National Aeronautics and Space Administration

SUPERNOVA!
Outreach ToolKit Manual

Distributed for members of the *NASA Night Sky Network*

The Night Sky Network is sponsored and supported by:

- **NASA Education and Public Outreach at Sonoma State University: GLAST, Swift and XMM-Newton missions:**
  http://www.nasa.gov/glast
  http://swift.gsfc.nasa.gov
  http://xmm.sonoma.edu
- **Suzaku Mission E/PO Program at NASA/Goddard Space Flight Center: http://suzaku-epo.gsfc.nasa.gov**
- **NASA's *Solar System Education Forum***
- **The SETI Institute under NASA Grant NAG 2-6066 for the *Kepler Mission***
- **JPL's** Exoplanet Exploration Program
- **NASA's *Origins Education Forum***

The Night Sky Network was founded by:

JPL's Exoplanet Exploration (*PlanetQuest*) public engagement program

NASA Night Sky Network: http://nightsky.jpl.nasa.gov/

Contacts

The non-profit Astronomical Society of the Pacific (ASP), one of the nation's leading organizations devoted to astronomy and space science education, is managing the Night Sky Network in cooperation with NASA and JPL. Learn more about the ASP at http://www.astrosociety.org.

For support contact:

Astronomical Society of the Pacific (ASP)
390 Ashton Avenue
San Francisco, CA 94112
415-337-1100 ext. 116
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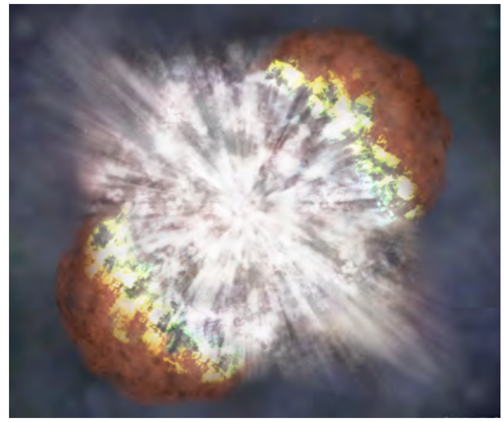
Introduction: SUPERNOVA!



A hundred years ago, we believed we lived in a quiet, safe universe. Today we know the universe is filled with powerful radiation and fast-moving atomic particles:

- Gamma-rays
- X-Rays
- Accelerated atomic particles (cosmic rays)

Much of which originates from

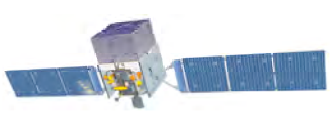
- monstrous black holes in the centers of galaxies
- from neutron stars with powerful magnetic fields
- and more commonly from . . . supernovae!

A massive star ends its life in a spectacular supernova explosion. High-energy radiation is generated from the intense heat and pressure that builds up during the star's core collapse and subsequent explosion. The power of the explosion provides the additional energy needed to convert huge numbers of atomic nuclei into elements heavier than iron, like copper, silver, and gold.

The intense shock wave from the supernova explosion blows what was left of the star and these newly-formed heavy atomic nuclei into space. A tiny fraction of these nuclei (a few times the amount of mass in the Earth) is accelerated to nearly the speed of light. These are called "cosmic rays."

Our eyes cannot detect this high-energy radiation. Furthermore, Earth's atmosphere and magnetic field prevent much of this radiation from reaching the surface. To overcome this problem, NASA places telescopes out in space, high above the Earth's atmosphere, in order to detect gamma rays, x-rays, and cosmic rays. The missions featured in this ToolKit are **Swift**, **GLAST** (Gamma-ray Large Area Space Telescope), **XMM-Newton** (a joint European Space Agency and NASA mission), and **Suzaku** (a joint Japanese and U.S. mission).

Supernovae liberate essentially all of the elements needed for life to exist. These include oxygen, carbon, iron, and sodium. Supernovae may seem dangerous, but a universe without supernovae would be a universe without life!



GLAST

Swift

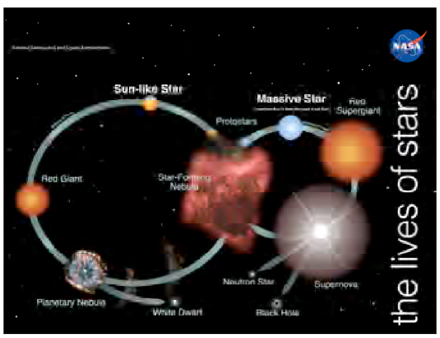
XMM-Newton

Suzaku

Summary of activities and resources:

The SUPERNOVA! ToolKit 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.

1. Media & Resources
   a) *PowerPoint: SUPERNOVA!*
   b) *Electromagnetic Spectrum poster*
   c) *Training DVD* is for training your club members on the ToolKit
   d) *Manual & Resources CD* contains the ToolKit Manual and a variety of other resources



2. Supernovae in the Lives of Stars
   a) *The Lives of Stars:* A banner and associated handout that gives an overview of the lifecycle of stars and which ones will go supernova.
   b) *Let's Make A Supernova!* Using balls, an activity that illustrates what happens when a star explodes.
   c) *Star Maps:* Stars likely to go Supernova!

3. Protecting Earth from Cosmic Radiation
   a) *Nuclear Fusion, Supernovae, and Cosmic Radiation:* Using marshmallows and macaroni, explain nuclear fusion and the radiation generated from a supernova explosion.
   b) *Protecting Earth from Cosmic Radiation:* An activity where visitors try to make cosmic radiation hit Earth's surface
   c) *Air as a Radiation Shield:* a quick demonstration of how our atmosphere protects Earth from x-rays and gamma-rays.
   d) *Gamma-Ray Bursts:* demonstrating the power of radiation concentrated into beams

4. A Universe Without Supernovae
   a) *A Universe Without Supernovae:* An activity where visitors discover the importance of supernovae in the universe.
   b) *Booklet & Poster: What is your Cosmic Connection to the Elements?* A reference for your club members.

In general, there are activities in this ToolKit appropriate for ages 10 to adult. Refer to each activity for guidance regarding age-appropriateness.

Thanks to the ToolKit Testers

NASA and the Astronomical Society of the Pacific (ASP) wish to thank the members of the astronomy clubs around the country who took the time and made the commitment to help develop and test these activities in a variety of settings and with a wide range of audiences. Their dedication and feedback helped to make this ToolKit appropriate and enjoyable for the members of the Night Sky Network.

Astronomy Club	State
Amateur Astronomers Association of Pittsburgh	PA
Astronomical Society of Kansas City	MO
Astronomical Society of Northern New England	ME
Astronomical Society of the Toms River Area	NJ
Barnard Astronomical Society	TN
Bucks-Mont Astronomical Association	PA
City Lights Astronomical Society for Students	TX
Mount Diablo Astronomical Society	CA
Norman North Astronomy Club	OK
North Houston Astronomy Club	TX
Space Science for Schools	NV
Statesboro Astronomy Club	GA
Tri-State Astronomers	MD
Warren Rupp Observatory	OH
Westminster Astronomical Society	MD

Ideas and Suggestions from the ToolKit Testers

Here are some comments from a few of the astronomy clubs who tested the SUPERNOVA! ToolKit in answer to the following questions.

"If you had just 2 minutes to tell someone in your club about this ToolKit, what would you say?"

Space Science for Schools
Here is a wonderful opportunity to present to the general public a topic area in which there is much misunderstanding and confusion. With a little bit of planning and rehearsal, you will sound like a pro, able to make a difficult subject very easy to conceptualize and understand. This kit is an excellent tool to introduce the great drama - the life and death of stars - that is being played out in our universe.

Statesboro Astronomy Club
There are some great hands-on activities that make some of the concepts easy to understand that otherwise might be hard to explain. It's great to have at any public event.

Mt. Diablo Astronomical Society
The creators of NASA's Night Sky Network have developed another great toolkit that will help others understand the universe we live in. Students of all ages will enjoy understanding how our atmosphere protects us from cosmic rays, gamma rays, and x-rays. But they'll be amazed when they learn what our universe would be like without supernovae!

Norman North Astronomy Club
This kit in particular focuses on the events of a large mass star which goes Supernova! And that is not the end of the story! What happens to these particles flung across the cosmos, the connection with the Periodic Table of the Elements, and the use of the electromagnetic spectrum is invaluable to discussing questions such as: Why does life exist here on Earth? What if supernova explosions didn't occur? What happens if some of this radiation is directed at the Earth?

Astronomical Society of Northern New England
This Supernova kit is jam packed with fun and exciting activities for ages 5-100. There's something for everyone from small groups to large. Make a supernova, watch one happening, demonstrate how Earth is protected, see how the elements for almost everything in the universe, including you, were forged in stars.

Astronomical Society of Kansas City
The kit contains some of the most fun and easy to use activities to demonstrate that we are "stardust" that I have ever used. Kids and adults enjoy playing with the demonstrations and don't even realize they are learning.

North Houston Astronomy Club
The public knows the term “Supernova" but they thirst for more information about what they are, what threats they pose, and where they might occur. This toolkit provides lots of information about the good, and the bad, of supernovae.

Westminster Astronomical Society
Would you have ever thought that you could learn how the Sun works, how true the phrase “from dust to dust” is, how well our planet protects us from the deadly skies, and have fun – all from one box.

“If you were to give advice to other clubs regarding this ToolKit, what would it be?”

Warren Rupp Observatory
The Supernova kit is an awesome tool, but please take the time to review the training video and manual before presenting. While some of it is very intuitive, it also contains a lot of material and new ways of presenting information we understand – but rarely have the opportunity to expand on.

City Lights Astronomical Society for Students
Have fun, bring in the kids, let them "play" with it. They will learn if you bring it down to their age levels. Try not to be very technical with kids.

Norman North Astronomy Club
Have enough tennis and ping-pong balls for everyone to create the SUPERNOVA explosion. It is most effective and they really get the idea if they can all participate at the same time.

Astronomical Society of Kansas City
This kit is excellent to use both indoors and out. Activities from this kit can be used to fill the time when waiting for it to get dark at star parties and can serve as a transition into tours of the stars and constellations, during which you can point out examples of stars in various stages of evolution.

Space Science for Schools
I especially like this kit since it is a near perfect lead in for the Night Sky Network Black Hole kit.

Keep the kids motivated by activity. The marshmallow fusion game really works. Maybe the extra sugar does the trick!

Westminster Astronomical Society
Make a game with as many of the activities as you can. The people will have fun – almost as much fun as you will.

Astronomical Society of Northern New England
The PowerPoint is a great starting point from which you can add different activities. You are going to LOVE this toolkit!!

Media & Resources

The "Media and Resources" bag includes:

- The Manual and Resources CD
- The Training Video as a DVD

In the ToolKit box:

- Poster: The Electromagnetic Spectrum

The "Training Video DVD" should be viewed as soon as you receive the ToolKit. This will provide an introduction to the activities and materials.

Explore the "Manual and Resources CD":

- For the **Supernova ToolKit Manual**, open the file: "**0SNManual.pdf**." This file is the "SNManual.pdf" referred to in the documentation and on the Training DVD. **You need the free Adobe Acrobat Reader to view the manual: http://www.adobe.com/products/acrobat/readstep2.html.**

- The **"Addl_Resources" folder contains:**
  - *"ElementsOfLifeArticles.pdf"* is a PDF that contains two articles from Sky & Telescope magazine, providing additional background on the fusion process and what happens during a supernova.
  - *"CosmicConnection.pdf"* is a PDF that is the electronic version of the booklet "What is your Cosmic Connection to the Elements?" found with the activity "A Universe without Supernovae."
  - *"SNStars.xls"* is a Microsoft Excel file listing the stars likely to go supernova at the end of their lives. This is discussed in the activity, "Supernovae in the Lives of Stars."

- The **"Banner_Artwork" folder contains:**
  - *"LivesOfStarsDiagram.pdf"* is a PDF that can be used by a printing company to make additional copies of the Lives of Stars banner.
  - *"TableOfElements.pdf"* is a PDF that can be used by a printing company to make additional copies of the Table of Elements banner.

- The “**LogosLabels**” **folder** contains labels and logos associated with this ToolKit, which includes the following:

    - The logo for the ToolKit as a jpeg file, “*SNLogo.jpg*”.
    - A PDF file “*CDDVDlabels.pdf*” to make labels for any additional DVDs and CDs that you choose to copy. Formatted for printing on Avery labels 5931 and 8692.
    - A PDF file for the ToolKit Box labels, “*SNBoxLabel.pdf*”. These are 3-1/3” x 4” labels. Formatted for Avery label 5524.
    - A PDF file named “*MiscLabels5160.pdf*” that contains the labels for the various bags in the ToolKit along with the labels for the telescopes in the activity, “Protecting the Earth from Cosmic Radiation.” These are formatted for Avery Labels 5160.

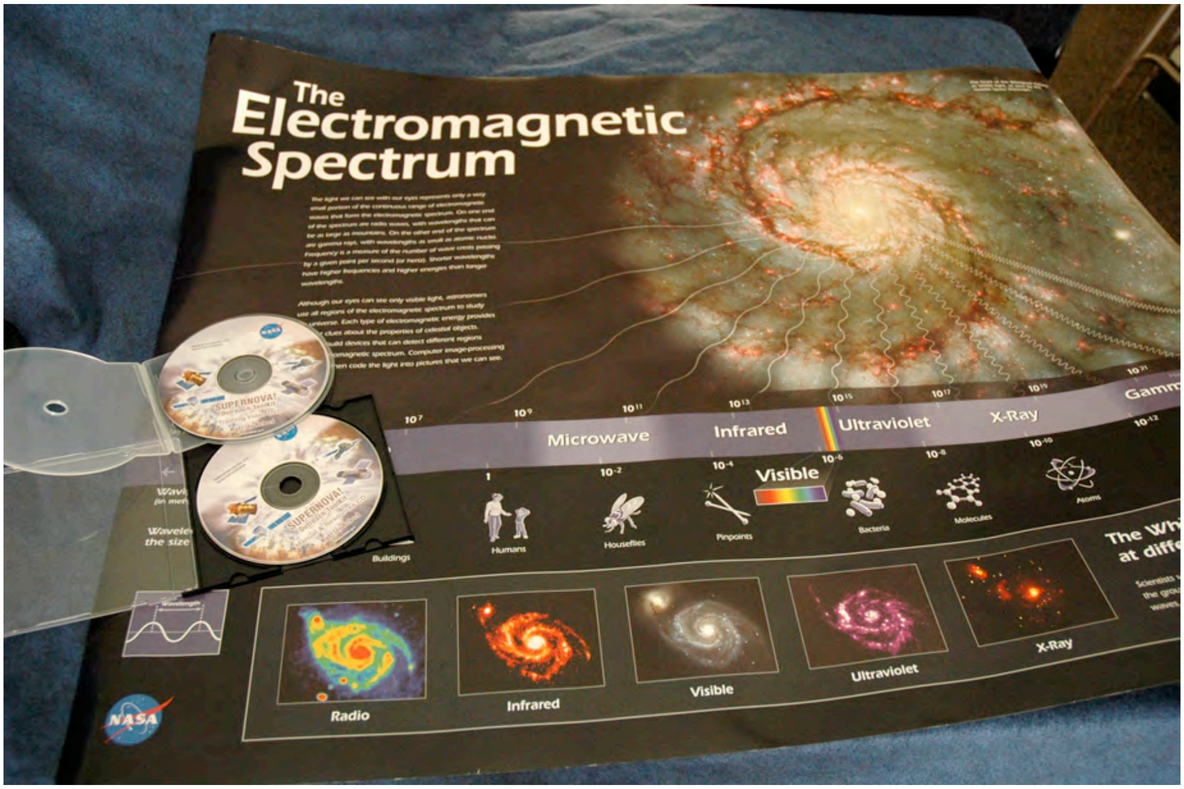
- The **“PowerPoint” folder contains**:

    - The **PowerPoint “SUPERNOVA!”**, and its suggested script. The script is “SupernovaPPTScript.doc” and as a PDF: “SupernovaPPTScript.pdf”. There are two PowerPoint files. The one formatted for a PC (Microsoft Windows) is “***SupernovaPC.ppt***.” The one formatted for a Mac (Apple) is “***SupernovaMAC.ppt***.” This PowerPoint provides an overview of the topics covered in the ToolKit and can be used as an introduction to any of the activities. The PowerPoint is recommended for 7^{th} grade to adult.
    - The **movie of the supernova** used in the PowerPoint. There are two versions: one for Windows Media Player: ***classic_supernovaWin.wmv,*** and one for QuickTime: ***classic_supernovaQT.mov.*** In case you have a problem running the movie in the PowerPoint, you can run it separately. You will need **Windows Media Player** or **QuickTime Player** to play the video.
    - **PPT_README.pdf** file provides more information about the movies and the PowerPoint.

The handouts for the activities can be found in 0SNManual.pdf so you can personalize them with your club information and print out copies for your guests and other club members. This manual also includes sources where you can get more materials.

The poster “**The Electromagnetic Spectrum**” provides additional information about the highest energy radiation: gamma-rays and x-rays, and where it appears in the electromagnetic spectrum. You may want to laminate the poster or mount it on posterboard for durability.

Feel free to make copies of the **Training DVD** and **Manual & Resources CD** for distribution to other club members or educators. All materials must be provided free or at your cost.



Materials for Media & Resources

Copies of the **Training DVD** and **Manual & Resources CD** can be made at your local photo center or other media duplication service.

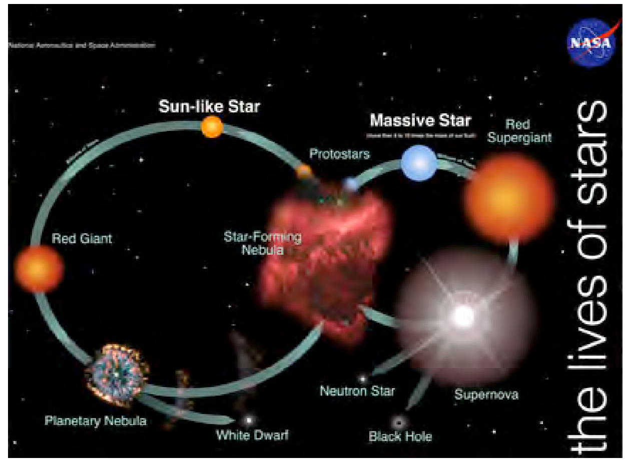
The **Electromagnetic Spectrum Poster** can be requested from the Office of Public Outreach, Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218. You may want to laminate the poster or mount it on posterboard for durability.

WHERE COULD I USE THE RESOURCES INCLUDED HERE?

MEDIA / RESOURCE	Pre-Star Party –Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)
			K-4	5-8	9-12		
PowerPoint: SUPERNOVA!	√	√		√	√	√	√
Electromagnetic Spectrum Poster	√	√		√	√	√	√
Training DVD						√	
Manual & Resources CD						√	

Supernovae in the Lives of Stars

What's this activity about?



Big Questions:

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

Big Activities:

- **The Lives of Stars:** Overview of the lifecycle of stars and which ones will go Supernova.
- **Let's Make A Supernova!** Using balls, an activity that illustrates what happens when a star explodes.
- **Supernova Star Maps:** Find stars in the night sky likely to go supernova!

Participants:

From the club: A minimum of one person.

Visitors: Activities are appropriate for families with children over the age of 9, the general public, and school groups in grades 5 and up. Any number of visitors may participate.

Duration:

- The Lives of Stars: 5 – 10 minutes
- Let's Make A Supernova: 2 – 5 minutes
- Star Maps: Which Stars will go Supernova: A few minutes, up to 20 minutes, depending on the length of the discussion about the questions on the Supernova Information Sheet.

Topics Covered:

- The lifecycle of stars like our Sun compared to massive stars
- Stages in the lives of stars
- The fate of our Sun
- Why supernovae happen
- Observation of stars that will one day go supernova

WHERE COULD I USE THIS ACTIVITY?

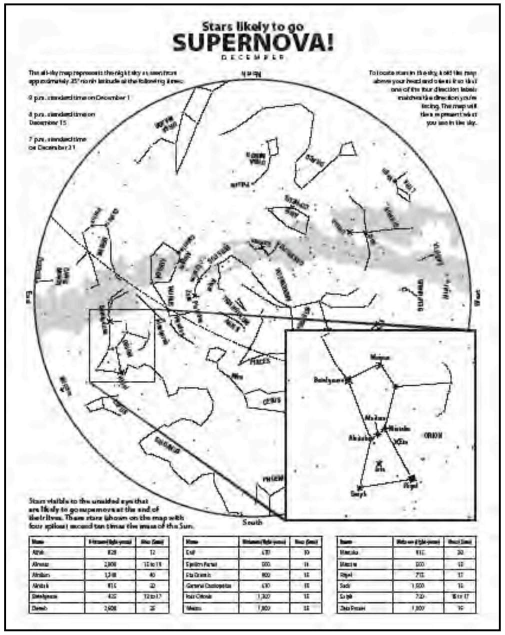
ACTIVITY	Star Party	Pre-Star Party –Outdoors	Pre-Star Party –Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
1. The Lives of Stars		√	√	√		√	√	√	√	√
2. Let’s Make a Supernova		√	√	√		√	√	√		√
3. Star Maps: Stars likely to go Supernova!	√	√	√							√

WHAT DO I NEED TO DO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Optional: Additional tennis balls and ping-pong balls.	*Optional:* Salad macaroni (uncooked)	Make needed copies of handouts

Helpful Hints

SUPERNOVA Star Maps:



The star map (left) is marked with the brightest stars that are likely to one day go supernova. These stars are shown on the map with four spikes. These are all the stars that are:

- 3rd magnitude or brighter
- visible from the continental United States
- with at least 10 times the mass of our Sun

Many sources state that stars more than 8 solar masses will go supernova. This limit is somewhat uncertain, but choosing stars that have more than 10 times the mass of the Sun pretty much guarantees that they will go supernova.

On the reverse side of the star map is the Supernova Information Sheet (right) with a list of common questions people ask about supernovae. There is a place at the bottom for you to insert your club information.

There is an Excel spreadsheet on the Manual & Resources CD that lists all these stars with all their particulars. The file is called "**SNStars.xls**." *Source: http://www.astro.uiuc.edu/~kaler/sow/sowlist.html. The table is reproduced here:

Potential Supernovae Candidates (naked eye - brighter than 3rd mag								
VISIBLE FROM Continental USA - evening	COMMON NAME	Astronomical Name	CONSTELL-ATION	Mass (solar masses) Per Kaler*	DIST (Light Years)	Apparent Magnitude	How soon will star go supernova?	CLASS
Nov-Apr	Almaaz	Epsilon Aur	Auriga	15 to 19	2000?	3.03		A9 Iae + B
Jan-Apr	Mirzam	Beta CMa	Canis Maj	15	500	1.98		B1II-III
Jan-Apr	Aludra	Eta CMa	Canis Maj	15	3200	2.45		B5Ia
Jan-Apr	Wezen	Delta CMa	Canis Maj	17	1800	1.84		F8Iab
Jan-Apr	Adhara	Epsilon CMa	Canis Maj	10 to 12	430	1.5		B2II
Jul-Apr (yr round above 35 N)	Gamma Cas	Gamma Cas	Cass	15	610	2.47		B0IVpe
May-Jan (yr round above 35 N)	alfirk	beta Cep	Cepheus	12(?)	820	3.23		B1 III
Jun-Jan	Deneb	Alpha Cyg	Cygnus	25	2600	1.25		A2Ia
Jun-Jan	Sadr	Gamma Cyg	Cygnus	12(?)	1500	2.2		F8Ib
May-Oct	Zeta Oph	Zeta Oph	Ophiuchus	20	460	2.56		O9.5V
Dec-Apr	Nair al Saif	Iota Ori	Ori	15	1300	2.77		O9III
Dec-Apr	Rigel	Beta Ori	Ori	17	775	0.12		B8Iab
Dec-Apr	Meissa	lambda Ori	Ori	25	1000	3.39		O8 IIIf
Dec-Apr	Alnilam	Epsilon Ori	Ori	40	1340	1.7		B0Ia
Dec-Apr	Betelgeuse	Alpha Ori	Ori	12 to 17	425	0.7	could go anytime; would be bright as crescent moon	M2Iab
Dec-Apr	SAIF AL JABBAR (dbl)	eta Ori	Ori	15 (primary) and 9	900	3.35		B0.5 V + B
Dec-Apr	Saiph	Kappa Ori	Ori	15 to 17	720	2.06		B0.5Ia
Dec-Apr	Alnitak (dbl star)	Zeta Ori	Ori	20 (primary) and 14	815	1.74		O9.5Ibe+B0III
Dec-Apr	Mintaka	Delta Ori	Ori	20+	915	2.23		B0III+O9V
Jul-Jan	Enif	Epsilon Peg	Peg	10	670	2.39		K2Ib
Oct-Mar	epsilon Per	epsilon Per	Perseus	14	500	2.9		B0.5 IV
Oct-Mar	zeta Per	zeta Per	Perseus	19	1000	2.84		B1 Ib
Y- Mar-Apr	Naos	Zeta Pup	Puppis	60	1400	2.25		O5Ia
Y- Mar-Apr	Pi Puppis	Pi Puppis	Puppis	13 to 14	1100	2.71		K3 Ib

May-Sep	Graffias	Beta Sco	Sco	10	530	2.5		B1V+B2V
May-Sep	Kappa Sco	Kappa Sco	Sco	10.5	450	2.41		B1.5III
May-Sep	Shaula	Lambda Sco	Sco	11	365	1.63		B1.5IV+B2
May-Sep	pi Sco	pi Sco	Sco	11	500	2.89		B1V+B2V
May-Sep	Dschubba	Delta Sco	Sco	12	400	2.32	could go in 10 to 15 million yrs	B0.3IV
May-Sep	al niyat (tau)	tau Sco	Sco	12	400	2.82		B0 V
May-Sep	Iota-1 Sco	Iota-1 Sco	Sco	12	4000?	2.99		F2 Ia
May-Sep	al niyat (sigma)	sigma Sco	Sco	12 to 20	520	2.91		B1 III
May-Sep	Antares	Alpha Sco	Sco	15 to 18	600	0.96	could go anytime in the next million yrs inc. today	M1.5Ib
Mar-Aug	Spica	Alpha Vir	Vir	11	260	1.04		B1III-IV+B2V

Background Information

The SUPERNOVA! ToolKit 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.

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

For general information on high-energy radiation, this site has a number of links:
http://imagine.gsfc.nasa.gov/docs/science/

These websites explain the physics behind the "Let's Make a Supernova" activity with the tennis ball and ping-pong ball:
http://chandra.harvard.edu/edu/formal/demos/ejection.html

http://www.bu.edu/gk12/kelly/momentum%20demo.htm

Detailed Activity Descriptions

1. The Lives of Stars

<table>
<tr><td>Leader's Role</td><td>Participants' Role (Anticipated)</td></tr>
<tr><td colspan="2">Materials: "The Lives of Stars" banner and handouts with description of lifecycles on the back. (Note that the "Lives of Stars" Handout has two choices: one with a dark background and one with a white background. The reverse side also has two choices: one with a blank space at the bottom and one where you can type in your club information at the bottom before making copies. See pages 32 to 35)</td></tr>
<tr><td colspan="2">Objective:
Allow visitors to discover the lifecycle of stars and when supernovae happen.</td></tr>
<tr><td><u>To say:</u>
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?

