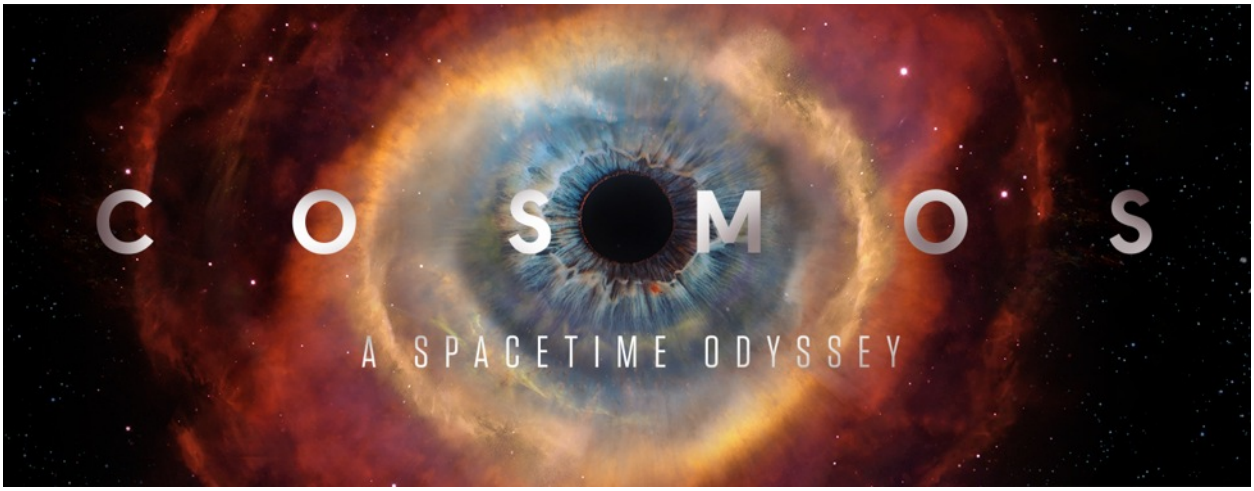

Quests and Discussions for Students, Episode 5

Written by Ann Druyan
Produced by Cosmos Studios

Overview
Episode 5, “Hiding in the Light,” is about the various meanings of light and enlightenment – curiosity about light as a motive force in discovery and the critical role of free inquiry in the history of science.

Grade Levels
6-12

Episode Summary
The keys to the cosmos have been lying in plain sight all along. Light, itself, holds so many of them, but we never realized they were there until we learned the basic rules of science.

A quirk of light may have moved us to paint our first pictures in pre-historic times. The natural phenomenon of the camera obscura is explained.

Our earliest experiments with light begin with a two thousand year old Chinese movie described by the ancient philosopher, Mozi. The violent suppression of his work, free thought and speech by China’s first emperor make us an eyewitness to history’s first book-burning.

We visit the Europe and North Africa of the 11th century, to the golden age of Islam, when Arabic was the language of science. While there, we encounter Ibn al-Hazen, the physicist who first understood and demonstrated experimentally how we see and how light travels. These are epochal achievements to be sure, but by no means al-Hazen’s greatest. al-Hazen devised a machine for making countless other discoveries – the scientific method.

It is also the true fairy tale of the 19th century penniless Bavarian orphan who was rescued by a prince from the rubble of a house where he labored in indentured servitude. Joseph Fraunhofer grew up to discover the signature hidden in the light of every star, to found the

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science of astrophysics, and to preside over a top-secret laboratory hidden away in an ancient monastery. The secrets of the discoveries he made there would confound another genius (the hero of chapter 9) decades later and ultimately provide another us with another key to the cosmos.

Discussion Topics

- Most star names we have today come from their Arabic names. Find 12 words that begin with the letters “al-“ and discuss their meanings as they pertain to astronomy, chemistry, and mathematics.
- Scientists use spectroscopy to determine the chemical composition of stars. What are some of the more “down-to-Earth” applications of spectroscopy?
- As we learn in this episode, it is possible “to see” in many different wavelengths. Name a wavelength you would like to use to view a particular thing in the universe and why.
- What does the United States Bill of Rights have to do with science? For example, what role do Freedom of Speech, the Right to Assembly, and the right not to be constrained in the questions you ask have in scientific progress?
- Discuss how the lengths of an organ pipe relates to the sound it produces.

Proposed Activities

- Using a thermometer, reproduce Herschel’s experiment with regards to whether color has temperature.
- Using the Online Resource section, have students construct their own camera obscura.

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Online Resources

- http://www.getty.edu/education/teachers/classroom_resources/tips_tools/downloads/aa_camera_obscura.pdf

Relevant Scenes from COSMOS

- Act One: The First Movie
- Act Two: Ibn al-Hazen
- Act Three: Newton and Herschel's experiments with light
- Act Four: Joseph Fraunhofer
- Act Five: Nature's Astonishing Palette
- Act Six: Wavelengths

For a deeper dive, more subjects touched on in Episode 5:

- Optics
- Ancient Chinese philosophy and science
- Methodology of science
- Islamic history
- Physics of light
- Galileo and the first telescope
- Impact on humans and other species of ambient light pollution
- Paradoxical properties of light
- Newton's decryption of the rainbow
- Herschel's experimental discovery of the infrared wavelengths in sound and light
- Carmina Burana
- The birth of spectroscopy and astrophysics
- The physical nature of color
- Spectral lines and atomic structure
- Quantum reality

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- The behavior of electrons
- Atomic elements
- The solar photosphere and stellar physics
- Dark matter
- X-ray, radio, gamma-ray and microwave light

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