Content Clarification for Modeling the Universe: Earth and Space Science—Origin and Evolution of the Universe

Vision of Lasting Knowledge and Skills: Related Content Knowledge and Adult Science Literacy statements from SFAA, NSES, Benchmarks	**Grade Level Learning Goals and Inquiry Abilities** (combined Benchmarkes for Science Literacy and National Science Education Standards)	**Ideas about Student Learning** from formal and informal research (compiled from NSES essays, Benchmarks Ch 15, AER, informal education evaluations)	**MTU investigations/ activities/resources** **Fill in connections to YOUR curriculum topics/ related content**
Finding our place in the cosmic scheme of things and how we got here is a task for the ages-past, present, and future. The scientific effort to understand the universe is part of that enduring human imperative, and its successes are a tribute to human curiosity, resourcefulness, intelligence, and doggedness. If being educated means having an informed sense of time and place, then it is essential for a person to be familiar with the scientific aspects of the universe and know something of its origin and structure. **In thinking about what students should learn about the heavens, at least three aspects of the current scientific view ought to be taken into account: (1) the composition of the cosmos and its scale of space and time; (2) the principles on which the universe seems to operate; and (3) how the modern view of the universe emerged.**	**Grades 6-8** • The sun is a medium-sized star located near the edge of a disk-shaped galaxy of stars, part of which can be seen as a glowing band of light that spans the sky on a very clear night. The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot. • The sun is many thousands of times closer to the earth than any other star. Light from the sun takes a few minutes to reach the earth, but light from the next nearest star takes a few years to arrive. The trip to that star would take the fastest rocket thousands of years. Some distant galaxies are so far away that their light takes several billion years to reach the earth. People on earth, therefore, see them as they were that long ago in the past. • Nine planets of very different size, composition, and surface features move around the sun in nearly circular orbits. Some planets have a great variety of moons and even flat rings of rock and ice particles orbiting around them. Some of these planets and moons show evidence of geologic activity. The earth is orbited by one moon, many artificial satellites, and debris. • Large numbers of chunks of rock orbit the sun. Some of those that the earth meets in its yearly orbit around the sun glow and disintegrate from friction as they plunge through the atmosphere-and sometimes impact the ground. Other chunks of rocks mixed with ice have long, off-center orbits that carry them close to the sun, where the sun's radiation (of light and particles) boils off frozen material from their surfaces and pushes it into a long, illuminated tail.	While there is quite a bit of research on students ideas about the Earth, Moon, Sun and Solar System, there is much less information on how students think about the universe outside the solar system. Here are some of the ideas from small studies and preliminary research: Many students do not distinguish between the terms “solar system”, “galaxy” and “universe” An Adler Planetarium study of visitors sorting pictures of the universe found: • In "Picturing the Universe" most people spontaneously created an "Earth stuff" category, some created a "Solar System" or "Planets" category, but almost none created either a "Milky Way" or "Universe" category • Many adults created a "Solar System" category. No children created such a grouping, although many created a "Planets" category [apparently, as hinted at in Joslyn Schoemer's study, it is common to learn about the planets without reference to what makes them part of a "system."] • Visitors don't know as much about astronomical items in the realms furthest from Earth, nor do they have as much confidence in their knowledge of those "far away" realms • People conceive of the Universe in terms of what's closer and what's farther away, and less familiar things are assumed to be farther away	What are your ideas about models? Pre and Post- Assessment Survey Modeling the Universe activity and Journal Reflections How big is the universe? scaling demo How old is the universe? Timeline inquiry What’s in the Universe? Tour Modeling the Universe presentation on development of scientific models of the universe

High School is the time for all of the pieces to come together. Concepts from physics and chemistry, insights from history, mathematical ways of thinking, and ideas about the role of technology in exploring the universe all contribute to a grasp of the character of the cosmos. In particular, the role of gravity in forming and maintaining planets, stars, and the solar system should become clear. The scale of billions will make better sense, and the speed of light can be used to express relative distances conveniently.	**Grades 9-12** • The stars differ from each other in size, temperature, and age, but they appear to be made up of the same elements that are found on the earth and to behave according to the same physical principles. Unlike the sun, most stars are in systems of two or more stars orbiting around one another. • On the basis of scientific evidence, the universe is estimated to be over ten billion years old. The current theory is that its entire contents expanded explosively from a hot, dense, chaotic mass. Stars condensed by gravity out of clouds of molecules of the lightest elements until nuclear fusion of the light elements into heavier ones began to occur. Fusion released great amounts of energy over millions of years. • Eventually, some stars exploded, producing clouds of heavy elements from which other stars and planets could later condense. The process of star formation and destruction continues. • Increasingly sophisticated technology is used to learn about the universe. Visual, radio, and x-ray telescopes collect information from across the entire spectrum of electromagnetic waves; computers handle an avalanche of data and increasingly complicated computations to interpret them; space probes send back data and materials from the remote parts of the solar system; and accelerators give subatomic particles energies that simulate conditions in the stars and in the early history of the universe before stars formed. • Mathematical models and computer simulations are used in studying evidence from many sources in order to form a scientific account of the universe. •	• Some evidence suggests the belief that stars are sprinkled throughout the universe, including within the solar system These results show that the scientist's view of the hierarchical structure of the cosmos—a concept important to understanding the principles on which the universe as a whole operates— is not second nature to many people. Many students believe the Earth was created in the Big Bang, along with all other structures in the Universe Using light years to express astronomical distances is not as straightforward as it seems. (Many adults think of light years as a measure of time.) Beginning with analogs such as "automobile hours" may help.	