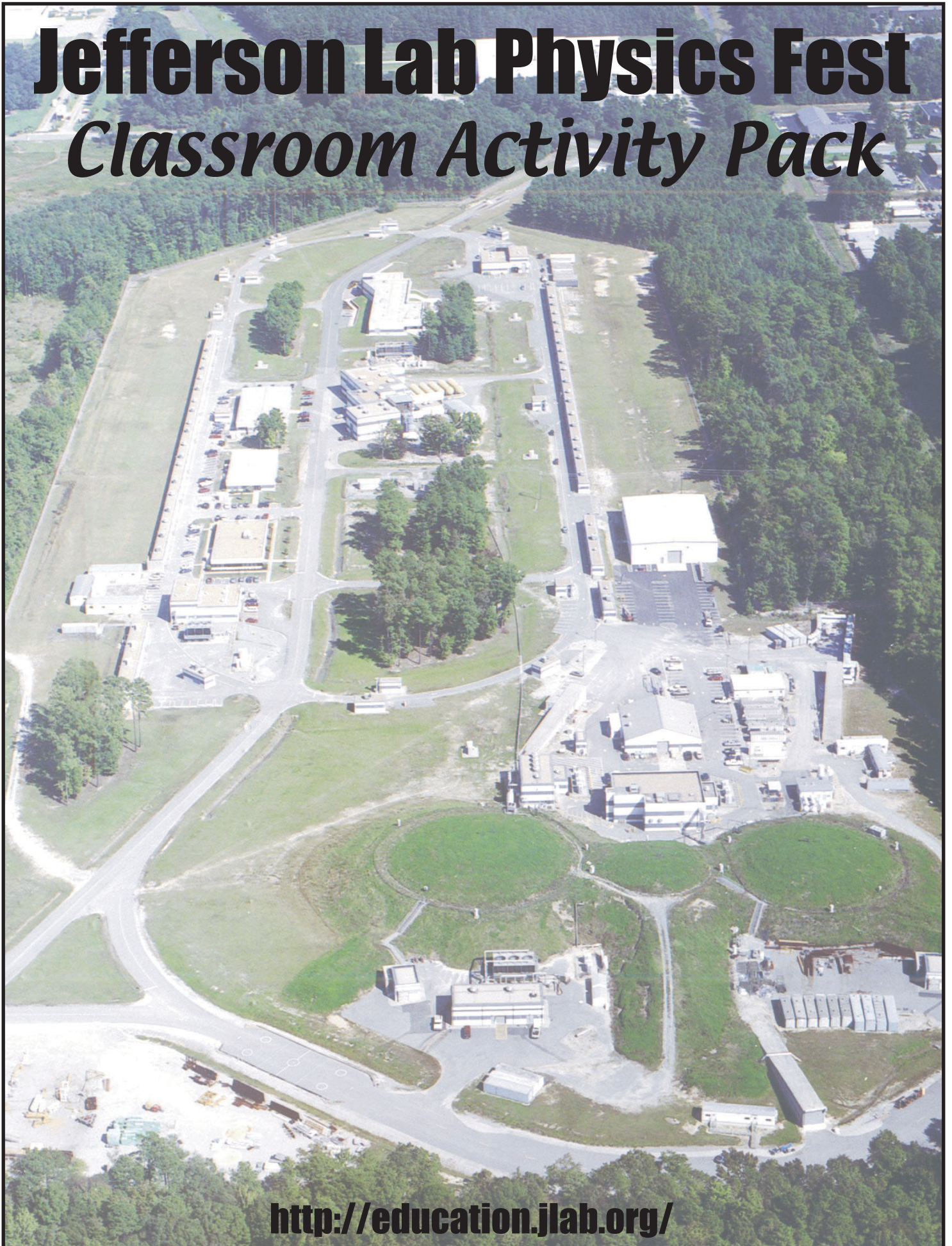


Jefferson Lab Physics Fest *Classroom Activity Pack*



<http://education.jlab.org/>

Introduction to Jefferson Lab

What is Jefferson Lab?