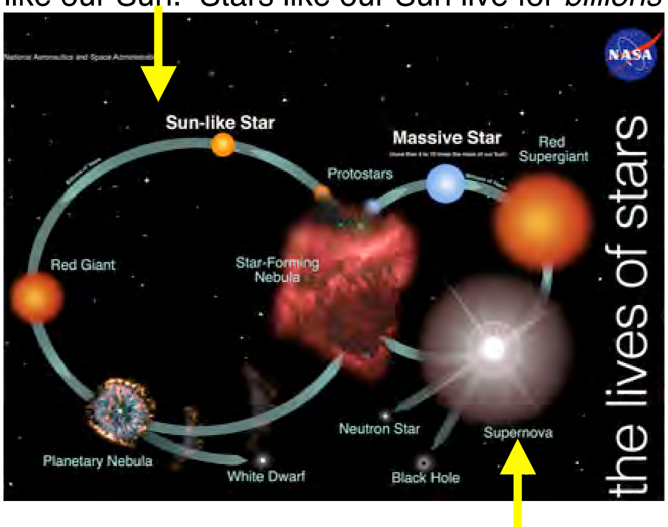
Well, they are all different stages in the life of a star.
Let's see what that means.

<u>To do:</u>
Show lifecycle banner.
Pass out handouts.</td><td>
Hands go up.

Huh?

They are all different kinds of things in the universe.</td></tr>
<tr><td colspan="2">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.</td></tr>
</table>

<table>
<tr><th>Leader's Role</th><th>Participants' Role (Anticipated)</th></tr>
<tr><td><u>To say:</u>
[referring to banner] 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.

<u>To do:</u>
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 34). The steps are printed on the reverse side of the handouts.</td><td>Types of stars?

Discuss.</td></tr>
<tr><td colspan="2">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 banner 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.</td></tr>
<tr><td><u>To Do:</u>
You might want to use the activity "Let's Make A Supernova" as part of your discussion.</td><td></td></tr>
</table>

Leader's Role	Participants' Role (Anticipated)
To Say: So will our Sun go supernova? Why not?	 No! It'll turn into a white dwarf – it's not big enough to explode.
Optional: If a telescope observing session follows the presentation: *To Say:* 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!"

2. *Let's Make a Supernova!*

<table>
<tr><th>Leader's Role</th><th>Participants' Role (Anticipated)</th></tr>
<tr><td colspan="2">Materials: Tennis balls and ping-pong balls.
Optional: Wooden spools (or uncooked salad macaroni) representing gamma-rays. Salad macaroni is preferred in this activity since you might lose the wooden gamma-ray models in an outdoor or cluttered environment.
<u>NOTE:</u> This must be done on a hard surface, like a bare floor or in a parking lot. Heavily carpeted floors or grass lawns don't work as well.</td></tr>
<tr><td colspan="2">Objective: Allow visitors to understand what happens during a supernova.</td></tr>
<tr><td><u>To do:</u>
Hand out one tennis ball and one ping-pong ball to each person.
<u>To say:</u>
Each of these large balls represents a small part of the core of the star – where all the fusion is taking place. The small ball represents the outer layers of the atmosphere of the star.
Let's imagine we are all inside of a massive star, holding a part of the core [indicate the tennis ball] and a part of the outer layers [indicate the ping-pong ball].
<u>To do:</u>
Start tossing one of the balls up in the air and catching it when it comes back down.
<u>To say:</u>
Everyone toss up one of the balls [this is easier with the tennis ball]. As long as you keep pushing a ball up, it will stay in the air. What happens if you stop pushing?

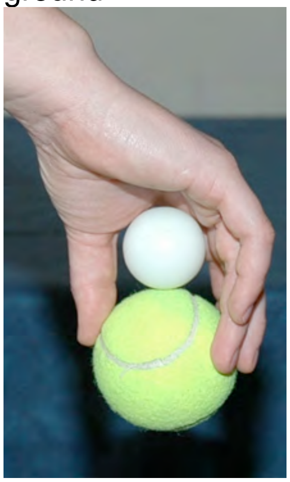
<u>To do:</u>
Allow ball to drop.</td><td>Oh! These are hot!

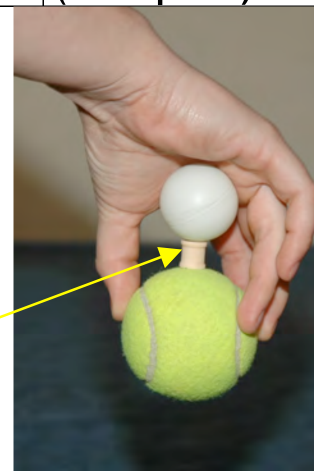
(tosses balls)

It falls.</td></tr>
</table>

Leader's Role	**Participants' Role (Anticipated)**
To say: You are using energy to push the ball up. What's making the ball come back down? *To do:* Continue tossing. *To say:* Same kind of thing happens inside a star. The heat generated by fusion in the core creates pressure which pushes out on the rest of the star. What happens if the core stops generating heat? *To say:* Right! Let's imagine we're all standing inside of a massive star. In its core the star continues to fuse atoms into heavier and heavier elements – hydrogen to helium to carbon to silicon – generating lots of heat until we get to … iron. Because the fusion process stops at iron, the core stops generating heat. Then the core collapses under its own weight. And the outer layers start falling in and then . . . let's see what happens! Ready to make a supernova?	Gravity! Gravity takes over. YEAH!

Group counting down, ready to drop the balls and "make a supernova."

Leader's Role	**Participants' Role (Anticipated)**
To do: Hold the small ball on top of large ball about 2 to 3 feet above the ground  **One-handed hold** **(Leave a little space between your hand and the ping-pong ball so it doesn't stick to your palm.)**  **Two-handed hold**	
To say: Hold the parts of the star together – your part of the outer layers above your piece of the core [the small ball on top of the bigger ball]. I'll count down and we'll all let go of both balls at once and shout "SUPERNOVA!" Ready? 3, 2, 1 …	
To do: Drop both balls at once.	SUPERNOVA! Balls drop,
To say: SUPERNOVA! What happened?	The ping-pong balls went flying.
Yes! 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.	
Would you like to see stars in the sky that are likely to go supernova at the end of their lives?	YES!

Leader’s Role	Participants’ Role (Anticipated)
Alternate Presentation: To include the idea of the gamma-rays (and other radiation) generated by the tremendous heat of the supernova explosion, place one of the short spools (or salad macaroni) representing a gamma-ray in between the tennis ball and the ping-pong ball, then let go of all three at once. **Spool representing gamma-ray**  The spools are in the “Models for Cosmic Radiation” bag. See the activity “Protecting Earth from Cosmic Radiation.”	

Presentation Notes:

During core collapse, the core of the star (assuming that it is not massive enough to continue the collapse all the way to form a black hole) changes from a diameter of about 10,000 km (6,000 miles) to about 20 km (12 miles) – there is no longer any energy being generated to hold it up. Both the core and the outer layers of the star fall inward. During core collapse, the electrons and protons in the core of the star become so tightly packed that they interact to form neutrons (this is why, in this case, the remaining core of the star after the explosion is called a neutron star). Neutrinos are released from this process.

The core collapse stops when the neutrons can’t be packed any more tightly. In this demonstration, the floor represents the point at which this happens. When the collapse stops, all the material falling in will bounce back out. There's a momentum transfer from the denser material of the core (represented by the tennis balls) to the lighter material of the outer layers (represented by the ping-pong balls).

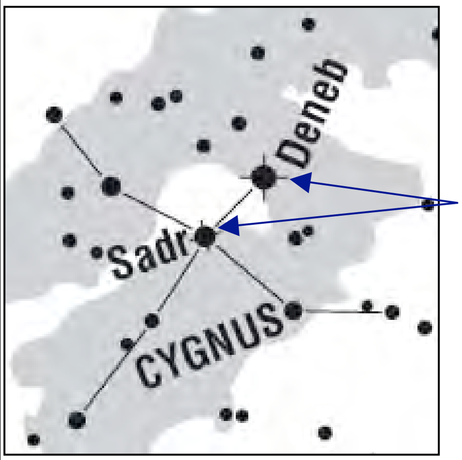
After your visitors make the supernova once (or twice) you might also have them imagine everyone on earth doing it, to get across the idea that the explosion is spherical.

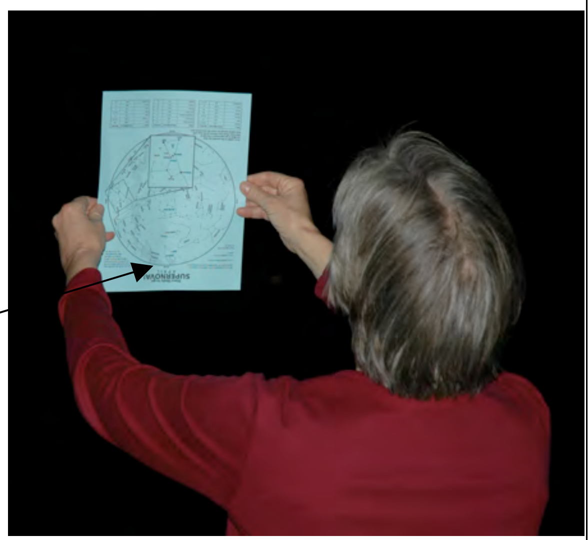
Actually, nature is a bit more complicated and the exact mechanism that causes the star to expel its outer layers violently is not completely understood. It is thought that some fraction of the copious neutrinos that are produced during core collapse are absorbed by the infalling outer layers, heating it and blasting the star's outer parts into space. The details of this mechanism are still uncertain however.

Leader's Role	Participants' Role (Anticipated)
To imagine the dimensions of the star and its core: The star has become a red supergiant star prior to going supernova. Imagine Betelgeuse, which is roughly 900 million km in diameter, shrunk down so it would fit in the Pacific Ocean. The diameter of this red supergiant compared to the size of its core (before collapse) is about 100,000 to 1. Betelgeuse's core would fit inside a football stadium. During core collapse, its core would shrink to be 500 times smaller. So its core would collapse from the size of a football stadium to about the size of a basketball. And then: SUPERNOVA!	

There go the outer layers of the star! The core collapse of the star stops when the neutrons can't be packed any more tightly. In this demonstration, the sidewalk represents the point at which this happens. When the collapse stopped (when the tennis balls hit the sidewalk), all the material falling in (the ping-pong balls) bounced back out. There's a momentum transfer from the denser material of the core (represented by the tennis balls) to the lighter material of the outer layers (represented by the ping-pong balls).

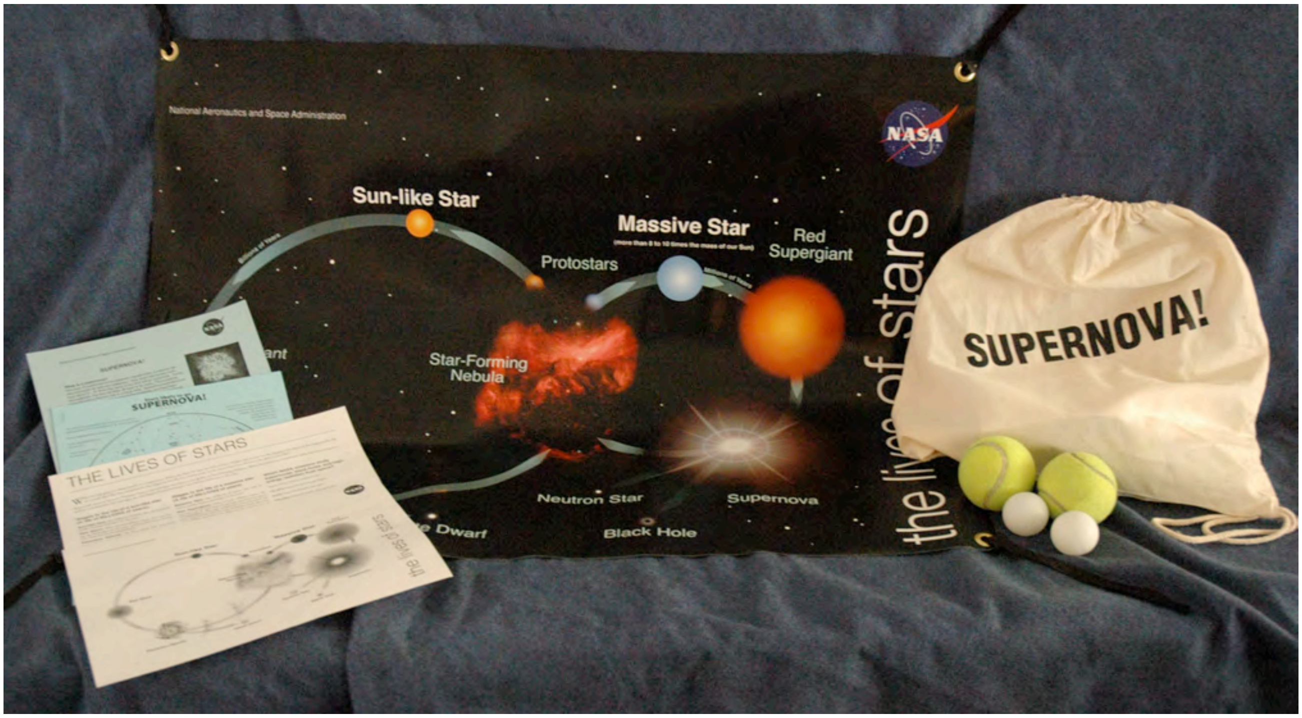
3 . Star Maps: Stars likely to go Supernova!

Leader's Role	Participants' Role (Anticipated)
Materials: Star Map with Supernova Information sheet on back	
Objective: Allow visitors to experience finding stars in the night sky that will eventually go supernova.	
To do: Pass out star maps with supernova information sheet on the back.  *To say:* Look on the side with the star map. It is marked with the brightest stars that will one day go supernova. These stars are marked with four spikes. It may look like a lot of the stars will go supernova. But we need to remember that we can only see the biggest and brightest of all the stars out there. Over 85% of the stars in our galaxy are small stars – stars like our Sun or smaller. But the stars are so far away that we can only see the brightest ones without a telescope. And the brightest stars also tend to be the most massive stars – the ones much more massive than our Sun. And it's the most massive stars that will go supernova.	Wow! There's a lot.
To say (if you'd like to use an analogy) It's like looking up at a commercial airplane, flying overhead at cruising altitude (about 7 miles or 11 km up). Do you see any lights on the airplane? Yes, the bright lights the airplane has on its wings and body. What lights wouldn't you be able to see? Would you see the light coming from the windows of the airplane? Light from the cockpit where the pilots are? Why not? It's the same with the stars. There are many more smaller, dimmer stars than there are bright stars, we just can't see them without a telescope.	Yes. White, red and green lights. Some are flashing. No. No! Too far away, too dim.

Leader's Role	**Participants' Role (Anticipated)**
To say: Let's look at the information on the other side. The next one to go is probably Betelgeuse or Antares – they could go anytime: tomorrow or a million years from now. Both are over 400 light years away. They would look really bright and would probably even be visible during the day. But they are too far away to affect us. Only a supernova happening within about 30 light years could damage life on Earth. For the rest of the marked stars, it'll be at least a few million years before they explode. Let's find a few of these stars in the sky. *To do:* Use the star maps and point out the stars that are likely to go supernova.	Someone may ask: "When will these stars blow up?"
To Do: You may want to provide a quick training on how to use a star map. *To Say:* Road maps are read with the map oriented down, where the roads are. A star map is oriented up, where the stars are. Let's all face north. Rotate your star map so the side of the map marked "North" is down toward the northern horizon. All the constellations in that quarter of the map will be visible in front of you.  Now let's turn toward the east. Rotate the map so the side of the map marked "East" is down toward the eastern horizon. All the constellations in that quarter of the map will be visible in front of you.	Visitors follow directions.

Leader's Role	**Participants' Role (Anticipated)**
To Say: Now look straight up. What part of the map will show the stars over your head? Right! Now, who can find [name a constellation]?	 The center of the map? Visitors use star map.

Materials



<u>What materials from the ToolKit do I need?</u>

In the activity bag:

1. Copies of the star lifecycle handouts, "The Lives of Stars" (Examples are the activity bag)
2. Copies of the Star Map handouts, "Stars Likely to go Supernova," with the Supernova Information Sheet on the back (Examples are the activity bag)
3. Velcro® straps

In the ToolKit Box:

4. Star lifecycle banner titled "The Lives of Stars" with the "Table of Elements" on the back. See photo at right.

Assembled into a drawstring bag labeled "SUPERNOVA!":

5. Tennis Balls
6. Ping-pong balls

<u>What must I supply?</u>

- *Optional:* Additional ping-pong and tennis balls

What do I need to prepare?

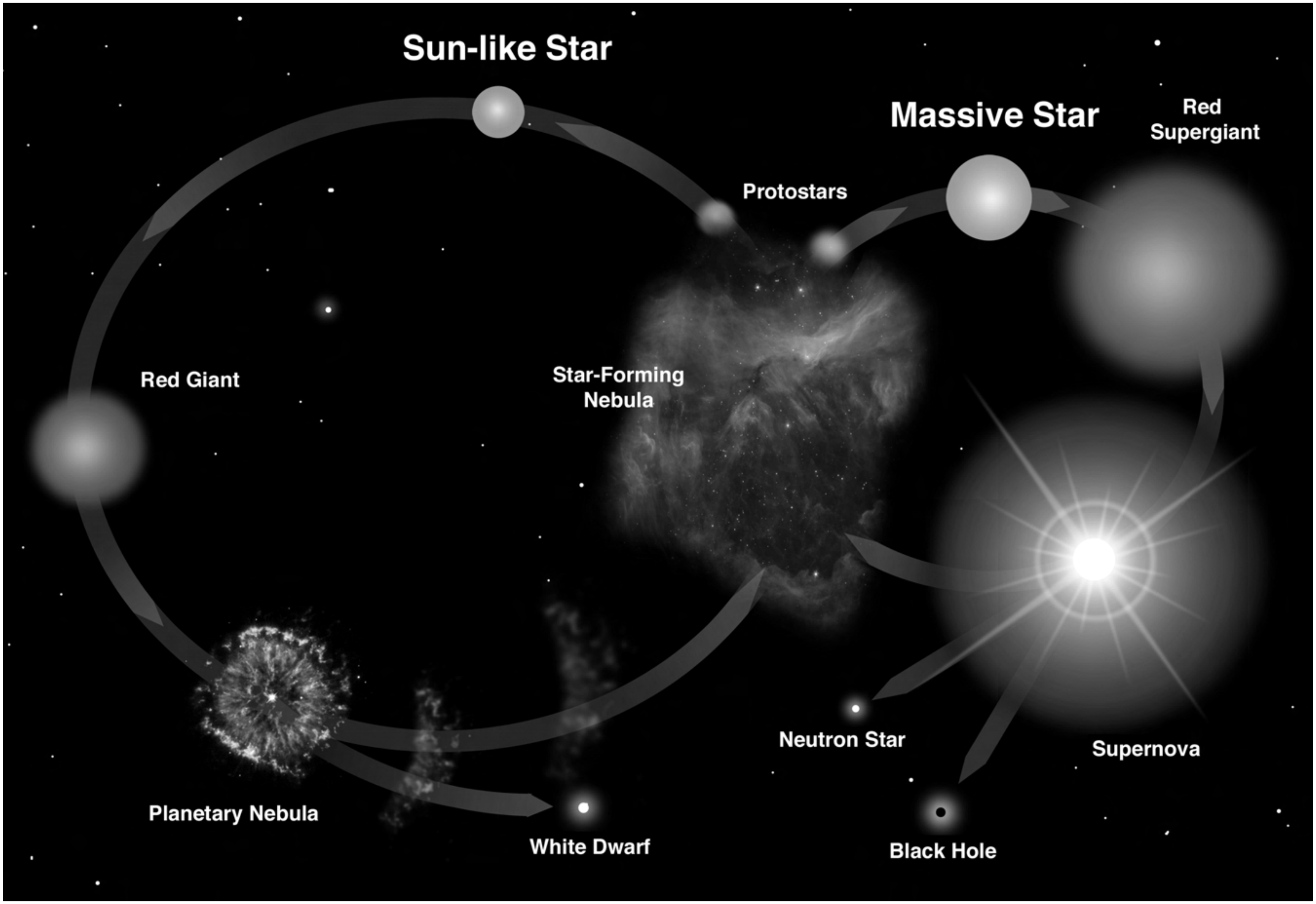
Attach Banner straps:

- Attach the Velcro® straps to the grommets on the banner as show at right.

- *Optional:* Enter your club information on the Lives of Stars handouts and on the Supernova Information Sheet handouts before making copies

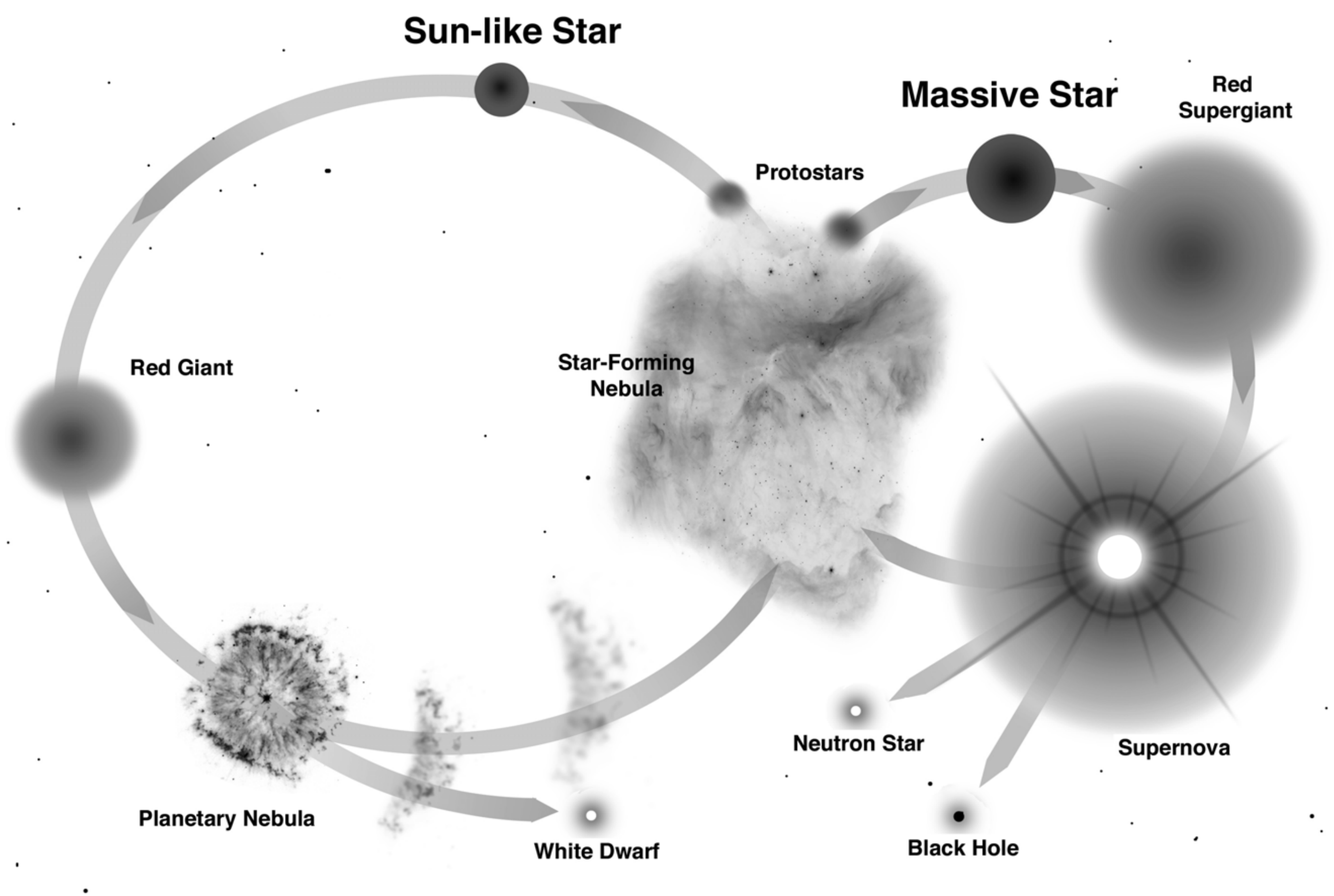
Where do I get additional materials?

1. Star lifecycle handouts (2-sided): print from the masters starting on page 32. Note that the masters gives you two choices for the front of the handout: one with a black background and one with a white background (to save on ink). The reverse side also has two choices: one with a blank space at the bottom and one where you can type in your club information at the bottom before making copies.
2. Star Maps with Supernova Information Sheet: print the Star Maps from the masters starting on page 38 and the Supernova Information Sheet on pages 36 and 37. The Supernova Information Sheet has two choices: one with a blank space at the bottom and one where you can type in your club information at the bottom before making copies.
3. Velcro® straps: office supply store
4. Star lifecycle banner: The PDF for the banner is on Manual and Resources CD in the "Banner_Artwork" folder. The file is "LivesOfStarsDiagram.pdf." You may have a full-size banner or poster made from this file at a copy store or other printing company.
5. Table of Elements banner: The PDF for the banner is on Manual and Resources CD in the "Banner_Artwork" folder. The file is "TableOfElements.pdf." You may have a full-size banner or poster made from this file at a copy store or other printing company. Table of the Elements posters are also available commercially. Search the Internet for "Periodic Table" or "Table of Elements".
6. Tennis Balls: Ask a tennis pro or members of a tennis club for used tennis balls.
7. Ping-pong balls: sporting goods store.



the lives of stars

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/

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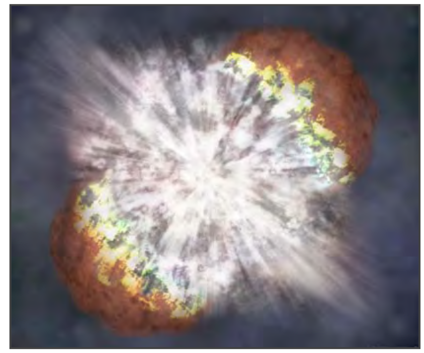
XMM-Newton: http://xmm.sonoma.edu

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

Click here and enter Club Name and up to 2 other lines of information;
Print and make copies.

National Aeronautics and Space Administration

SUPERNOVA!



What is a supernova?

One type of supernova is the explosion caused when a massive star (more than about 8 to 10 times the mass of our Sun) exhausts its fuel and collapses. During the explosion, the star will blow off most of its mass. The remaining core will form a neutron star or a black hole. Supernova explosions are among the most energetic events in the Universe, and they forge elements such as calcium, silver, iron, gold, and silicon. The supernova explosion scatters the elements out into space. These are the elements that make up stars, planets, and everything on Earth – including us!

