

Newton's Dark Secrets

PROGRAM CONTENTS

NOVA presents the life and science of Sir Isaac Newton (1642–1727), one of the greatest scientists who ever lived.



The program:

- chronicles Newton's upbringing in the early part of the Scientific Revolution.
- recounts Newton's attendance at Trinity College at Cambridge University in England, where he studied the latest scientific ideas, and his return to his hometown of Woolsthorpe four years later when the plague struck Cambridge.
- reviews the advances Newton made in gravity, calculus, and the composition of light while he was at Woolsthorpe.
- relates Newton's return to Cambridge, where he was appointed the Lucasian Professor of Mathematics, a chair currently held by physicist Stephen Hawking.
- reports how Newton solved the problem of chromatic aberration in refracting telescopes by designing and building a reflecting telescope based on mirrors rather than lenses.
- recounts Newton's election to the Royal Society and details the contentious relationship between Newton and fellow society member Robert Hooke, who accused Newton of stealing his ideas.
- explores Newton's interests in alchemy and religion.
- explains Newton's concepts of the inverse square law, the laws of motion, and gravity.
- describes the 1687 publication of *Philosophiæ Naturalis Principia Mathematica*, a work generally acknowledged as the greatest scientific book ever written.
- relates how Newton had what some believe was a nervous breakdown; following his recovery, he takes a job as warden of the Mint in London.
- reports how Newton published his second great work, *Opticks*, the year after Hooke died.
- concludes by noting how, more than 250 years after his death, a new picture of Newton—as scientist, alchemist, and theologian—is emerging.

BEFORE WATCHING

- 1 Ask students what they know about Sir Isaac Newton. List student answers on the board. Where and when did he live? What did he do? What is he most known for?
- 2 Organize students into three groups. As they watch, have each group take notes on one of the following topics: Newton's key scientific and mathematical discoveries, his religious journey, and his work in alchemy.

AFTER WATCHING

- 1 Have students who took notes on the same topic meet and present their notes. Ask the following questions as different teams share their notes: What were some of Newton's mathematical and scientific contributions? Which are important in the world today? What role did religion play in his life? Why was he interested in alchemy?
- 2 Lead a discussion about Newton's interest in alchemy. What first attracted Newton to alchemy? What was he looking for? Why might Newton have felt the need to keep his alchemical work a secret? Why did he eventually abandon alchemy? How does alchemy compare to today's chemistry?
- 3 Provide students with information about Newton from different science and history texts. How does the information compare to what they saw in the program? How, if at all, have their impressions about Newton changed after viewing the program?

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

CLASSROOM ACTIVITY

Activity Summary

Students will read and interpret a passage from a famous alchemical text titled *The Twelve Keys of Basil Valentine*.

Materials for Each Team

- copy of the “Secret Symbols” student handout
- copy of the “The Keys to the Stone” student handout
- highlighting pen

Materials for Teacher Demonstration

- copper sulphate
- water
- ungalvanized steel nail

Background

Alchemy was a form of early modern chemistry. Alchemists sought to create the so-called philosophers’ stone in order to, among other goals, change metals such as lead into gold. For Newton and other practicing alchemists of the 17th century, there was a philosophical and spiritual aspect of their work that involved transforming the chaos of our everyday world into a pure enlightened state. This journey to enlightenment is known as the Great Work.

Alchemists heavily coded their work in symbols and metaphors to both prevent backlash from the church and to keep the uninitiated from penetrating their secrets. Animals, humans, plants, colors, and celestial bodies were used to indicate different substances, processes, and the desired result of those processes. While there were no fixed rules in the use of symbolism (different symbols were often used to represent the same thing), there are a few common themes. Seven base elements—gold, silver, iron, mercury, tin, copper, and lead—for example, were associated with particular planets and zodiac signs. The products of chemical processes were represented by colors. Kings and queens represent gold and silver, respectively.

In this activity, students will read and interpret a medieval alchemical passage.

LEARNING OBJECTIVES

Students will be able to:

- identify Sir Isaac Newton as a scientist and mathematician who practiced alchemy.
- explain that alchemy is a medieval chemical philosophy.
- interpret symbols and metaphors that describe different materials and procedures in an alchemical text.
- practice using symbols and metaphors to conceal work as alchemists did.

KEY TERMS

alchemy: A medieval chemical philosophy that aimed to change base metals to gold, discover a universal remedy for illness, and prepare an elixir that would enable one to live forever.

antimony: a metallic element with four allotropic forms; used in a wide variety of alloys.

elements: The seven base metals plus arsenic and sulfur. They were not elements in the modern sense.

philosophers’ stone: A mythical substance believed to cure disease, confer immortality, and turn ordinary metals like lead into gold.

symbol: A printed or written sign for the purpose of representing an operation or action, an element, a quantity, a quality, or a relation (as in music).

symbolism: The practice of representing things using symbols or attributing symbolic meaning(s) to objects, events, or relationships.

CLASSROOM ACTIVITY (CONT.)

