November 2009
IYA Discovery Guide

This Month's Theme:

The Lives of Stars

Featured Activity:

Lives of Stars

Featured Observing Object:

Crab Nebula

The International Year of Astronomy is a global celebration of astronomy and its contributions to society and culture, highlighted by the 400th anniversary of the first use of an astronomical telescope by Galileo Galilei.
Join us as we look up!
http://astronomy2009.us

The Astronomical Society of the Pacific increases the understanding and appreciation of astronomy by engaging scientists, educators, enthusiasts and the public to advance science and science literacy.
http://www.astrosociety.org

November's Topic:
The Lives of Stars

Back in 1054 AD, Chinese and Arab astronomers recorded seeing a "new star" that was bright enough to be visible even during the day. 450 years later, Galileo also saw a bright "star" appear, just a few years before he made his telescope. But for both of those events, no one knew what they were seeing. We have learned now that ancient astronomers saw a special event called a supernova – the flashy end to a giant star's life. Stars spend most of their lives shining brightly without much change. But the sight of their birth and death can be spectacular.

Every star begins its life in a stellar nursery of gas and dust. As enough of this star-building material falls together it becomes hot and dense enough to form a star. Because the dense clouds where stars form block visible light, it is often easier to study them using infrared light which can pass right through the clouds. NASA's Spitzer Space Telescope and Hubble Space Telescope have both used infrared light to study star formation in our own galaxy and in distant ones. You can see a stellar nursery where stars are being born if you look at the December IYA Discovery Guide, which features the Orion Nebula.


Crab Nebula: Credit Hubble Space Telescope

At the end of their lives, very large stars will go supernova. This huge explosion blows off the outer layers of the star in a bright display. It releases oxygen, iron, and other heavier elements into the surrounding space. These contribute to making a new stellar nursery and eventually get recycled into new stars. Many of the elements that make up the Earth and even us came from many supernovae that occurred billions of years ago.

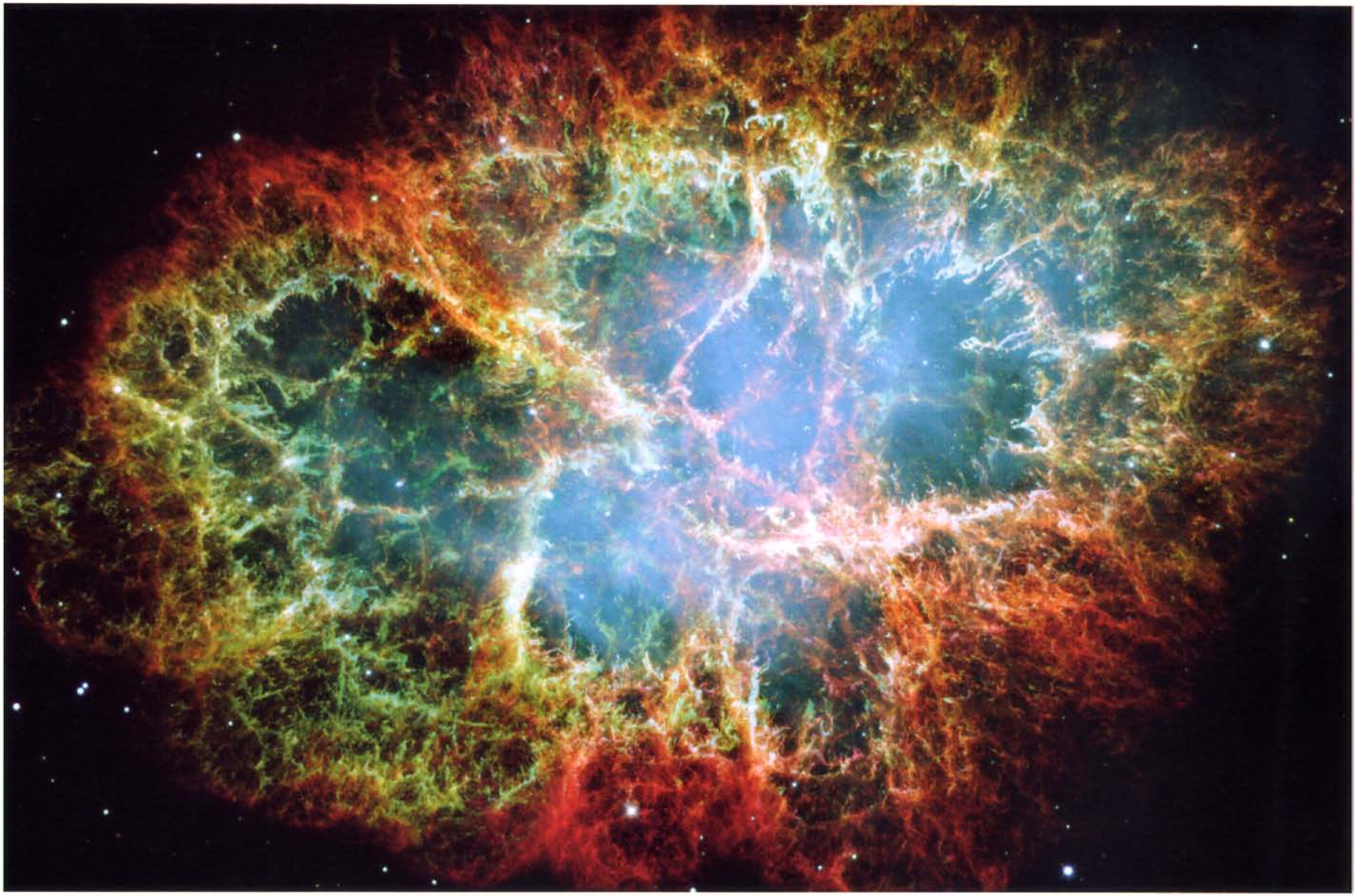
The supernova that was observed in 1054 faded after about a year. Now, when we look at the same place in the sky we see a supernova remnant called the Crab Nebula (right). You can locate this blast of material with the Finder Chart in this guide. Giant stars also leave something else behind. In the Crab nebula, there is a neutron star that is so dense that a teaspoon would weigh as much as a train of boxcars loaded to maximum capacity that stretched all the way from Canada to Mexico! And the very biggest stars leave behind a black hole, which is even denser and more mysterious, and also invisible.