Will our Sun go supernova?

No, smaller stars like our Sun end their lives as dense hot objects called white dwarfs. Only stars that contain more than about 8 to 10 times the mass of our Sun will go supernova.

Why do massive stars go supernova?

A star's core is an element factory. It fuses atoms into heavier and heavier elements, all the while producing energy, until it reaches iron. Iron is the end of the line for fusion. When the core is finished producing iron it has no way to keep producing energy. This causes gravity to take over and the core begins to collapse. The atoms smash into each other, forming neutrons. The collapse stops when the neutrons can't be packed together any more tightly. This sudden stop and, the energy released from forming neutrons, causes a shock wave to travel outward, blasting most of the star into space. If the star is very massive nothing can stop the collapse of the core and a black hole is created.

If a star goes supernova near us, is it dangerous?

Yes it would be. Fortunately, there are no stars likely to go supernova that are near enough to be any danger to Earth. Distance is important because the closer the supernova explosion, the more cosmic radiation would reach us. Even if Earth's atmosphere and surrounding magnetic field protect us, an explosion closer than 30 light years would overwhelm this protection. The nearest stars likely to go supernova within the next few million years are Betelgeuse and Antares. Both are over 400 light years away, far more than the 30 light years at which the explosion could become dangerous. Another VERY massive star, Eta Carinae, visible in the southern hemisphere, could go even sooner. But it is 7,500 light years away.

What's a GRB?

Gamma-ray bursts (GRBs for short) are bursts of very high-energy radiation in space. Thanks to NASA missions, astronomers know there are different kinds of GRBs. One kind is produced in supernova explosions where most of the gamma-ray energy is focused into narrow beams. Because the energy is concentrated in these beams, if one of the beams pointed in the direction of Earth, they appear brighter when we detect them (think of the difference between a 100-watt light bulb and the focused energy of a 100-watt metal cutting laser pointed at you!). GRBs have been detected in very distant galaxies, more than a billion light years away, too far away to harm us here on Earth. That distance is like that same laser placed more than twice the distance of the Moon away from you.

Some of the NASA missions that study supernovae and high-energy radiation from space:
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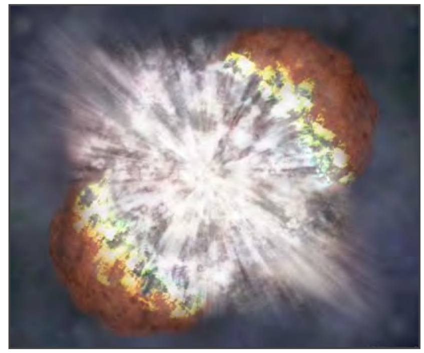
For more information on supernovae and high-energy radiation: http://imagine.gsfc.nasa.gov/docs/science/

National Aeronautics and Space Administration

SUPERNOVA!



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For more information on supernovae and high-energy radiation: http://imagine.gsfc.nasa.gov/docs/science/

Click here and enter Club Name and up to 2 other lines of information;
Print and make copies.

Stars likely to go

SUPERNOVA!

JANUARY

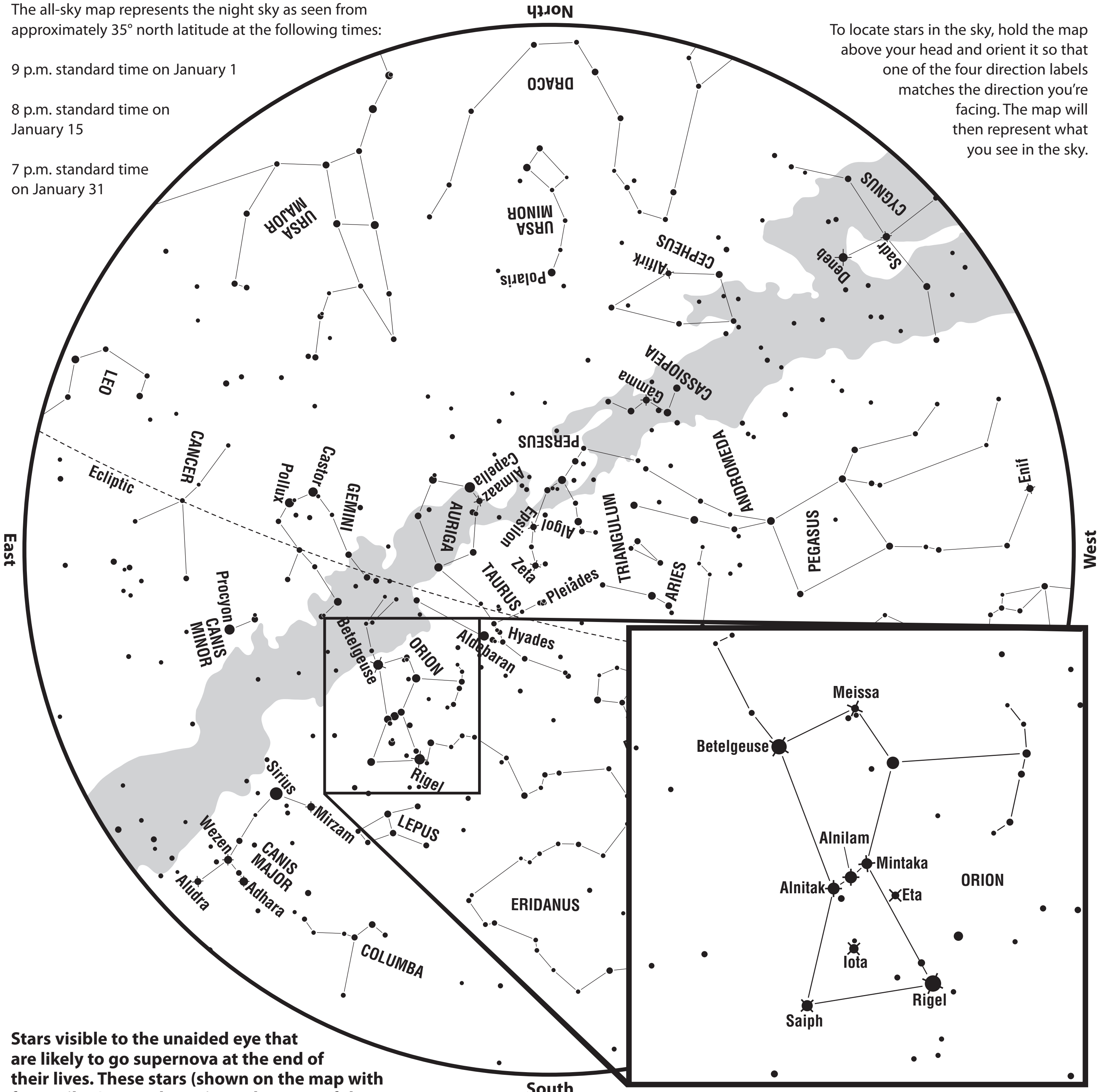
The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

9 p.m. standard time on January 1

8 p.m. standard time on January 15

7 p.m. standard time on January 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Stars visible to the unaided eye that are likely to go supernova at the end of their lives. These stars (shown on the map with four spikes) exceed ten times the mass of the Sun.

Name	Distance (light-years)	Mass (Suns)
Adhara	430	10 to 12
Alfirk	820	12
Almaaz	2,000	15 to 19
Alnilam	1,340	40
Alnitak	815	20
Aludra	3,200	15
Betelgeuse	425	12 to 17

Name	Distance (light-years)	Mass (Suns)
Deneb	2,600	25
Enif	670	10
Epsilon Persei	500	14
Eta Orionis	900	15
Gamma Cassiopeiae	610	15
Iota Orionis	1,300	15
Meissa	1,000	25

Name	Distance (light-years)	Mass (Suns)
Mintaka	915	20
Mirzam	500	15
Rigel	775	17
Sadr	1,500	12
Saiph	720	15 to 17
Wezen	1,800	17
Zeta Persei	1,000	19

Stars likely to go

SUPERNOVA!

FEBRUARY

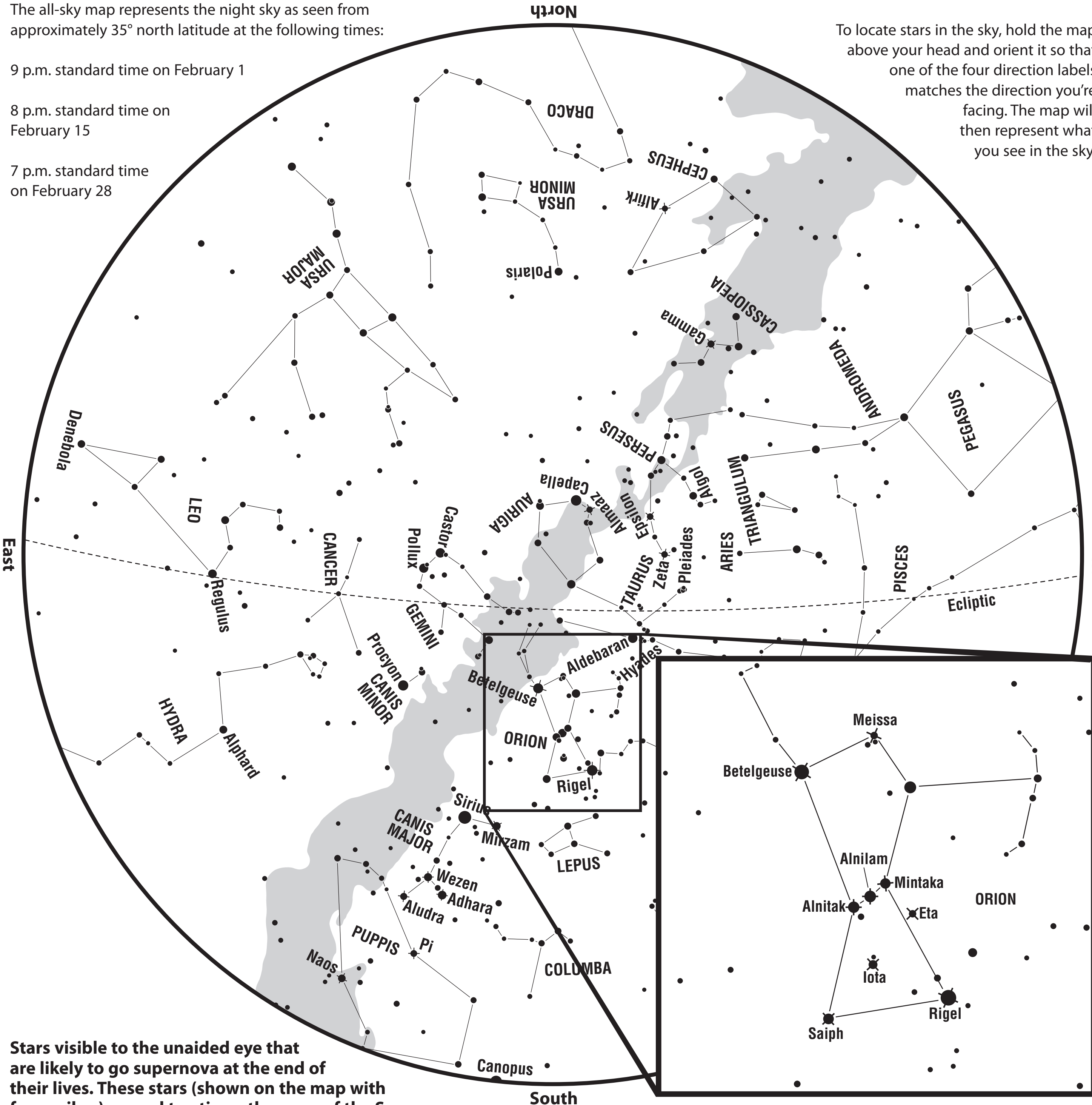
The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

9 p.m. standard time on February 1

8 p.m. standard time on February 15

7 p.m. standard time on February 28

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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Adhara	430	10 to 12
Alfirk	820	12
Almaaz	2,000	15 to 19
Alnilam	1,340	40
Alnitak	815	20
Aludra	3,200	15
Betelgeuse	425	12 to 17

Name	Distance (light-years)	Mass (Suns)
Epsilon Persei	500	14
Eta Orionis	900	15
Gamma Cassiopeiae	610	15
Iota Orionis	1,300	15
Meissa	1,000	25
Mintaka	915	20

Name	Distance (light-years)	Mass (Suns)
Mirzam	500	15
Naos	1,400	60
Pi Puppis	1,100	13 to 14
Rigel	775	17
Saiph	720	15 to 17
Wezen	1,800	17
Zeta Persei	1,000	19

Stars likely to go

SUPERNOVA!

M A R C H

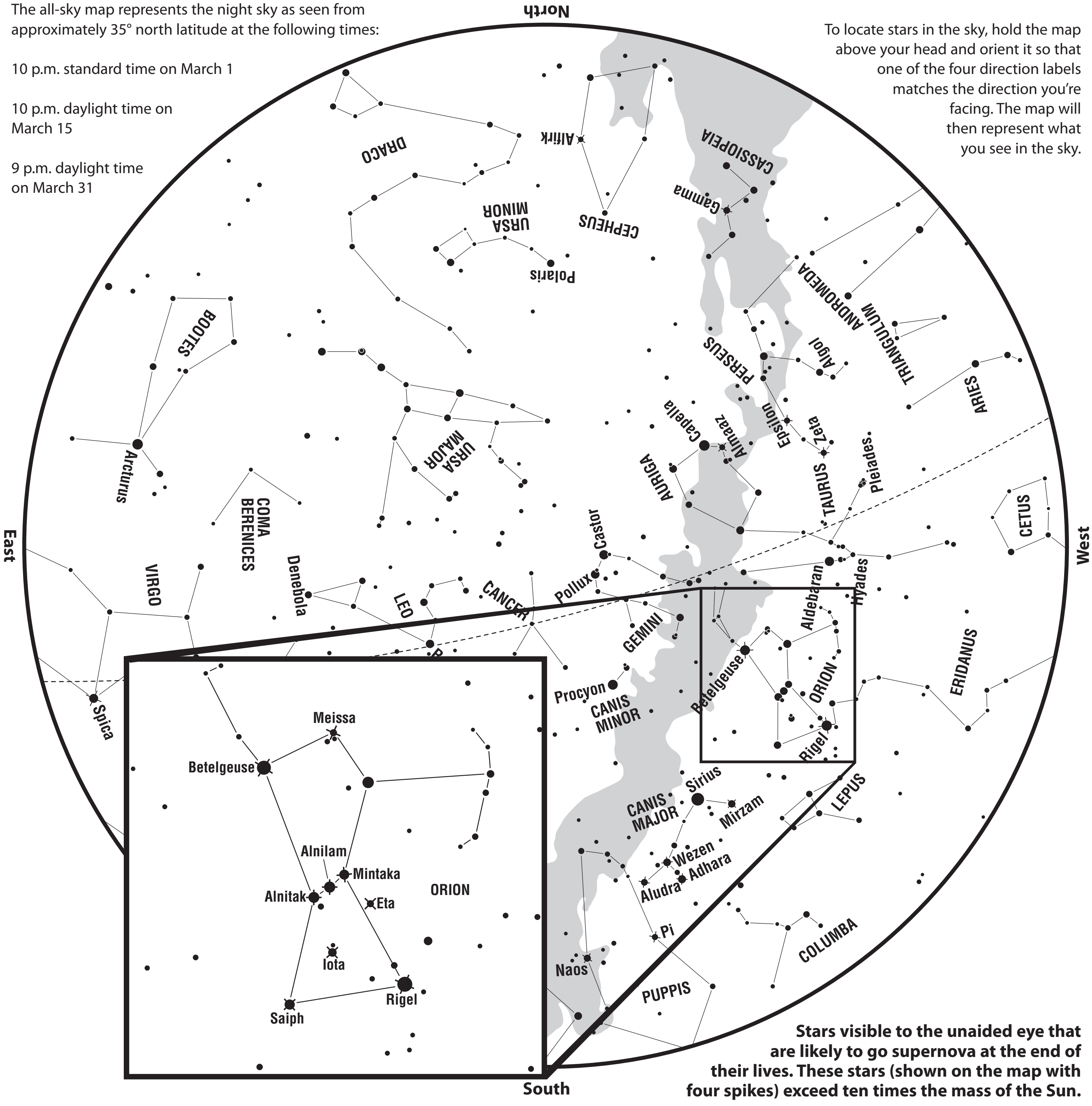
The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

10 p.m. standard time on March 1

10 p.m. daylight time on March 15

9 p.m. daylight time on March 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Stars visible to the unaided eye that are likely to go supernova at the end of their lives. These stars (shown on the map with four spikes) exceed ten times the mass of the Sun.

Name	Distance (light-years)	Mass (Suns)
Adhara	430	10 to 12
Alfirk	820	12
Almaaz	2,000	15 to 19
Alnilam	1,340	40
Alnitak	815	20
Aludra	3,200	15
Betelgeuse	425	12 to 17

Name	Distance (light-years)	Mass (Suns)
Epsilon Persei	500	14
Eta Orionis	900	15
Gamma Cassiopeiae	610	15
Iota Orionis	1,300	15
Meissa	1,000	25
Mintaka	915	20
Mirzam	500	15

Name	Distance (light-years)	Mass (Suns)
Naos	1,400	60
Pi Puppis	1,100	13 to 14
Rigel	775	17
Saiph	720	15 to 17
Spica	260	11
Wezen	1,800	17
Zeta Persei	1,000	19

Stars likely to go

SUPERNOVA!

APRIL

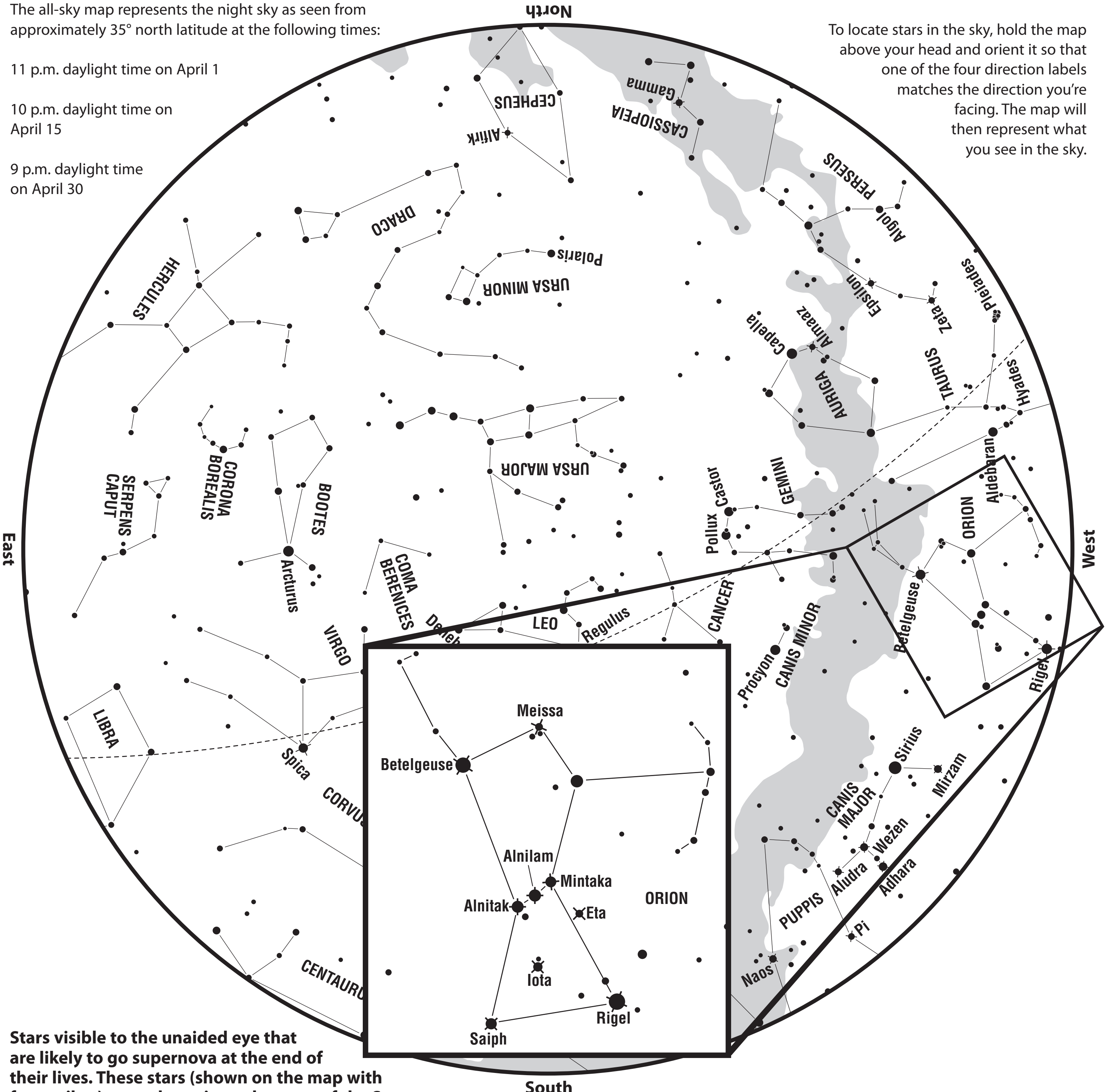
The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

11 p.m. daylight time on April 1

10 p.m. daylight time on April 15

9 p.m. daylight time on April 30

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Stars visible to the unaided eye that are likely to go supernova at the end of their lives. These stars (shown on the map with four spikes) exceed ten times the mass of the Sun.

Name	Distance (light-years)	Mass (Suns)
Adhara	430	10 to 12
Alfirk	820	12
Almaaz	2,000	15 to 19
Alnilam	1,340	40
Alnitak	815	20
Aludra	3,200	15
Betelgeuse	425	12 to 17

Name	Distance (light-years)	Mass (Suns)
Epsilon Persei	500	14
Eta Orionis	900	15
Gamma Cassiopeiae	610	15
Iota Orionis	1,300	15
Meissa	1,000	25
Mintaka	915	20
Mirzam	500	15

Name	Distance (light-years)	Mass (Suns)
Naos	1,400	60
Pi Puppis	1,100	13 to 14
Rigel	775	17
Saiph	720	15 to 17
Spica	260	11
Wezen	1,800	17
Zeta Persei	1,000	19

Stars likely to go SUPERNOVA!

MAY

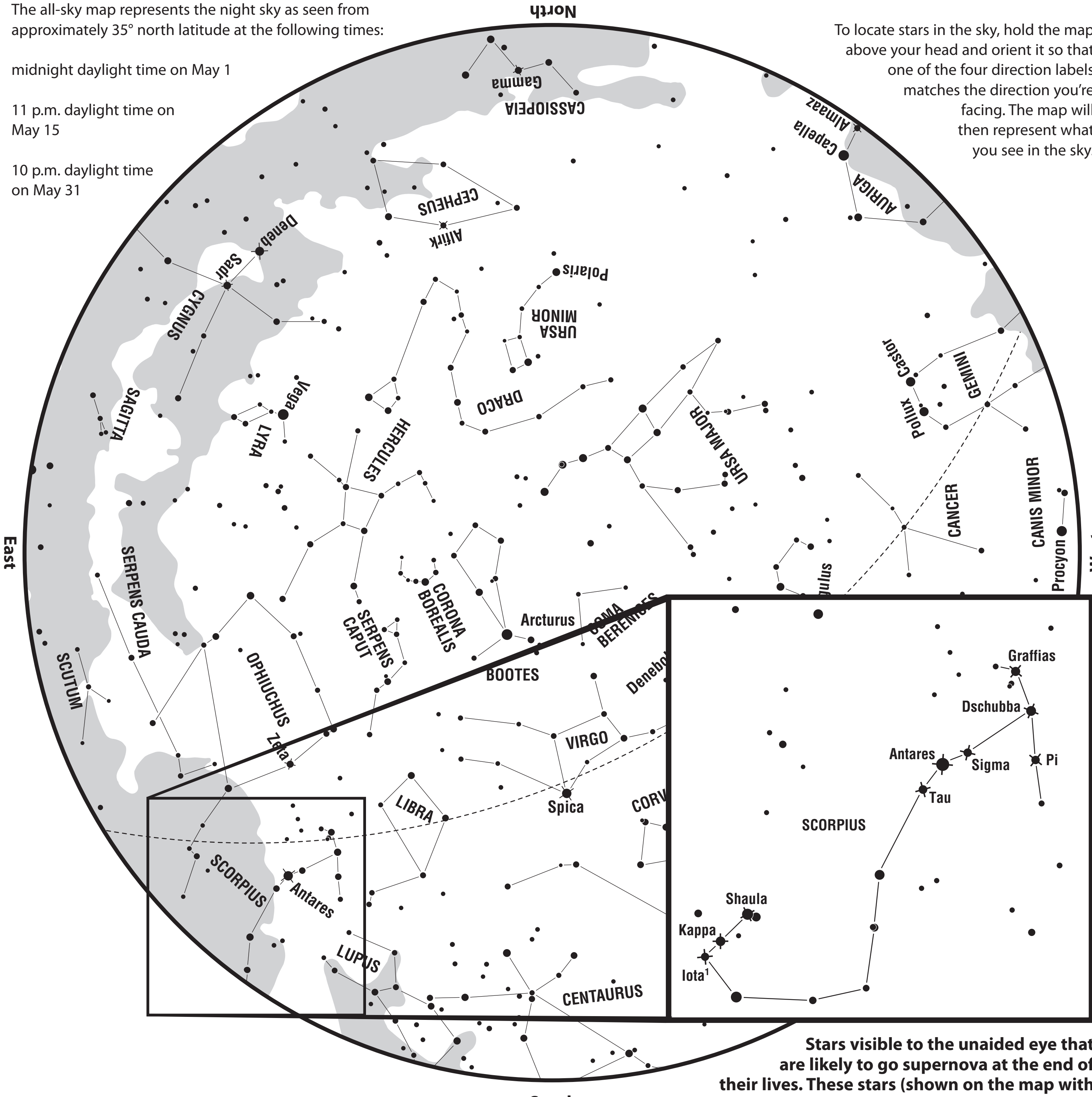
The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

midnight daylight time on May 1

11 p.m. daylight time on May 15

10 p.m. daylight time on May 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Stars visible to the unaided eye that are likely to go supernova at the end of their lives. These stars (shown on the map with four spikes) exceed ten times the mass of the Sun.

Name	Distance (light-years)	Mass (Suns)
Alfirk	820	12
Almaaz	2,000	15 to 19
Antares	600	15 to 18
Deneb	2,600	25
Dschubba	400	12

Name	Distance (light-years)	Mass (Suns)
Gamma Cassiopeiae	610	15
Graffias	530	10
Iota[1] Scorpii	4,000	12
Kappa Scorpii	450	10.5
Pi Scorpii	500	11
Sadr	1,500	12

Name	Distance (light-years)	Mass (Suns)
Shaula	365	11
Sigma Scorpii	520	12 to 20
Spica	260	11
Tau Scorpii	400	12
Zeta Ophiuchi	460	20

Stars likely to go

SUPERNOVA!

