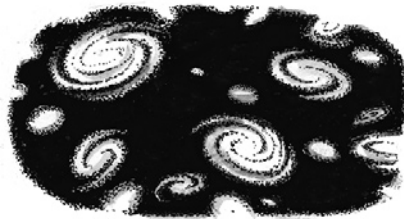


Origins: Back to the Beginning

PROGRAM OVERVIEW

NOVA chronicles the discoveries that led to scientists' current understanding of how the universe was formed.



The program:

- describes the serendipitous discovery of the Cosmic Microwave Background (CMB) radiation, a faint energy signal believed to be left over from the big bang.
- notes that initial studies of the CMB revealed a smooth, uniform glow that gave no indication of any regions of density that may have provided the basis for today's cosmic structures.
- explains that researchers sought a higher-resolution image of the CMB to discover what happened during the big bang that made it possible for the universe to evolve into its current form.
- relates findings by the 1991 Cosmic Background Explorer satellite that first revealed hints of variations in the CMB.
- follows the scientific teams working on the Cosmic Background Imager (CBI) and the Wilkinson Microwave Anisotropy Probe (WMAP) as they compete to provide a higher-resolution picture of the CMB.
- explains how elements are formed in a star—hydrogen and helium fuse into increasingly heavy elements until a star collapses and explodes, thereby providing enough energy for the remaining iron to undergo reactions that create all known remaining elements.
- speculates that a critical abundance of heavy elements is necessary for life to form and that already enriched star nurseries like the Eagle Nebula might be prime locations for the development of solar systems with habitable planets.
- details scientists' discovery of thousands of galaxies rich in heavy elements, leading some scientists to believe that life could emerge almost anywhere in the universe.

Taping Rights: Can be used up to one year after the program is taped off the air.

BEFORE WATCHING

- 1 Ask students how they think TV images are transmitted. (Via radio waves.) How do they think a television remote works? (Through infrared waves.) How does a light bulb give off light? (With light waves.) Tell students that these are all the result of the transmission of different kinds of energies that travel in waves. Review the electromagnetic spectrum with students, informing them that each part of the spectrum provides different information about the universe. Find out more at amazing-space.stsci.edu/resources/explorations/light/ems-frames.html www.lbl.gov/MicroWorlds/ALSTool/EMSpec/EMSpec2.html
- 2 Organize students into two groups. As students watch, have one group take notes on the Cosmic Background Imager science team and the other take notes on the team that developed the Wilkinson Microwave Anisotropy Probe. Have students note who makes up each team, what each team is working to accomplish, and what motivates each team.

AFTER WATCHING

- 1 Discuss students' notes about the CBI and WMAP science teams. What did the teams have in common? What were their main differences? What were some of the positive and negative aspects of the competition between them?
- 2 Ask students what they think it means when astronomers say, "We are made of stardust." How are humans and stars connected? (As stars burn fuel over their lifetimes, they eventually forge all known chemical elements. Generations of stellar explosions create a rich soup of elements that get recycled to become new stars, planets, and eventually the chemicals that make up humans.)

CLASSROOM ACTIVITY

Objective

To learn about the elements and their roles in the universe.

Materials

- copy of the “Elemental Puzzler” student handout

Procedure

- 1 All the elements known are formed in stars. This activity will help students explore some of the elements found in the Periodic Table of Elements and what role some of them play in the universe.
- 2 Ask students how many elements they think exist in the Periodic Table (as of mid-2004, there were 115 elements; elements 116 and 118 were believed to have been found but scientists later retracted results). Review the table’s basic organization (see Activity Answer on page 4 for more information).
- 3 You may want to note to students that the table is subject to change; new elements are added as they are discovered (only 94 of the elements exist naturally on Earth). Most of the heavier elements, which are created in particle accelerators or nuclear accelerators, exist for a fraction of a second before decaying.
- 4 Have students do the puzzle. If they are having difficulty, point them to the following Web sites:
 - WebElements™ Periodic table
www.webelements.com/
 - Periodic Table of the Elements
pearl1.lanl.gov/periodic/default.htm
 - Elements in Fireworks
chemistry.about.com/library/weekly/bfireworks.htm
- 5 When students have completed the puzzle, tell them that some of the elements listed in their puzzles have a special significance to the universe. Have students research answers to the questions on their handouts that are related to what role some of the elements play in the cosmos. Review student answers as a class, clarifying any misconceptions students may have.
- 6 As an extension, have students research the astronomer’s periodic table of elements that maps the abundance of the elements in the universe. Ask them to choose one of the elements on the table and create a poster about its role in the universe. Find one table at www.webelements.com/webelements/elements/text/periodic-table/geol.html

STANDARDS CONNECTIONS

The “Elemental Puzzler” aligns with the following National Science Education Standards.