NASA is studying black holes and other high-energy x-ray and gamma-ray sources with the Suzaku and XMM-Netwon Missions. The Swift and Fermi missions are orbiting Earth to study the dramatic deaths of very large stars. To learn more about the lives of these giant stars and to see what happens to stars like our Sun at the end of their lives, see the activity included in this packet.

Learn more about the Lives of Stars from NASA.
Find more activities featured during IYA 2009.
See what else is planned for the International Year of Astronomy.

THE UNIVERSE YOURS TO DISCOVER
INTERNATIONAL YEAR OF ASTRONOMY 2009

National Aeronautics and Space Administration



The Crab Nebula (M1)

The Crab Nebula (M1)

Celestial Fireworks

Americans celebrate Independence Day by peppering the sky with fireworks. Nearly a thousand years ago, on July 4, 1054, a more powerful explosion brightened the heavens.

Chinese astronomers witnessed the debut of a bright star appearing in the sky within the constellation Taurus. They described the "guest star" as about as brilliant as the full Moon. This star was so bright that people saw it during the day for almost a month. The star remained visible in the evening sky for more than a year before fading from sight.

More than 700 years later, while hunting for comets, Charles Messier spotted an interesting fuzzy object in the same area of the sky as the Chinese guest star. He noted that it was not a star, nor a comet, and placed it on his list of objects that comet hunters should avoid. It became well known to astronomers as the first entry in Messier's catalogue, published in 1774.