JUNE

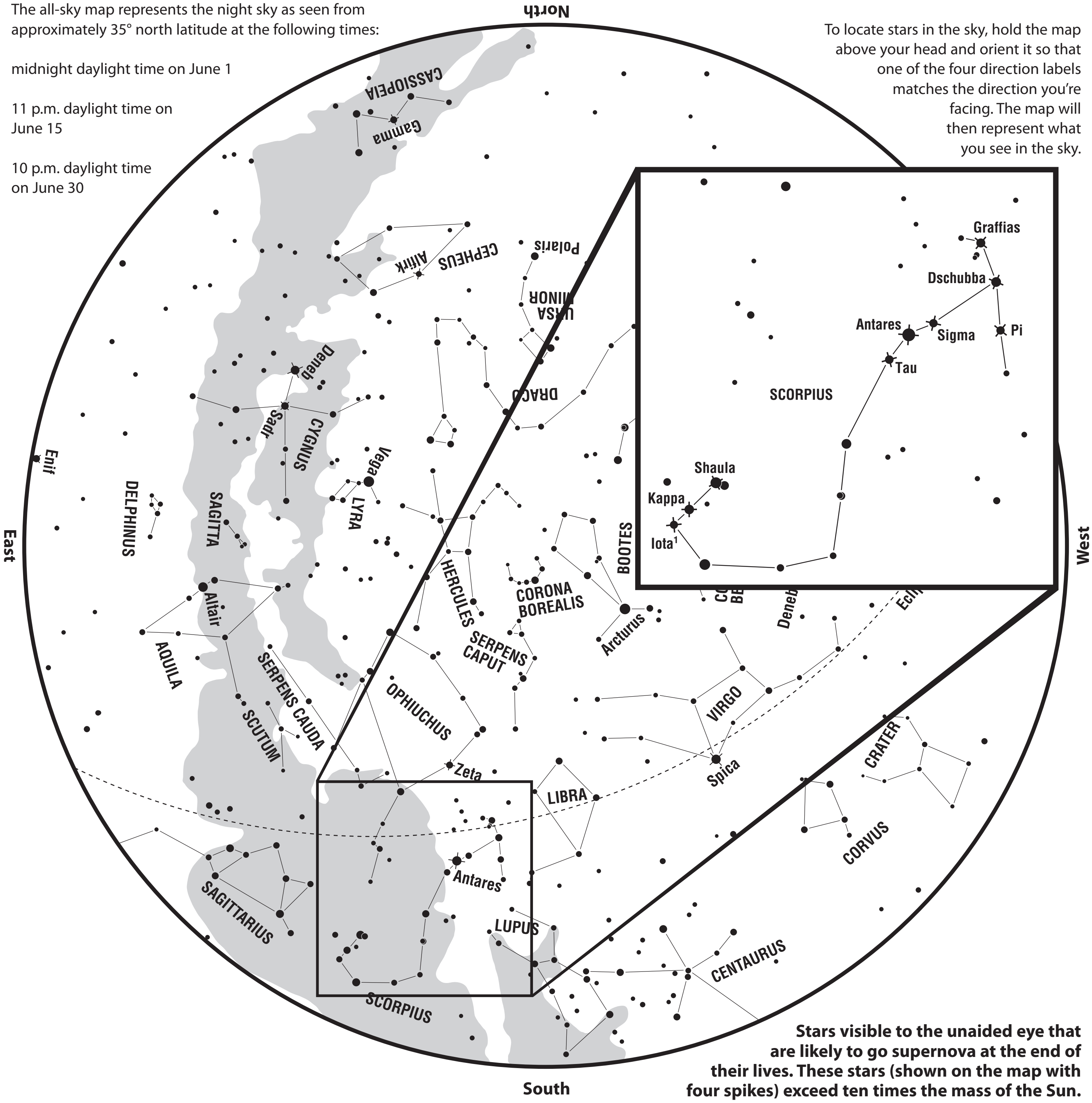
The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

midnight daylight time on June 1

11 p.m. daylight time on June 15

10 p.m. daylight time on June 30

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Stars visible to the unaided eye that are likely to go supernova at the end of their lives. These stars (shown on the map with four spikes) exceed ten times the mass of the Sun.

Name	Distance (light-years)	Mass (Suns)
Alfirk	820	12
Antares	600	15 to 18
Deneb	2,600	25
Dschubba	400	12
Enif	670	10

Name	Distance (light-years)	Mass (Suns)
Gamma Cassiopeiae	610	15
Graffias	530	10
Iota[1] Scorpii	4,000	12
Kappa Scorpii	450	10.5
Pi Scorpii	500	11
Sadr	1,500	12

Name	Distance (light-years)	Mass (Suns)
Shaula	365	11
Sigma Scorpii	520	12 to 20
Spica	260	11
Tau Scorpii	400	12
Zeta Ophiuchi	460	20

Stars likely to go SUPERNOVA!

JULY

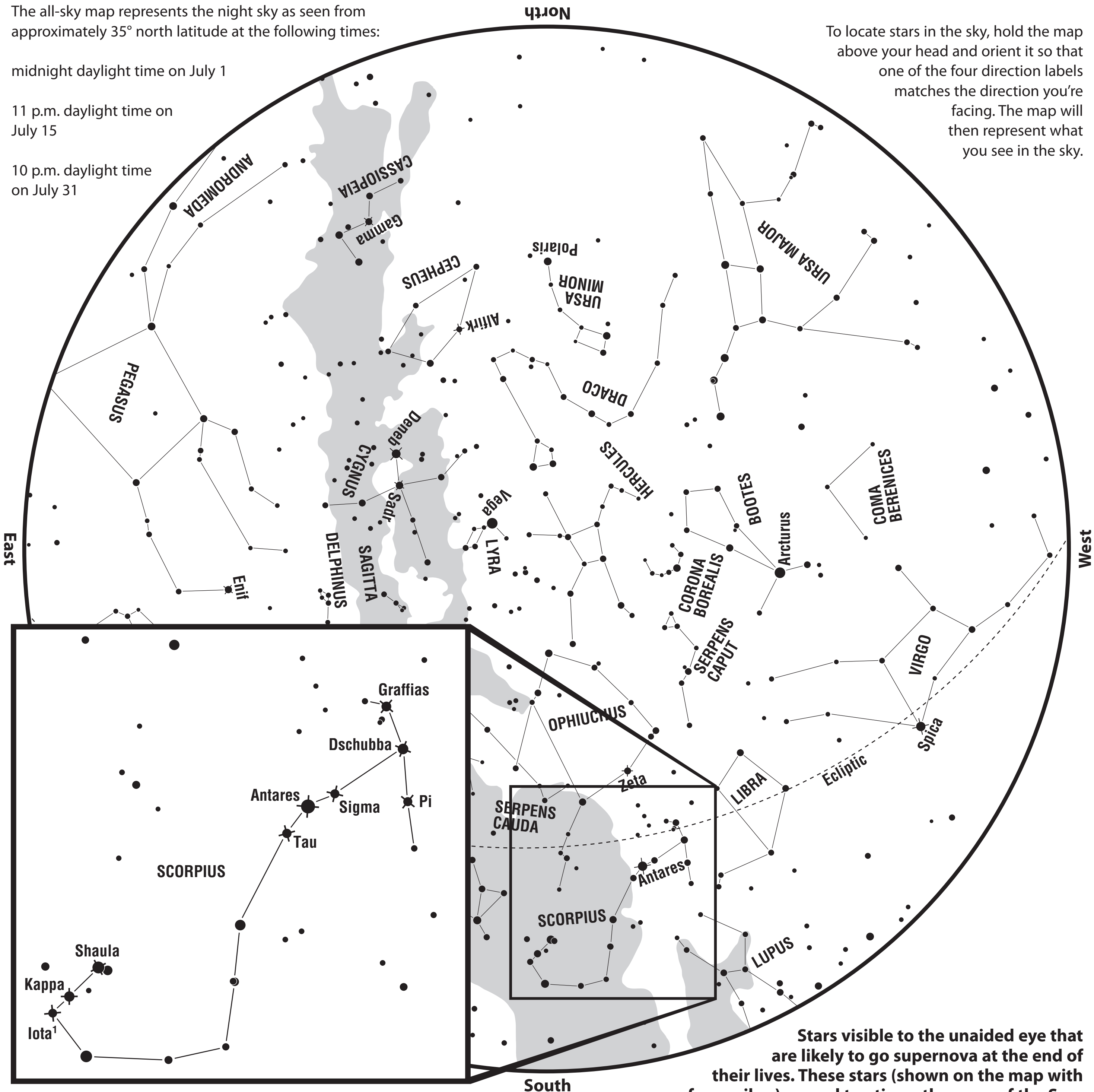
The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

midnight daylight time on July 1

11 p.m. daylight time on July 15

10 p.m. daylight time on July 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Stars visible to the unaided eye that are likely to go supernova at the end of their lives. These stars (shown on the map with four spikes) exceed ten times the mass of the Sun.

Name	Distance (light-years)	Mass (Suns)
Alfirk	820	12
Antares	600	15 to 18
Deneb	2,600	25
Dschubba	400	12
Enif	670	10

Name	Distance (light-years)	Mass (Suns)
Gamma Cassiopeiae	610	15
Graffias	530	10
Iota[1] Scorpii	4,000	12
Kappa Scorpii	450	10.5
Pi Scorpii	500	11
Sadr	1,500	12

Name	Distance (light-years)	Mass (Suns)
Shaula	365	11
Sigma Scorpii	520	12 to 20
Spica	260	11
Tau Scorpii	400	12
Zeta Ophiuchi	460	20

Stars likely to go SUPERNOVA!

AUGUST

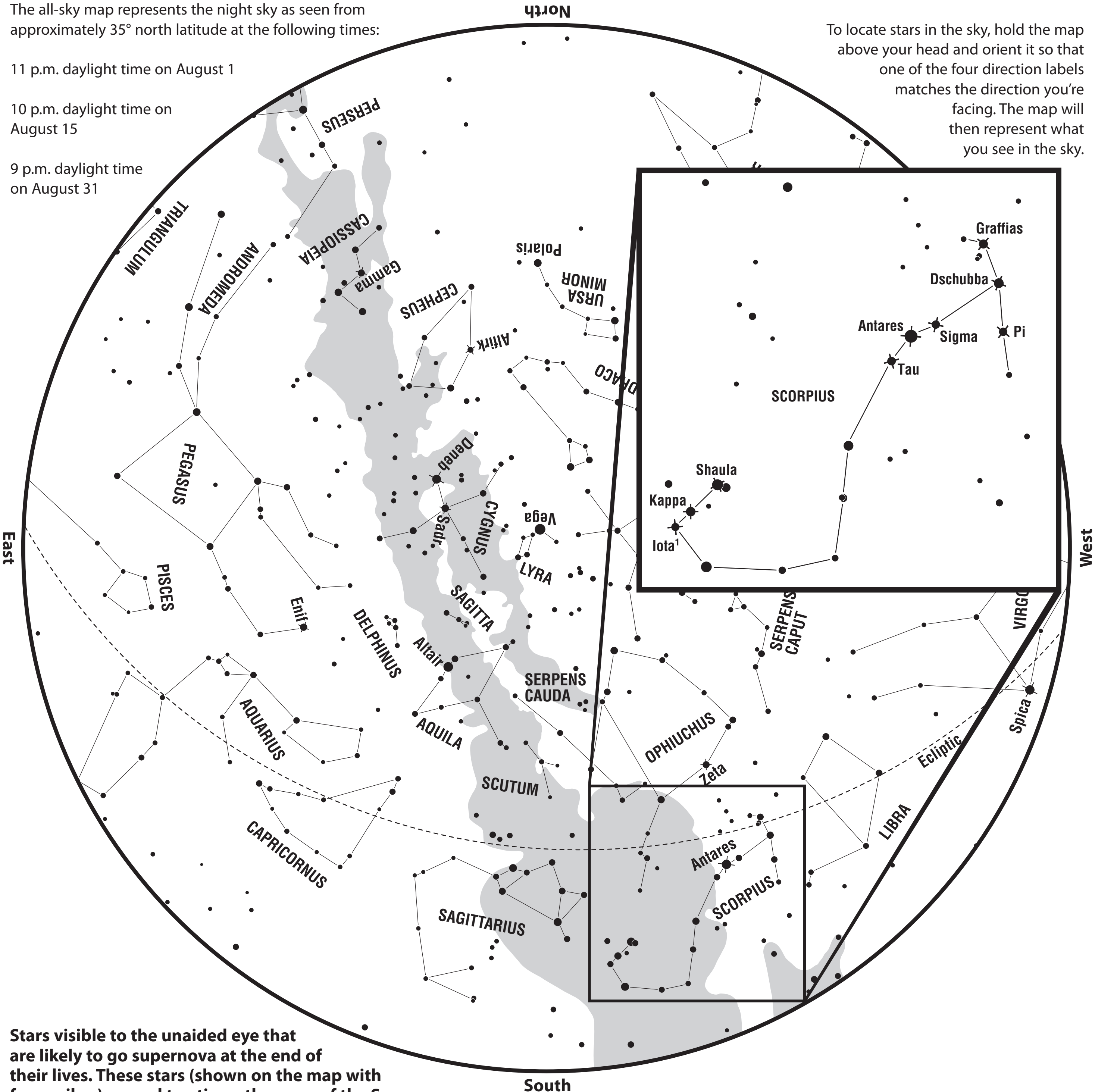
The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

11 p.m. daylight time on August 1

10 p.m. daylight time on August 15

9 p.m. daylight time on August 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Stars visible to the unaided eye that are likely to go supernova at the end of their lives. These stars (shown on the map with four spikes) exceed ten times the mass of the Sun.

Name	Distance (light-years)	Mass (Suns)
Alfirk	820	12
Antares	600	15 to 18
Deneb	2,600	25
Dschubba	400	12
Enif	670	10

Name	Distance (light-years)	Mass (Suns)
Gamma Cassiopeiae	610	15
Graffias	530	10
Iota[1] Scorpii	4,000	12
Kappa Scorpii	450	10.5
Pi Scorpii	500	11
Sadr	1,500	12

Name	Distance (light-years)	Mass (Suns)
Shaula	365	11
Sigma Scorpii	520	12 to 20
Spica	260	11
Tau Scorpii	400	12
Zeta Ophiuchi	460	20

Stars likely to go SUPERNOVA!

SEPTEMBER

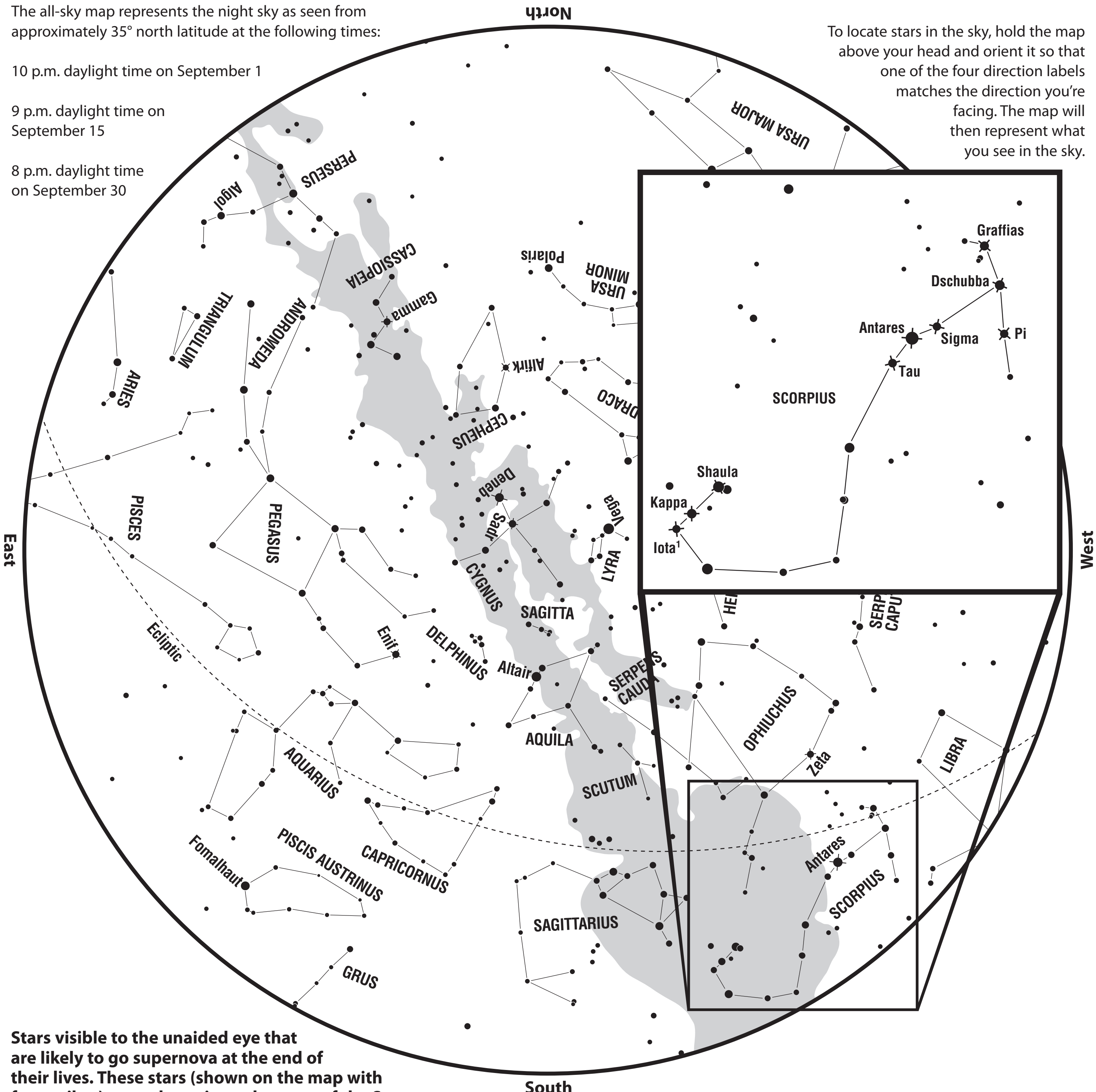
The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

10 p.m. daylight time on September 1

9 p.m. daylight time on September 15

8 p.m. daylight time on September 30

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Stars visible to the unaided eye that are likely to go supernova at the end of their lives. These stars (shown on the map with four spikes) exceed ten times the mass of the Sun.

Name	Distance (light-years)	Mass (Suns)
Alfirk	820	12
Antares	600	15 to 18
Deneb	2,600	25
Dschubba	400	12
Enif	670	10

Name	Distance (light-years)	Mass (Suns)
Gamma Cassiopeiae	610	15
Graffias	530	10
Iota[1] Scorpii	4,000	12
Kappa Scorpii	450	10.5
Pi Scorpii	500	11

Name	Distance (light-years)	Mass (Suns)
Sadr	1,500	12
Shaula	365	11
Sigma Scorpii	520	12 to 20
Tau Scorpii	400	12
Zeta Ophiuchi	460	20

Stars likely to go

SUPERNOVA!

OCTOBER

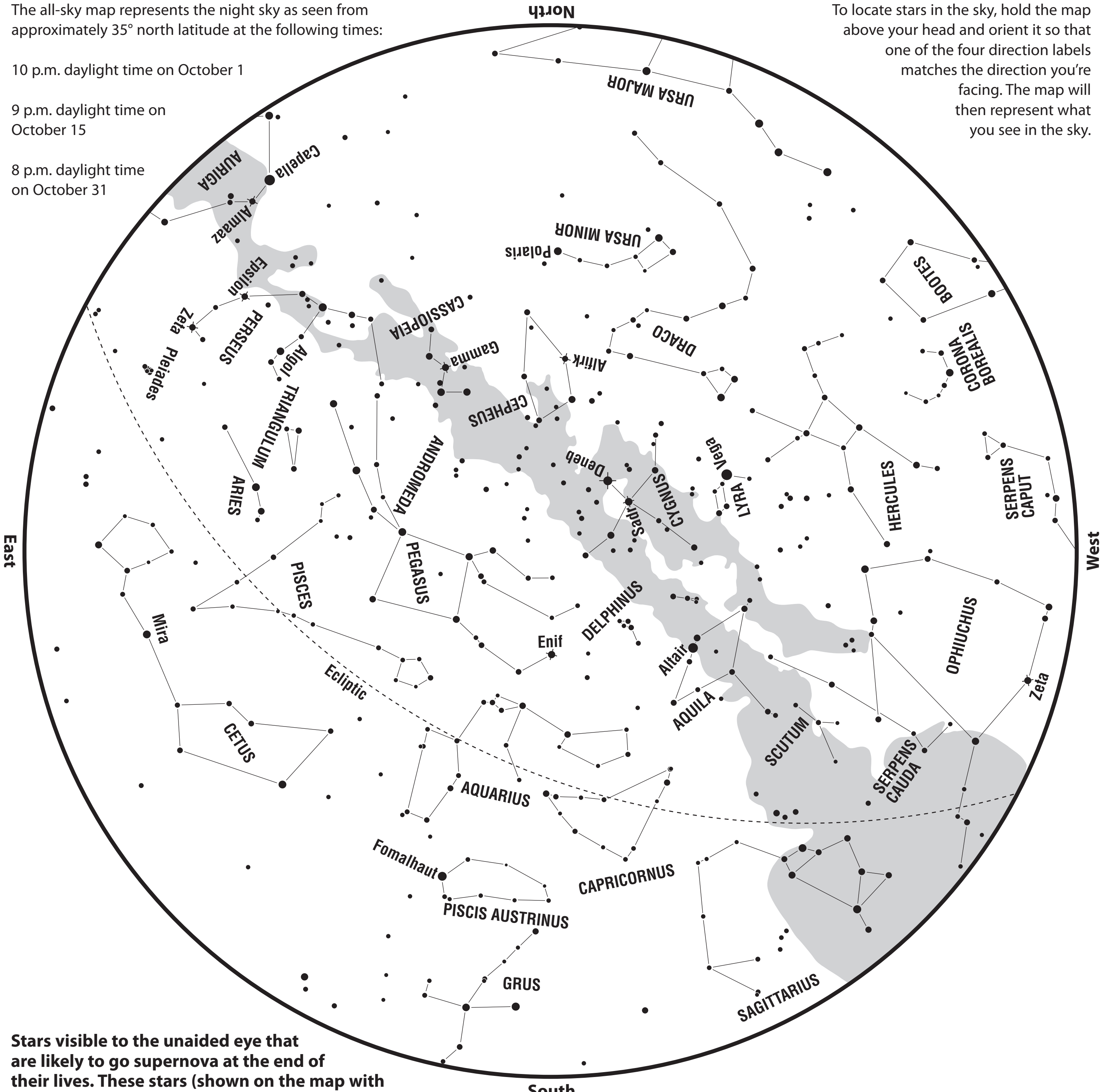
The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

10 p.m. daylight time on October 1

9 p.m. daylight time on October 15

8 p.m. daylight time on October 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Stars visible to the unaided eye that are likely to go supernova at the end of their lives. These stars (shown on the map with four spikes) exceed ten times the mass of the Sun.

Name	Distance (light-years)	Mass (Suns)
Alfirk	820	12
Almaaz	2,000	15 to 19
Deneb	2,600	25

Name	Distance (light-years)	Mass (Suns)
Enif	670	10
Epsilon Persei	500	14
Gamma Cassiopeiae	610	15

Name	Distance (light-years)	Mass (Suns)
Sadr	1,500	12
Zeta Ophiuchi	460	20
Zeta Persei	1,000	19

Stars likely to go SUPERNOVA!

NOVEMBER

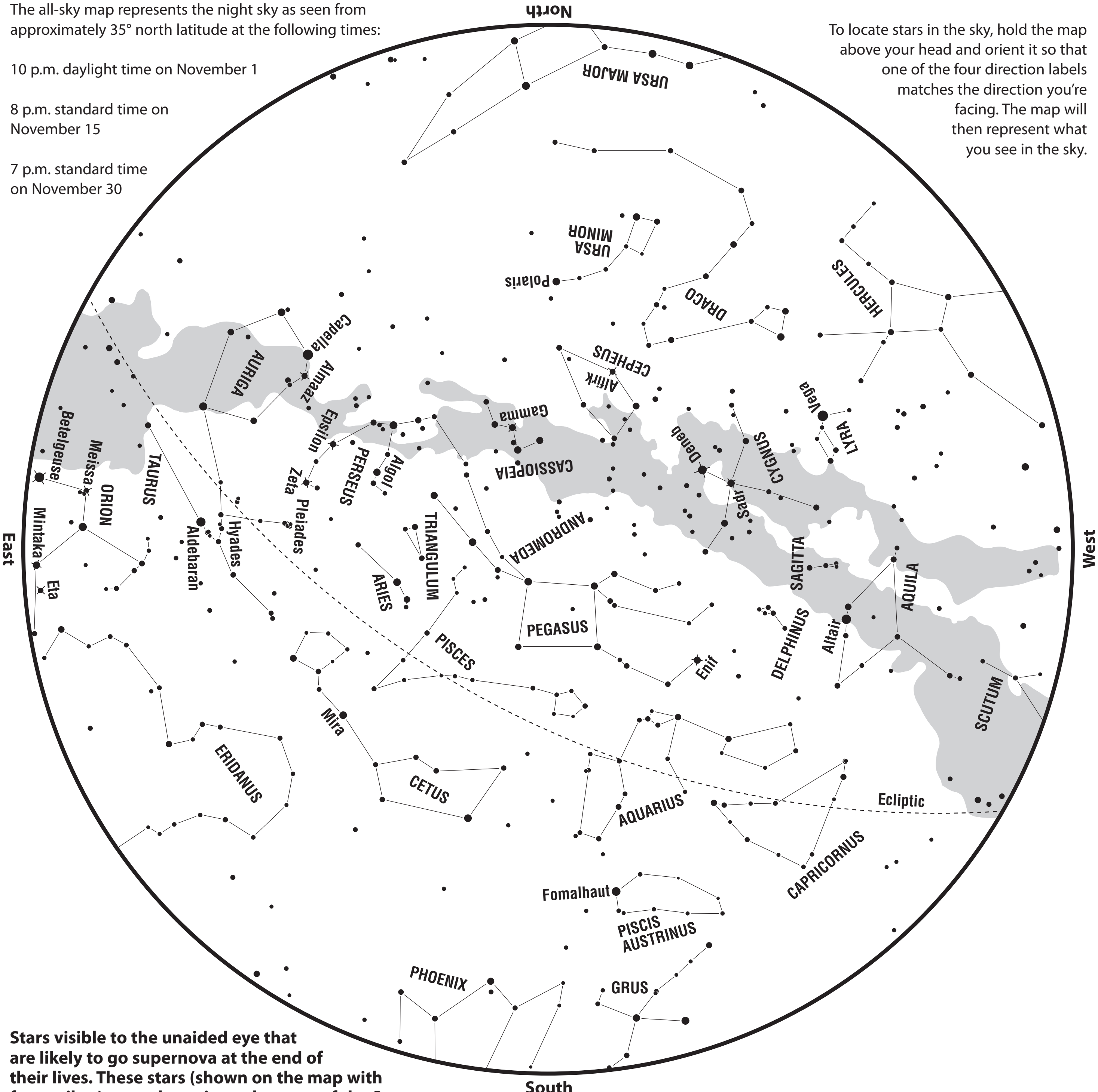
The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

10 p.m. daylight time on November 1

8 p.m. standard time on November 15

7 p.m. standard time on November 30

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Stars visible to the unaided eye that are likely to go supernova at the end of their lives. These stars (shown on the map with four spikes) exceed ten times the mass of the Sun.

