National Aeronautics and
Space Administration

UNIVERSE DISCOVERY GUIDES

November

WHAT IS THE FATE OF THE UNIVERSE?

Andromeda Galaxy: The gravitational attraction between our Milky Way Galaxy and its neighboring spiral galaxy is stronger than the overall expansion of the universe. For the story behind this image: http://www.galex.caltech.edu/media/glx2012-03r_img01.html Credit: GALEX, JPL-Caltech, NASA

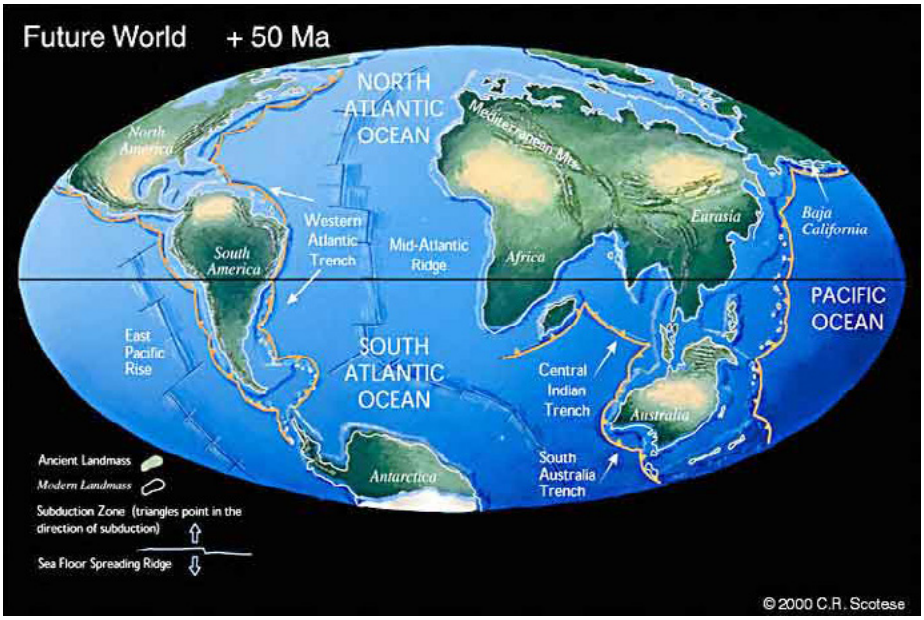
IN THIS GUIDE

Published 2013.

The universe is a place of change. NASA missions advance our understanding of the changing universe. www.nasa.gov

WHAT IS THE FATE OF THE UNIVERSE?

What does the future hold? Humans have been asking this question since before recorded history. You might not be able to predict exactly what will happen to you next week or next year, but when we look at the bigger picture, there is a lot we can predict. By collecting data and using models, we can predict how the weather is likely to change over the next several days, how the population of Earth is likely to change over the next several decades, and how Earth's continents are likely to change over the next several millennia.



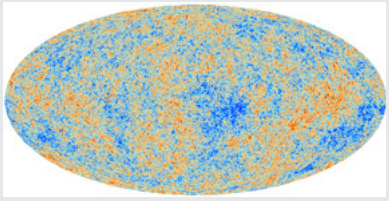
Predicted change in the continents 50 million years from now. More info at Science at NASA. Image Credit: Dr. C. Scotese

Let's step out even farther. Cosmologists study the nature of the whole universe and have collected data and constructed models as they look for answers about the future of the universe.

Most astronomers today accept the abundant evidence that the universe began about 14 billion years ago. We can observe how the universe has changed since then. But because we cannot see into the future, the fate of the universe is more difficult to predict.

Early Predictions for the Fate of the Universe

In 1929, Edwin Hubble discovered that the universe is expanding. Then in 1990, NASA's COBE satellite showed that the universe was originally extremely hot and dense. So the universe started small and hot and is expanding: getting bigger and cooler. Based on modeling and what was known about gravitational attraction, scientists predicted the rate of expansion would slow down over time, and maybe even reverse.



