Online Modules from The University of Chicago

Multiwavelength Astronomy: The History of X-ray Astronomy, by Herbert Friedman
http://ecuip.lib.uchicago.edu/multiwavelength-astronomy/x-ray/history/index.html

Subject(s): Astronomy/Space Science

Grade(s) Level: 9-12

Duration: Two to Three Class Periods

Objectives:

Students will

- Identify key steps in a text's description of a process related to scientific history;
- Gain knowledge about the history of X-ray technology and use the central ideas, or information of a primary or secondary source, to provide an accurate summary of how key events or ideas develop over the course of the text;
- Analyze in detail a series of events described in text and determine whether earlier events caused later ones or simply preceded them.

Materials: Internet connection and browser for displaying the lesson; Reading Guide (appended at the end of this lesson plan).

Pre-requisites: Students should be familiar with the Electromagnetic Spectrum generally, and with X-rays in particular.

Procedures: Students will read each section of the X-ray history lesson and respond to questions in the Reading Guide. Students then pair off with a partner and discuss their answers. The class reconvenes to share their responses as a group and discuss. After this part of the lesson is complete, students form small groups to create a skit drawn from elements of the Reading Guide.

Introduction:

The Electromagnetic Spectrum describes all the wavelengths of light, both seen and unseen. These wavelengths can be detected using instruments that make this light/energy visible. However, higher energy wavelengths cannot be "seen" from the ground because they are absorbed by the protective atmosphere of Earth. Exploration of high energy phenomena requires placing instruments above the atmosphere, but even then, these wavelengths present significant challenges in detection and imaging. The pioneers of X-ray astronomy tackled many of the scientific, engineering and design problems fundamental to all space-based research, leading the way for future space investigations in all wavelengths.

Adaptations:

This lesson was created with considerations of special needs students. Different modalities are included. Visuals are included with the Reading Guide; students can be paired with a peer tutor; students respond with whole body experience during dramatization.

Additional Discussion Questions:

- Did earlier events cause later ones, or did they simply precede them?
- Which events were caused by earlier ones? What events do you think simply preceded earlier ones?
- What evidence did you find of scientific processes?

Evaluation: Student self-evaluation form for group project

http://www.iidc.indiana.edu/styles/iidc/defiles/INSTRC/TuesTips/Student_Self_eval_benefits.pdf

Extensions:

Classroom-Ready Activities from the Chandra X-Ray Observatory Mission http://chandra.harvard.edu/edu/formal/

Suggested Readings: The lessons on the science, tools, and impact of X-ray Astronomy from the Multiwavelength Astronomy website.

Links: These websites are recommended for providing background and supplemental information:

Tour of the Electromagnetic Spectrum
http://missionscience.nasa.gov/ems/
X-Rays (from the Electromagnetic Spectrum site) http://missionscience.nasa.gov/ems/11_xrays.html
Imagine the Universe – How Does the Universe Generate X-rays? http://imagine.gsfc.nasa.gov/docs/science/how_l2/xray_generation.html

A History of X-ray Astronomy
http://chandra.harvard.edu/xray_astro/history.html

Rocketry at the Naval Research Laboratory
http://www.nrl.navy.mil/accomplishments/rockets/

Vocabulary: The following terms are used and defined in the lesson. Teachers may want to review these in advance of using the lesson with students.

Aerobee
American Science and Engineering (AS&E)
Apollo Program
aurora
binary pulsar
black hole
Buck Rogers
Brooklyn College
The California Institute of Technology (Caltech)
celestial
Chandra X-Ray Observatory
Compton Gamma-Ray Observatory
constellation
Cygnus X-1
efficient
Einstein Observatory
extragalactic
Franck, James
galaxy
Geiger counter
Giacconi, Riccardo
Goddard, Robert Hutchings
Great Observatories Program
High Energy Astronomy Observatory (HEAO)
Hubble Space Telescope
Hulburt, Edward O.
hydrogen
ionization chamber
Kennedy, John F.
Johns Hopkins University
Lyman alpha line
Marshall Space Flight Center (MSFC)
Massachusetts Institute of Technology (MIT)
metallurgy
molecular oxygen
Nixon, Richard M.
Nobel Prize
Orbiting Astronomical Observatories (OAO)
Orbiting Solar Observatories (OSO)
photon
quasar
radio pulsar
Rossi, Bruno
Scorpius X-1 (Sco X-1)
Simpson, John A.
Space Science Board
Sputnik 1
Stuhlinger, Ernst
supernova
United States Naval Research Laboratory (NRL)
University of Chicago
V-2 rocket
van Allen, James
Vanguard
von Braun, Wernher
White Sands, New Mexico

Standards: This lesson addresses NGSS: HS-PS4-5; and Common Core standards CCSS.ELA-Literacy.RST.9-10.1, 9-10.2, 9-10.4, 9-10.7, 9-10.8 and 9-10.9.