Name	Distance (light-years)	Mass (Suns)
Alfirk	820	12
Almaaz	2,000	15 to 19
Betelgeuse	425	12 to 17
Deneb	2,600	25

Name	Distance (light-years)	Mass (Suns)
Enif	670	10
Epsilon Persei	500	14
Eta Orionis	900	15
Gamma Cassiopeiae	610	15

Name	Distance (light-years)	Mass (Suns)
Meissa	1,000	25
Mintaka	915	20
Sadr	1,500	12
Zeta Persei	1,000	19

Stars likely to go SUPERNOVA!

DECEMBER

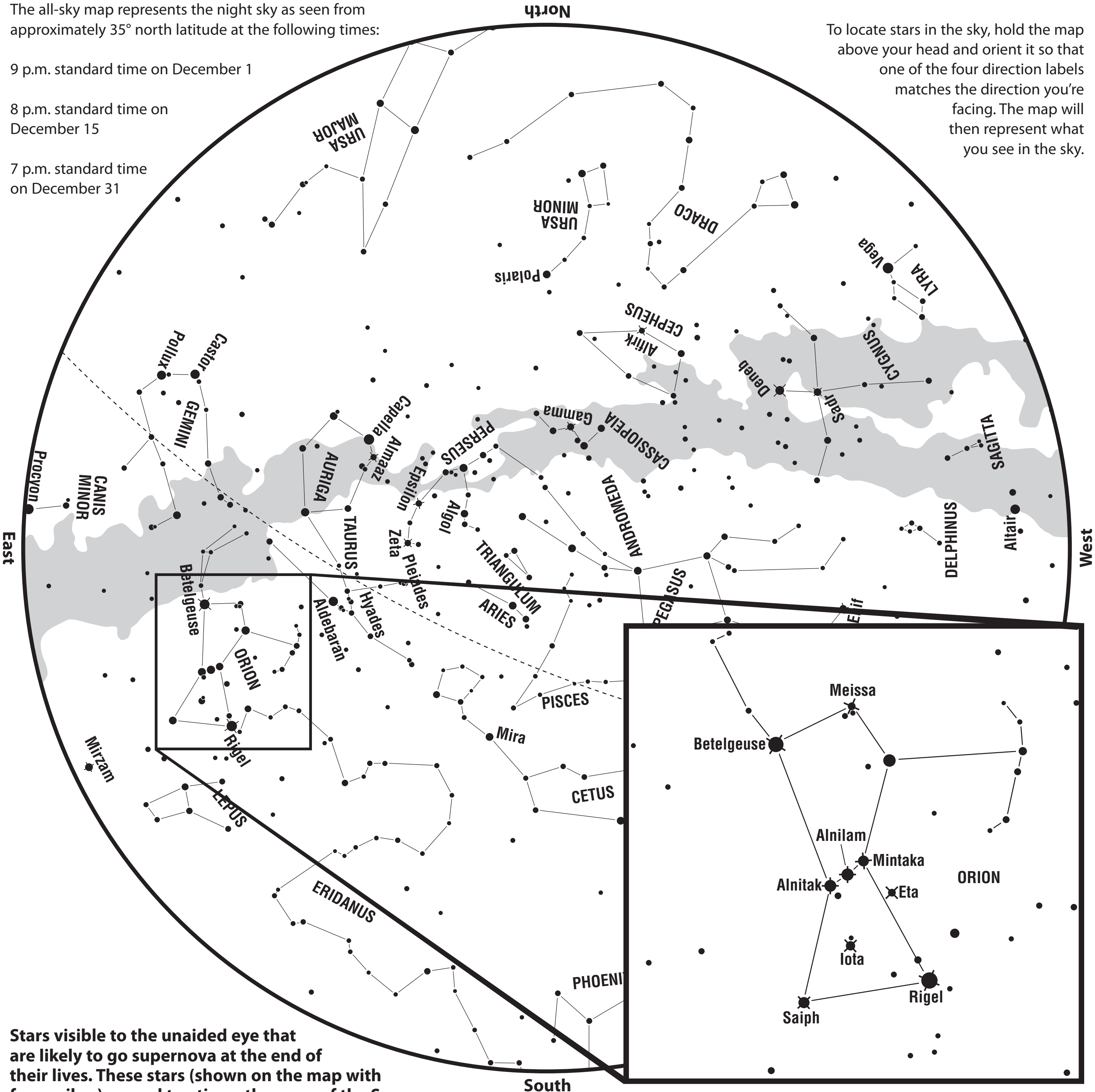
The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

9 p.m. standard time on December 1

8 p.m. standard time on December 15

7 p.m. standard time on December 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Stars visible to the unaided eye that are likely to go supernova at the end of their lives. These stars (shown on the map with four spikes) exceed ten times the mass of the Sun.

Name	Distance (light-years)	Mass (Suns)
Alfirk	820	12
Almaaz	2,000	15 to 19
Alnilam	1,340	40
Alnitak	815	20
Betelgeuse	425	12 to 17
Deneb	2,600	25

Name	Distance (light-years)	Mass (Suns)
Enif	670	10
Epsilon Persei	500	14
Eta Orionis	900	15
Gamma Cassiopeiae	610	15
Iota Orionis	1,300	15
Meissa	1,000	25

Name	Distance (light-years)	Mass (Suns)
Mintaka	915	20
Mirzam	500	15
Rigel	775	17
Sadr	1,500	12
Saiph	720	15 to 17
Zeta Persei	1,000	19

Protecting Earth from Cosmic Radiation

What's this activity about?

Big Questions:

- What is cosmic radiation and where does it come from?
- How are the elements in the universe generated?
- How are supernovae involved?
- How dangerous is this cosmic radiation and how is Earth protected?
- How does NASA study this radiation?

Big Activities:

- **Nuclear Fusion, Supernovae, and Cosmic Radiation**: A simple activity with marshmallows that explains nuclear fusion and how radiation is generated by stars and from supernova explosions.
- **Protecting Earth from Cosmic Radiation:** An activity where visitors use models to try make gamma-rays, x-rays, atomic particles, and visible light reach Earth's surface.
- **Air as a Radiation Shield:** a quick demonstration of how our atmosphere protects Earth from x-rays and gamma-rays.
- **Gamma-Ray Bursts and Supernovae**: demonstrating the power of radiation concentrated into beams.

Participants:

From the club: A minimum of one person.

Visitors: Activities are appropriate for families, the general public, and school groups in grades 5 and up. Any number of visitors may participate.

Duration:

- Nuclear Fusion, Supernovae, and Cosmic Radiation: 5 – 8 minutes.
- Protecting Earth from Cosmic Radiation: 5 – 10 minutes
- Air as a Radiation Shield: 3 – 5 minutes
- Gamma-Ray Bursts and Supernovae: 3 – 5 minutes.

Topics Covered:

- How stars make the elements in the universe
- Sources of high-energy cosmic radiation
- Why supernovae are dangerous if you are too close to them
- How Earth's atmosphere and magnetic field protect life from high-energy cosmic radiation.
- Some types of supernovae may generate gamma-ray bursts (GRBs).

WHERE COULD I USE THIS ACTIVITY?

ACTIVITY	Star Party	Pre-Star Party –Outdoors	Pre-Star Party –Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
1. Nuclear Fusion, Supernovae, and Cosmic Radiation (Marshmallows)	√	√	√	√		√	√	√	√	√
2. Protecting Earth From Cosmic Radiation	√	√	√	√		√	√	√		√
3. Air as a Radiation Shield	√	√	√	√		√	√	√		√
4. Gamma-Ray Bursts & Supernovae	√	√	√	√		√	√	√		√

WHAT DO I NEED TO DO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Duct tape or wide packing tape Small sharp knife Pencil with an eraser Scissors 2 – AA Batteries *Optional*: Felt-tip pen	**Marshmallows:** mini multi-colored ones are best. White and full-sized marshmallows also work. **Bowl** for marshmallows. *Optional*: Salad macaroni	Assemble GRB light Assemble model of Earth's Atmosphere and magnetic field

Helpful Hints

Protecting Earth from Cosmic Radiation (Styrofoam sheet atmosphere model):

Be sure participants just hold the spools and marbles at the top edge of the Styrofoam sheet, then let go. Don't allow throwing or pushing of the objects down the sheet. This will defeat the purpose of the demonstration.

Using salad macaroni in place of the gamma-ray spools allows you to have a more distinct difference between the objects representing gamma-rays and x-rays (compare photos below). Salad macaroni can be purchased at almost any grocery store.

Gamma-ray spools and macaroni

Spools representing gamma-rays (left) and x-rays.

IMPORTANT DEFINITION:
Cosmic Radiation: We are limiting the use of the scientific term "cosmic rays" and instead using the more descriptive term "fast-moving (or accelerated) atomic particles." This is to reduce confusion with the term "**cosmic radiation**" which is used here to refe to the combination of electromagnetic radiation (particularly the high-energy x-rays and gamma-rays) AND accelerated atomic particles coming from space. Atomic particles can be atomic nuclei or individual protons, neutrons, or electrons.

Background Information

For more information on gamma-ray and x-ray astronomy, gamma-ray bursts, and Earth's atmosphere and magnetic field as a shield from cosmic radiation:
http://imagine.gsfc.nasa.gov/docs/science/science.html

For background on nuclear fusion and nucleosynthesis, review the booklet "What is your Cosmic Connection to the Elements?" included in the ToolKit or download the PDF from:
http://imagine.gsfc.nasa.gov/docs/teachers/elements/

For more information about exposure to radioactivity and its effects on the body, search the Internet for "radiation sickness".

NASA Missions studying high-energy radiation

Swift (http://swift.gsfc.nasa.gov) is a first-of-its-kind multi-wavelength observatory dedicated to the study of gamma-ray burst (GRB science. It was launched into a low-Earth orbit in November of 2004 and has detected hundreds of bursts.
For downloadable information and handouts related to the Swift Mission:
http://swift.sonoma.edu/resources/multimedia/pubs/
For downloadable animations on the Swift mission and GRBs:
http://swift.sonoma.edu/resources/multimedia/animations/index.html

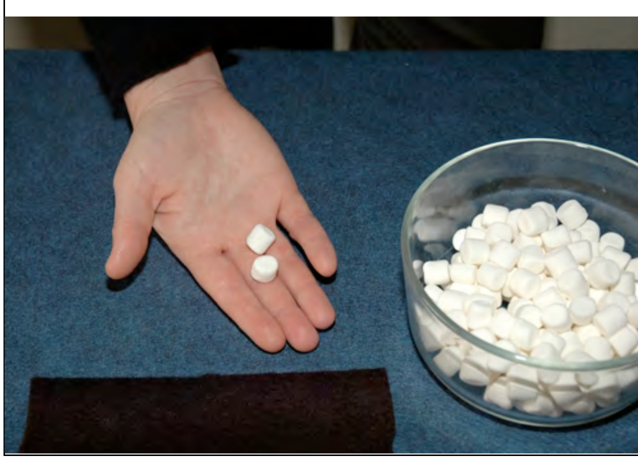
The **Gamma-Ray Large Area Space Telescope** (GLAST: http://www.nasa.gov/glast) is an international and multi-agency missior studying the cosmos looking at objects that emit the highest energy wavelengths of light. Launched in 2008 into low-Earth orbit, its main mission objectives include studying active galaxies, supernovae, pulsars, and gamma-ray bursts.
For downloadable images, animations, and posters on the GLAST Mission:
http://glast.sonoma.edu/resources/

XMM-Newton (http://xmm.sonoma.edu/) is a joint NASA-European Space Agency (ESA) orbiting observatory, designed to observe high-energy x-rays emitted from exotic astronomical objects such as pulsars, black holes and active galaxies. It was launched in 1999 from the ESA base at Kourou, French Guiana.
For more information on the XMM-Newton Mission: http://xmm.esac.esa.int/

The **Suzaku** (http://suzaku-epo.gsfc.nasa.gov/) satellite provides scientists with information to study extremely energetic objects like neutron stars, active and merging galaxies, black holes, and supernovae in the x-ray energy range. Astronomers hope it will help answer several important questions: When and where are the chemical elements created? What happens when matter falls onto a black hole? How does nature heat gas to x-ray emitting temperatures? Suzaku was launched in July 2005 and is a collaboration between Japanese and US institutions including NASA.
For more information on the Suzaku Mission: http://www.nasa.gov/mission_pages/astro-e2/main/index.html

Detailed Activity Descriptions

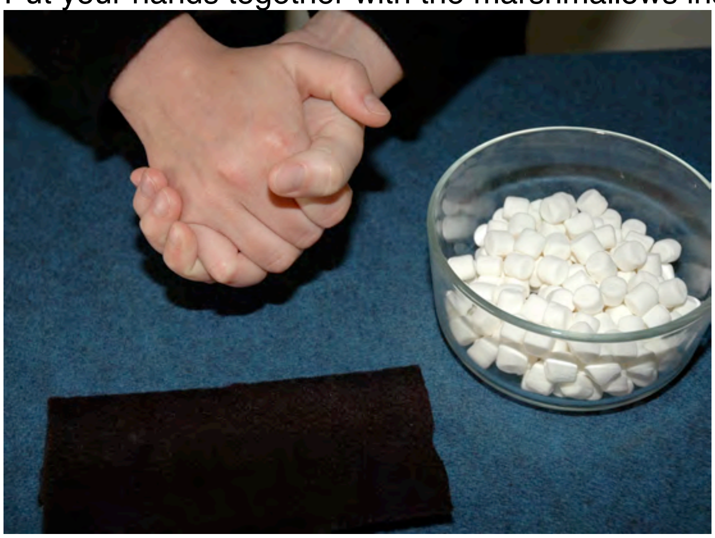
1. Nuclear Fusion, Supernovae, and Cosmic Radiation

Leader's Role	**Participants' Role (Anticipated)**
Materials: Gamma-ray spools (or salad macaroni), x-ray spools, wooden rods for visible light, magnetic marbles. Table of Elements banner and/or handouts **You Supply:** Small or large marshmallows (or small balls of clay or Play-Doh®) in a bowl. *Optional*: Electromagnetic Spectrum Poster *Optional:* Napkins to place marshmallows on.	
Objective: Allow visitors to have an introduction to nuclear fusion and the energy it releases. Understand how cosmic radiation is generated by stars and from supernova explosions.	
To Do: Display the Table of Elements side of the banner and/or pass out the Table of Elements handouts. *To say:* Throughout its life, a star generates new elements by fusing atoms together in its core, What's fuse mean?	Join together.
Stars are mostly hydrogen and helium. *To Do:* Point to Hydrogen and Helium on the Table of Elements. Hold up a marshmallow (or small ball of clay). *To say:* This represents a proton. The number of protons an atom has in its nucleus determines what kind of element it is. [pointing to Hydrogen on banner or handout] A Hydrogen atom has one proton in its nucleus. So how many hydrogen atoms does this represent?	One.
To Do:  Have each person take 2 marshmallows out of the bowl.	

<table>
<tr><th>Leader's Role</th><th>Participants' Role (Anticipated)</th></tr>
<tr><td><u>To say:</u>
Take two protons representing the nucleus of two Hydrogen atoms. Generally fusion happens with two atomic nuclei at a time.

What element has two protons in its nucleus? [point to Helium on handout or banner]

Let's see how a star makes helium.

<u>To do:</u>
Put your hands together with the marshmallows inside.

<u>To Say:</u>
We'll pretend your hands are the core of a star. Temperatures are so hot and pressures so great inside stars that the atoms are moving tremendously fast and crashing into one another. And sometimes they fuse. Can you make your protons fuse?
Let's say the magic words: Nuclear fusion!
<u>To do:</u>
Crush the marshmallows together.

<u>To say:</u>
The two hydrogen atoms have fused to make the nucleus of what element?

Now nuclear fusion doesn't generate just new, heavier atoms. Each time two atoms lighter than iron fuse, the reaction releases energy. In the form of gamma-ray radiation. We're using this to represent the released gamma-ray.</td><td>Helium.

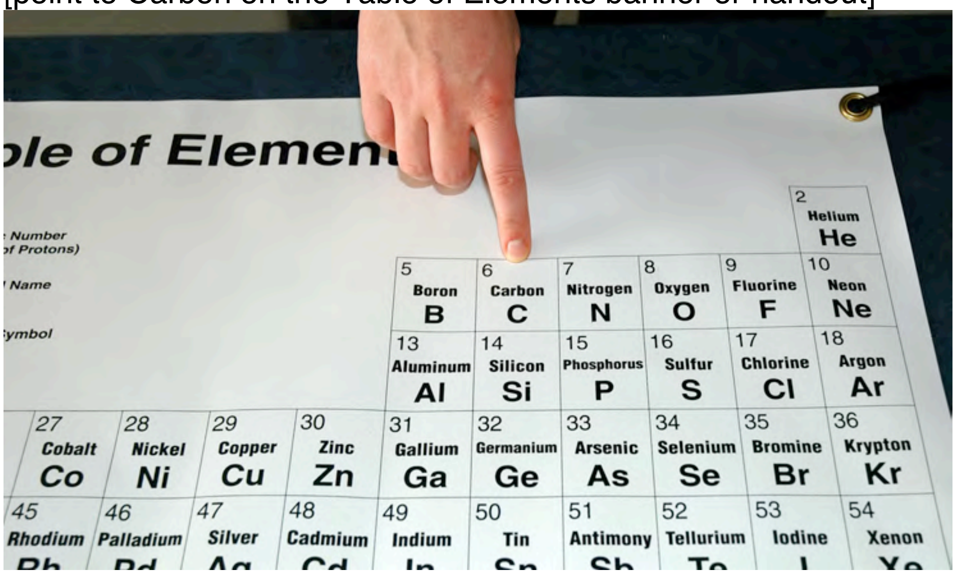
NUCLEAR FUSION!

Helium!</td></tr>
</table>

Leader's Role	Participants' Role (Anticipated)
To do: Set a short spool (or one piece of salad macaroni) representing a gamma ray on the table. 	
Presentation Tip: *If you have a more advanced audience:* It might be helpful here to point to the Electromagnetic Spectrum Poster and point out that gamma-rays are the highest energy radiation. You might also want to explain that it is the atomic nuclei that fuse, not the whole atom – which would include its electrons. Temperatures are so high in the core of the star that the nuclei have all been stripped of their electrons. The nucleus of an atom contains only protons and neutrons. In the core of a star, the atomic nuclei and the electrons are moving about independent of each other.	

Leader's Role	**Participants' Role (Anticipated)**
To Say: Let's make another Helium. Take two more marshmallows – I mean, Hydrogen! *To do:* Pick up and smash two more marshmallows. *To Say:* Say the magic words: Nuclear fusion!	NUCLEAR FUSION!
To do: Set out a gamma-ray piece. *To Say:* And another.	NUCLEAR FUSION!
To do: Pick up and smash two more marshmallows. Set out a gamma-ray piece. *To Say:* Now we have three helium atoms – how many protons are here? 	Six.
Let's smash two of these together. Magic words?	NUCLEAR FUSION!

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td>
<u>To do:</u>
Smash two of the Helium marshmallows together.
Set out a gamma-ray piece.
<u>To Say:</u>
Then smash your other helium atom into this and …
Say it again!
We have . . . an atomic nucleus with how many protons?
What element is that?
[point to Carbon on the Table of Elements banner or handout]



</td><td>
NUCLEAR FUSION!

Six.
Carbon.
</td></tr>
</table>

Presentation Tips:

1. Two Helium nuclei fuse to form Beryllium (with 4 protons in its nucleus). But Beryllium is so unstable that it will disintegrate in a tiny fraction of a second. However, when another Helium nucleus hits it before it disintegrates, Carbon is formed (6 protons). This is referred to as the “triple-alpha” process. Helium nuclei are also called “alpha particles.”

2. *“We are stardust”:* If your audience had clean hands while they were making the Helium and Carbon, when they get to Carbon, you can let them eat the Carbon marshmallow atomic nucleus, adding to their understanding that they are made of material that was made inside stars. “Living things, like you and me, have carbon in them. So if you want to eat your carbon atom, you can see that you are made of atoms that were made in stars.”

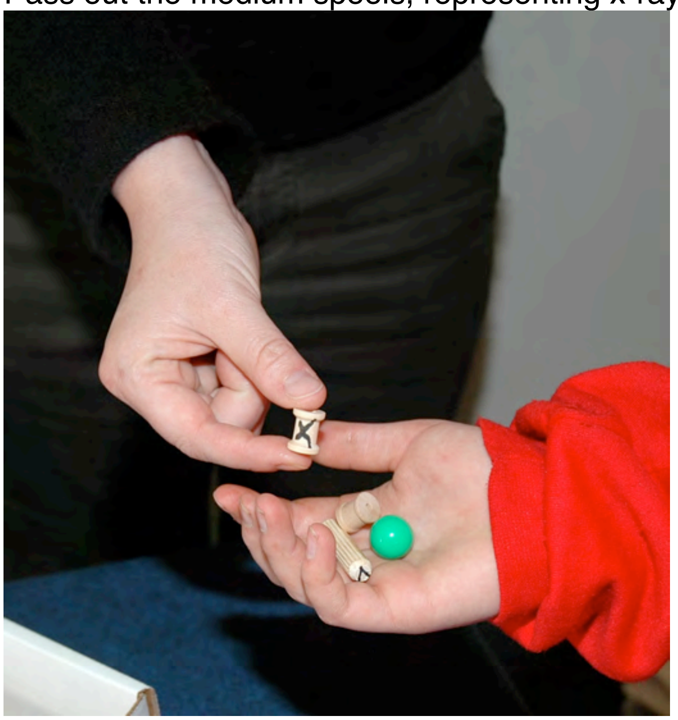
Leader's Role	**Participants' Role (Anticipated)**
To say: Hydrogen atoms fuse to make Helium, Helium to Carbon, and then on to Oxygen, and so on. So the core of the star ends up filled with a variety of elements, releasing energy each time. This process powers the stars, including our star, the Sun. If we're inside a massive star, more than 8 to 10 times the mass of our Sun, nuclear fusion continues until it reaches iron. [pointing to Iron on banner or handout] Iron is the end of the line for fusion. Since the core no longer generates heat, the core starts to cool down. Then what happens? The core collapses under its own weight, followed by a supernova explosion. During these last stages, the central temperature of the star goes from over a hundred million degrees to over a hundred BILLION degrees. This tremendous heat generates huge amounts of gamma-ray energy.	
To do: Grab a handful of gamma-ray pieces. *To say:* So when nuclear reactions are going on or extremely high temperatures are reached inside the star, a LOT of gamma-ray energy is generated. Gamma-rays are what NASA's Swift and GLAST missions are designed to detect. *To do:* Pass out the pieces representing the short wavelength of a gamma-ray to your visitors. *To say:* Gamma-rays are also released from radioactive material here on Earth, like uranium. And what happens if we are exposed too long to radioactivity? Right. It can increase cancer risk and cause other health problems.	Visitors take pieces. We get sick or die.

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td>To say:
What else do you suppose is generated in the explosion?

The intense shock wave from the supernova explosion accelerates some of the material blown out of the star and the material surrounding the star to speeds close to the speed of light. These fast-moving atomic particles are also called “cosmic rays.”
To do:
Pass out magnetic marbles, representing atomic particles (charged particles like atomic nuclei).</td><td>Visitors take marbles</td></tr>
<tr><td colspan="2">Presentation Tip:
Of all the mass blown away from the star (several times the mass of the Sun), only about a millionth of it is being is accelerated to nearly the speed of light to become cosmic rays. This tiny amount, however, still amounts to a few times the mass of the Earth.</td></tr>
</table>

<table>
<tr><th>Leader's Role</th><th>Participants' Role (Anticipated)</th></tr>
<tr><td><u>To say:</u>
We can see a supernova so it also releases the longer wavelengths of visible light.
<u>To do:</u>
Pass out the wooden rods, representing visible light.

<u>To say:</u>
Once the shock wave from the supernova explosion slams into the blown-off outer layers of the star, x-rays are also generated. The Suzaku and XMM-Newton missions are studying these and other sources of x-ray radiation.

<u>To do:</u>
Pass out the medium spools, representing x-rays.

Try to make sure each visitor has at least one of items representing some form of cosmic radiation.

<u>To say:</u>
And that is how supernovae generate cosmic radiation. Now hang onto those and we'll see how Earth is protected from this radiation.</td><td>

Visitors take rods

Visitors take spools</td></tr>
</table>

Leader's Role	Participants' Role (Anticipated)
Presentation Tip: You can also use the ping-pong ball & tennis ball demo ("Let's Make a Supernova!"), this time placing a "gamma-ray" piece between the tennis ball and the ping-pong ball (see photo below) and dropping it all. Both the ping-pong ball and the gamma-ray will go flying, simulating the concept of cosmic radiation spreading out into the universe. 	

2. Protecting Earth from Cosmic Radiation

Leader's Role	Participants' Role (Anticipated)
Materials: Assembled Styrofoam model of Earth's Atmosphere, labeled telescope buckets, gamma-ray spools (or salad macaroni), x-ray spools, longer wooden rods, magnetic marbles.	
Objective: Provide an understanding of how Earth's atmosphere and magnetic field protect Earth from high-energy radiation and accelerated atomic particles.	
<u>*To say:*</u> So how is Earth protected from cosmic radiation? How have we survived all this time? <u>*To do:*</u> If you haven't done so already, pass out the spools, wooden rods, and magnetic marbles to your visitors. Try to make sure each visitor has at least one of the items representing some form of cosmic radiation. <u>*To say:*</u> You are holding models for visible light as well as high-energy cosmic radiation: gamma rays, x-rays, and atomic particles like protons and electrons. Powerful objects in the universe like black holes, neutron stars, and supernovae emit high-energy radiation, which can be dangerous to life. So how are we protected here on Earth from this high-energy radiation coming from the universe? It might seem weird, but our atmosphere and the magnetic field around the Earth help protect us. Let's see how. This board represents our atmosphere. These holes represent atoms in our atmosphere – magnified about a trillion times. The atoms are more widely spaced at the top to represent that the atmosphere gets thinner the higher up you go. Earth also has a magnetic field around it. Here's Earth's surface at the bottom.	Guesses

Leader's Role	**Participants' Role (Anticipated)**
We're going to place our cosmic radiation models here, at the top, then let go. Let's see if any of these can reach Earth's surface. Who has visible light – the long rods? What happened?	 Visitors roll the rods. They rolled all the way down.

Presentation Tip:

Be sure your visitors just hold the radiation models (spools, marbles, etc) at the top of the Styrofoam sheet, then let go, allowing the objects to roll down the sheet. You might want to demonstrate this to them as shown at right.