2013 image of the oldest light in our Universe when the Universe was just 380,000 years old and very hot and dense. Image from ESA's Planck Satellite. This is a higher-resolution improvement on the COBE satellite data from 1990. Credit: ESA and the Planck Collaboration

Discovery of mysterious Dark Energy

New discoveries often mean that scientists have to change their models. That was the case in 1998, when two separate groups came to a shocking conclusion. Using the Hubble Space Telescope and ground-based telescopes, researchers found that not only is the universe expanding, it is also accelerating! It appears that there is some unknown force "pushing" the universe apart at a faster and faster rate. This force has been named "Dark Energy" and scientists continue searching for what this energy could be and what is causing it. From what we know today, the universe is likely to keep on expanding at an ever increasing rate.

The existence of dark energy was deemed such an extreme shift in the understanding of the cosmos that the two teams who independently made the discovery were awarded the Nobel Prize in Physics in 2011.

So what does the future hold?

The universe has been constantly changing since it began about 14 billion years ago, and the ultimate fate of the universe is trillions of years in the future. By observing and collecting data today to construct models of the future, we can make predictions about how the universe will change in the eons ahead of us.

Just like predicting the weather, though, those predictions may change as new observations and new instruments allow scientists to refine and improve our understanding. What will we learn in the coming years and centuries about what the future holds for our universe?

SKY FEATURE: ANDROMEDA GALAXY

How to Find it

Distance: 2.5 million light-years

Visual Magnitude: 3.4

To view: Just your eyes under dark skies, binoculars or telescope

Click here to jump to the full-sky November Star Map.

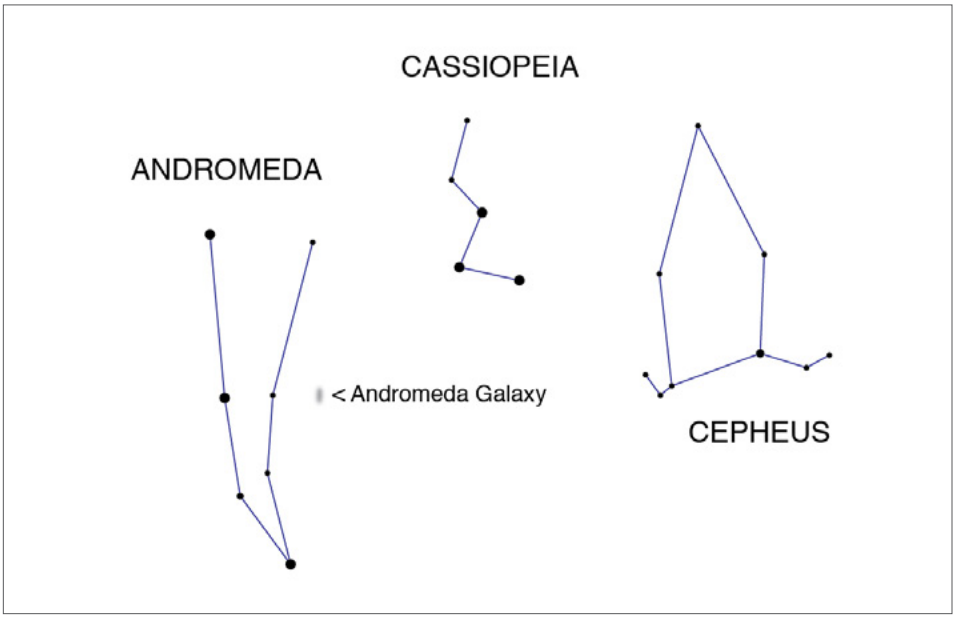
Scientists predict that the universe will continue to expand for trillions of years into the future. While distant galaxies are rushing away from our Milky Way Galaxy, predictions are quite different for our little corner of the universe. Our neighbor, the Andromeda Galaxy, is rushing toward us under the stronger force of our mutual gravitational attraction.

