

## Homegrown Particle Accelerators Educator Guide

A resource for using QUEST video in the classroom

Watch it online <http://www.kqed.org/quest/television/homegrown-particle-accelerators> | 12:07 minutes



### QUEST SUBJECTS

<p><b>Life Science</b></p>	<p>Biology Health Environment</p>
<p><b>Earth Science</b></p>	<p>Geology Climate Weather Astronomy</p>
<p><b>Physical Science</b></p>	<p>Physics Chemistry Engineering</p>

### CA SCIENCE STANDARDS

#### Grade 8

*Structure of Matter (Focus on Physical Sciences)*

3. (a) An atom is composed of protons, neutrons and electrons.

#### Grades 9-12

*Electric and Magnetic Phenomena (Physics)*

5. (e, f) Charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges; magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.

*Nuclear Processes (Chemistry)*

11. (a, g) Protons and neutrons in the nucleus are held together by nuclear forces that overcome the electromagnetic repulsion between the protons; protons and neutrons have substructures and consist of particles called quarks.

### PROGRAM NOTES

Activated in 2008, the Large Hadron Collider particle accelerator in Switzerland cost billions of dollars to build and takes 13,000 students and scientists from 50 countries to operate. **QUEST** journeys back through scientific history to examine early "atom smashers" and reveal how Bay Area physicists helped pave the way for modern accelerators like the Large Hadron Collider.



In this segment you'll find...

- ⦿ a history of particle accelerators and their uses.
- ⦿ what physicists have learned from experimenting with particle accelerators.
- ⦿ facts about the Large Hadron Collider and its purpose.

### TOPIC BACKGROUND

Subatomic research has come a long way since its earliest history. During the 1800s, most scientists believed the atom, the basic building block of all matter, was indivisible and unchangeable. But by the late 1800s, physicists like Marie Curie and Ernest Rutherford were already beginning to develop radical new theories about the structure of the atom. Their work focused on the rays that shoot out of radioactive substances. As scientists started to recognize that the once mystical "rays" they observed emitting from radioactive substances were actually particles, the question of whether or not an atom was truly indivisible became more acute. If such tiny particles were emitted from an atom, wouldn't that mean that atoms were made up of smaller particles? If so, how could they be indivisible?

In the early 1900s, the discovery of "cosmic rays" by Austrian-American physicist Victor Hess shed even more light on subatomic activity. The cosmic rays he witnessed during his experiments with a hot air balloon turned out to be extremely penetrating particles of radiation that struck our atmosphere from extraterrestrial locations like the Sun or exploding supernovas and reacted with other particles in Earth's atmosphere. New fields of physics research sprang up as other scientists took on similar experiments and continued expanding the findings on radiation and subatomic particles. In 1929, Ernest Lawrence built the first particle accelerator to perform subatomic tests in a lab setting rather than outside with hot air balloons. From the beginning, particle accelerators allowed physicists to simulate "cosmic rays" by firing a beam of particles at top speeds and then observing what happened when the particles collided with other particles. Called the cyclotron, this type of particle accelerator relied on cloud chambers that allowed scientists to view higher-energy particles, lower-energy particles and electrons independently. Such a chamber consists of an enclosed volume of clean air full of water vapor. When the volume expands, the air temperature lowers and the mixture becomes super-saturated. If a charged particle passes through the chamber, water vapor clings to it and its image can be photographed and studied. Although more modern particle accelerators typically use a bubble chamber full of heated liquid, the cloud chamber is still in use today.

## VOCABULARY

### Dark Matter

a hypothesized form of matter that does not reflect or emit electromagnetic radiation and is thought to make up approximately 90 percent of the universe

### Electromagnetism

a unified fundamental force of physics that combines the aspects of electricity and magnetism

### Element

a substance made up of atoms that all have the same number of protons

### Ion

an atom or group of atoms that has gained or lost one or more electrons to have a net positive or negative electrical charge

### Matter

any substance made up of atoms and molecules that has mass and occupies space

### Subatomic Particle

any of various units of matter smaller in size and less complex than an atom

### Quark

a subatomic elementary particle that is a fundamental constituent of matter

## PRE-VIEWING

- How can experiments help scientists learn more about our universe?
- What kinds of subatomic particles do you know about?

## VIEWING FOCUS

NOTE: You may choose to watch the television segment twice with your students: once to elicit emotional responses and get an overview of the topic and again to focus on facts and draw out opinions.

- Through the years, what questions have physicists hoped to answer through experimenting with particle accelerators?
- Who was Ernest Orlando Lawrence? How did he help advance the field of particle acceleration?
- How do linear accelerators work? What makes them different from cyclotrons?
- What are scientists hoping to discover using the Large Hadron Collider? How does this particle accelerator differ from other particle accelerators?