Some visitors may attempt to throw or push the spools and marbles down the sheet. Explain to your visitors that they should just allow the models to roll down the sheet on their own. Radiation doesn't get a "push" from anywhere – x-rays, gamma-rays, and visible light are all moving at the same speed: the speed of light. The fast-moving atomic particles are moving close to the speed of light – accelerated to that speed by the supernova environment.

Leader's Role	**Participants' Role (Anticipated)**
To say:	
Who has a gamma-ray or an x-ray – the short spools?	Visitors roll the rods.
What happened?	Most went into the atoms.
The atoms in our atmosphere absorb gamma-ray and x-ray radiation protecting us from that kind of radiation.	
Who has an atomic particle – the colored marbles?	Visitors roll the magnetic marbles.
What happened?	Whoops – they moved all around – what was that?
Earth's magnetic field deflects or captures most of the fast-moving atomic particles.	

Additional information:
Even though the atoms in the atmosphere are widely spaced, the total thickness of the atmosphere is large (over 100 km or 60 miles) and the total number of atoms is enormous. An x-ray photon passing through the atmosphere will encounter as many atoms as it would in passing through a 5 meter (16 ft) thick wall of concrete!

What happens when an x-ray is absorbed in the atmosphere?
The energy of the x-ray goes into blasting one of the electrons away from its orbit around the nucleus of a nitrogen or an oxygen atom.
http://chandra.harvard.edu/xray_astro/absorption.html

What happens when a gamma-ray is absorbed in the atmosphere?
A gamma-ray can collide with a molecule of nitrogen gas (N_2) and break the molecule into highly-reactive nitrogen atoms (N). The nitrogen atom then reacts fairly quickly with oxygen (O_2) to form nitrogen oxide (NO). The nitrogen oxide molecule can then destroy ozone (O_3) through a catalytic process.
http://www.nasa.gov/vision/universe/starsgalaxies/gammaray_extinction.html

Some of the magnetic marbles get past the magnetic field. Is this OK?
Yes. Some cosmic rays do penetrate Earth's magnetic field, so it's all right if some of the magnetic marbles pass through the magnetic field on the model.

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td>
<u>To say:</u>

So, if most of the radiation cannot get through our atmosphere, we cannot detect it here on Earth’s surface. How do we know this radiation exists? Where does NASA need to put telescopes to detect it?

Right!

<u>To do:</u>
Turn the board over and empty out the spools, etc into the box. Hand the items back to the visitors. Replace the board into the box.

<u>To say:</u>
Now we’ll fix this up with telescopes – one in space and one on Earth.
<u>To do:</u>
Snap the buckets representing telescopes into the wires installed on the atmosphere sheet, as shown below.


</td><td>
Out in space!
</td></tr>
</table>

Leader's Role	Participants' Role (Anticipated)
To say: Let's attack Earth with radiation again.	 Visitors roll balls and spools.
What can detectors in space collect? Right – all the radiation! NASA has Swift & GLAST looking for gamma-ray radiation and spacecraft like Suzaku and XMM-Newton detecting x-rays – studying the high-energy radiation coming at us from space.	Everything!
What did the telescope on Earth collect?	Just visible light.
So you can see why we need telescopes in space to study high-energy radiation – that kind of radiation rarely reaches Earth's surface!	

Participants use the atmosphere model to discover how Earth's atmosphere and magnetic field protect Earth from cosmic radiation.

3. *Air as a Radiation Shield*

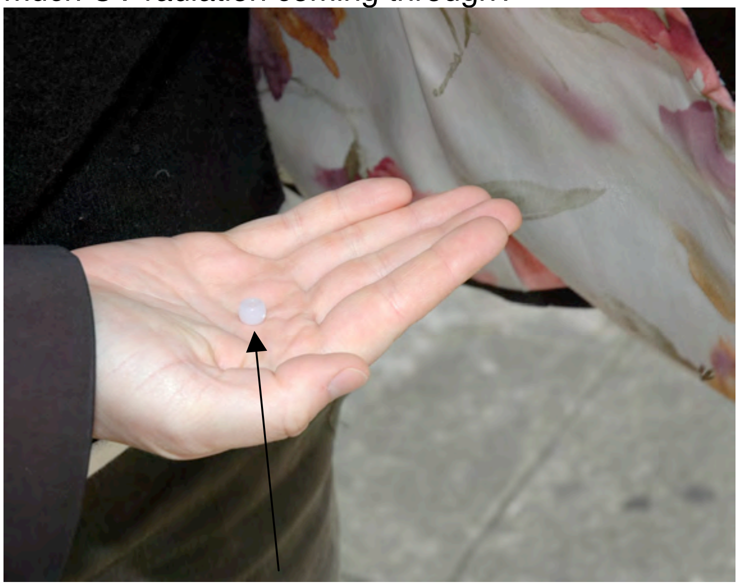
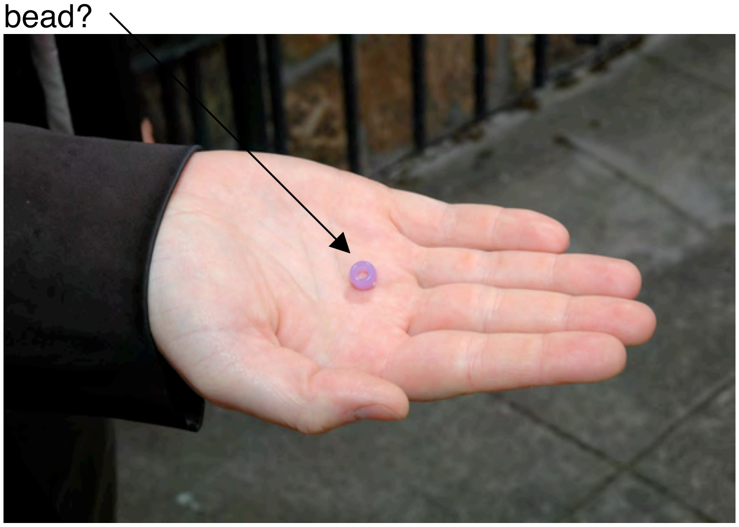
<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td colspan="2">Materials: 4” x 4” box containing card with image of Earth, UV resistant plastic, and several UV beads (keep the beads in a pocket or other shielded location).

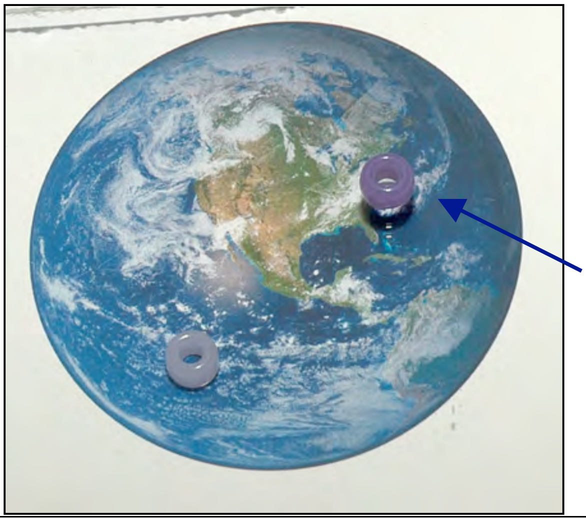
Place the Earth image in the bottom of the box, place one to four UV beads on top of it (representing telescopes on Earth’s surface) then place the square of UV-resistant plastic over it. Place one UV bead on top of the plastic sheet (representing a telescope in space).

This is best done in sunlight, but it can be done on a partly cloudy day.
This cannot be done indoors since most indoor lighting does not contain ultraviolet light.

Optional: Electromagnetic Spectrum poster.</td></tr>
<tr><td colspan="2">Objective:
A quick demonstration and discussion of how Earth is protected from radiation coming from space.</td></tr>
<tr><td><u>To say:</u>
The universe is filled with radiation coming from powerful objects like black holes, neutron stars, or supernovae. These objects radiate primarily at high energies in x-rays and gamma-rays. This very high-energy radiation can be dangerous for life.

So how are living things here on Earth protected from this radiation?
<u>To do:</u>
Hand out a few of the UV beads to a few visitors.
<u>To say:</u>
Keep this bead inside your closed fist until I tell you to open your hand.
These beads detect ultraviolet radiation or just “UV” for short.
The Sun emits ultraviolet radiation and that’s what can give you a sunburn.
To prevent skin damage, what do we need to do?</td><td>Wear a hat. Put on sunscreen.</td></tr>
<tr><td>Yes, we need to block UV radiation.
So these detectors can be used to see how much UV radiation is hitting you. What happens to the bead if I hold it in the sunshine?
<u>To do:</u>
Hold bead in sunshine.</td><td>It turns purple.</td></tr>
</table>

Leader's Role	**Participants' Role (Anticipated)**
To say: Hold your fist under your coat or hat and open your hand – how much UV radiation coming through?  The bead stays white under your coat. Now open up your hand in the sunlight. What happened to the bead?  The bead changes from white to purple and the darker the bead gets, the more UV radiation is being detected. So we can see that the Earth's atmosphere does not completely block UV radiation.	(Holds bead under clothing) Not much It changed to purple!

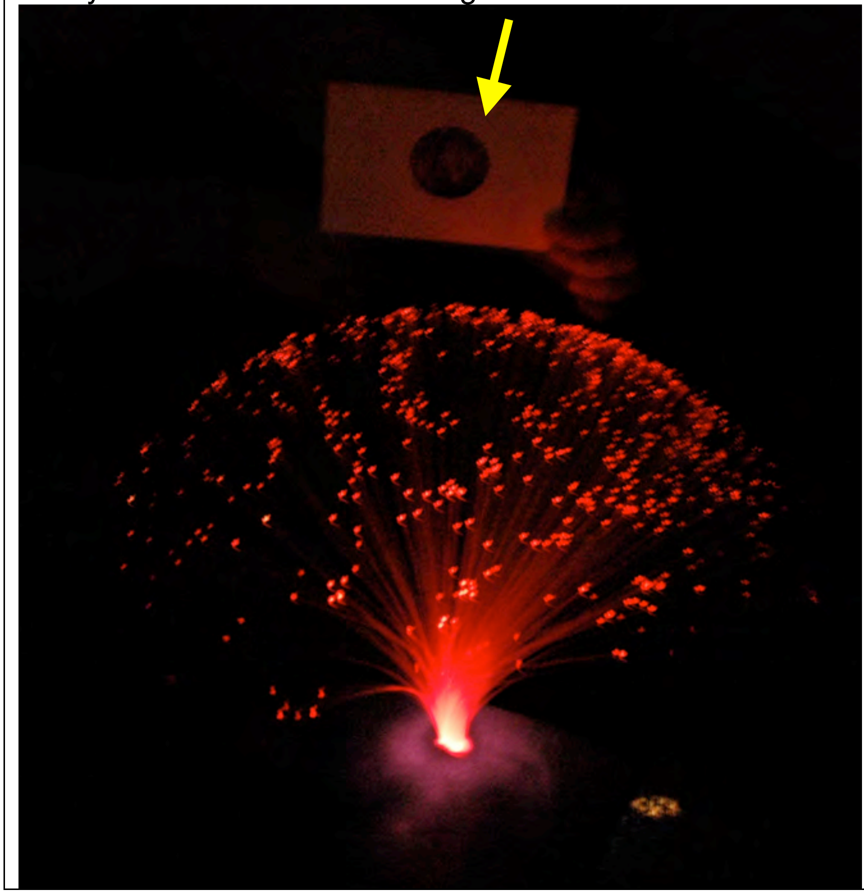
Leader's Role	**Participants' Role (Anticipated)**
To say: But we're now going to imagine these beads as representing not UV detectors, but x-ray and gamma-ray detectors. X-rays and gamma-rays are very high energy radiation.  This sheet represents our atmosphere. Let's place a detector on Earth's surface and another detector above the atmosphere, out in space. Which bead turned purple? What happened to the one on Earth's surface?	 The one above the atmosphere. It stayed white.
So what's this mean about Earth's atmosphere as a shield from high-energy cosmic radiation? Yes, our atmosphere is pretty effective! So you can see why we can't use x-ray and gamma-ray telescopes on Earth's surface. Since the radiation is absorbed high in our atmosphere, any detectors need to be above the atmosphere. That's why missions like Swift and GLAST, which are detecting gamma-rays, and Suzaku and XMM-Newton which are detecting x-rays, are all telescopes launched out into space.	It works as a good shield. The atmosphere prevents the radiation from reaching Earth
Presentation Tip: The UV beads under the plastic sheet may turn a very light purple, especially in direct sunlight. The UV-resistant plastic sheet is not a perfect barrier, but does filter out most of the UV, just like our atmosphere!	

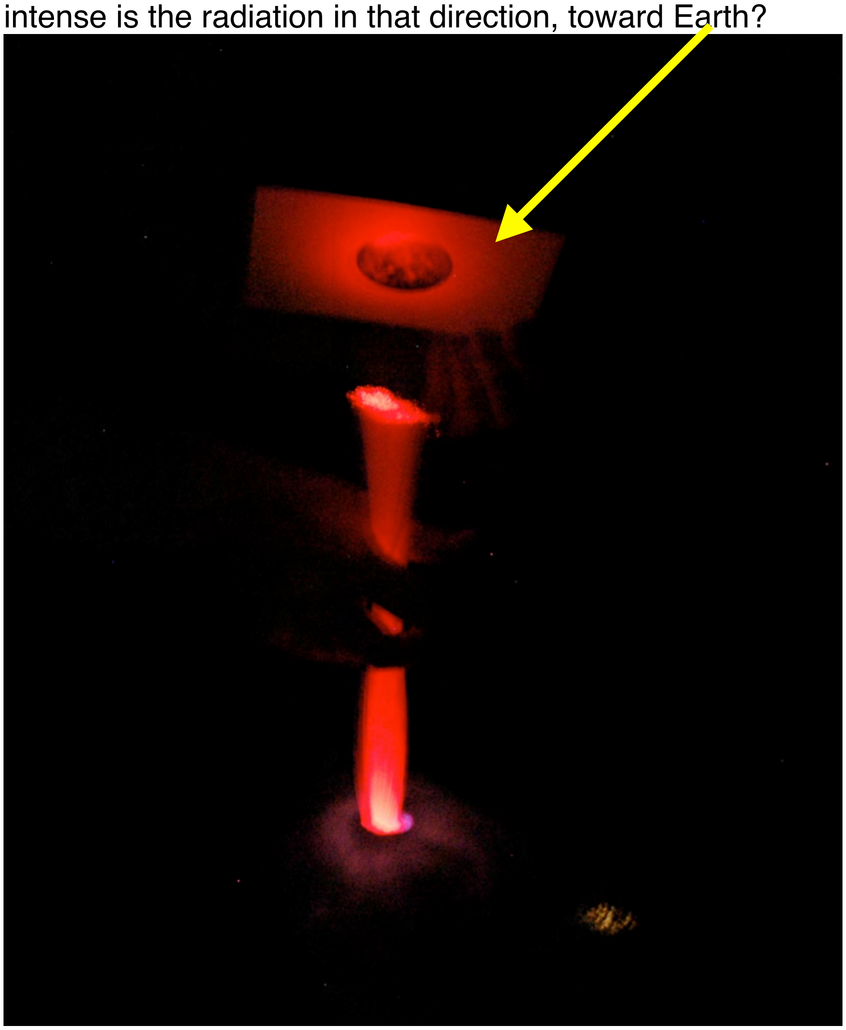
4. Gamma-Ray Bursts and Supernovae

<table>
<tr><th>Leader's Role</th><th>Participants' Role (Anticipated)</th></tr>
<tr><td colspan="2">Materials: Assembled gamma-ray burst lamp model (UFO Lamp), Earth image on a card.
This needs to be done in the dark – it's best outside at night, but can be done in a darkened room.
</td></tr>
<tr><td colspan="2">Objective:
Demonstrate a Gamma-Ray Burst (GRB) – the power of beamed radiation.</td></tr>
<tr><td><u>To say:</u>
Scientists have been detecting a lot of what are called gamma-ray bursts, also abbreviated to GRB. These are intense, short bursts of gamma-ray radiation lasting less than a second to a few minutes. We have not detected any GRBs originating in our galaxy, their sources are in very distant galaxies – over a billion light years away.

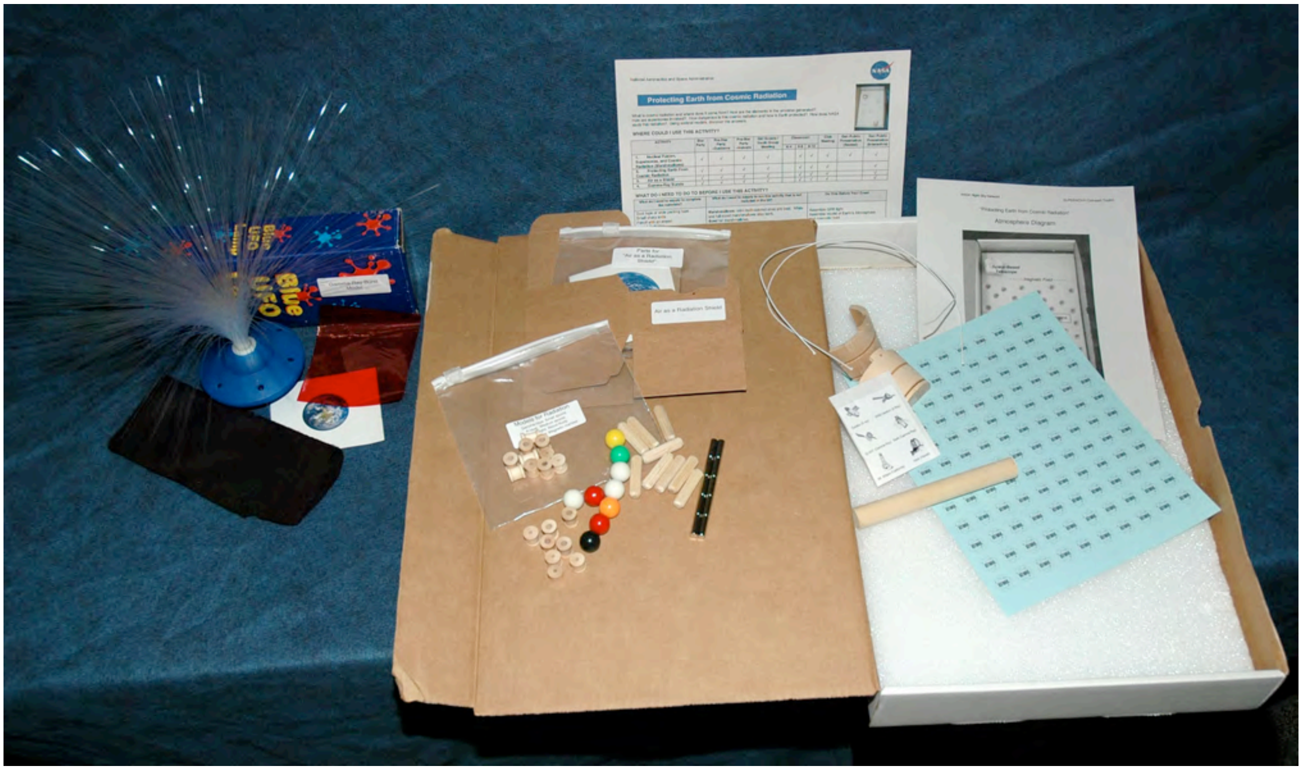
In general there are a number of mechanisms that produce gamma-rays – fusion of lighter elements to heavier elements, and the heat from supernova explosions. Only the heat from supernova explosions contributes to some types of gamma-ray bursts.</td><td></td></tr>
<tr><td><u>To say:</u>
Based on data collected by NASA's Swift mission and subsequent follow-up studies, the current thinking is that one possible source of GRBs is the explosion of an immensely massive star where all the gamma-ray energy released is focused into two opposite beams instead of blowing out in all directions.

Some GRBs might mark the creation of a black hole from a massive star, a star that was over 50 times the mass of our sun. These beams of energy are so powerful, they can be detected from billions of light years away.</td><td></td></tr>
</table>

Leader's Role	**Participants' Role (Anticipated)**
To do: Show the GRB lamp model. *To say:* This light represents the radiation blasting in all directions away from a supernova explosion. *To do:* Hand the card with the image of Earth to a visitor. *To say:* This card has an image of Earth on it. You represent the direction of Earth. Hold Earth close to the ends of the fibers – so it can be hit by the radiation coming from the supernova – represented by the light from this lamp. Hold the card so everyone can see Earth.	Visitor holds card near lamp.
Can you see the radiation hitting Earth? 	Yes, but it's pretty faint.

Leader's Role	Participants' Role (Anticipated)
To do: Hold all the fibers together. *To say:* Now, if all the gamma-ray radiation is focused into two opposite beams - we're just showing one beam here – how much more intense is the radiation in that direction, toward Earth?  Now, how much farther away does a GRB source need to be from Earth to hit us with the same amount of radiation as a supernova? Well, the general consensus is that a supernova beyond a distance of 30 light years would not be harmful to Earth. Not to worry – the closest supernova candidate is much further away than that. And as long as a gamma-ray burst source is over 8,000 light years away, it would not do serious damage. The closest GRB source so far detected is over a billion light years away – far outside our galaxy, much farther than the 8,000 light year danger zone.	Wow – it's really bright now!

Materials



<u>What materials from the ToolKit do I need?</u>

The large flat box labeled “Protecting Earth from Cosmic Radiation” contains:

1. Styrofoam sheet 12” x 18” (30.5 cm x 46 cm)
2. Dowel for punching indentations in the Styrofoam sheet
3. “Atom” stickers
4. Half buckets representing telescopes
5. Telescope labels
6. Wire (to secure half-buckets to Styrofoam)
7. Atmosphere Diagram (for preparing the Styrofoam sheet)
8. Flat tan box: 4” x 4” x 2” (10 cm x 10 cm x 5 cm) labeled “Air as a Radiation Shield”

Assembled into a plastic bag labeled “Parts for ‘Air as a Radiation Shield’”

9. Large Earth image printed on card stock
10. UV beads
11. Square of UV-resistant plastic (you need to remove the paper coating)

Assembled into a plastic bag labeled “Models for Radiation”

12. Small spools for gamma-rays
13. Medium spools for x-rays
14. Longer rods for visible light

15. Magnetic marbles for atomic particles
16. Rod magnets (these are used with the Styrofoam atmosphere model)

A separate box labeled: "GRB model" (also with the imprinted name "UFO Lamp") contains:

17. Fiber Optic Lamp
18. Small Earth image printed on card stock
19. Square of red cellophane
20. Square of black cloth

Table of Elements Handout (see page 123 of this manual)
Table of Elements Banner on the reverse of the Lives of Stars banner.

<u>What must I supply?</u>

- Duct tape or wide packing tape
- 2 – AA batteries
- Small sharp knife
- Pencil with an eraser
- Sharp scissors
- Marshmallows (mini or regular) in a bowl
- *Optional*: Felt-tip pen
- *Optional*: Salad macaroni

What do I need to prepare?

Assemble “Air as a Radiation Shield”:

Parts for "Air as a Radiation Shield **Completed box**

Open up the small flat box.
Fold the large bottom flaps together. Tuck in the shorter flaps. Fold the lid.

Place the large Earth image in the box and put the UV beads in on top.
Remove the paper cover from the UV-resistant plastic square, representing Earth’s atmosphere. Place it in the box and close the lid.

Assemble the GRB Model:

Parts to assemble GRB Model

Completed GRB Model

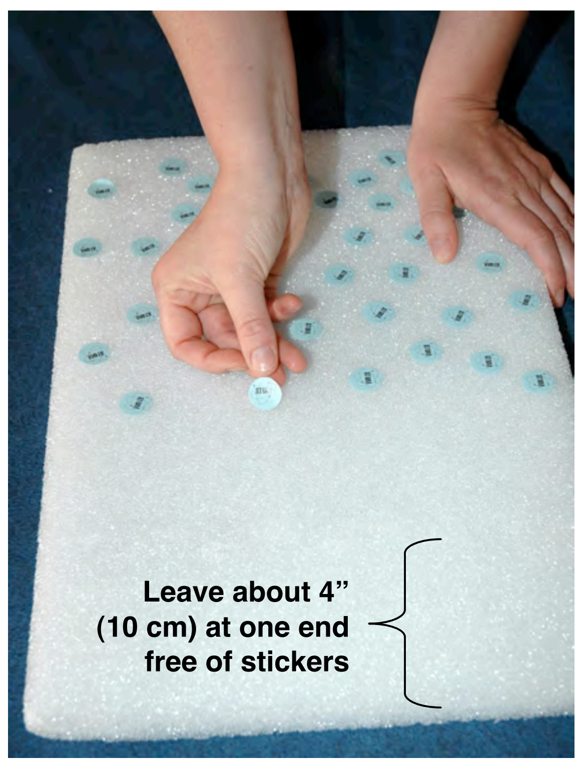
- Open the box labeled "Gamma-Ray Burst Model" (also labeled "Blue UFO Lamp")
- Take out the black cloth, cellophane, card with Earth image, the lamp, and the fiber bundle.
- Fold the black cloth into quarters and use scissors to nip out the center to make a 1/2" (1 cm) hole in the center of the cloth. See photo at right.

- Place your own two AA batteries in the bottom of the lamp.
- Put the bottom of the fiber bundle through the hole in the black cloth.
- Wrap the red cellophane around the bottom of the fiber bundle and press it into the top of the lamp. The red cellophane to used to change the white light coming from the lamp to red light.
- Drape the black cloth to hide the lamp. This is to prevent light from the lamp itself from interfering with the demonstration. Only the light coming through the fiber bundle should be visible.
- The on/off switch is on the bottom of the lamp.

Assemble the model of a slice through Earth's Atmosphere:

Parts for "Protecting Earth from Cosmic Radiation"

You will put together a model of a slice through Earth's atmosphere and its magnetic field. See page 86 for the "Atmosphere Diagram."



Make the Atoms:

Remove the Styrofoam sheet from the box and place the sheet on a hard surface. Using the "Atmosphere Diagram" on page 86 as a guide, use the "Atom" stickers to lay out where you want the atoms on the Styrofoam sheet. These represent the atoms in Earth's atmosphere.

IMPORTANT: Make sure you leave the top 4 to 4-1/2 inches free of stickers. This region is for installing Earth's magnetic field and the telescope that is above the atmosphere.

It's not important to get the stickers perfectly spaced, but you do want them offset from one another.   This is to ensure that the spools representing cosmic radiation will encounter several "atoms" before reaching Earth's surface.

Notice also that the atoms are more widely spaced toward the top than they are nearer the surface of the Earth. Though it is not to scale, this is to illustrate how the atmosphere gets thinner the higher you go.

Once you have the "Atom" sticker pattern the way you want it, center the end of the dowel over each sticker and press round indentations into the Styrofoam sheet.