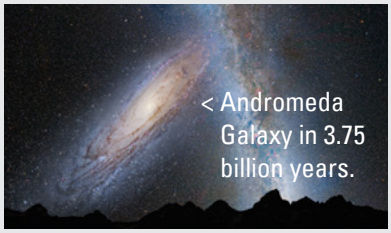
Over the next four billion years, our distant descendants should have quite a show as the Andromeda Galaxy approaches and grows ever larger in the night sky. Amazingly, when the galaxies actually merge, the stars in galaxies are so far apart that it is very unlikely that any of them will actually collide. The gravitational interaction will eventually create one giant galaxy from the two colliding galaxies.

Find the whole story from NASA and view animations of the merger here:

http://www.hubblesite.org/newscenter/archive/releases/galaxy/2012/20/

In November, you can see the Andromeda Galaxy in the early evening high overhead in the constellation of Andromeda.





The top illustration shows the apparent size of the Andromeda Galaxy in the night sky today. The lower image shows how the approaching galaxy will look in about 3.75 billion years. (Credit: NASA; ESA; Z. Levay and R. van der Marel, STScI; T. Hallas; and A. Mellinger)

TRY THIS!

The Andromeda Galaxy is actually much larger than the Milky Way Galaxy.

Although evidence shows our Milky Way Galaxy is slightly more massive than the Andromeda Galaxy, our galaxy is smaller in diameter. Our galaxy is about 100,000 light-years across compared to a diameter of about 250,000 light-years for the Andromeda Galaxy. Compare a CD to a large dinner plate and you have roughly the right size comparison.

Illustration of Milky Way as a CD. Credit: ASP

Image of Andromeda Galaxy on a dinner plate. Galaxy image credit: NOAO/AURA/NSF

Place the CD and the dinner plate approximately eight feet (2.4 meters) apart. That is about the current distance between the galaxies. That distance will gradually diminish over the next few billion years. Since they are relatively close to the each other, the gravitational attraction between the Milky Way and Andromeda galaxies is quite strong. It is stronger than the overall expansion of the universe that makes more distant galaxies to appear to be moving away from us.

To build a model of the Universe with a group of people, try out the activity, A Universe of Galaxies: http://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=389

Cosmic Times

Understand how our knowledge of the universe has changed over the past 100 years with Cosmic Times. It consists of six posters, each resembling the front page of a newspaper from a particular time in history, with articles describing the groundbreaking discoveries, from Einstein's theory of gravity to the discovery of dark energy. The language of the articles mimics that of a newspaper from its respective era.
http://cosmictimes.gsfc.nasa.gov/

For more education and public outreach activities from the Goddard Space Flight Center's High Energy Astrophysics Science Archive Center: http://heasarc.gsfc.nasa.gov/docs/outreach.html

Capture your own image of the Andromeda Galaxy!

NASA's portal to the MicroObservatory Network allows you to control a telescope right from your home computer or mobile device and tell the telescope to take your own images of the Andromeda Galaxy and many other features of the sky.

It's easy! Start here to select your target: http://mo-www.harvard.edu/cgi-bin/OWN/Own.pl

OBSERVING WITH NASA

MicroObservatory Robotic Telescope Network, Harvard Smithsonian Center for Astrophysics

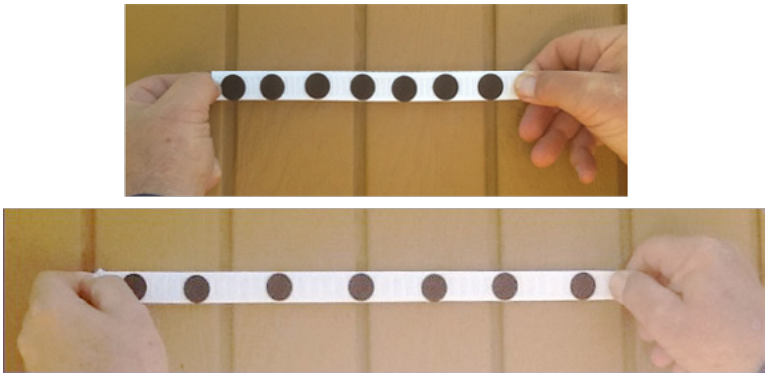
ACTIVITY: MODELING THE EXPANDING UNIVERSE