Procedure

- 1 Have students name some universal symbols they commonly see. *(Some symbols include graphic road signs, warning signs, or musical notes.)* Ask students to name some symbol systems that do not use words. *(Some examples include hieroglyphics, Braille, Zip codes, bar codes, or ISBN numbers.)* Discuss with students why symbols are used. *(Some reasons include to communicate without language, to encourage secrecy, or to efficiently communicate information.)* Explain that alchemists used symbols and metaphors to describe different materials and procedures in alchemical texts and art.
- 2 Alchemists believed in the transmutation of metals. One chemical reaction they used to support their claims was the change that occurred when iron came in contact with copper sulfate pools found near mines. Since there was no way to weigh the copper in the pools, it looked to many as though the naturally occurring copper sulfate was transmuting the iron into copper. You can demonstrate this reaction to students. Make a solution of copper sulfate and water. *(The concentration is not important, but the solution should have a bright blue color, like that of the dry copper sulfate.)* Dip an ungalvanized steel nail in the solution and let it stay there for about a minute. When you remove it, the nail will be plated with copper. *(Point out to students that weighing the initial and final products would have shown that the iron did not transmute into copper.)*
- 3 Organize students into teams. Provide copies of the student handouts and highlighting pens to each team. Review *The Twelve Keys of Basil Valentine* and the “Keys to the Stone” with students.
- 4 Have teams read the passage and then use the description of the common alchemical symbols to create their own interpretation of the text.
- 5 When teams have finished interpreting the passage, discuss their results. How similar was each team’s interpretation? What might account for any differences in interpretations? Why might teams—who worked from the same passage and key code—end up with different interpretations?
- 6 As an extension, have students view the complete passage and/or additional passages of the *Twelve Keys of Basil Valentine* online at www.levity.com/alchemy/twelvekey.html

STANDARDS CONNECTIONS

The “Secret Symbols” activity aligns with the following National Science Education Standards (see books.nap.edu/html/nses).

GRADES 5–8
Science Standard G
History and Nature of Science
History of science

GRADES 9–12
Science Standard G
History and Nature of Science
Historical perspectives

Video is not required
for this activity.

Classroom Activity Author

Margy Kuntz has written and edited educational materials for 20 years. She has authored numerous educational supplements, basal text materials, and trade books in science, math, and computers.

ACTIVITY ANSWER

In the excerpted passage:

- grey wolf is stibnite, an ore of antimony
- Mars is iron
- Saturn is lead
- the king is gold

Students' answers should reflect that the passage describes the preparation of gold by mixing impure gold with stibnite and then heating the mixture in a hot fire three times to purify the gold. Other interpretations of the passage may include that the stibnite is derived from lead [the offspring of ancient Saturn], that stibnite is added to impure gold [cast to him the body of the king], that after being heated three times there is no stibnite left [when this has been performed thrice the Lion has overcome the wolf and will find nothing more to devour in him], and that at the end of the experiment, the king—or the gold—has been prepared [our Body has been rendered fit for the first stage of our work].

Student Handout Questions

- 1 Compare your team's interpretation of the text to others in the class. Did different teams come up with the same answer? Why or why not? Discuss and defend your choices. *While students should all be able to identify the basic materials and procedure outlined in the text passage, the exact interpretation will vary among students based on their understanding of the procedure and context of the text. In addition, interpretations will vary due to the fact that different students will identify different sections and phrases of the passage as more important and/or having more relevance than others.*
- 2 Newton used his own symbols and phrases to describe the steps he took when performing alchemical experiments. Explain why he might have done this. *Newton might have done this because he was obsessed with the idea of keeping his work a secret both from the society at large and from other alchemists.*

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LINKS AND BOOKS

Links

NOVA—Newton's Dark Secrets

www.pbs.org/nova/newton

Discover more about who Sir Isaac Newton really was, find out what inspired the Principia, read what Einstein wrote about his predecessor, see one of Newton's 300-year-old manuscripts decoded, and learn about seven of Newton's greatest accomplishments.

Alchemy Web and Virtual Library

www.levity.com/alchemy/index.htm

Offers comprehensive library of imagery, symbols, music, alchemical texts, and commentary.

Newton's Alchemy, Recreated

www.indiana.edu/~college/WilliamNewmanProject.shtml

Describes a project to decipher Newton's chemical laboratory notebooks and manuscripts.

The Newton Project

www.newtonproject.ic.ac.uk/

Provides digital facsimile images of Newton's papers alongside text-encoded transcriptions on a split screen.

Books

A Dictionary of Alchemical Imagery

by Lyndy Abraham.

Cambridge University Press, 2001.

Documents alchemical symbolism from the early centuries AD to the late-20th century.

Alchemy Tried in the Fire: Starkey, Boyle, and the Fate of Helmontian Chymistry

by William R. Newman and Lawrence M. Principe.

University of Chicago Press, 2002.

Examines the goals and practices of mid-17th century alchemists and prominent scientists and how their work contributed to the development of modern chemistry.

Secret Symbols

Sir Isaac Newton is well known for his mathematical and scientific achievements, yet few people know about his work as an alchemist. Some people believe that Newton pursued alchemy with the hopes that it might help him better understand great truths about nature and the universe. Many alchemists described their work in symbols and metaphors. In this activity, you will use a glossary of alchemical symbols to interpret a passage from a famous alchemical text called *The Twelve Keys of Basil Valentine*.