*For all media see:*

- Segment Summary Student Sheet  
[http://www.kqed.org/quest/downloads/QUEST\\_SegSum\\_StudentSheet.pdf](http://www.kqed.org/quest/downloads/QUEST_SegSum_StudentSheet.pdf)
- Personal Response Student Sheet  
[http://www.kqed.org/quest/downloads/QUEST\\_PersResp\\_StudentSheet.pdf](http://www.kqed.org/quest/downloads/QUEST_PersResp_StudentSheet.pdf)

## LESSON PLANS and RESOURCES from QUEST, PBS and NPR

### The World's Largest Particle Accelerator NPR

<http://www.npr.org/templates/story/story.php?storyId=9473392>

An April 9, 2007, broadcast from NPR's **All Things Considered** examines the \$10 billion Large Hadron Collider and the questions that physicists hope this machinery will answer.

### “Big Bang Machine” Smashes Energy Record NPR

<http://www.npr.org/templates/story/story.php?storyId=125346156>

This March 30, 2010, story from **All Things Considered** discusses the scientific progress already made by the Large Hadron Collider and addresses possible dangers associated with this enormous particle accelerator.

### The Atom Teachers' Domain

<http://www.teachersdomain.org/resource/lsp07.sci.phys.matter.theatom/>

**ChemThink** presents an interactive activity for students to use while investigating subatomic particles, their properties and their relative locations inside an atom.

### Atom Builder Teachers' Domain

<http://www.teachersdomain.org/resource/phy03.sci.phys.matter.atombuilder/>

This interactive feature from **NOVA Online** allows students to virtually build a carbon atom from subatomic particles and explore where ions and radioactive materials come from.

### Quarks: Inside the Atom Teachers' Domain

<http://www.teachersdomain.org/resource/phy03.sci.phys.matter.quark/>

Watch this video segment adapted from **NOVA** to learn about the evolution of atomic theory and see what modern physicists are doing to advance our knowledge of quarks.

### Discuss the Homegrown Particle Accelerators story on the QUEST Blog QUEST

<http://www.kqed.org/quest/blog/2010/07/27/producers-notes-homegrown-particle-accelerators/>

## VISIT OUR PARTNERS

The Bay Institute  
[www.bay.org](http://www.bay.org)

California Academy of Sciences  
[www.calacademy.org](http://www.calacademy.org)

Chabot Space and Science Center  
[www.chabotspace.org](http://www.chabotspace.org)

East Bay Regional Park District  
[www.ebparks.org](http://www.ebparks.org)

Exploratorium  
[www.exploratorium.edu](http://www.exploratorium.edu)

Girl Scouts of Northern California  
[www.girlscoutsnorcal.org](http://www.girlscoutsnorcal.org)

Golden Gate National Parks Conservancy  
[www.parksconservancy.org](http://www.parksconservancy.org)

The J. David Gladstone Institutes  
[www.gladstone.ucsf.edu](http://www.gladstone.ucsf.edu)

Lawrence Berkeley National Laboratory  
[www.lbl.gov](http://www.lbl.gov)

Lawrence Hall of Science  
[www.lawrencehallofscience.org](http://www.lawrencehallofscience.org)

Monterey Bay Aquarium  
[www.mbayaq.org](http://www.mbayaq.org)

Monterey Bay Aquarium Research Institute  
[www.mbari.org](http://www.mbari.org)

Oakland Zoo  
[www.oaklandzoo.org](http://www.oaklandzoo.org)

The Tech Museum of Innovation  
[www.thetech.org](http://www.thetech.org)

UC Berkeley Natural History Museums  
<http://bnhm.berkeley.edu/>

U.S. Geological Survey  
[www.usgs.gov](http://www.usgs.gov)

## MORE EDUCATIONAL RESOURCES FOR USING QUEST MULTIMEDIA TO ENHANCE 21<sup>st</sup> CENTURY SKILLS IN TEACHING AND LEARNING

### Why Use Multimedia in Science Education?

<http://www.kqed.org/quest/downloads/QUESTWhyMedia.pdf>

- Read about the importance of using multimedia in the 21st century science classroom.

### How to Use Science Media for Teaching and Learning

<http://www.kqed.org/quest/downloads/QUESTMediaTips.pdf>

- A collection of tips, activities and handouts to actively engage students with multimedia.

### Science Multimedia Analysis

<http://www.kqed.org/quest/downloads/QUESTMediaAnalysis.pdf>

- Give your students the tools to recognize the purposes and messages of science multimedia.

### Create Online Science Hikes with Google Maps

[http://www.kqed.org/quest/files/download/52/QUEST\\_ExplorationCreation.pdf](http://www.kqed.org/quest/files/download/52/QUEST_ExplorationCreation.pdf)

- Do you like the science hike Explorations on the QUEST site? Use this place-based educational guide to create similar science-based maps with youth.

## OTHER WAYS TO PARTICIPATE IN QUEST



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89.3 FM Sacramento**



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**KQED Channel 9**

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