Time: 10 minutes

Age: 8 and up

Excerpted and adapted from the Cosmic Questions Educator Guide, available in its entirety here: http://www.cfa.harvard.edu/seuforum/exhibit/resources/resources.htm
Developed by the Harvard-Smithsonian Center for Astrophysics

We say the universe is expanding and distant galaxies appear to be rushing away from our Milky Way Galaxy. Does it mean that the Milky Way is standing still at the center of the universe and all those galaxies are moving away from us?



Small model of elastic band with stickers attached representing galaxies. The top photo is before expansion. The bottom photo shows space, represented by the elastic band, expanding. Credit: ASP

Elastic band model of the universe — a one-dimensional model

Materials Needed

- Six-foot length of one-inch wide (or greater) elastic ribbon, or exercise band
- Several stickers approximately 1/2-inch round
- Stapler
- Ruler or tape measure
- White board or chalk board

Procedure

Prepare the model of the universe. Stickers represent galaxies in space. The elastic band represents space.

- Start from the center and place the stickers evenly along the elastic at approximately one-inch intervals. Staple the stickers to keep them from slipping.
- Ask two participants to each take an end of the elastic and hold it taut without stretching against the board. On the board, mark the points of the stickers.
- Label one sticker Galaxy A.
- To model the universe expanding, hold Galaxy A still and gradually pull on both ends of the elastic.
- Observe what happens to the distance between the galaxies as the space between them expands.
- Measure the distance between the galaxies.
- Now choose a new sticker and label it as Galaxy B. Repeat the process, holding Galaxy B still.

Discussion Notes

- Are the galaxies moving away from each other? Is there a center to the expanding universe?
- Are the galaxies themselves expanding? Is there any pattern to how far apart the galaxies appear to be?

This model shows how galaxies farther away from us appear to be moving faster. That is, as space expands, the galaxies farthest from the reference galaxy move a greater distance in the same amount of time. It does not matter which galaxy is chosen as the reference galaxy. There is no center of expansion. Evidence shows that the expansion of space is not only increasing since the Big Bang, but accelerating. The acceleration of the expansion of space is due to the mysterious force scientists have named “dark energy.”

Find more NASA Activities

Looking for more Earth and Space Science formal and informal education activities?

Try out NASA’s digital collection of resources at NASA Wavelength: http://nasawavelength.org

http://nasawavelength.org

CONNECT TO NASA SCIENCE

How do we know?

What is the evidence for the mysterious force called “Dark Energy” that is causing space to expand at an accelerating rate? Find out here:

http://www.hubblesite.org/hubble_discoveries/dark_energy

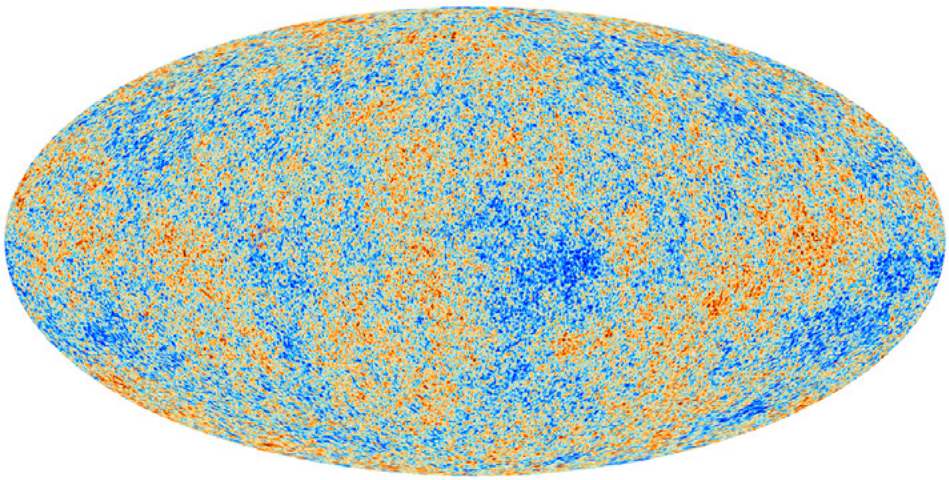
For the latest news from Hubble, visit:
http://hubblesite.org/newscenter/