Procedure

- 1 Read the text passage on this page. Use a pencil or highlighting pen to mark any words or phrases you think might be clues to the text's meaning.
- 2 As a team, use the description of common symbolism for alchemical substances, principles, and elements on the "Keys to the Stone" handout to decipher the text. Note that some symbols and images have more than one meaning.
- 3 Together, write your interpretation of the text on a separate piece of paper, and then share your work with the class. When interpreting the text, refer to the line number in which the word or phrase appears.

Questions

Write your answers on a separate sheet of paper.

- 1 Compare your team's interpretation of the text to others in the class. Did different teams come up with the same answer? Why or why not? Discuss and defend your choices.
- 2 Newton used his own symbols and phrases to describe the steps he took when performing alchemical experiments. Explain why he might have done this.

The *Twelve Keys of Basil Valentine*

The *Twelve Keys of Basil Valentine* is a famous alchemical text that appears to have first been published in Germany around 1599. The text was later translated into Latin, Greek, and English. The author, "Basilius Valentinus," claimed to be a Benedictine monk. The author's true identity is unknown. The text itself contains 12 coded passages, or keys, that describe the process of creating the Philosopher's Stone, a mythical substance believed to cure disease, confer immortality, and turn ordinary metals into gold. The following is a part of the first step, which involves preparing the materials to be used in the creation of the stone.

- 1 *If you would operate by means of our bodies, take*
- 2 *a fierce grey wolf, which, though on account of its*
- 3 *name it be subject to the sway of warlike Mars, is*
- 4 *by birth the offspring of ancient Saturn, and is found*
- 5 *in the valleys and mountains of the world, where he*
- 6 *roams about savage with hunger. Cast to him the*
- 7 *body of the King, and when he has devoured it, burn*
- 8 *him entirely to ashes in a great fire. By this process*
- 9 *the King will be liberated; and when it has been*
- 10 *performed thrice the Lion has overcome the wolf,*
- 11 *and will find nothing more to devour in him. Thus*
- 12 *our Body has been rendered fit for the first stage*
- 13 *of our work.*



Keys to the Stone

Some Common Symbols in Alchemical Texts and Images

baths: cleansing; dissolving a solid in a liquid

black cow: black or purifying matter

black raven/blackbird: a black mixture

bone of whale: a white mixture

child: offspring of the king and queen, the result of their marriage or union; a naked child symbolizes the innocent soul; a child crowned or clothed in purple robes signifies salt or the Philosopher's Stone

crown: completion; perfection of a metal



dragon/serpent: fire; the dragon in flames is a symbol of fire and calcination (breaking down a substance by heating or burning it); dragons with wings represent the volatile principle (mercury); dragons without wings represent the fixed principle (sulfur); a dragon biting its own tail is the ouroboros and signifies the fundamental unity of all things



eagle: volatilization and air

egg: the sealed vessel of creation

hermaphrodite (half man/half woman): conjunction; the union of two opposites

king: man, solar consciousness, and gold; the red king is sophic sulfur (considered the seed of gold); the king united with the queen symbolizes conjunction (the joining of two opposite natures)

lion: raw matter and acid; red lion is the red acetate of lead in crystalline form; green lion is the green acetate of lead in liquid or crystal form; black lion represents carbon; the winged lion is mercury or sophic salt



ouroboros (a serpent biting its tail): completion

queen: woman, lunar consciousness, and silver; the white queen is sophic mercury (considered the quintessence of metals); the queen united with the king is the operation of conjunction (the joining of two opposite natures)

stag: the soul

trees: the process of transformation

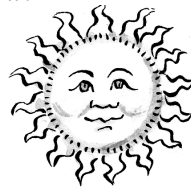
whale: water

wolf, grey wolf: stibnite, an ore of antimony

Metals Used by Alchemists

antimony: wolf, grey wolf

gold: sun, king, perfect sphere, Leo the Lion, Sunday



silver: moon, queen, white rose, crescent, rain cup, Cancer the Crab, Monday

iron: Mars, shield and spear, Scorpio the Scorpion and Aries the Ram, Tuesday

mercury: Mercury or Hermes, caduceus (twined serpents on a staff), Virgo the Virgin and Gemini the Twins, Wednesday

tin: Jupiter, lightning, Pisces the Fish and Sagittarius the Archer, Thursday

copper: Venus, hand mirror, Taurus the Bull and Libra the Scales, Friday

lead: Saturn, old man carrying a scythe or hourglass, Capricorn the Goat and Aquarius the Water Carrier, Saturday

Properties of the Alchemical Principles

sophic sulfur: symbolized by the red king or red rose

sophic mercury: symbolized by the white queen or white rose

sophic salt: symbolized by the ouroboros, the stone, and the astral body

Alchemical Elements

air: spirit into the manifested world; hot and wet; sanguine

earth: manifestation, birth, and material creation; cold and dry; melancholy

fire: activity and transformation; hot and dry; choleric

water: cleansing and purification; cold and wet; phlegmatic

