

Astrobiology Learning Progressions: a Tool for Scientists and Educators to Plan and Conduct Education and Outreach

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Abstract

Learning progressions provide a sequence, or progression, of concepts from naive to sophisticated. Astrobiology educators and scientists have identified the need to develop learning progressions for core, interdisciplinary concepts in astrobiology to support both educators of K-12 students to bring astrobiology concepts into their classrooms, and scientists to communicate with a range of audiences. The Astrobiology Learning Progressions resource organizes core concepts around the essential questions of astrobiology, and includes connections to the Next Generation Science Standards, progressed storylines, and concept boundaries for four levels: primary or adult naïve learners, elementary or emerging adult learners, middle school or building learner, and high school or sophisticated learner. The resource also links lesson plans and other learning materials to each core concept.



NASA Astrobiology Learning Progressions

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<https://astrobiology.nasa.gov/education/alp/>



Astrobiology educators and scientists identified the need to develop learning progressions for core concepts in astrobiology to support both educators of K-12 students to bring astrobiology concepts into their classrooms, and scientists to communicate with a range of audiences.

Informed by the Astrobiology Primer v.2.0, the planetary decadal survey, and existing curriculum, seven core learning questions were identified.

- 1. How does understanding the origin and evolution of the Universe inform our understanding of the origins of life?**
- 2. How did Earth become a planet on which life could develop?**
- 3. What is life?**
- 4. How did life on Earth originate?**
- 5. How have life and Earth co-evolved?**
- 6. How has life evolved to survive on diverse environments on Earth?**
- 7. How do we explore beyond Earth for signs of life?**



Sub-question: 1.1: Are we really made of star stuff?

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1.1: Are we really made of star stuff?

Grades K-2 or Adult Naïve Learner

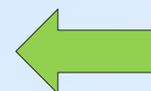
Story Line | Disciplinary Core Ideas for Teachers | Concept Boundaries for Scientists

Resources

Have you ever wondered what we're made of? Would you believe that you and me and all of the plants and all of the animals that we can see are all made of the same kind of stuff that makes up books and rocks and mountains and the ocean? We're all made from the same kind of stuff, and we call that stuff "matter".

Four Levels

- Primary or adult naïve learners
- Elementary or emerging adult learners
- Middle school or building learner
- High school or sophisticated learner



Learning progressions provide a sequence, or progression, of concepts from easy to more difficult.

The Astrobiology Learning Progressions Website has storylines, Disciplinary Core Ideas, concept boundaries and resources for each level..



1.1: Are we really made of star stuff?

Grades 3-5 or Adult Emerging Learner

Story Line | Disciplinary Core Ideas for Teachers | Concept Boundaries for Scientists

Resources

The story of where we came from begins in space, a long time ago, even before the Sun and the planets in our solar system formed. A lot of the stuff, the matter, that makes up you and me and everything we see on Earth was formed inside of stars long ago.

Sometimes when we talk about stars, we talk about them as if they're living things. So, we'll say that a star is born, it has a life, and then it dies, and we call this a "lifecycle." A star can be born and start its lifecycle when a bunch of dust and ice in space comes together. Just like when you drop something and it falls because of gravity, when there's a lot of ice and dust together in space, it can fall together because of gravity and make up an entire star. Once a star is born, it starts to make light and heat, just like our Sun, and, when that happens, it starts creating different kinds of matter inside. Even right now, our own Sun is making new kinds of matter inside of it from the other stuff that's there.

So, how does all of that new matter that's created inside of stars get out and end up inside of you and me and other stuff? Well, some stars, when they get old and are at the end of their life cycles, will explode and send all of that new matter out into space. Then, later on, when new stars and new planets are forming, some of that new matter ends up in them. So, a lot of the matter that's inside of our Sun and inside of our planet and even inside of us was made within stars long, long ago. That means that you are made of star stuff!

Grades K-2 or Adult Naïve Learner

Story Line | Disciplinary Core Ideas for Teachers | Concept Boundaries for Scientists

Resources

- PS1.A: Structure and Properties of Matter
 - Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties. (2-PS1-1)
 - Different properties are suited to different purposes. (2-PS1-2, 2-PS1-3)
 - A great variety of objects can be built up from a small set of pieces. (2-PS1-3)
- ESS1.A: The Universe and Its Stars: Patterns of the motion of the Sun, moon, and stars in the sky can be observed, described, and predicted. (1-ESS1-1)
- ESS1.B: Earth and the Solar System: Seasonal patterns of Sunrise and Sunset can be observed, described, and predicted. (1-ESS1-2)
- ESS1.C: The History of Planet Earth: Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe. (2-ESS1-1)

Grades K-2 or Adult Naïve Learner

Story Line | Disciplinary Core Ideas for Teachers | Concept Boundaries for Scientists

Resources

- **Big Ideas:** The solar system consists of Earth and seven other planets spinning around the Sun. The Sun and planets formed from a huge cloud of gas and dust. Everything is made of matter. Much of the matter that makes up people and planets was made inside of stars long ago.
- **Boundaries:** By the end of 2nd grade, students can understand/describe the patterns of the Sun, the Moon, and the stars as viewed from Earth, and make observations/predictions about them. Students will also understand seasonal patterns of Sunrise and Sunset. Grade level appropriate observations include: the Sun and moon appear to rise and set in different parts of the sky, and star visibility at night, but not in the day (except for our Sun). These observations can be used as evidence in supporting their understanding of Earth's place in the universe.
- **Crosscutting Concepts:** Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (K-LS1-1)

Grades 9-12 or Adult Sophisticated Learner

Story Line | Disciplinary Core Ideas for Teachers | Concept Boundaries for Scientists

Resources

Our planet and all of the living things on it are made from matter. Most of that matter was created during the big bang and the rest was mostly created within the cores of ancient stars. During the big bang, all of the hydrogen, most of the helium, and some of the lithium in our universe was created from subatomic particles, like protons and neutrons. Protons and neutrons are sometimes called "nucleons", since they are in the nuclei of atoms. Since protons and neutrons came together to make the nuclei of these lighter elements during the big bang, we call this process "big bang nucleosynthesis."

It was this earliest matter, composed of the three lightest elements on the periodic table, that made the very first stars. And these stars were big and bright and they burned out really fast. We call them the "first generation stars". It was within the cores of these first stars that the process of nuclear fusion first started creating elements heavier than lithium. The hydrogen and the helium inside were squeezed so tightly and with so much energy, that they started forming things like carbon and nitrogen and oxygen. Much like big bang nucleosynthesis, where new elements had been formed, we call this process of forming new elements from nuclear fusion within stars "stellar nucleosynthesis."

When those first stars "burned up" their elemental "fuel," they went through a process called "supernova", where the stars explode and send a lot of their matter out into space. Then, new stars were able to form from the matter that had clumped up in space, including these heavier elements that were made from stellar nucleosynthesis. In this way, each new generation of stars will have more and more of the heavier elements inside of them.