GRADES 5–8

Science Standard B:

Physical Science

Properties and changes of properties in matter

- There are more than 100 known elements that combine in a multitude of ways to produce compounds, which account for the living and nonliving substances that we encounter.

GRADES 9–12

Science Standard B:

Physical Science

Structure and properties of matter

- An element is composed of a single type of atom. When elements are listed in according to the number of protons (called the atomic number), repeating patterns of physical and chemical properties identify families of elements with similar properties.

RELATED ACTIVITIES

Origins

www.amnh.org/education/resources/programs/origins/beginning.php

Investigate what elements make up in the sun and learn about cosmic microwave background radiation in this American Museum of Natural History site that offers articles and student materials related to NOVA’s “Back to the Beginning” program.

*Video is not required
for this activity.*

Classroom Activity Author

Developed by WGBH Educational Outreach staff.

ACTIVITY ANSWER

Dmitri Ivanovitch Mendeleev published the first iteration of the Periodic Table of Elements in 1869. The modern table is divided into metal, nonmetal, and metalloid groups. Each group contains elements with similar physical properties. Metals make up 75 percent of the table.

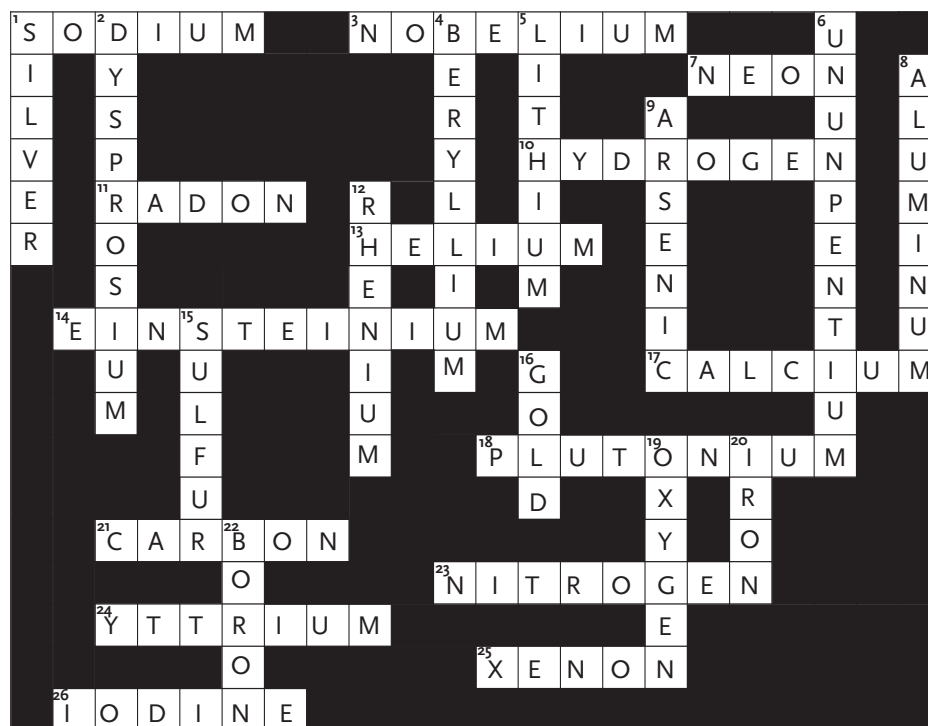
In each horizontal row, the number of protons increases from left to right, starting with hydrogen, which has one proton. The number of protons in an element defines its atomic number. Elements along each row have the same number of principal electron shells (energy levels) while in an unexcited state, while elements found in vertical columns have similar outer electron

configurations. Elements in the first two and last six columns have the same number of outer shell (valence) electrons (transition elements in the ten intervening columns follow a separate set of rules).

The five most abundant elements that make up atomic matter in the universe and the approximate percentages in which they occur (as a percentage of total number of atoms) are hydrogen (91.2%), helium (8.7%), oxygen (.078%), carbon (.043%), and nitrogen (.0088%). Approximate percentages by mass are (71.0%), helium (27.1%), oxygen (.97%), carbon (.40%), and nitrogen (.096%).