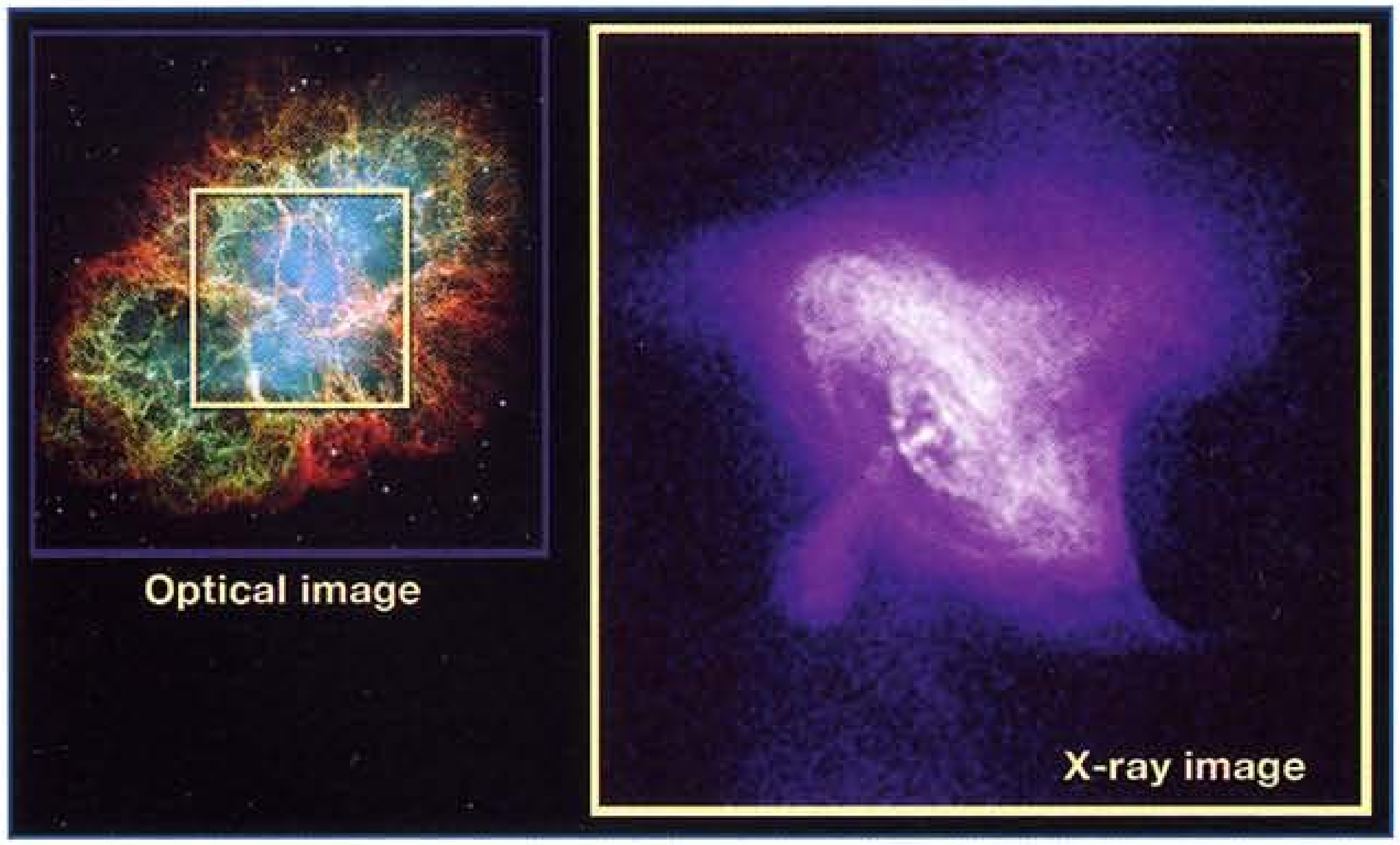
Seventy years later, British astronomer Lord Rosse used the largest telescope of his day to spy Messier's fuzzy object. The object consisted of glowing strings of gas and dust, called a nebula. He christened it the "Crab" because its tentacle-like structure resembled the legs of the crustacean.

The Crab Nebula is actually the glowing remains of a star. In 1054, a star about 10 times the mass of our Sun reached the end of its life and exploded as a supernova. The gas in the nebula represents the outer layers of the star, blown across interstellar space at several million miles per hour. The colors in the filaments and outer regions of this Hubble image, taken in visible light, represent the elements oxygen and sulfur. They were created in the star during its life and were expelled by its explosive death.

The development of telescopes that detect other wavelengths of light, such as radio waves and X-rays, allowed astronomers to see features in the Crab Nebula that cannot be seen in visible light. In 1968, they uncovered a rapidly spinning neutron star — the dense, compact core of the exploded star — at the nebula's center. Only about six miles (10 kilometers) across, the neutron star would fit inside a small city. Radio astronomers observed bursts of radio waves 30 times a second and called it a pulsar. These radio outbursts are caused by twin searchlight beams that sweep across our viewpoint, making the neutron star appear to blink on and off. The Crab Pulsar was the first pulsar discovered. Electrons whirling at nearly the speed of light within the neutron star's intense magnetic field create abundant high-energy X-ray emissions. The same process powers the nebula's eerie interior bluish glow seen in this Hubble image.

Due to its relative proximity to Earth and energetic emissions at many wavelengths, the Crab Nebula is one of the most studied objects in space. It has revealed intricate details of the death throes of massive stars. Eventually, the elements created in this supernova explosion will be recycled through interstellar gas clouds and will become part of the next generation of stars.

Credits for Hubble image: NASA and ESA.



Buried deep within the Crab Nebula is the powerhouse creating the high-energy fireworks detected by astronomers. The image on the left, taken in visible light by the Hubble telescope, shows the pulsar's location at the heart of the nebula. The pulsar cannot be seen in visible light.

The X-ray image on the right, taken by the Chandra X-ray Observatory, shows two rings of material around the Crab Pulsar. Winds from the central pulsar slam into the surrounding material, creating knots and clouds of energetic X-ray–emitting particles. The pulsar also powers two turbulent jets shooting off perpendicular to the rings at half the speed of light.

Credits for Chandra X-Ray Telescope image: NASA and ESA.

FAST FACTS / VOCABULARY

Location: Constellation Taurus

Distance: 6,500 light-years away

Neutron star: A neutron star is the collapsed remnant of a massive star after a supernova. A neutron star is one of the few possible endpoints of a star's life.