NASA SCIENCE | ASTROPHYSICS

http://science.nasa.gov

The Universe started out hot and dense: How did it grow from birth to today?

The European Space Agency’s Planck space telescope, with NASA participation, produced the most detailed map ever created of the relic radiation from the Big Bang, which is called the “cosmic microwave background.” By analyzing the images from Planck, scientists can determine the composition and evolution of the Universe from its birth to the present day. http://www.nasa.gov/mission_pages/planck/news/planck20130321.html



2013 image of the oldest light in our Universe from ESA’s Planck Satellite. Credit: ESA and the Planck Collaboration

For the latest news from Planck visit:
http://planck.caltech.edu/news.html

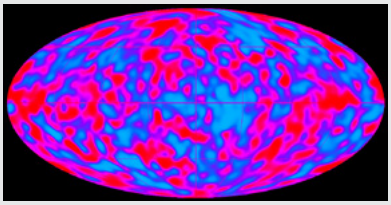
The Planck mission produced the highest resolution follow-up to previous NASA missions that mapped the cosmic microwave background (CMB). The first, COBE, was launched in 1989. This was followed by the WMAP mission, launched in 2001.

To read more about the NASA COBE mission, visit:

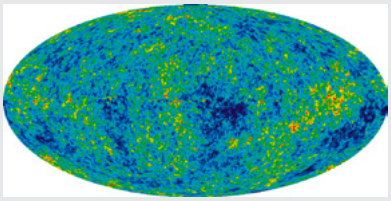
http://science.nasa.gov/missions/cobe/

To read more about the NASA WMAP mission, visit:

http://map.gsfc.nasa.gov/



COBE mission image of the CMB. Credit: NASA



WMAP mission image of the CMB. Credit: NASA / WMAP Science Team

The Universe may be expanding, but our neighbor keeps plowing into other galaxies

NASA's Spitzer Space Telescope uncovers evidence of a recent collision between the Andromeda Galaxy and a dwarf galaxy. So the Milky Way is not the only galaxy Andromeda has had in its sights.

http://www.spitzer.caltech.edu/images/2220-sig06-025-Forensic-Evidence-of-a-Galactic-Collision

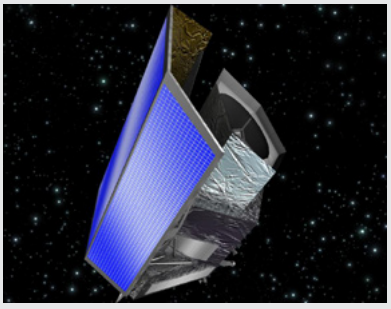
For the latest news from Spitzer, visit:
http://www.spitzer.caltech.edu/news

ESA partners up with NASA to research Dark Energy

The European Space Agency (ESA) is partnering with NASA science teams to participate in ESA's planned Euclid mission, scheduled for launch in 2020. The mission is specially designed to study the mysteries of the dark forces in the universe.

http://www.nasa.gov/mission_pages/euclid/news/euclid20130212.html

For the latest news about Euclid visit:
http://www.nasa.gov/mission_pages/euclid/main



