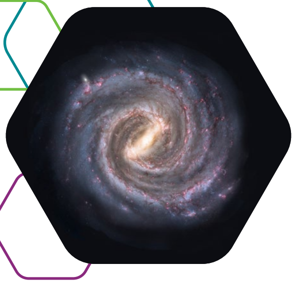

FACILITATOR GUIDE
Star Formation

Learning objectives

- The space between stars, planets, and other large objects is not empty—it contains gas and dust.
- Stars are born when huge amounts of gas and dust clump together.
- The more gas and dust that clump together, the higher the new star's mass.
- NASA scientists use telescopes to learn more about how stars form.

Materials

- Wire basket with ⅛" plexiglass cover and white shelf
- Clear collection cup
- Hair dryer
- Polystyrene balls
- Clear measuring tube with red cap and clear box stand
- 3 colored bands and flag labels
- Wide-mouth funnel
- 30-second timer
- Power strip with on/off switch
- Data collection board, dry-erase markers, & eraser
- Stickers
- Twist-ties
- Ruler
- Activity and facilitator guides
- Information sheets
- *Tips for Leading Hands-on Activities*

The Explore Science toolkit comes complete with all necessary materials for this activity. Materials are also readily available online or at local retail stores to create or restock activity kits. Graphic files can be downloaded from *www.nisenet.org.*

Safety

The hair dryer included in the toolkit has the cold air bypass permanently taped down. If this is removed or eventually wears away, the end of the hair dryer may become hot while in operation. Do not touch it. To reduce the risk of being shocked, do not expose the hair dryer to water or pull on its cord.

Advance preparation

- Before doing this activity for the first time you'll need to **remove** the protective cover from the plexiglass sheet so that participants can look down through it at the balls in the basket.
- **This activity requires power.** Ensure your setup is near a power outlet or that you have an extension cord for the included power strip and hair dryer. Plug the hair dryer into the power strip, and the power strip into the outlet.
- Set the basket on the shelf and secure it by adding twist ties at the corners and edges so it doesn't slide around.
- Place the clear collection cup inside the basket and pour the balls into the basket. Use 40 larger balls (3cm) and 80 smaller balls (2cm).
- Give participants a head start by placing several of the smaller balls in the clear collection cup. This also improves the model by showing gas and dust everywhere in space.
- Ensure the red cap is on one end of the measuring tube. Place the red-capped end of the tube in the small clear box stand that will act as a base.
- Using the ruler, check that the colored bands are on the measuring tube in the right order and position. From bottom to top: purple at 3" from the base of the stand (gas giant planet), red at 7" (low-mass star), and blue at 10" (high-mass star). Add the corresponding flag to each colored band on the measuring tube.
- Create a data collection grid by using the dry-erase board divided into three equal columns labeled "Gas Giant Planet," "Low-Mass Star," and "High-Mass Star." You can choose to use the dry-erase markers or stickers provided to collect participant data.

Notes to the presenter

You can make small changes to this activity to make it easier or harder for different audiences to create each type of space object ("Gas Giant Planet," "Low-Mass Star," and "High-Mass Star"). Reaching all levels of the measuring tube should be possible. High-mass star formation should be difficult, but not impossible to achieve! The colored bands on the measuring tube, representing the threshold of mass needed, are **adjustable** so that facilitators can make changes to best fit their institution's needs and audience. For example, children's museums or museum with younger visitors may want to move all the bands down the tube a little so that forming a star is easier for younger participants less skilled with the hair dryer. Or you might move the bands up to make it more challenging for adult participants to get the "High-Mass Star". Similarly, the guide suggests using the hair dryer on HIGH is 30 seconds per participant, but facilitators can increase (or decrease) the amount of time if necessary.

After recoding the data from multiple activity trials, the data collection board probably won't accurately reflect the real distribution of space objects. The activity is set up—or can be easily adjusted—so that high-mass stars occur more rarely than low-mass stars, as scientists have observed in space. Beyond this result, the percentages of gas giants and low-mass stars likely won't be proportionally accurate given the skills of participating visitors or the length of number of completed trials. For example, it's possible that all your participants at an event only managed to collect enough matter to obtain low-mass stars, leaving the gas giant column empty. While it is still a useful visual aid, and can demonstrate interesting trends throughout a day of use, presenters should be aware of these limits.

A power strip with an on/off switch is included to give the facilitator control over the hair dryer, even when it is being handled by participants. The facilitator can use the on/off switch to control the 30 seconds of use for each trial. This method will also prevent participants from changing the HIGH setting on the hair dryer.

The clear collection cup, with the included top, can also double as a storage container for the 120 polystyrene balls after the activity is complete.

After participants finish the activity, have a conversation about the space object they made. If they are interested, you can walk them through the different life cycles of low- and high-mass stars to highlight the differences.

You'll need to pour the balls from the measuring tube back into the wire basket (with just a few in the collection cup) to **reset** the activity.

Conversational prompts

Greet participants by inviting them to try the game and asking some opening questions and sharing some content such as, "Did you know that space isn't empty? There are clouds of gas and dust in the space between stars, planets, and other large objects."

In step 1, let the participant blow the hair dryer under the wire basket for 30 seconds. Switch the hair dryer on and off with the power strip and use the sand timer or a nearby clock to keep track of time. Make sure the clear top is on the wire basket. Try explaining that, "The balls in this basket represent gas and dust in space (called nebulas). But gas and dust in space does not just stand still—it moves around due to turbulence. This turbulence can be in the form of stellar wind from a star, for example, or shockwaves from a cosmic explosion even. Use the hair dryer to add energy and move the balls around to see how many you can collect in the clear container, which represents a growing clump of gas and dust (matter). What do you think happens next?"