You can get images and other information about the Hubble Space Telescope on the World Wide Web. Visit **http://www.stsci.edu/outreach** and follow the links.

The corresponding classroom activity for this lithograph can be found at: **http://amazing-space.stsci.edu/** or may be obtained by contacting the Office of Public Outreach at the Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218.

National Aeronautics and Space Administration

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www.nasa.gov

STScI L-06-03 LG-2006-08-108-GSFC

November 2009
Featured Observing Object:

M1: Crab Nebula
Finder Chart

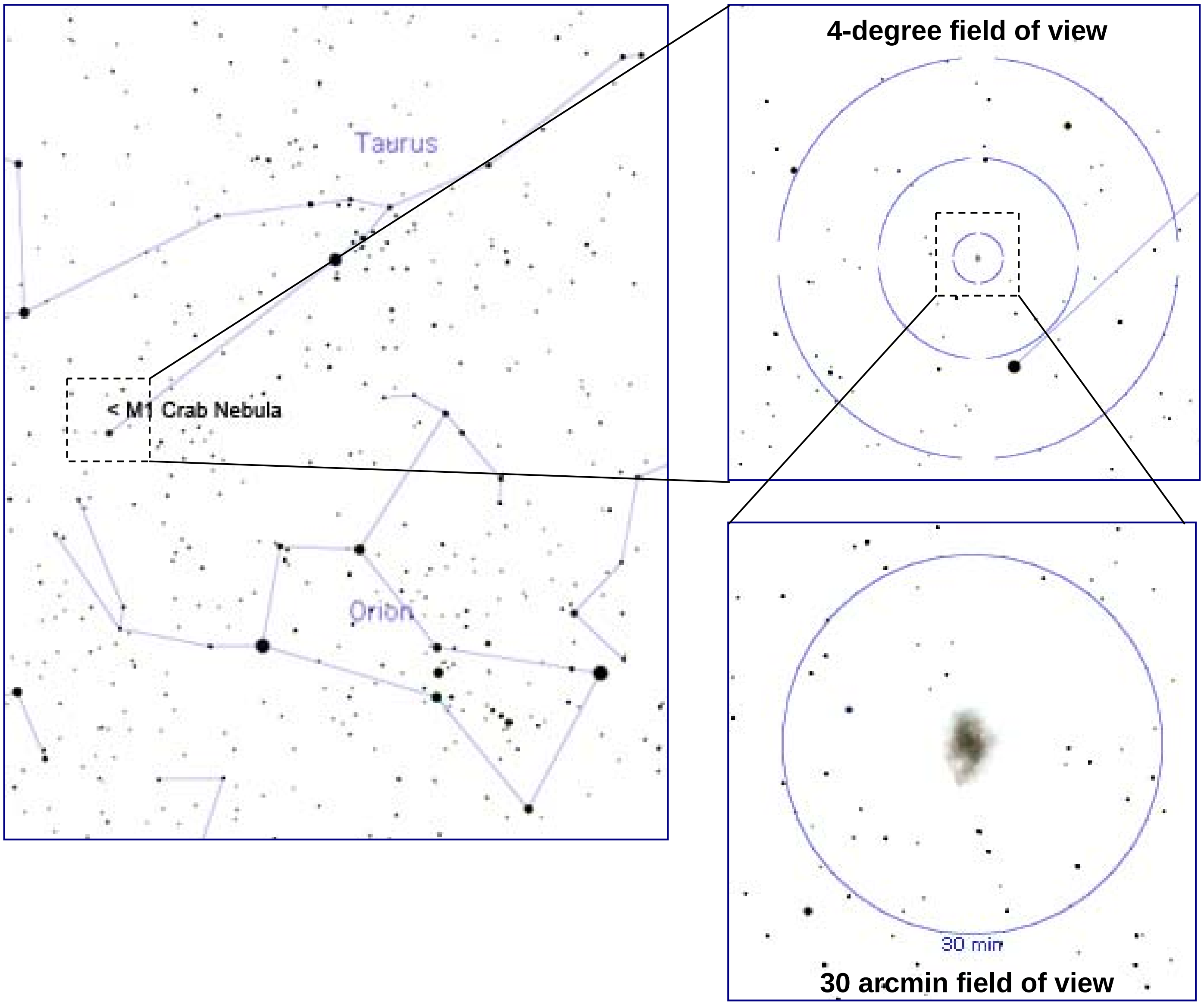
For information about M1:
http://seds.org/messier/M/m001.html

Image credit: NASA/JPL-Caltech/R. Gehrz

R.A. 5h 34.5m
Dec +22:01
Distance: 63,000 light years
Visual Magnitude: 8.4
Apparent Dimension: 6 x 4 arcminutes

To view: Telescope in dark skies

In November 2009 in the late evening, the Crab Nebula is above the east to northeast horizon, in the constellation of Taurus, the Bull. One of the few supernova remnants visible in backyard telescopes, M1 is near the star marking the tip of the Bull's horn nearest Orion.