Reading Guide

The History of X-ray Astronomy, by Herbert Friedman

It all began with a rocket …

Who is this man and what sits on top of the frame?

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Who is this man and what is he standing in front of?

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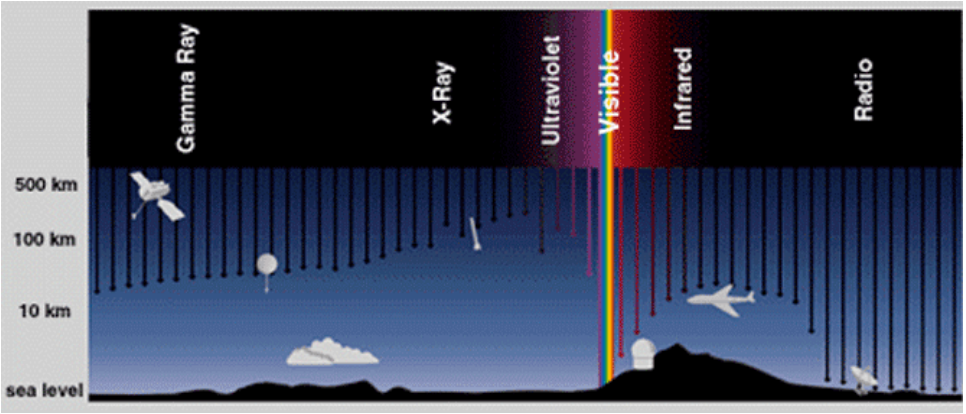
Write a caption for this diagram in 20 words or less.



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Growing Up

When Herbert Friedman went to Brooklyn College, what did he begin to study? What are some of the reasons why he changed his course of study? Were you surprised by his change of plans? Explain why or why not.

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Graduate School

Who is this man and what was his part in Friedman's story?

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What does this diagram depict?
Why was it an improvement over earlier designs?

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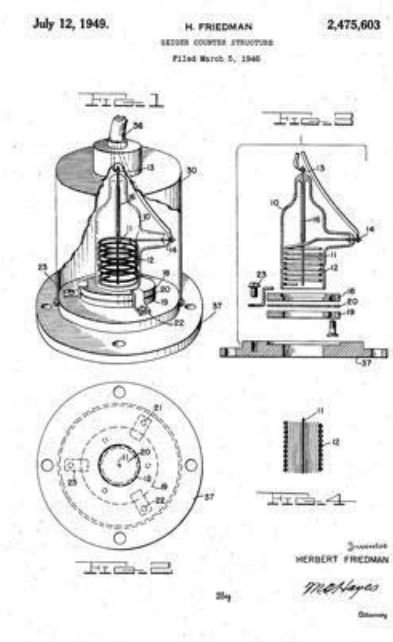

Wartime Physics

Identify this picture and describe what type of work Friedman did here.

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What problem was encountered when they wanted to send in survey teams to map out the distribution of radioactivity after the bombing of Japan?

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What was the feeling of scientists after the bombing of Hiroshima?

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Early Rocket Experiments

Explain why the Aerobee was developed.

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Have you ever built and launched a rocket? Would this be interesting to you? Explain why or why not.

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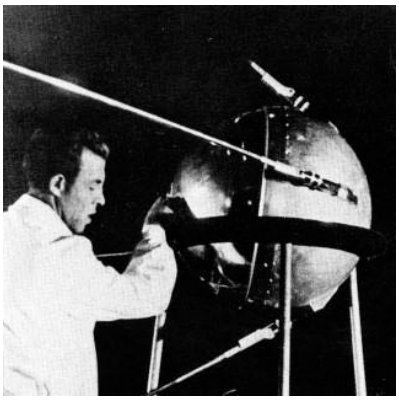
The Sputnik Era

What is this a picture of and what does it have to do with cigars?



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Who dubbed this the “grapefruit satellite”?
What do you think was the attitude of this person towards the Vanguard I rocket team?

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Friendly Competition

What if the National Aeronautics and Space Act of 1958 had not been signed into law? Hypothesize the nature of space exploration.

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Early X-ray Observations

Give some examples of the successes and failure of early X-Ray observations.

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From Rockets to Satellites to Observatories

Compare Friedman's ideas with Giacconi's for the post-Apollo Mission.

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The Space Shuttle and Space Telescope

What moment in history does this picture represent?
Who are the men shown in the picture?

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What was the recommendation by the Space Task Group of NASA engineers in response to the question, "What's next for NASA?" Do you think the scientists and engineers held the same views about the future of space investigations? What might be some similarities and differences in their views?

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The High Energy Astronomy Observatory Program (HEAO)

Describe the differences between the HEAO-1 and HEAO-2 (Einstein Observatory) missions and explain why the differences are significant.

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The Amazing Universe

Finish the sentence below in a paragraph or two.

In my opinion, the future of space exploration …