SEEING STARLIGHT
with the James Webb Space Telescope

Developed in collaboration with the National Institute of Aerospace and in coordination with NASA’s Goddard Space Flight Center.

Mad Science offers hands-on STEM programs and birthday parties for kids ages 3-12. For more information, visit us online!

MadScience.org  @MadScience  @MadScienceGroup
Star Life Cycle Loops

Stars are not alive, but they change over time in a way that can be described as a life cycle. The birth, growth, and death of stars is illustrated in the Star Life Cycle Journeys poster. The poster helps you picture the two looping life cycles while you make this two-loop bracelet.

What you need

- String or yarn to form your bracelet (about 50 cm or 20 in)
- Scissors
- 1 green bead
- 2 blue beads
- 2 yellow beads
- 2 red beads
- 1 orange bead
- 1 white bead
- 1 purple bead
- 1 black bead

What you do

Step 1: Measure the length of your double bracelet by wrapping the string three times around your wrist. Cut the string at this length. Make your string easier to thread through the beads by wrapping a square of tape around each end, like a shoelace.

Step 2: Fold this instruction sheet in half and then open it again to form a central fold. This is where you can store your beads while you make the bracelet.

Step 3: Each bead represents a stage in a sun-like or a massive star’s life cycle. Match the colors on the Star Life Cycle Journeys poster. Place the beads along the crease in the following order: Green, Blue, Yellow, Red, Orange, White, Blue, Yellow, Red, Purple, Black.

Step 4: All stars form from a star-forming nebula. This is the green bead. Slip it onto your string and tie a knot around it to hold it in place in the middle of the string.

Step 5: Add the blue, yellow, red, orange, and white beads, in this order, to one side of the string. These beads represent the life cycle of a star like our Sun. Push the beads as close to the center of the bracelet as possible so that they do not slip off.

Step 6: Prepare the second side of the string to create the life cycle of a massive star. Add the blue, yellow, red, purple, and black beads, in this order, to this side of the string. Push the beads as close to the center of the bracelet as possible, so that they do not slip off.

Step 7: Thread the tip of one end of the string through the green bead. Then thread the tip of the other end through the green bead, in the OPPOSITE direction.

Step 8: Tie off your bracelet in one of these two ways:
   a) Tie the two tips in a knot around the green bead to form a bracelet; or
   b) Wrap one end of the string around the bracelet loops. Tie a knot with that string. Repeat with the other end of the string, on the other side of the green bead.

What’s going on

You just made a bracelet with a code that represents what we know about the life cycles for both sun-like and massive stars! Space telescopes help us understand these details of our universe.

The James Webb Space Telescope (Webb) builds on the successes of the Hubble Space Telescope (Hubble). Webb is 100 times more powerful than Hubble with a much larger mirror. Webb’s science goals push beyond the science learned by Hubble, helping us peer into the earliest galaxies and massive clouds of dust where stars and planetary systems are born.

Need Some Beads?
Replace the plastic beads with paper life cycle beads.

**What you need**
- Life Cycle Strips
- Scissors
- Glue stick
- Pencil

**What you do**

Step 1: Cut along the white lines around each Life Cycle Strip.

Step 2: Start the beads by wrapping the wide end of one triangle strip around the pencil.

Step 3: Rub the glue stick along the non-printed side of the strip (but do not glue the bead to the pencil).

Step 4: Roll the strip around itself on the pencil, adding more glue if needed, all the way to its tip. You’ve made the first paper bead!

Step 5: Repeat to make the other beads.

**What’s going on**

Each strip shows one stage in a star’s life cycle described in the Star Life Cycle Journeys poster. The chart below matches the plastic beads to the paper beads.

### Sun-like Star
- Green Bead / 0 -- Star-forming Nebula

### Massive Star
- Blue Bead / A1 - Protostar
- Yellow Bead / A2 - Sun-like Star
- Red Bead / A3 - Red Giant
- Orange Bead / A4 - Planetary Nebulae
- White Bead / A5 - White Dwarf

© 2021 Mad Science Licensing Inc. - All rights reserved. MAD SCIENCE is a trademark owned by Mad Science Licensing Inc. and is used under licence.
Gravity pulls the star inwards while explosions from burning its fuel push the star outwards. Stars like our Sun burn for billions of years.