Supernovae in the Lives of Stars

What is a supernova? Where does it fit in the lives of stars? Will the Sun go supernova?

About the Activity

Allow visitors to discover the lifecycle of stars and when supernovae happen. Many people think the different stages in the life of a star are actually different *types* of stars, rather than just *stages* in the life of a single star.

Topics Covered

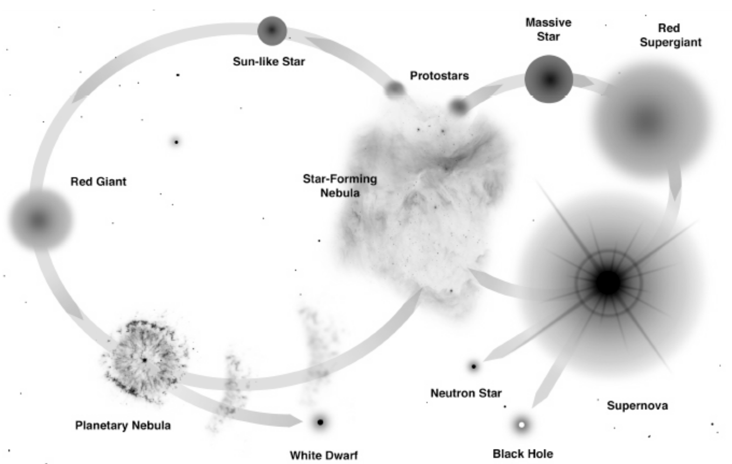
- The lifecycle of stars like our Sun compared to massive stars
- Stages in the lives of stars

Location and Timing

This activity can be used indoors or outdoors, before a star party, in a classroom, or at a club meeting. It takes about 5 to 10 minutes.

Materials Needed

- Copies of handouts and/or banner: Lives of Stars
- *(Optional)* Telescopes



Participants

Activities are appropriate for families with children over the age of 9, the general public, and school groups in ages 10 and up. Any number of visitors may participate.

Included in This Activity

Set Up
Detailed Activity Description
Background Information
Lives of Stars handout (double-sided)

Additional astronomy activities can be found here: http://nightsky.jpl.nasa.gov

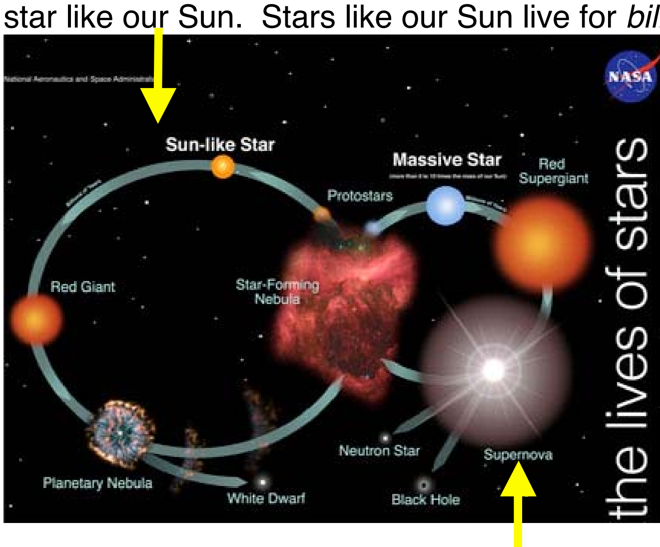
Set Up Instructions

Make copies of Lives of Stars handouts for your visitors. The presenter(s) may want a copy of the list of stars that will go supernova for reference. (Note that the "Lives of Stars" Handout has two choices: one with a dark background and one with a white background.)

Detailed Activity Description

The Lives of Stars

Leader's Role	**Participants' Role (Anticipated)**
Objective: Allow visitors to discover the lifecycle of stars and when supernovae happen.	
To say: How many have heard of a supernova? Black holes? White dwarf stars? Red giant stars? How about a planetary nebula? Who can tell me how are all these things related? Well, they are all different stages in the life of a star. Let's see what that means. *To do:* Show lifecycle banner. Pass out handouts.	Hands go up. Huh? They are all different kinds of things in the universe.
Misconception Tip: Many people think the different stages in the life of a star are actually different TYPES of stars, rather than just STAGES in the life of a single star. Like the difference between TYPES of insects (a butterfly, a bee, or a housefly) rather than the different STAGES in the life of a single type of insect. For example, a butterfly's lifecycle starts as an egg, then it becomes a caterpillar, then a pupa, then a full-grown butterfly. Its appearance changes at each stage. Stars also change their appearance as they go through stages in their lives.	

