole may well be an essential ingredient in galaxy formation during the early universe. The James Webb Space Telescope, due to replace Hubble in 2011, will be able to see the epoch when galaxies first formed. This should reveal what role giant black holes have in galaxy formation.

(Gemini North)

Credit: Gemini Observatory - GMOS-S Commissioning Team

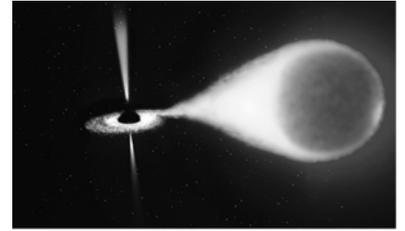
Fascinating fact: For spiral galaxies, the bigger the central bulge, the bigger the black hole.

## Q&A

### Potential questions from the public :

1. What happens when you fall through the event horizon? You would not know when you passed thru the event horizon – it is not a physical boundary – it’s a particular distance from the center of the black hole. You would get squeezed and stretched and things would become very uncomfortable the closer you approached to the black hole.
2. I’ve heard things actually can escape back out of a black hole? Yes- discussion of Hawking radiation
3. Do black holes occasionally encounter each other with so many of them out there? Yes. NASA’s LISA mission is being developed to detect gravitational waves from such an encounter. <http://lisa.jpl.nasa.gov/>
4. Don’t the supermassive black holes in the centers of galaxies affect the properties of the galaxy in same way? Size of black hole correlates with mass of stars in central bulge – black hole tends to be 0.1% of the mass of the spherical component of the galaxy (central bulge in spirals).
5. What is a “white hole”? Science fiction concept – times runs backwards.
6. Why does gravity bend/attract light as well as mass? Light is energy.  $E = mc^2$ . Mass and energy are equivalent. Gravity affects mass and energy (i.e. light) the same way.
7. Our galaxy is a spiral – it looks like all the material is spiraling into the black hole in the center? Basic discussion on orbits
8. Do black holes have anything to do with the Big Bang? Unknown yet.
9. Do black holes have anything to do with making life? Not likely.
10. Can there be a stable orbit around a black hole? Objects outside 3x the event horizon – circular orbits are stable. Inside 3x, orbits not stable.
11. What is the evidence for millions of black hole in the Milky Way? Originally there was speculation that black holes were a significant source of dark matter – subsequent research disproves this. We know how many massive stars form in the lifetime of a galaxy and how long massive stars live. So this is a statistical argument to say that there are likely to be millions – it is not based on observation.
12. If a star dies, does it always turn into a black hole? Discuss the three types of remains a star can leave: white dwarf, neutron star, or black hole.
13. Is there a minimum size for a black hole? Theoretically, yes – 3 solar masses for normal massive star death. Tiny black holes may have formed in the very early universe – no evidence for this yet.
14. How common are binary and multiple star systems? More than half the stars.
15. Couldn’t galactic black holes be formed by galaxy collisions? Yes, mergers of galaxies drive gas into black hole and accrete gas around the black hole. Central black holes can merge. (Show “Galaxy Merge” from the animations)
16. Will a black hole ever disappear? What is its fate? Theoretically, black holes can evaporate, but the process is exceedingly slow: hundreds of billions to trillions of years.

## BLACK HOLE FAQ's



1. **What is a black hole?** A black hole is a region of space that has so much mass concentrated in it that there is no way for a nearby object to escape its gravitational pull. There are three kinds of black hole that we have strong evidence for:
  - a. Stellar-mass black holes are the remaining cores of massive stars after they die in a supernova explosion.
  - b. Mid-mass black hole in the centers of dense star clusters
  - c. Supermassive black hole are found in the centers of many (and maybe all) galaxies.
2. **Can a black hole appear anywhere?** No, you need an amount of matter more than 3 times the mass of the Sun before it can collapse to create a black hole.
3. **If a star dies, does it always turn into a black hole?** No, smaller stars like our Sun end their lives as dense hot stars called white dwarfs. Much more massive stars end their lives in a supernova explosion. The remaining cores of only the *most* massive stars will form black holes.
4. **Will black holes suck up all the matter in the universe?** No. A black hole has a very small region around it from which you can't escape, called the "event horizon". If you (or other matter) cross the horizon, you will be pulled in. But as long as you stay outside of the horizon, you can avoid getting pulled in if you are orbiting fast enough.
5. **What happens when a spaceship you are riding in falls into a black hole?** Your spaceship, along with you, would be squeezed and stretched until it was torn completely apart as it approached the center of the black hole.
6. **What if the Sun became a black hole without gaining or losing any mass?** The Sun can't turn into a black hole, but if it did, the Earth would get very dark and very cold. The Earth and the other planets would not get sucked into the black hole; they would keep on orbiting in exactly the same paths they follow right now.
7. **Is a black hole a portal ("wormhole") to another part of the universe?** In some science fiction shows, people sometimes travel through wormholes. This leads many people to think black holes are wormholes and therefore lead to other places. There is no evidence that wormholes exist.
8. **Can I see a black hole?** No. The light produced or reflected by objects makes them visible. Since no light can escape from a black hole, we can't see it. Instead, we observe black holes indirectly by their effects on material around them.
9. **What evidence is there that black holes exist?** Fast-moving stars orbiting "unseen" objects and strong X-rays emitted from a very small area of space. NASA missions and projects are in the process of discovering more about black holes.

For more info: <http://cfa-www.harvard.edu/seuforum/blackholelanding.htm>

More FAQs: <http://cosmology.berkeley.edu/Education/BHfaq.html>