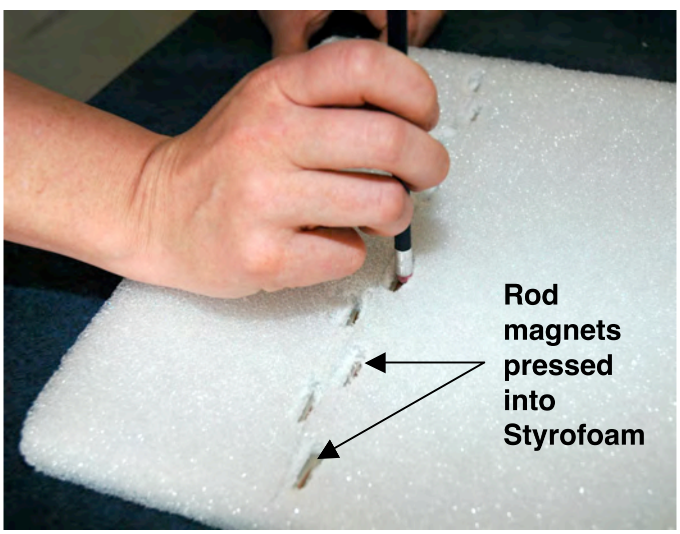
Don't press all the way through the sheet, just about 1/2" (1.3 cm) deep.

You might want to make a pencil mark 1/2" (1.3 cm) from the end of the dowel as a guide (see photo below).

The indentations you are making represent the atoms in our atmosphere.

IMPORTANT: You are not required to use the "Atom" stickers, if you would prefer not to. Just press round indentations into the Styrofoam sheet with the end of the dowel as shown in the photo below. Space the indentations at approximately the spacing shown on the "Atmosphere Diagram" on page 86.

Install the Magnetic Field:
Turn the sheet over, laying it on a flat hard surface. About 4 inches (10 cm) down from the top, you will install the rod magnets in a line to represent Earth's magnetic field.



Starting about 1/2" (1.3 cm) from one edge, use the knife to cut a slit about 1/2" deep in the Styrofoam. Press one of the magnets into the slit. Continue cutting slits and placing the magnets in a line, with about a quarter to half of an inch (approx. 1 cm) between the ends of each magnet. For best results, alternate the magnets north end to north end, then south to south, and so on. The ends that repel each other have the same pole. You may offset the magnets slightly from each other so that the Styrofoam is less likely to break along the line of magnets.

Push the magnets in a little more than 1/2" (about 1.5 cm) deep. Use the eraser on the end of a pencil to seat them.

At this point, you might want to test it**.** Lift the top of the model up about 2 inches (5 cm) and roll a few of the magnetic marbles down the sheet. If most of the magnetic marbles get past the magnetic field, you don't have the magnets pushed in deep enough. You'll need to provide a strip of duct tape or wide packing tape to place over the line of magnets to secure the magnets in place.

Install Telescopes:
The half-buckets represent a space-based telescope and a ground-based telescope. Choose the label for the mission you'd like to feature on the space-based telescope. Then choose which label you prefer for the ground-based telescope. Attach the labels to the buckets. You may need to trim the labels to fit. (Photo A)


Photo A

Make sure the bottom of the space-based telescope is placed about 4 inches (10 cm) down from the top of the sheet. (Photo B)

Secure the buckets by bending the wire around them and pushing the wire through the Styrofoam sheet (Photos C and D). Turn the sheet over, twist the ends of the wire together (Photo E), and cut off the loose ends. You can easily remove the buckets when you want to by pushing up on the bottom of the bucket to pop it out from under the wire. To replace it, snap it back under the wire.

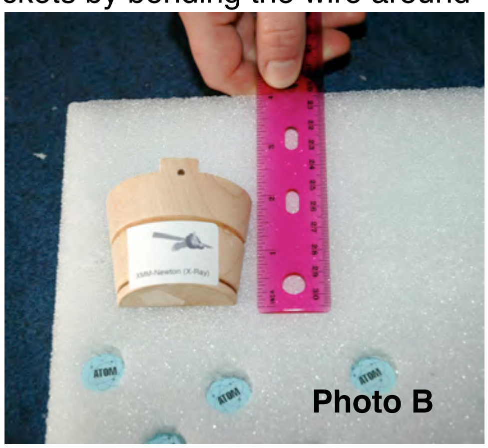


Photo B

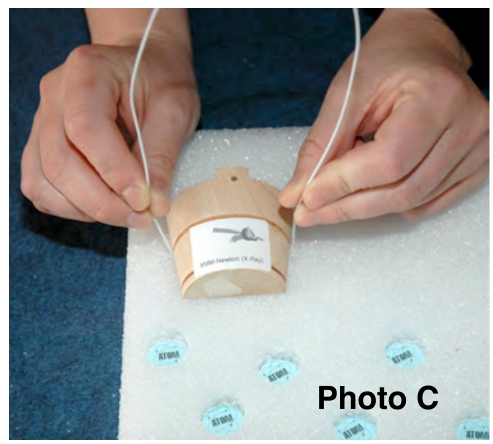


Photo C


Photo D

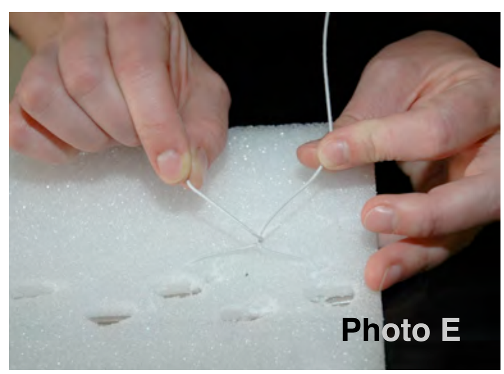


Photo E

Completing the model:

Place the completed atmosphere model back in the box and prop up the upper end of the box on a book or another box – no taller than 2" (5 cm) though – the "Gamma-Ray Burst Model" box (also labeled "Blue UFO Lamp") is the right height. If the box is tilted much higher, the spools and magnetic marbles will travel down the sheet too fast and could just skip over the magnetic field and the holes.

OPTIONAL: **Label the Cosmic Radiation Models**

You might want to use a felt tip pen to mark the spools and rods with an initial for what they represent – "G" for gamma-ray, "X" for x-ray, and "V" for visible light.

Where do I get additional materials?

For the Atmosphere Model in the activity, "Protecting Earth from Cosmic Radiation":

1. Styrofoam sheet 12" x 18" (30.5 cm x 46 cm): Craft store.
2. Dowel – 3/4" (1.9 cm) diameter, about 6" (15 cm) long: Craft or hardware/lumber store.
3. "Atom" stickers: The 3/4" (1.9 cm) diameter round labels in the ToolKit were obtained from www.PlanetLabels.com: use their "white uncoated 3/4 diameter circle" labels. The master on page 89 of this manual is formatted for those labels. Alternatively, you can make the Atmosphere Model without the labels. Just use the dowel to press holes in the Styrofoam.
4. "Telescope" half-buckets: The ones in the ToolKit were obtained from www.craftparts.com: "Washtub Bucket." They were cut in half at a wood shop. Small cardboard favor boxes from a craft store can be used as a substitute.
5. "Telescope" labels: Print onto Avery 5160 (1" x 2-5/8") (2.5cm x 6.7cm) label material from the file "MiscLabels5160.pdf" on the Manual & Resources CD in the "LabelsLogos" folder.
6. Wire (to secure the half-buckets to Styrofoam). The wire used in the ToolKit is floral wire. It can be obtained from a craft store or a floral shop.
7. Atmosphere Diagram: Print from page 86 of this manual.
8. Rod magnets 1/4" x 3/4" (0.6 cm x 1.9 cm): You need 10 of them. Search the Internet for NdFeB Rod magnets. The ones in the ToolKit were acquired from www.amazingmagnets.com.

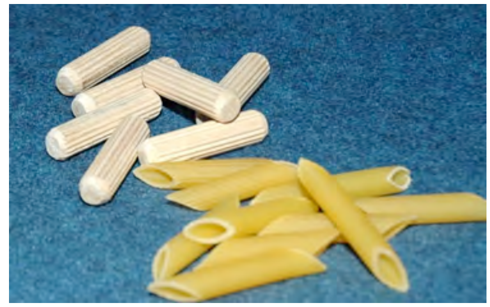
For the activity "Air as a Radiation Shield":

9. 4" x 4" (10 cm x 10 cm) Box: craft store
10. Large Earth image printed on card stock: Print from the master on page 87 of this manual.
11. UV beads: search the Internet for "ultraviolet detecting beads." The ones in the ToolKit were acquired from www.teachersource.com.
12. UV-resistant plastic: search the Internet for "UV-resistant plastic" or "ultraviolet filtering acrylic." The one in the ToolKit was acquired from Tap Plastics.

For the radiation models:

13. Gamma-ray spools: These are wooden spools 1/2"H x 1/2"D 1/8"Hole (13mm x 13mm x 3mm). Search the Internet for wooden spools. The ones in the ToolKit were obtained from www.craftparts.com. A good (and in some cases, preferred) substitute is uncooked salad macaroni (just don't use it in damp conditions).

14. X-Ray spools: These are wooden spools 5/8"H x 1/2"D 7/32"Hole (16mm x 13mm x12.7mm x 5.5mm). Search the Internet for wooden spools. The ones in the ToolKit were obtained from www.craftparts.com.
15. Longer rods for visible light: These are wooden rods 3/8" diameter x 1-1/2" long (9.5mm x 38mm). Search the Internet for dowel pins. The ones in the ToolKit were obtained from www.craftparts.com. A good substitute is uncooked penne pasta (just don't use it in damp conditions).



16. Magnetic marbles: These are 5/8" in diameter (16mm). Search the Internet for "magnetic marbles." The ones in the ToolKit can be acquired from www.teachersource.com.

For the Gamma-Ray Burst Model:

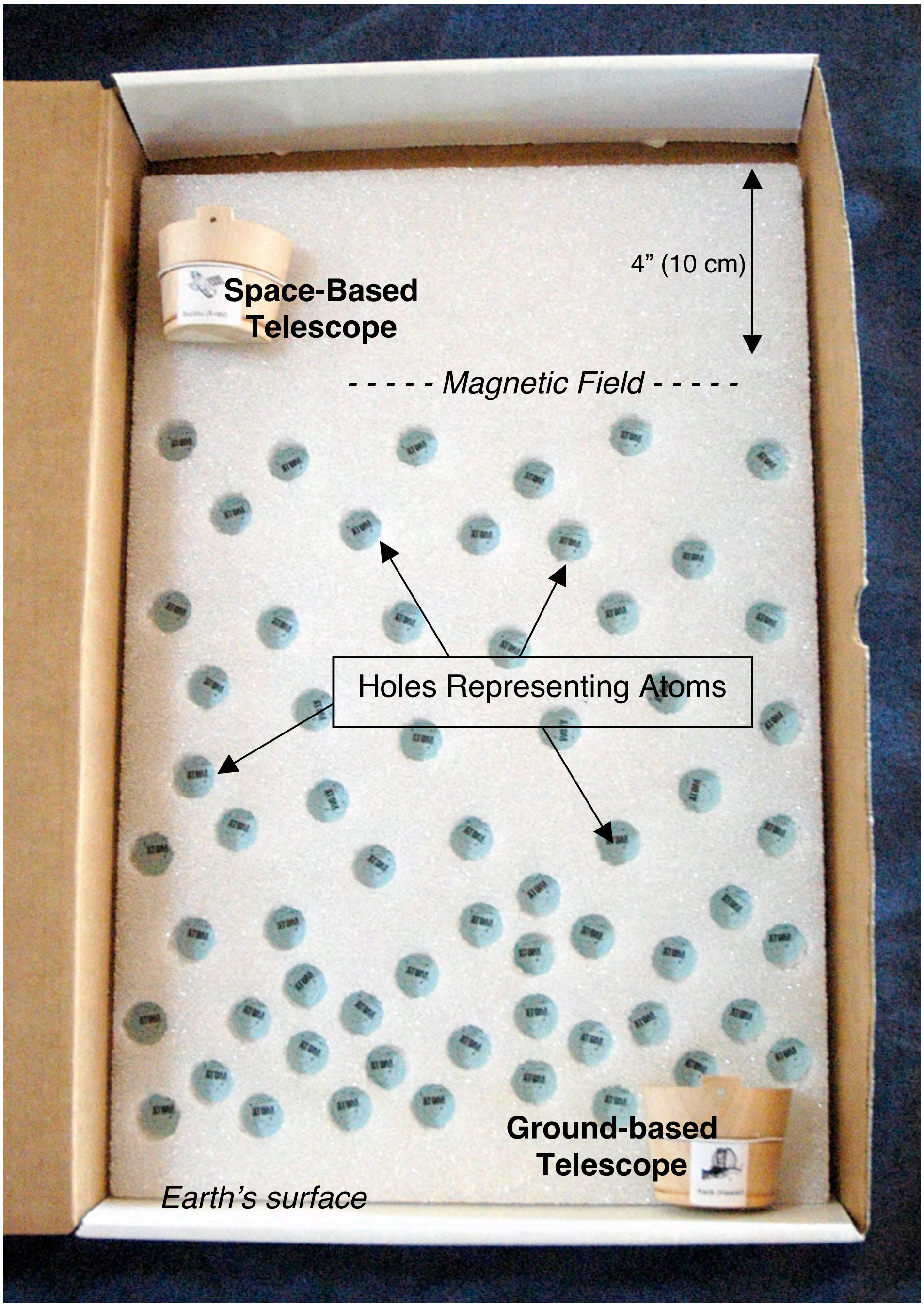
17. Fiber Optic Lamp: Search the Internet for "Plastic Mini UFO Lamps." The one in the ToolKit was acquired from www.OrientalTrading.com.
18. Small Earth image printed on card stock: Print from the master on page 88 of this manual.
19. Red cellophane: about 3" x 3" (8 cm x 8 cm): craft stores
20. Black cloth: 8" x 8" (20 cm x 20 cm): Fabric store

For the Nuclear Fusion activity with marshmallows:

- Marshmallows: Mini-marshmallows or regular-sized marshmallows can be purchased from most grocery stores.
- Table of Elements banner: The PDF for the banner is on Manual and Resources CD in the "Banner_Artwork" folder. The file is "TableOfElements.pdf." You may have a full-size banner or poster made from this file at a copy store or other printing company. Table of the Elements posters are also available commercially. Search the Internet for "Periodic Table" or "Table of Elements".
- Table of Elements Handout: Print from the master on page 123 of this manual.

“Protecting Earth from Cosmic Radiation”

Atmosphere Diagram



Use as a guide to prepare the sheet of Styrofoam
to be a model for Earth’s atmosphere and magnetic field.









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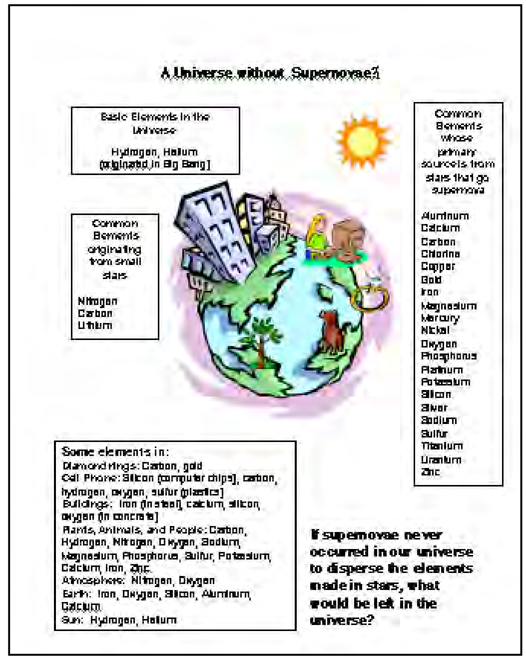
A Universe Without Supernovae

What's this activity about?



Big Question:

Supernovae seem dangerous, but what would the universe be like if supernovae never happen?

Big Activity:

Active game that illustrates the value of supernovae in the universe.

Participants:

From the club: A minimum of one person.

Visitors: This activity is appropriate for families with older children, the general public, and school groups in grades 5 and up. Plan on a minimum of 10 visitors, but you can easily involve up to about 40 people.

Duration:

10 – 15 minutes.

Topics Covered:

- The supernova explosion releases a lot of the elements that were created in the star during its lifetime and also generates new elements during the explosion, all in the matter of a few seconds.
- If these stars didn't explode, all those elements would remain locked up inside the star.
- Almost all the elements except hydrogen were originally generated inside stars and without supernovae to disperse those elements, almost everything we see around us, including us, would not exist.

WHERE COULD I USE THIS ACTIVITY?

ACTIVITY	Star Party	Pre-Star Party –Outdoors	Pre-Star Party –Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
A Universe Without Supernovae	√	√	√	√		√	√	√	√	√

WHAT DO I NEED TO DO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Scissors or paper cutter. *Optional:* Laminating.	*Optional:* Everyday objects; trash can	Cut apart the Object cards and Element cards (*optional:* Laminate the cards). Make needed copies of handouts

Helpful Hints

The Element cards used in this activity are white, yellow, or blue.

The front of the card (example at left) names the element, where it originates, how many protons it has (also known as its “atomic number”), and its chemical symbol.

The back of the card (example at right) lists a number of things the element is found in.

The cards classify sources of some of the elements in the universe into these categories:

- “Originated in the Big Bang” (White cards): Hydrogen and helium were present in the early universe. Helium is also produced in all stars, small and large, where the core is hot enough to fuse hydrogen into helium. These cards are used to show what elements existed in our universe before stars formed.

- “Originates from small stars” (Yellow cards – for the yellow/white sun-like stars): These are elements that can form from fusion in small stars. (Carbon and nitrogen are also produced in large stars, but these cards are used to show what elements COULD exist in a universe where stars didn’t explode as supernovae.) A small star can contribute these elements to the interstellar medium as it loses its outer layers in the planetary nebula that forms around the aging star.
- “Primarily from stars that go supernova” (Blue cards – for massive, hot, bluish stars): These are elements that generally need the mass of large stars and/or the power of supernovae to be produced.

These classifications have been collected from research about the cosmic origin of the chemical elements and are presented as “What is your Cosmic Connection to the Elements?”, found here:
http://imagine.gsfc.nasa.gov/docs/teachers/elements/elements.html

The classifications for the element cards are somewhat simplified from the detailed categories in that document. Note that the “large stars” and “supernovae” categories have been put together under “primarily from stars that go supernova”, since large stars are defined as those that will one day die in a supernova explosion. Elements whose primary source is fragmentation from cosmic rays, neutron capture, or from radioactive decay are not included or addressed in this activity.

The origin of the elements is not a simple story, so that makes it challenging, but also more interesting, to explain.

For a general summary, however, nuclear fusion in the core of small stars can generate elements up to carbon (with 6 protons) and nitrogen (with 7 protons). Nuclear fusion at the core of large stars can generate elements up to iron (with 26 protons). Elements heavier than iron are generated in the shock of the supernova explosion as well as through a much longer process called “neutron capture” in the cores of all stars (a process that occurs over thousands of years).

Please read the booklet “What is your Cosmic Connection to the Elements?” for the more complete story about element formation in stars and how the elements are dispersed into the interstellar medium.
http://imagine.gsfc.nasa.gov/docs/teachers/elements/elements.html

Background Information

Website:
Refer to NASA's Imagine the Universe! website under the activity "What is your Cosmic Connection to the Elements?" for background information on this activity:
http://imagine.gsfc.nasa.gov/docs/teachers/elements/elements.html

The introduction from this document summarizes the concepts:

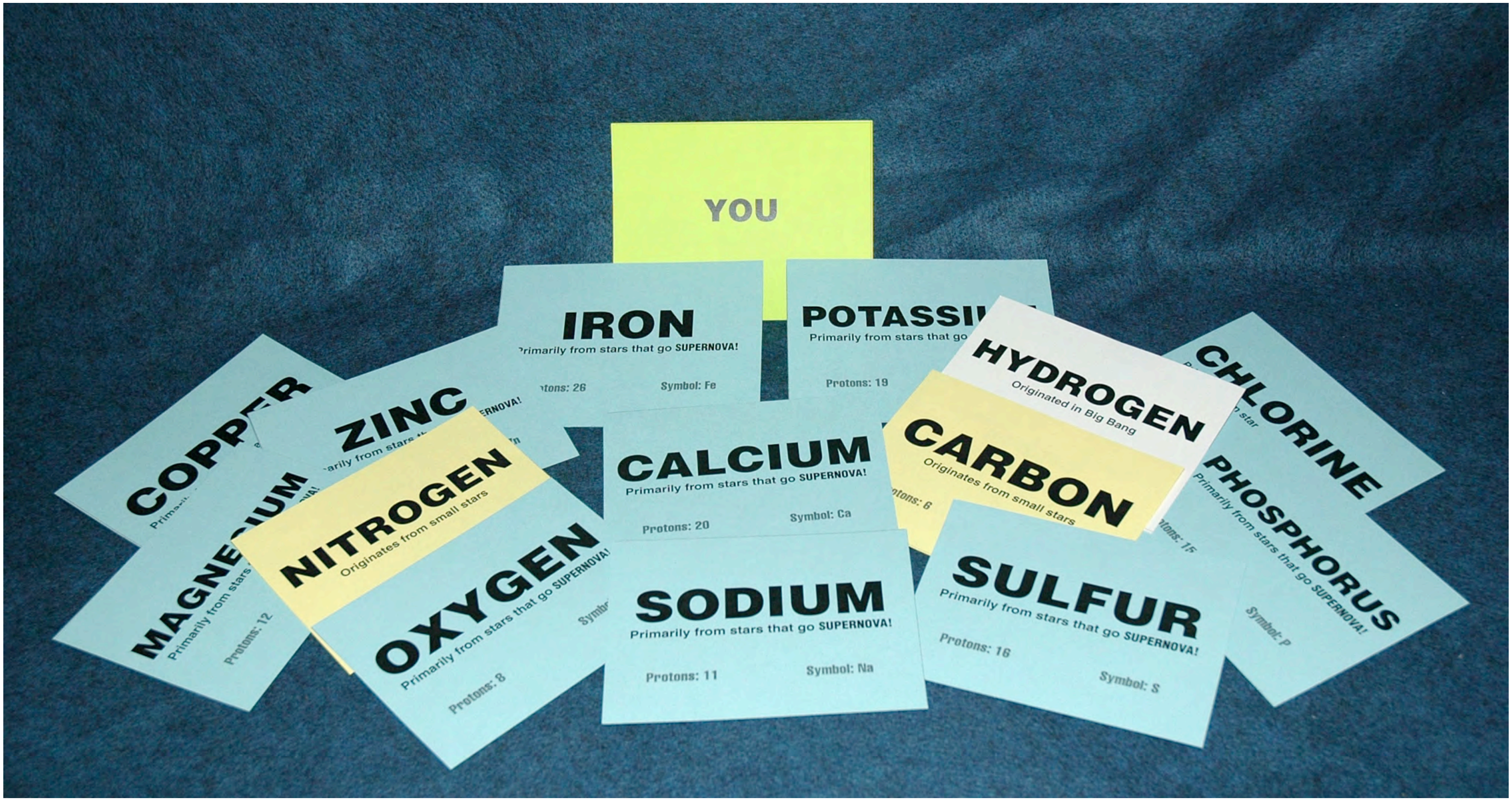
> Chemical elements are all around us, and are part of us. The composition of the Earth, and the chemistry that governs the Earth and its biology are rooted in these elements.
>
> The elements have their ultimate origins in cosmic events. Further, different elements come from a variety of different events. So the elements that make up life itself reflect a variety of events that take place in the Universe. The hydrogen found in water and hydrocarbons was formed in the moments after the Big Bang. Carbon, the basis for all terrestrial life, was formed in small stars (as well as large stars). Elements of lower abundance in living organisms but essential to our biology, such as calcium and iron, were formed in large stars. Heavier elements important to our environment, such as gold, were formed in the explosive power of supernovae. And light elements used in our technology were formed via cosmic rays. The solar nebula, from which our solar system was formed, was seeded with these elements, and they were present at the Earth's formation. Our very existence is connected to these elements, and to their cosmic origin.

"Large" stars are defined as those that will one day die in a supernova explosion. These are the massive, hot, blue stars at least eight to ten times the mass of our star, the Sun.

Why does our Sun have heavier elements in it?

As you may know, our Sun is 99% hydrogen and helium, but it also contains small amounts of elements like silicon (with 14 protons), calcium (with 20 protons), and iron (with 26 protons). If our Sun cannot generate those elements through its own nuclear processes, where did these elements come from? Our star, the Sun, is only a few billion years old. The universe is many billions of years old. The nebula of gas and dust from which our Sun and its planets formed was enriched with these heavy elements by early supernovae in our galaxy. Just as the planets contain heavy elements from that nebula, so does our Sun. Those heavy elements have been part of the Sun since its formation, even before nuclear fusion began at the Sun's core.

Heavier elements CAN form inside a small star like our Sun through a process called neutron capture, but only if heavy elements were already present in the star at the time of the star's formation. In addition, when a white dwarf experiences a nova, a few elements heavier than carbon and nitrogen can form. Once again, this is all more fully explained in "What is your Cosmic Connection to the Elements?": http://imagine.gsfc.nasa.gov/docs/teachers/elements/elements.html.



Many elements are required to make YOU. All the blue cards are elements that are made from stars that go supernova.

Detailed Activity Descriptions

A Universe without Supernovae

Leader's Role	Participants' Role (Anticipated)
Materials: • Handouts: "A Universe Without Supernovae" with the Supernova Information Sheet on the back. Note that the Supernova Information Sheet comes in two versions: one with a blank space at the bottom and one where you can type in your club information in the space before printing. • Element Cards of the elements & what the element is found in. These are white, yellow, and blue. • Object Cards for objects to analyze: would this exist if no supernovae? These are green. Pick out 8 to 10 of your favorites, but be sure to include "Stars", "Earth", and "You". • *Optional:* Table of Elements Banner and/or Table of Elements Handout **You supply:** • *Optional:* Trash can • *Optional:* Everyday objects as examples of items on the Object Cards • *Optional:* Make up you own objects based on where you are (e.g. if outside, point to a nearby tree, a parked car, or a telescope) **Small Groups:** At minimum you should hand out the following Element cards: • Hydrogen, Helium, Carbon, Nitrogen, Calcium, Gold, Iron, Silicon, Sulfur, and Sodium. It's OK for one person to have more than one Element card. **Large Groups:** When you have more than about 30 people, you might want to print an extra set of Element Cards. It's OK for two people to have the same element, especially the Hydrogen, Helium, Carbon, and Nitrogen.	
Objective: Visitors discover that almost all elements that make up the Earth and all its living things were made inside stars that go supernova. Without supernovae to disperse these elements, the universe as we know it couldn't exist.	
Presentation Tip: To use this activity as it is, it is helpful for your audience to be a little familiar with: • What an atom is and that it has protons in the nucleus. • The number of protons in the atom's nucleus determines what kind of element it is. • The basic lifecycle of stars, specifically when a supernova occurs • It can be helpful to understand a little about the process of nuclear fusion inside stars. Depending on the knowledge of your audience, you may want to introduce this activity by using one (or more) of the other activities in this ToolKit: • Use the banner, The Lives of Stars, and review the lifecycle of Sun-like stars and of massive stars (from the activity "**The Lives of Stars**") • The nuclear fusion demonstration with marshmallows.	