Leader's Role	**Participants' Role (Anticipated)**
To say: [referring to handouts] What do you suppose this represents? Well, THIS side shows drawings of the stages in the life of a star like our Sun. Stars like our Sun live for *billions* of years.  And THIS side shows the life of a massive star – several times the mass of the Sun. These large, hot stars only live for *millions* of years. *To do:* Let participants explore the banner and discuss each step. Walk through each step in the lifecycle of both types of stars as discussed on the back of the handout (see page XX). The steps are printed on the reverse side of the handouts.	Types of stars? Discuss.

Leader's Role	Participants' Role (Anticipated)
Presentation Tip: There may be a few kids (or adults) among your visitors who are familiar with some of the stages in the life of a star. Allow them to explore the handout and provide their ideas before presenting all the answers. It is important to explain that the nebula in the middle of the diagram is representative of the many nebulae in our galaxy. The blown off material from stars generally does <u>not</u> go back into the nebula from which the star was formed, but just adds material to other clouds of gas and dust between the stars.	
<u>To Do:</u> You might want to use the activity "Let's Make A Supernova" as part of your discussion: http://nightsky.jpl.nasa.gov/download-search.cfm	
<u>To Say:</u> So will our Sun go supernova? Why not?	 No! It'll turn into a white dwarf – it's not big enough to explode.
<u>Optional: If a telescope observing session follows the presentation:</u> *<u>To Say:</u>* You can see for yourself some of the stages in the lives of stars by looking through the telescopes. Star-forming nebulae, planetary nebulae, or the remains of a supernova. How many will you find? Ask the telescope operators what they are showing you and see if it fits into the lifecycle of a star.	

A young visitor remarks, "This is what our Sun could look like in a few billion years!"

<u>Background Information</u>

This activity concentrates on the lives of massive stars: stars more than 8 to 10 times the mass of our Sun and the energy they generate. These are the stars that end their lives in spectacular supernova explosions called **"Type II"** supernovae.

Another basic type of supernova happens when a white dwarf pulls too much material off a companion star and then explodes. This is called a **"Type 1a"** supernova. This type of supernova is not addressed in this ToolKit.

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From this website, download more details about stellar lifecycles:
http://imagine.gsfc.nasa.gov/docs/teachers/lifecycles/

For more information about supernovae:
http://imagine.gsfc.nasa.gov/docs/science/know_l1/supernovae.html

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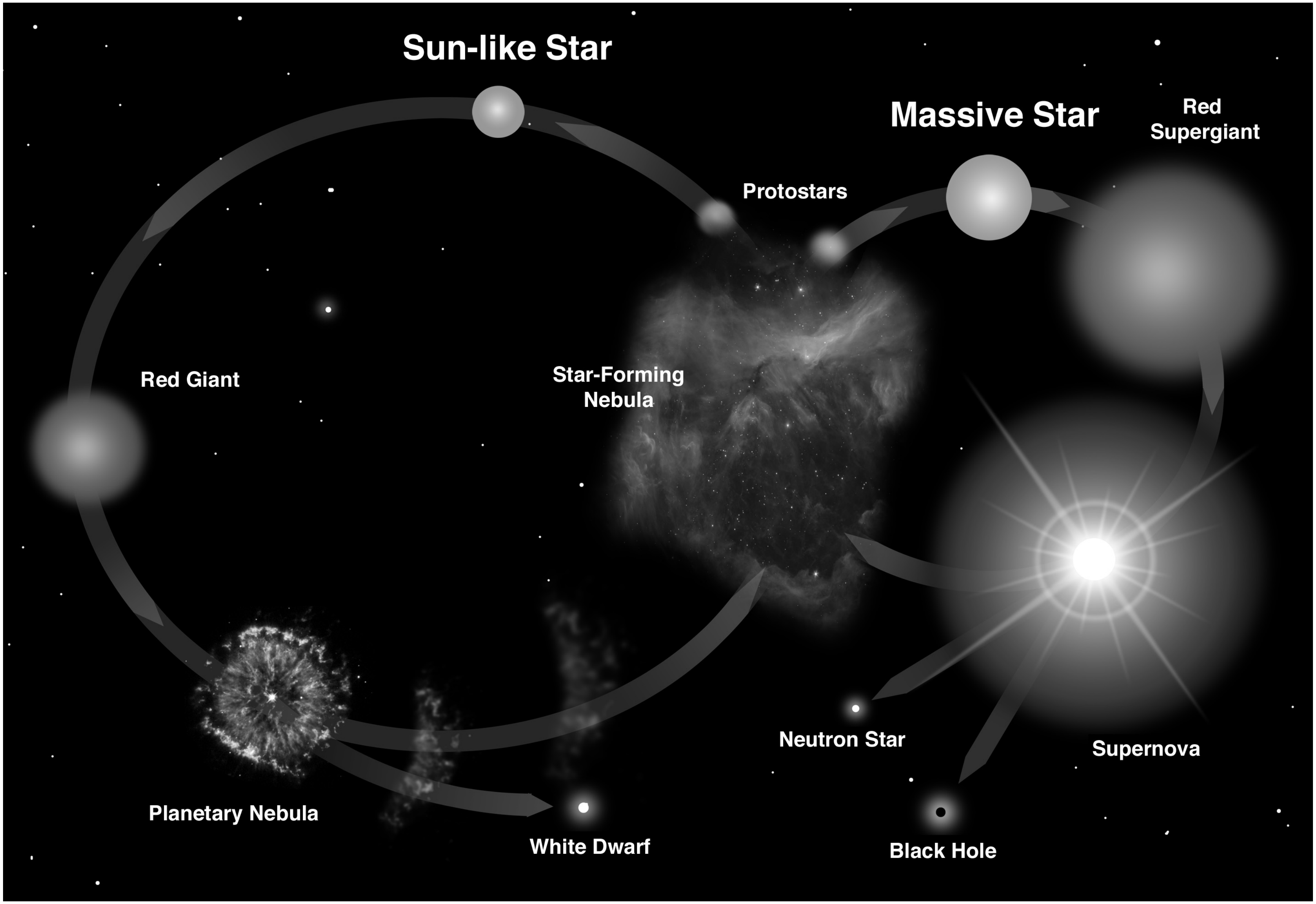