Artist's concept of Euclid spacecraft. Image credit: ESA/C. Carreau

Understanding our Neighbor: Andromeda Galaxy in X-ray and Infrared Light

The Herschel Space Observatory and the XMM-Newton X-ray space telescope have imaged the Andromeda Galaxy to give us a glorious view of our neighbor's star forming regions (infrared in orange hues) and locations of stellar death (X-ray in blue).

http://www.herschel.caltech.edu/index.php?SiteSection=News&NewsItem=nhsc2011-001

For the latest news from Herschel, visit:
http://www.herschel.caltech.edu/index.php?SiteSection=News&NewsCategory=Press%20Release

For the latest news from XMM-Newton, visit:
http://xmm.esac.esa.int/external/xmm_news/latest_news.shtml

Credit: ESA/Herschel/PACS/SPIRE/J. Fritz, U. Gent; X-ray: ESA/XMM Newton/EPIC/W. Pietsch, MPE)

NASA's WISE mission offers a Gallery of Andromeda Images

See the Andromeda Galaxy with infrared eyes that highlight old stars, young stars, dust and gas, each in different representational colors.

http://wise.ssl.berkeley.edu/gallery_andromeda.html

For the latest news from WISE, visit:
http://wise.ssl.berkeley.edu/news.html

Credit: NASA/JPL-Caltech/WISE Team

ACKNOWLEDGEMENTS

The Universe Discovery Guides are a collaborative effort between members of the NASA Astrophysics education and public outreach (E/PO) community and the NASA Astrophysics Science Education and Public Outreach Forum. We also gratefully acknowledge the informal educators from the Astronomy from the Ground Up (AFGU) and the Sky Rangers communities who field-tested the guides.

Contributing NASA Astrophysics E/PO programs include: Afterschool Universe, Alien Earths, Astronomy Picture of the Day (APOD), the Chandra X-ray Observatory, the Cosmic Background Explorer (COBE), Cosmic Questions, the Euclid mission, Exoplanet Exploration, the Fermi Gamma-ray Space Telescope, the Galaxy Evolution Explorer (GALEX), the Herschel Space Observatory, the High Energy Astrophysics Science Archive Research Center (HEASARC), the Hubble Space Telescope, Imagine the Universe, the Infrared Processing and Analysis Center (IPAC), the James Webb Space Telescope, the Kepler Mission, the Milky Way Project, the Night Sky Network (NSN), the Nuclear Spectroscopic Telescope Array (Nu-STAR), Observing with NASA (OwN), Other Worlds, the Planck mission, PlanetQuest, Planet Hunters, the Spitzer Space Telescope, StarChild, the Stratospheric Observatory for Infrared Astronomy (SOFIA), the Swift mission, the Two Micron All-Sky Survey (2MASS), the Wide-Field Infrared Survey Explorer (WISE), the Wilkinson Microwave Anisotropy Probe (WMAP), the X-ray Multi-Mirror Mission (XMM-Newton), and Zooniverse.