Leader's Role	**Participants' Role (Anticipated)**
To say: Who has heard of a supernova? What is it? Supernovae might seem dangerous (and they are if you're standing too close…), but they are very useful to the evolution of the universe. If no stars were massive enough to explode, and they just cooled off instead, the universe would be a very different place indeed. The supernova explosion not only generates and ejects new elements, it also disperses all of the elements created during the life of the star. If these stars never exploded, the elements they make would be locked inside the star and would not contribute to the making of new stars or planets. The lighter elements generated during the lives of small stars, like our Sun, are spread back into the galaxy in the nebula that expands away from the star as it ages. *To do:* Pass out "A Universe without Supernovae" handouts *To say:* Let's a take a look at this sheet. *To do:* Point to each area of the handout as you ask the question. *To say:* Where did a lot of the helium in the universe originate? And where can nitrogen come from? What about oxygen?	An exploding star Big Bang Small stars Stars that go Supernova
To do: Pass out element cards randomly to visitors. ***Variation:*** Have visitors group themselves into three groups, based on card color: Big Bang, Small Stars, Stars that go Supernova. ***Variation****:* Have visitors line up by number of protons in their element.	
Presentation Tip: At minimum you should hand out the following Element cards: **Hydrogen, Helium, Carbon, Nitrogen, Calcium, Gold, Iron, Silicon, Sulfur, and Sodium**. It's OK for one person to have more than one Element card.	

Leader's Role	**Participants' Role (Anticipated)**
To do: If you are using the Table of Elements banner or handouts, point to the location of each named element on the banner or handout.	
To say: Everyone will become an element in the universe.	Hands up with cards.
Note that these are color-coded.	Hydrogen. Helium.
Who has a white card? Hold up your card. These elements were around at the beginning of the universe. (Point to each person) What's your element?	Hands up with cards.
Who has a yellow card? Elements on yellow cards can be made in stars more like our sun – smaller stars that don't explode and only disperse some of the elements made in the star. Lighter elements, those with fewer protons, can be made inside small stars.	Carbon. Nitrogen.
What's your element?	Hands up with cards.
Who has a blue card? Hold them up! The blue cards represent elements made primarily in those massive stars that go supernova, dispersing all those elements back into the galaxy.	

Leader's Role	**Participants' Role (Anticipated)**
To say: Look on the back of your card to see a number of things that your element can be found in. Hold up "Diamond Ring" card. Who has an element that might be found in diamond rings or necklaces? Hold your cards up! (Carbon, gold, silver, platinum)	Cards up.
Look around. Are any of those cards blue?	Yes – some of them.
Those are the elements that are generated in stars that go supernova. Diamonds are made of carbon, which can be generated in small stars, but jewelry also needs elements generated in stars that go supernovae, like gold or silver – the blue cards. So would we have rings or necklaces in a universe where supernovae didn't happen – where stars didn't explode to disperse these elements back into the galaxy?	No!
So no jewelry in a universe without supernovae. Away it goes. *To do:* Throw away the "Diamond Ring" card – for suggestions on disposing of Object cards, see "Presentation Tip" below.	

Presentation Tip:

Here are a few ways you can dispose of Objects that would not be in a universe without supernovae:

- Have a trash can next to you and throw the Object card in the trash can.
- In a large crowd, give the Object cards to people without Element cards and have the people stand on one side of you. The Objects that WOULD exist in a universe without supernovae could be held by people standing on the other side of you.
- Have a bulletin board behind you with "YES" and "NO" signs on it. Use push pins to secure the Object cards to the appropriate sides.

Someone may bring up that not all jewelry is made of gold, silver, or platinum, but elements like titanium and aluminum are also made primarily in supernovae.

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td><u>To do:</u>
Hold up the “Computer” card.
<u>To Say:</u>
How about computers? Who has an element that’s in something found in computers, including cell phones?
(Silicon, plastics come from oil which is made primarily of carbon, hydrogen, oxygen, and sulfur)</td><td>Cards up.</td></tr>
<tr><td>Do you see any blue cards?

So computers require elements made in stars that go supernova. No electronics!

<u>To do:</u>
Throw “Computer” away.

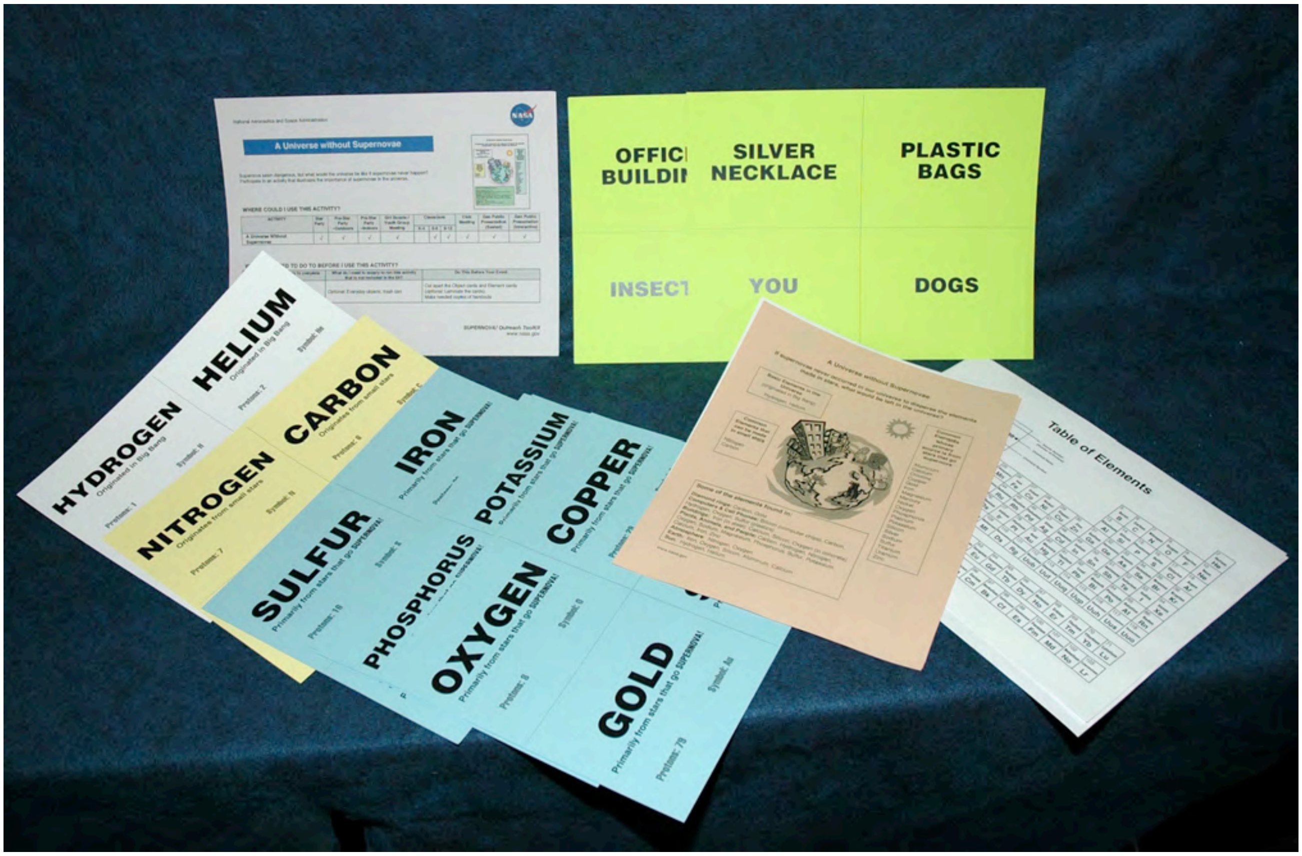

Repeat this with a few more items (e.g. Dogs, Oak Trees, Office Building) then hold up “STARS”
<u>To Say:</u>
Well, are we going to have anything left in a universe without supernovae? How about stars – what elements are required for stars?</td><td>Yes. Lots of them.

Hydrogen & Helium cards are held up.</td></tr>
<tr><td>Any blue cards?</td><td>No! Only white cards.</td></tr>
<tr><td>So could we have stars in a universe without supernovae? OK. We’d still have stars.</td><td>YES!</td></tr>
</table>

Leader's Role	Participants' Role (Anticipated)
To do: Put "Stars" on the side with things we WOULD have. Keep going with a few more items (e.g. Insects, Earth's Atmosphere, Jupiter, Earth), ending with "YOU" *To Say:* Let's look at what we've got. What would we still have in a universe without supernovae? Mostly we'd have stars and gas giant planets, like Jupiter. Jupiter & Saturn would not have any moons and Saturn wouldn't have rings. But there would be no Earth and none of us would be here.	
So aren't you glad we live in this universe where stars explode as supernovae?	YES!
As you pass the cards back up here, look around you.	Visitors pass cards back.
Almost all the atoms in the things around us and in your body were made billions of years ago inside stars. So for our age, we're pretty well-preserved!	Wow.

Visitors at an astronomy event holding up Element Cards for "TELEVISION."

Materials



<u>What materials from the ToolKit do I need?</u>

In the activity bag:

1. Element Cards (white, yellow, and blue cards)
2. Object Cards (green cards)
3. Universe without Supernovae and Supernova Information Sheet handouts
4. Rubber bands
5. Table of Elements Handouts

From the ToolKit box:

6. *Optional:* Table of Elements Banner

Reference Materials:

7. Poster: Your Cosmic Connection to the Elements
8. Booklet: Your Cosmic Connection to the Elements

<u>What must I Supply?</u>

- Scissors
- Additional handouts as needed
- *Optional:* Trash can

- *Optional:* Enter your club information on the handouts. Note that the Supernova Information Sheet comes in two versions: one with a blank space at the bottom and one where you can type in your club information in the space before printing it.
- *Optional:* Add your own Object cards or provide actual objects.

What do I need to prepare?

Cut apart the Object Cards and the Element Cards. You may want to laminate them to make them last longer. Place a rubber band around each set of cards.

Where do I get additional materials?

1. Element Cards: Print 2-sided on white card stock from masters on pages 106 through 117 of this manual. Note that the odd-numbered pages are printed on the back of the even-numbered pages.
2. Object Cards: Print on white card stock from the masters on starting on page 118 of this manual.
3. Universe without Supernovae and Supernova Information Sheet handouts: Print the Universe without Supernovae handout from the masters on pages 104 and 105 of this manual. Note that the Universe without Supernovae handout comes in two versions: one in color and one in black and white. Print the Supernova Information Sheet on the back of the Universe without Supernovae handout from the masters on pages 36 and 37 of this manual. The Supernova Information Sheet has two choices: one with a blank space at the bottom and one where you can type in your club information at the bottom before making copies.
4. Rubber bands: office supply
5. Table of Elements Handout: Print from the master on page 123 of this manual.
6. Table of Elements Banner: The PDF for the banner is on Manual and Resources CD in the "Banner_Artwork" folder. The file is "TableOfElements.pdf." You may have a full-size banner or poster made from this file at a copy store or other printing company. Table of the Elements posters are also available commercially. Search the Internet for "Periodic Table" or "Table of Elements".
7. Download the **poster** "What is Your Cosmic Connection to the Elements?" from the following location: http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/What_Is_Your_Cosmic_Connection_Poster.html
8. Download the **booklet** "What is Your Cosmic Connection to the Elements?" from the following location: http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/What_Is_Your_Cosmic_Connection.html

A Universe without Supernovae

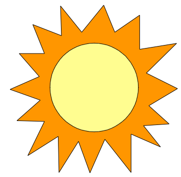
If supernovae never occurred in our universe to disperse the elements made in stars, what would be left in the universe?

Basic Elements in the Universe
(originated in Big Bang)

Hydrogen, Helium

Common Elements that can be made in small stars

Nitrogen
Carbon



Common Elements whose primary source is from stars that go supernova

Aluminum
Calcium
Chlorine
Copper
Gold
Iron
Magnesium
Mercury
Nickel
Oxygen
Phosphorus
Platinum
Potassium
Silicon
Silver
Sodium
Sulfur
Titanium
Uranium
Zinc

Some of the elements found in:

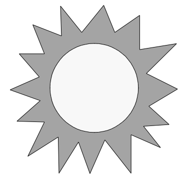
Diamond rings: Carbon, Gold
Computers & Cell Phones: Silicon (computer chips), Carbon, Hydrogen, Oxygen, Sulfur (plastics)
Buildings: Iron (in steel), Calcium, Silicon, Oxygen (in concrete)
Plants, Animals, and People: Carbon, Hydrogen, Nitrogen, Oxygen, Sodium, Magnesium, Phosphorus, Sulfur, Potassium, Calcium, Iron, Zinc
Atmosphere: Nitrogen, Oxygen
Earth: Iron, Oxygen, Silicon, Aluminum, Calcium
Sun: Hydrogen, Helium

A Universe without Supernovae

If supernovae never occurred in our universe to disperse the elements made in stars, what would be left in the universe?

Basic Elements in the Universe
(originated in Big Bang)

Hydrogen, Helium



Common Elements whose primary source is from stars that go supernova

Aluminum
Calcium
Chlorine
Copper
Gold
Iron
Magnesium
Mercury
Nickel
Oxygen
Phosphorus
Platinum
Potassium
Silicon
Silver
Sodium
Sulfur
Titanium
Uranium
Zinc

Common Elements that can be made in small stars

Nitrogen
Carbon

Some of the elements found in:

Diamond rings: Carbon, Gold
Computers & Cell Phones: Silicon (computer chips), Carbon, Hydrogen, Oxygen, Sulfur (plastics)
Buildings: Iron (in steel), Calcium, Silicon, Oxygen (in concrete)
Plants, Animals, and People: Carbon, Hydrogen, Nitrogen, Oxygen, Sodium, Magnesium, Phosphorus, Sulfur, Potassium, Calcium, Iron, Zinc
Atmosphere: Nitrogen, Oxygen
Earth: Iron, Oxygen, Silicon, Aluminum, Calcium
Sun: Hydrogen, Helium

OXYGEN

Primarily from stars that go **SUPERNOVA!**

Protons: 8

Symbol: O

COPPER

Primarily from stars that go **SUPERNOVA!**

Protons: 29

Symbol: Cu

GOLD

Primarily from stars that go **SUPERNOVA!**

Protons: 79

Symbol: Au

SILICON

Primarily from stars that go **SUPERNOVA!**

Protons: 14

Symbol: Si

COPPER

I am an element found in:

Humans
Animals
Plumbing
Electrical Wires
Coins
Electronics

OXYGEN

I am an element found in:

Plastics
Concrete
Humans
Animals
Plants
Water
Earth's Atmosphere
The Earth

SILICON

I am an element found in:

Computers
Concrete
Glass
Sand & Rocks

GOLD

I am an element found in:

Jewelry
Coins
Dentistry

SULFUR

Primarily from stars that go **SUPERNOVA!**

Protons: 16

Symbol: S

IRON

Primarily from stars that go **SUPERNOVA!**

Protons: 26

Symbol: Fe

SODIUM

Primarily from stars that go **SUPERNOVA!**

Protons: 11

Symbol: Na

MAGNESIUM

Primarily from stars that go **SUPERNOVA!**

Protons: 12

Symbol: Mg

IRON

I am an element found in:

Steel
Humans
Animals
Plants
The Earth

SULFUR

I am an element found in:

Plastics
Humans
Animals
Plants

MAGNESIUM

I am an element found in:

Humans
Animals
Plants

SODIUM

I am an element found in:

Humans
Animals
Plants

PHOSPHORUS

Primarily from stars that go **SUPERNOVA!**

Protons: 15

Symbol: P

POTASSIUM

Primarily from stars that go **SUPERNOVA!**

Protons: 19

Symbol: K

CALCIUM

Primarily from stars that go **SUPERNOVA!**

Protons: 20

Symbol: Ca

ZINC

Primarily from stars that go **SUPERNOVA!**

Protons: 30

Symbol: Zn

POTASSIUM

I am an element found in:

Humans
Animals
Plants

PHOSPHORUS

I am an element found in:

Humans
Animals
Plants

ZINC

I am an element found in:

Humans
Animals
Plants

CALCIUM

I am an element found in:

Concrete
Humans
Animals
Plants
The Earth

CHLORINE

Primarily from stars that go **SUPERNOVA!**

Protons: 17

Symbol: Cl

ALUMINUM

Primarily from stars that go **SUPERNOVA!**

Protons: 13

Symbol: Al

PLATINUM

Primarily from stars that go **SUPERNOVA!**

Protons: 78

Symbol: Pt

SILVER

Primarily from stars that go **SUPERNOVA!**

Protons: 47

Symbol: Ag

ALUMINUM

I am an element found in:

Food Packaging
Aircraft
The Earth

CHLORINE

I am an element found in:

Humans
Animals
Plants

SILVER

I am an element found in:

Jewelry
Coins
Photography
Electrical Parts

PLATINUM

I am an element found in:

Jewelry
Medicine
Cars
Missiles

NITROGEN

Originates from small stars

Protons: 7

Symbol: N

CARBON

Originates from small stars

Protons: 6

Symbol: C

NITROGEN

Originates from small stars

Protons: 7

Symbol: N

CARBON

Originates from small stars

Protons: 6

Symbol: C

CARBON

I am an element found in:

Plastics
Diamonds
Humans
Animals
Plants
Earth

NITROGEN

I am an element found in:

Humans
Animals
Plants
Earth's Atmosphere

CARBON

I am an element found in:

Plastics
Diamonds
Humans
Animals
Plants
Earth

NITROGEN

I am an element found in:

Humans
Animals
Plants
Earth's Atmosphere

HYDROGEN

Originated in Big Bang

Protons: 1

Symbol: H

HELIUM

Originated in Big Bang

Protons: 2

Symbol: He

HYDROGEN

Originated in Big Bang

Protons: 1

Symbol: H

HELIUM

Originated in Big Bang

Protons: 2

Symbol: He

HELIUM

I am an element found in:

Gas Planets
Stars

HYDROGEN

I am an element found in:

Plastics
Concrete
Humans
Animals
Plants
Water
Gas Planets
Stars

HELIUM

I am an element found in:

Gas Planets
Stars

HYDROGEN

I am an element found in:

Plastics
Concrete
Humans
Animals
Plants
Water
Gas Planets
Stars

SILVER NECKLACE

PLASTIC BAGS

YOU

DOGS

OAK TREES

EARTH

EARTH'S ATMOSPHERE

JUPITER

STARS

SUN

TELEVISION

COMPUTER

OFFICE BUILDING

LIONS

INSECTS

SHARKS

CREDIT CARDS

EAGLES

DIAMOND RING

SNAKES

Table of Elements

6 — Atomic Number (Number of Protons)
Carbon — Chemical Name
C — Chemical Symbol

1 Hydrogen H																	2 Helium He
3 Lithium Li	4 Beryllium Be											5 Boron B	6 Carbon C	7 Nitrogen N	8 Oxygen O	9 Fluorine F	10 Neon Ne
11 Sodium Na	12 Magnesium Mg											13 Aluminum Al	14 Silicon Si	15 Phosphorus P	16 Sulfur S	17 Chlorine Cl	18 Argon Ar
19 Potassium K	20 Calcium Ca	21 Scandium Sc	22 Titanium Ti	23 Vanadium V	24 Chromium Cr	25 Manganese Mn	26 Iron Fe	27 Cobalt Co	28 Nickel Ni	29 Copper Cu	30 Zinc Zn	31 Gallium Ga	32 Germanium Ge	33 Arsenic As	34 Selenium Se	35 Bromine Br	36 Krypton Kr
37 Rubidium Rb	38 Strontium Sr	39 Yttrium Y	40 Zirconium Zr	41 Niobium Nb	42 Molybdenum Mo	43 Technetium Tc	44 Ruthenium Ru	45 Rhodium Rh	46 Palladium Pd	47 Silver Ag	48 Cadmium Cd	49 Indium In	50 Tin Sn	51 Antimony Sb	52 Tellurium Te	53 Iodine I	54 Xenon Xe
55 Cesium Cs	56 Barium Ba	57-71 *	72 Hafnium Hf	73 Tantalum Ta	74 Tungsten W	75 Rhenium Re	76 Osmium Os	77 Iridium Ir	78 Platinum Pt	79 Gold Au	80 Mercury Hg	81 Thallium Tl	82 Lead Pb	83 Bismuth Bi	84 Polonium Po	85 Astatine At	86 Radon Rn
87 Francium Fr	88 Radium Ra	89-103 **	104 Rutherfordium Rf	105 Dubnium Db	106 Seaborgium Sg	107 Bohrium Bh	108 Hassium Hs	109 Meitnerium Mt	110 Darmstadtium Ds	111 Roentgenium Rg	112 Ununbium Uub	113 Ununtrium Uut	114 Ununquadium Uuq	115 Ununpentium Uup	116 Ununhexium Uuh	117 Ununseptium Uus	118 Ununoctium Uuo

*	57 Lanthanum La	58 Cerium Ce	59 Praseodymium Pr	60 Neodymium Nd	61 Promethium Pm	62 Samarium Sm	63 Europium Eu	64 Gadolinium Gd	65 Terbium Tb	66 Dysprosium Dy	67 Holmium Ho	68 Erbium Er	69 Thulium Tm	70 Ytterbium Yb	71 Lutetium Lu
**	89 Actinium Ac	90 Thorium Th	91 Protactinium Pa	92 Uranium U	93 Neptunium Np	94 Plutonium Pu	95 Americium Am	96 Curium Cm	97 Berkelium Bk	98 Californium Cf	99 Einsteinium Es	100 Fermium Fm	101 Mendelevium Md	102 Nobelium No	103 Lawrencium Lr

SUPERNOVA! Outreach ToolKit

Media & Resources

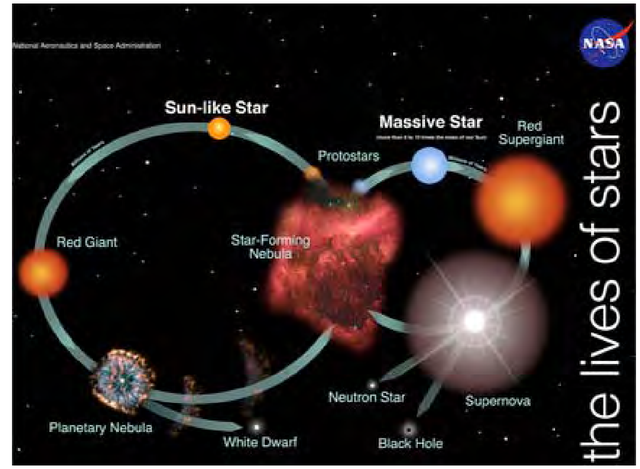
GETTING STARTED

1. **INSERT "MANUAL & RESOURCES CD" INTO YOUR COMPUTER. Click on SNManual.pdf to navigate through the ToolKit Manual. You need the free Adobe Acrobat Reader to view the manual: http://www.adobe.com/products/acrobat/readstep2.html.**
2. **For best results copy the entire CD onto your computer hard drive in any folder you choose.**
3. **VIEW THE TRAINING VIDEO as you review materials in the ToolKit – this is a DVD labeled "Training Video DVD."**
4. Questions? Contact nightskyinfo@astrosociety.org

WHERE COULD I USE THE RESOURCES INCLUDED HERE?

MEDIA / RESOURCE	Pre-Star Party –Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)
			K-4	5-8	9-12		
PowerPoint: SUPERNOVA!	√	√		√	√	√	√
Electromagnetic Spectrum Poster	√	√		√	√	√	√
Training DVD						√	
Manual & Resources CD						√	

Supernovae in the Lives of Stars



What is a supernova? Where does it fit in the lives of stars? Will the Sun go supernova?
Using the banner "The Lives of Stars" and visitor handouts, provide an overview of the lifecycle of stars and where supernovae fit in.
With a tennis ball and a ping-pong ball, give your visitors a fun experience to illustrate what happens when a star explodes.
Use star maps to find stars in the night sky likely to go supernova.

WHERE COULD I USE THIS ACTIVITY?

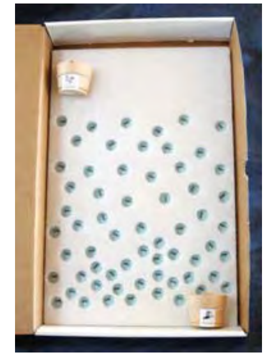
ACTIVITY	Star Party	Pre-Star Party –Outdoors	Pre-Star Party –Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
The Lives of Stars		√	√	√		√	√	√	√	√
Let's Make a Supernova		√	√	√		√	√	√		√
Star Maps: Stars likely to go Supernova!	√	√	√							√

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Optional: Additional tennis balls and ping-pong balls.	*Optional*: Salad macaroni (uncooked)	Make needed copies of handouts

Night Sky Network

Protecting Earth from Cosmic Radiation



What is cosmic radiation and where does it come from? How are the elements in the universe generated? How are supernovae involved? How dangerous is this cosmic radiation and how is Earth protected? How does NASA study this radiation? Using several models, discover the answers.

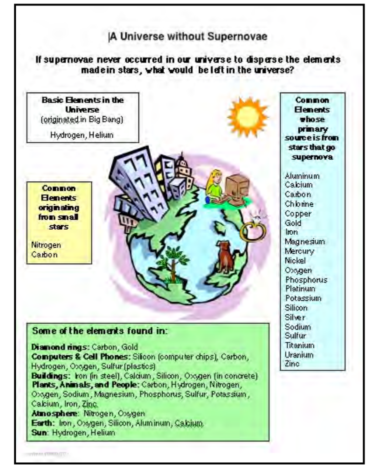
WHERE COULD I USE THIS ACTIVITY?

ACTIVITY	Star Party	Pre-Star Party –Outdoors	Pre-Star Party –Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
Nuclear Fusion, Supernovae, and Cosmic Radiation (Marshmallows)	√	√	√	√		√	√	√	√	√
Protecting Earth From Cosmic Radiation	√	√	√	√		√	√	√		√
Air as a Radiation Shield	√	√	√	√		√	√	√		√
Gamma-Ray Bursts	√	√	√	√		√	√	√		√

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Duct tape or wide packing tape Small sharp knife Pencil with an eraser 2 – AA Batteries *Optional*: Felt-tip pen, ruler	**Marshmallows:** mini multi-colored ones are best. White and full-sized marshmallows also work. **Bowl** for marshmallows. *Optional*: Salad macaroni	Assemble GRB light Assemble model of Earth's Atmosphere and magnetic field

A Universe without Supernovae



Supernova seem dangerous, but what would the universe be like if supernovae never happened? Participate In an activity that illustrates the importance of supernovae in the universe.

WHERE COULD I USE THIS ACTIVITY?

ACTIVITY	Star Party	Pre-Star Party –Outdoors	Pre-Star Party –Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
A Universe Without Supernovae	√	√	√	√		√	√	√	√	√

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Scissors or paper cutter. *Optional:* Laminate the cards.	*Optional:* Everyday objects; trash can	Cut apart the Object cards and Element cards (*optional:* Laminate the cards). Make needed copies of handouts

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