Some facts about hydrogen's role in the universe include that it is the most abundant element in the universe, it is the starting point for thermonuclear fusion, and it forms the molecular hydrogen clouds where stars are born.

Nitrogen and hydrogen combine to make ammonia. Iron is the final element created before a star undergoes a supernova explosion.



LINKS AND BOOKS

Links

NOVA Web Site—Origins

www.pbs.org/nova/origins/

In this companion Web site to the program, find out how life could have started and why water is needed for life; read about the latest discoveries in origins research; use raw data to assemble the famous Eagle Nebula image; insert your own values into the Drake Equation; decode cosmic spectra, and more.

The Electromagnetic Spectrum

www.nsta.org/main/news/stories/science_teacher.php?news_story_ID=48612

Provides an activity that allows students to identify substances based on the visible spectra they emit.

Timeline of the Universe

origins.jpl.nasa.gov/library/poster/poster.html

Offers a tutorial that traces the 15-billion year history of the universe, including the big bang, element formation, planetary system formation, the creation of Earth-like planets, and the chemistry of life.

Universe Forum: Learning Resources

cfa-www.harvard.edu/seuforum/learningresources.htm

Includes FAQs about the cosmos, information about the Center for Astrophysics' online telescope network, and links to additional lesson plans and activities.

WMAP Related Educational Resources

map.gsfc.nasa.gov/m_or/tr_list.html

Provides an overview of the project, classroom exercises, commonly asked questions about the universe, a glossary, and more.

Books

Couper, Heather and Nigel Henbest.

Big Bang: The Story of the Universe.

New York: DK Publishing, Inc., 1997.

Follows the story of the universe from its birth to the present and beyond.

Skurzynski, Gloria.

Waves: The Electromagnetic Universe.

Washington, D.C.: National Geographic Society, 1996.

Simplifies and clarifies the electromagnetic spectrum with colorful images and everyday applications.

Stwertka, Albert.

A Guide to the Elements.

New York: Oxford University Press, 1996.

Serves as an introductory resource, beginning with the basic concepts of chemistry and tracing the history and development of the periodic table of the elements. Each element is presented individually and accompanied by a photograph and practical application.

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 **Sprint**  **Google**



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FOUNDATION

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Elemental Puzzler

All the elements known have been produced in stars. Even the elements that make up you were created deep in the hearts of stars. Do you think you know your elements? Do this crossword puzzle and see. Then conduct research to answer the questions on this page. All answers can be found in your completed puzzle.

ACROSS

- 1 the main ingredient in table salt
- 3 named after the scientist who discovered dynamite
- 7 used in making advertising signs
- 10 when coupled with oxygen, this element makes a compound essential for life
- 11 occupies the last place in the zero group of gases
- 13 used to make balloons float
- 14 radioactive rare earth metal named after Albert Einstein
- 17 an essential component of leaves, bones, teeth, and shells
- 18 used as an explosive ingredient in nuclear weapons
- 21 the key component of carbohydrates in foods like pasta
- 23 the ___ cycle is one of the most important processes in nature for living organisms
- 24 named for the village of Ytterby, Sweden
- 25 atomic number is 54
- 26 atomic weight is 126.9045

DOWN

- 1 has the highest electrical and thermal conductivity of all metals
- 2 discovered in 1886 by Lecoq de Boisbaudran
- 4 also called glucinium
- 5 element pictured in the lower right-hand corner of crossword
- 6 the heaviest (as yet unconfirmed) element found, announced in February 2004
- 8 common component of sparklers
- 9 poison used in many mystery novels
- 12 heavier than tungsten, lighter than osmium
- 15 found in a firework's fuel
- 16 All that glitters is not ___
- 19 makes up most of a human body's mass
- 20 key component of hemoglobin
- 22 helps form the household-cleaning compound borax

Questions

Write your answers on a separate sheet of paper.

- 1 What are the five most abundant elements that make up atomic matter in the universe and in what approximate percentages do they occur?
- 2 State three facts about hydrogen's role in the universe.
- 3 Two elements in your crossword puzzle combine to make ammonia, which is found in cold interstellar gas clouds. What are the two elements?
- 4 A star burns throughout its life and releases energy. During this process, a star fuses together increasingly heavier and heavier elements. Finally, a star reaches the point where only this element exists, which it cannot fuse. Instead, it undergoes thermonuclear reactions and blows up in a supernova. What is this element?