In step 2, while pouring the balls into the measuring tube together, ask participants to identify what kind of space object they formed. "What did you make? Yes, you made a [*gas giant planet / low-mass star / high-mass star*]!" Help the participant pour by steadying the funnel. Ask them to read the result or read it along with them.

In step 3, invite participants to share what they made by adding a sticker or tick with the marker to record their data on the data collection board. "Add a tick mark (or sticker) to our data sheet! What do you notice about the space objects other people made today?"

Common Questions

What is the difference between a low-mass and high-mass star?
Low- and high-mass stars form very differently. In general, low-mass stars live much longer (billions of years) than high-mass stars (millions of years). For more information on the differences in stellar life cycles, see the included mini-poster.

Is our Sun a high-mass star?
No, the Sun is an average-sized low-mass star. There are stars in our galaxy that are 100 times more massive than the Sun.

What will happen to the Sun at the end of its life / after billions of years? And what will happen to Earth then?
The Sun is a low-mass star that will last for billions of years. When it runs out of fuel at the end of its life, it will become a red giant. It will cool and expand, swallowing up Mercury, Venus, and possibly Earth. Eventually, this expanded Sun may shed its outer layers and become a nebula.

Can a planet become a star?
Most planets are formed from the leftover matter after a star forms and are usually much smaller than stars. Gas giant planets, like Jupiter, in stable star systems similar to our solar system almost never become stars because there is no possibility that they will acquire enough mass.

Why do Jupiter and other planets in the night sky look like stars?
Sometimes other planets within our solar system appear to shine brightly in the night sky, looking similar to very bright stars. These planets are not producing their own light, but rather reflecting the light of the Sun. Moonlight is also reflected light from the Sun.

Difficult concepts

Many participants will have the idea that space is made up of large stretches of emptiness. But the areas between stars, planets, and other large objects in space are not completely empty. Clouds of gas and dust (nebulas) left over from past cosmic events like supernova explosions can be found throughout the universe.

You may hear participants describe a star as a ball of "fire." While a star, like the Sun, gives off energy like a flame, that energy does not come from chemical combustion—its source is nuclear fusion. The intense gravity of the Sun creates such internal pressure that hydrogen atoms fuse together to form helium, releasing massive amounts of energy.

Younger participants won't be familiar with the concept of density, but you can use the materials in the activity to model how the "gas and dust" clumps together.

Gravity is the force that causes clumps of gas and dust to form into planets and stars. Gravity is a force between any two bodies with mass. More massive clumps mean a stronger force of gravity squeezing all the gas and dust closer together. If there is enough mass in a clump, eventually the internal pressure will trigger nuclear fusion. This is why Jupiter is "just" a giant cloud of hydrogen gas, while the much more massive Sun is a star. In fact, the Sun accounts for 99.7% of the total mass in our solar system; all of the planets combined—including Jupiter—account for just 0.3% of the solar system's mass.

Models are used to help us think about phenomena that are too big, too small, or too far away to easily understand. This activity uses a model of star formation where the “turbulence” is supplied by a hair dryer and the “gravity” between the “gas and dust” balls is really the pull between the balls and the Earth. In space, the interactions between gravity and energy required to form stars are more complex than portrayed in this activity. While our model is a great first step toward understanding star formation, there are still many details it does not address. Models are not perfect, and can’t accurately represent all aspects of a phenomenon.

While this guide contains detailed information about nebulas and stars, it should not be implied that scientists know everything there is to know about these space science topics. Studying and further understanding the birth and death of stars, and many other phenomena in the universe, is an ongoing process we as a society choose to pursue.

Background information

Gas giants are very large planets like Jupiter and Saturn. They are usually made up of mostly hydrogen and helium, and can be hundreds of times more massive than the Earth, but they are still much smaller than stars.

Low-mass stars are stars with a mass similar to our Sun or smaller. They live for a long time—billions of years. After that time, they run out of fuel and can cool and expand into red giants, eventually shedding their outer layers forming a nebula. The leftover matter—gas and dust—may form nebulas and new stars.

High-mass stars are much more massive than our Sun, and last a short time for stars—just millions of years. After that time, they run out of fuel and can expand into enormous red supergiants—maybe even exploding in a violent event called a supernova. The leftover matter spread out by supernova explosions may form nebulas and new stars.

Staff training resources

Refer to the *Tips for Leading Hands-on Activities* sheet in your activity materials.

- Content Training Video: *https://vimeo.com/366777224*
- Activity Training Video: *https://vimeo.com/366776993*
- Edu-cathalon Facilitation Strategies Video: *https://vimeo.com/304241578*

The NISE Network has a curated list of programs, media, and professional development resources that directly relate to the toolkit. These resources can be viewed and downloaded from: *www.nisenet.org/earthspacekitextensions*

Credits and rights

This activity was adapted from Gas Model Science Snack, developed by the Exploratorium. Retrieved from: *https://www.exploratorium.edu/snacks/gas-model*

Image of Star Forming Region S106 courtesy of NASA & ESA.

Image of Stellar Nursery W51 courtesy of NASA/SOFIA/Lim and De Buizer et al. and Sloan Digital Sky Survey.

Many Sizes of Stars image courtesy ESO/M. Kornmesser.

Many Colors of Stars image courtesy ESA/Hubble.

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