the lives of stars

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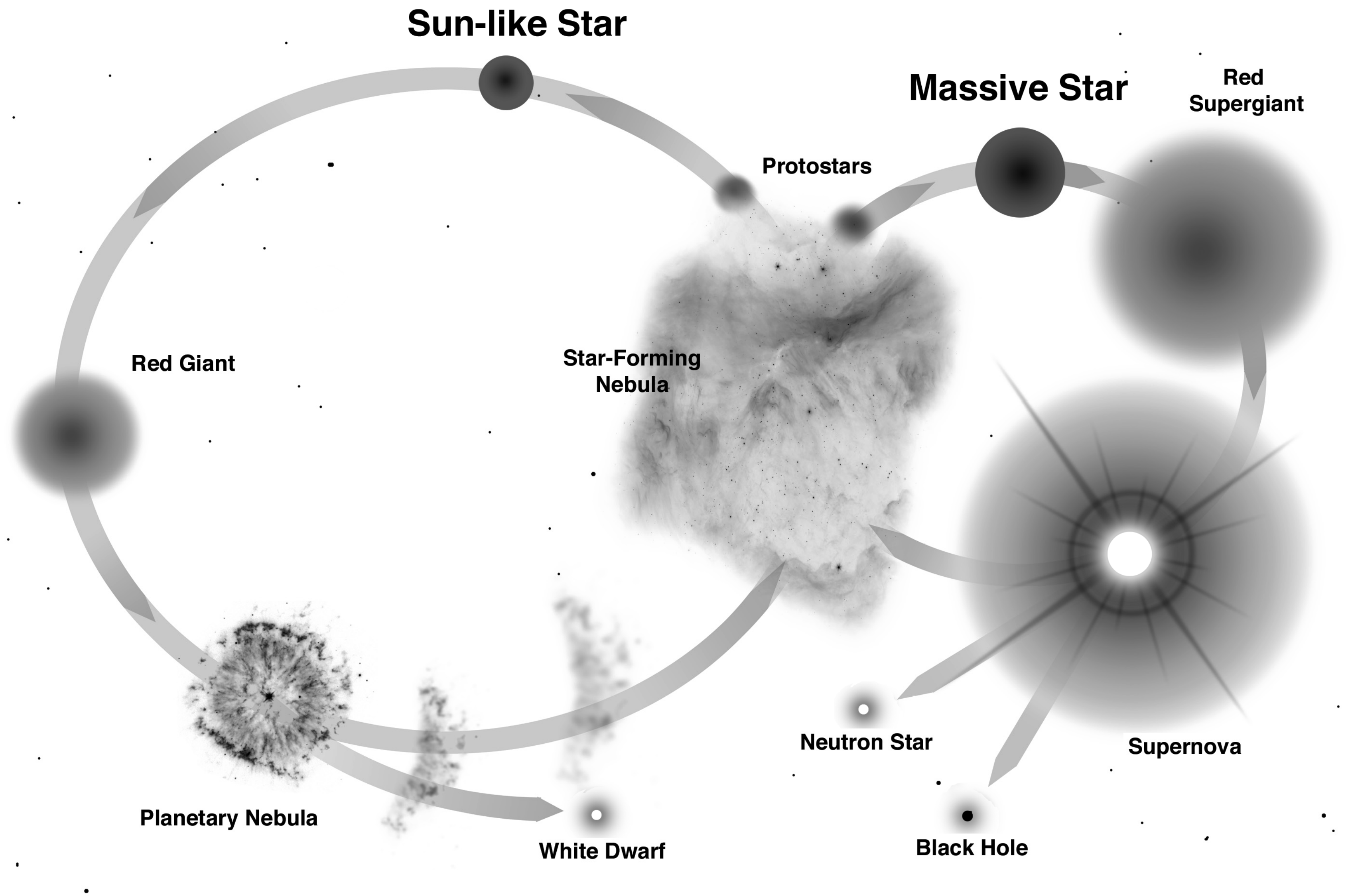
the lives of stars