The red giant is the stage when the star runs low on fuel in its core and starts to cool. The outer shell separates from the core and expands. This stage is billions of years away for our Sun.

Planetary nebulae form when the star cools even more and the outer layers expand further. Drifting star remnants may join other dust and gas clouds to become new star-forming nebula.

All stars are born within clouds of gas and dust called a nebula. The amount of material in the star impacts the next stage in that star’s life cycle. The life cycle of stars the size of our Sun is different than the life cycle of stars several times more massive than our Sun. The gas and dust leftover at the end of all stars’ life cycles may begin the process again with a new star-forming nebula!

Gravitation pulls the star inwards while explosions from burning its fuel push the star outwards. Stars like our Sun burn for billions of years.

Are you as massive as our Sun?

Protostars form as gravity pulls the dust and gas in the nebula together.

Gravity pulls inwards and the core of the star collapses into a white dwarf.

Content Citations: Star life cycles https://webbtelescope.org/webb-science/the-star-lifecycle | https://go.nasa.gov/3bVafSd
Dust and gas swirl within clouds of star-forming nebula.

Again, gravity pulls the dust and gas in the nebula together to form a protostar.

Your journey ends as a neutron star.

Your journey ends as a black hole.

More than 25x more massive

10x to 25x more massive

A supernova is created when the massive star’s core collapses and then explodes! It is so bright it can outshine its own galaxy for a few days or months.

Black holes or neutron stars: https://go.nasa.gov/3wNCs5t.
Our universe contains objects that make radiation. This is energy that travels and spreads out as it moves. Radiation has a spectrum of wavelengths such as radio waves, microwaves, infrared light, ultraviolet light, X-rays and gamma-rays. The part of this electromagnetic spectrum that our eyes can see is the visible spectrum, or visible light. Telescopes can view the universe in wavelengths that our eyes cannot see. Webb can see infrared light.

**Our Sky Viewed in Different Wavelengths**

Infrared light energy is invisible to human eyes, but can be felt as heat. Infrared cameras detect heat and change it into temperature maps.

**What Starry Secrets May the Webb Mission Reveal?**

Dust and gases absorb and reflect visible light which we see as clouds. Webb instruments can “see” past the dust and gases of a nebula cloud. This image shows the same part of space seen in the visible spectrum (what our eyes see) and the infrared (IR) spectrum (what Webb may see).

**How can Webb detect infrared from distant stars when our star (the Sun) is so close?**

Webb’s five-layer sunshield keeps its instruments cool at work. Webb detects light energy in the infrared wavelengths. Its sensors need to be shielded from all nearby sources of heat to detect these signals from distant objects. Webb’s sunshield keeps it constantly shaded from the heat of the Sun, Earth, and Moon.

Webb orbits far from heat sources such as Earth and its Moon. The Hubble Space Telescope orbits Earth. Webb orbits the Sun at a distance about four times farther than Earth’s distance to the Moon. This location is called the second Lagrange point (L2).

**Fun Fact!**

Webb will be orbiting too far from Earth for humans to visit.

Content Citations

Sunshield: https://go.nasa.gov/3hV4Ga8 | Star information: https://go.nasa.gov/3yluMD1 | Supernova: https://go.nasa.gov/3yHohAo
In telescopes, objects are farther than they appear! Telescopes have lenses and/or mirrors that focus light from far away. Bigger lenses or mirrors can collect more light than smaller ones, which can help them see farther.

Space telescopes are like time machines. They capture light sent out by stars from billions of years ago. The farther away that light traveled, the farther back in time it happened.

Look Up:
Supernova remnants (SNR) are beautiful nebulae, too!
Object: Cassiopeia A (Cas A) SNR
Distance: 11,100 light years away
Event: This star went supernova around 11,400 years ago!

The primary mirror is made up of 18 sections. On the back of each mirror segment are tiny mechanisms of motors and gears. These adjust the segments so that all 18 can be aligned to each other to act as one giant mirror.

Webb will look back through time. Webb’s mirror, with its large size and gold coating that reflects infrared light, will allow Webb to capture infrared light from the galaxies forming in the Early Universe. We have never seen this before.

Webb is able to capture light sent out over 13.5 billion years ago!

Did You Know?
Imagine a tennis court. That’s about the size of the Webb sunshield. Imagine the height of a three-story building. Webb stands about that tall! Webb folds origami-style into its space capsule and then unfolds in space.