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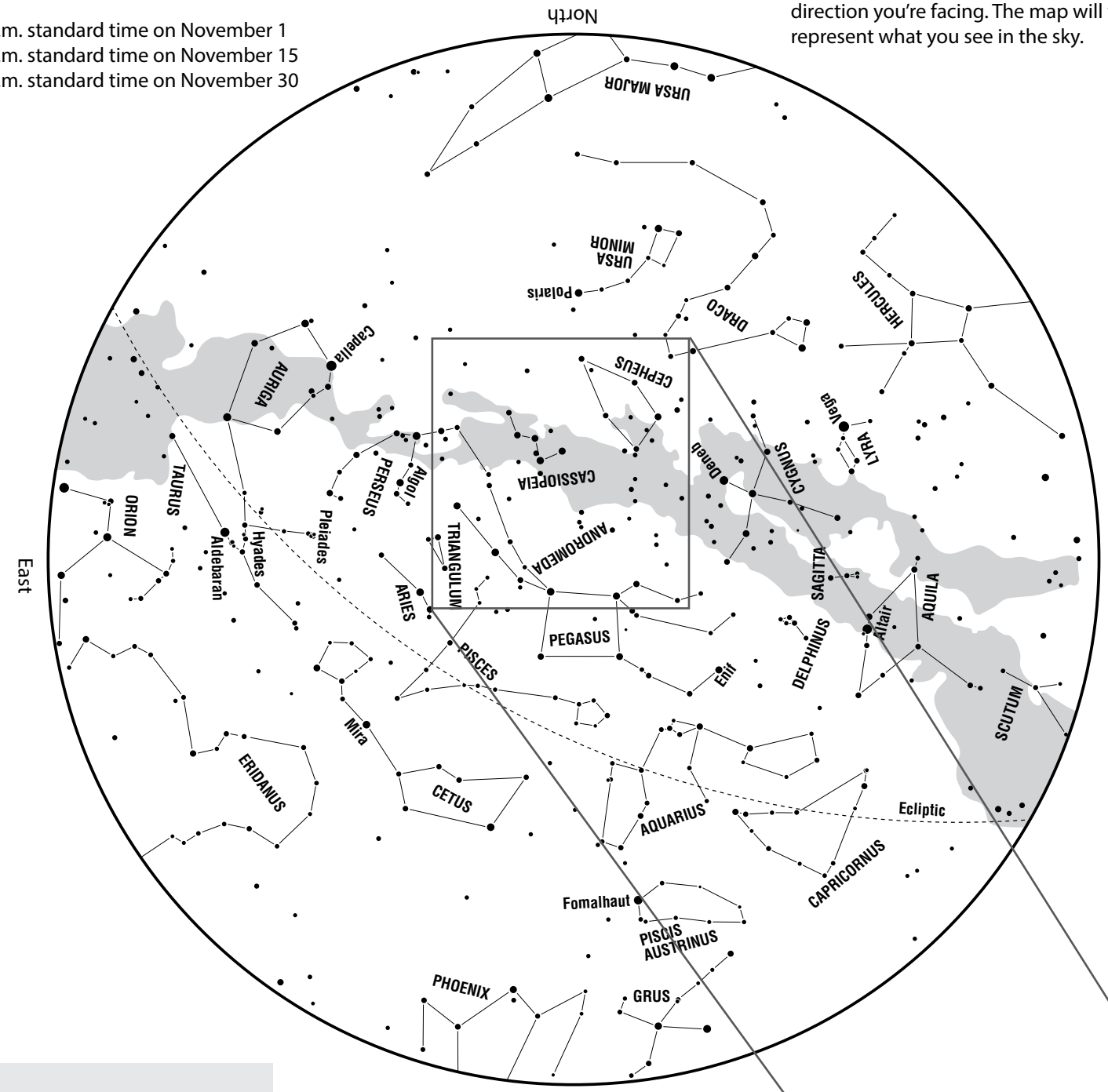
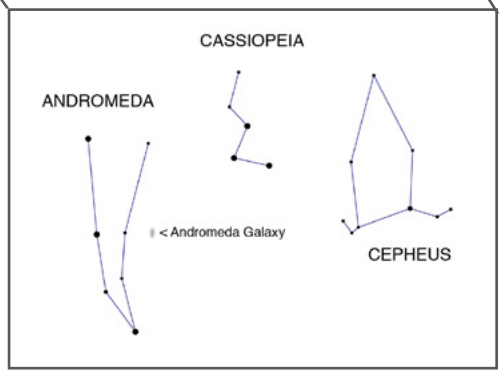
APPENDIX: NOVEMBER STAR MAP

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 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.





Tools to Find Constellations

For mobile device users: Search your app store for "planetarium" or "sky map" to find free or low-cost apps. These help you more easily locate constellations.

View a video on how to read a star map.

November Sky Feature: Andromeda Galaxy

Jump to Sky Feature to find out about the Andromeda Galaxy