THE LIVES OF STARS

What is a red giant, a white dwarf, or a supernova? Where do these fit into the lives of stars? Follow the arrows on the diagram and discover the stages in the life of a small Sun-like star compared to the stages in the life of a massive star (a star more than 8 to 10 times the mass of our Sun).

Stars of all sizes are born as *Protostars* from a cloud of gas and dust in our galaxy (a *Star-Forming Nebula*). When the protostar compresses under the force of gravity and its core becomes hot enough, the star begins fusing hydrogen into heavier elements in its core.

Stages in the life of a sun-like star (A life of BILLIONS of years):

Sun-like Star: For billions of years, the star remains stable, fusing hydrogen in its core.

Red Giant: After several billion years, the star uses up the hydrogen in its core, and it turns into a red giant, now mostly fusing helium.

Planetary Nebula: At this point the star goes through an unsettled stage where it starts losing its outer atmosphere in a planetary nebula which forms around the star.

On the diagram, the cycle continues from the planetary nebula back into the cloud of gas and dust. This represents the recycling of the elements created in the star back into the interstellar medium to provide material to make new stars.

White Dwarf: The leftover core of the star cools down and shrinks to a white dwarf. After billions of years, the white dwarf cools off so much that it no longer glows and becomes the dark, cold remains of the star.

Stages in the life of a massive star (A life of MILLIONS of years):

Massive Star: For millions of years, the star remains stable, fusing hydrogen in its core.

Red Supergiant: After several million years, the star uses up the hydrogen in its core and it turns into a red supergiant. The star continues to fuse atoms in its core into heavier and heavier elements until the core starts filling up with iron. Because the fusion process stops at iron, the core collapses under its own weight, no longer held up by the heat generated during fusion.

Supernova: An explosive shock wave and the energy generated from the core collapse starts moving outward, heating the surrounding layers of the star, and BOOM. Most of the star is blasted into space in a supernova explosion. On the diagram, the cycle continues from the supernova back into the cloud of gas and dust. This represents the recycling of the heavy elements created in the star and during the supernova explosion into the interstellar medium to provide the material to make new stars — and planets.

Neutron Star or Black Hole: After the explosion, the remaining core of the star turns into a neutron star or, if the core is more than three times the mass of the Sun, it turns into a black hole.

Which NASA missions study supernovae, black holes, and high-energy radiation from space?

Some of the NASA missions are:

GLAST: http://www.nasa.gov/glast

Swift: http://swift.gsfc.nasa.gov

Chandra: http://chandra.harvard.edu/

In collaboration with European Space Agency (ESA)
XMM-Newton: http://xmm.sonoma.edu

In collaboration with Japanese Aerospace Exploration Agency (JAXA)
Suzaku: http://suzaku-epo.gsfc.nasa.gov/

The Night Sky Network's International Year of Astronomy (IYA) Discovery Guides are supported and sponsored by these NASA Forums and missions:

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Special Advisor: Denise Smith
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Special Advisor: Michael Greene
NASA Lunar CRater Observation and Sensing Satellite (LCROSS)
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NASA Education Forum on Solar System Exploration
NASA Education and Public Outreach at Sonoma State University
NASA Goddard Space Flight Center Suzaku Mission E/PO Program
NASA's Kepler Discovery Mission

The Night Sky Network is a nationwide coalition of amateur astronomy clubs bringing the science, technology, and inspiration of NASA's missions to the general public.

We share our time and telescopes to provide you with unique astronomy experiences at science museums, observatories, classrooms, and under the real night sky.
http://nightsky.jpl.nasa.gov

The International Year of Astronomy (http://astronomy2009.us) aims to help citizens of the world rediscover their place in the Universe through the daytime and nighttime sky. Learn more about NASA's contributions to the International Year of Astronomy at http://astronomy2009.nasa.gov