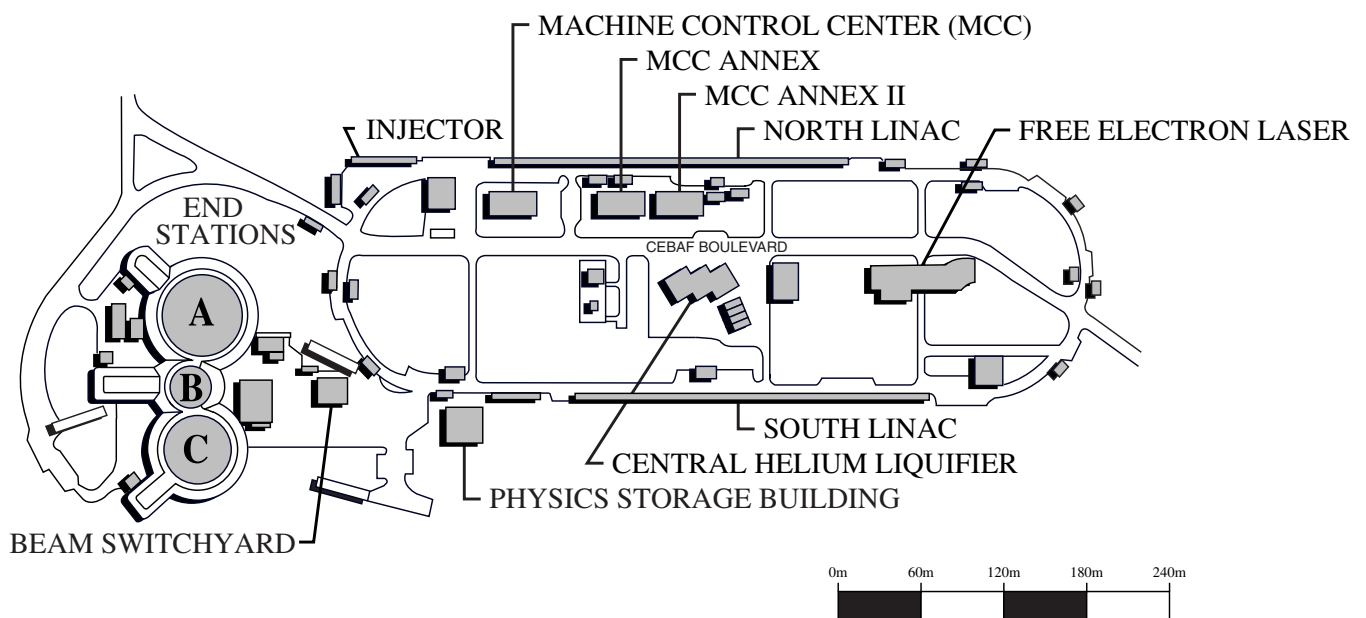
Jefferson Lab is a laboratory for basic research in nuclear physics. Nuclear physics is the science of studying the nucleus of the atom. Jefferson Lab also works with industry to develop technologies for businesses to use and with schools to motivate students and assist teachers.

Jefferson Lab's mission is to provide scientists around the world with opportunities to experiment with and learn more about nucleons.

Jefferson Lab's main instrument is a machine, called an accelerator, that is able to make electrons go really fast. The accelerator is in an underground, racetrack-shaped tunnel, 1.4 km around, that delivers a beam of electrons to experiments in three large experimental halls called end stations.

The facility is owned by the government's Department of Energy (DOE) and is managed by the Southeastern Universities Research Association (SURA). SURA is a group of 61 universities in fifteen southeastern states and the District of Columbia. SURA also manages other large research projects in the southeastern region of the United States.

About \$600 million was spent over ten years to build the facility in Newport News, Virginia. Scientists from around the world are currently using Jefferson Lab's accelerator for experiments to study the nucleus of the atom. These experiments can take months to run. Once scientists complete their work at the lab they must analyze the data they have gathered. What they find out may change what we know about the structure of nuclear matter, making Jefferson Lab a vital instrument of the scientific world.



Exploring Nuclei at Jefferson Lab

Over ninety years ago, scientists described the atom as a nucleus with orbiting electrons. Later, the nucleus was found to contain protons and neutrons (nucleons). Now each nucleon is seen as a collection of three quarks.

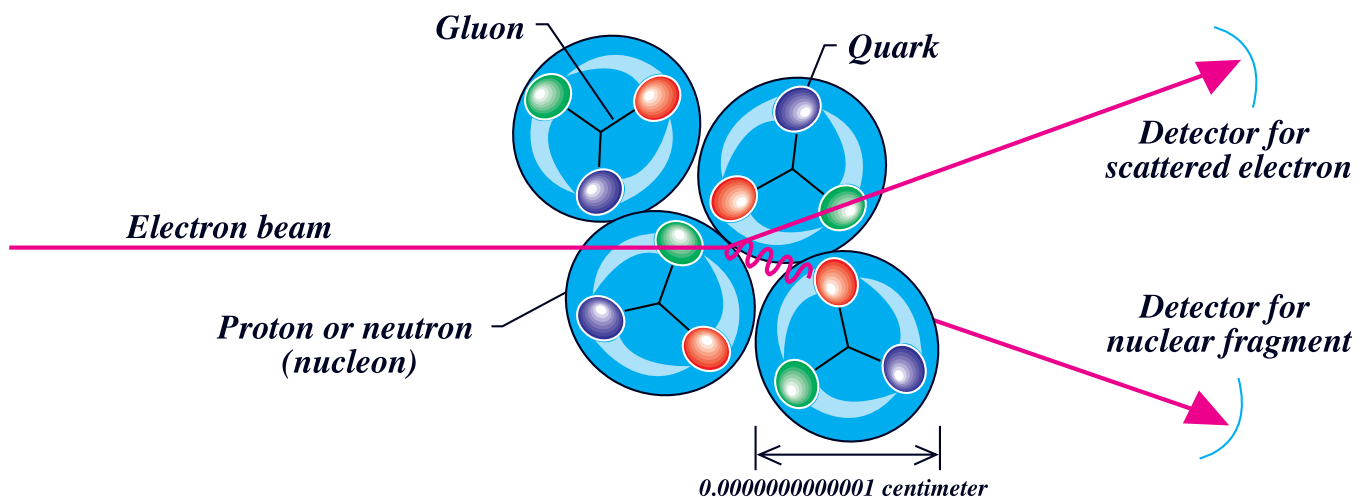
Scientists need Jefferson Lab to broaden their understanding of how quarks interact in the nucleus. Jefferson Lab provides scientists with beams of electron probes to explore the quark structure of the nucleus.

Point-like electrons can probe the nucleus with extreme accuracy. They interact cleanly with quarks in nuclear matter. The 'fingerprint' of each interaction - a deflected electron and one or more nuclear fragments - provides clues about the subnuclear world (see diagram below).

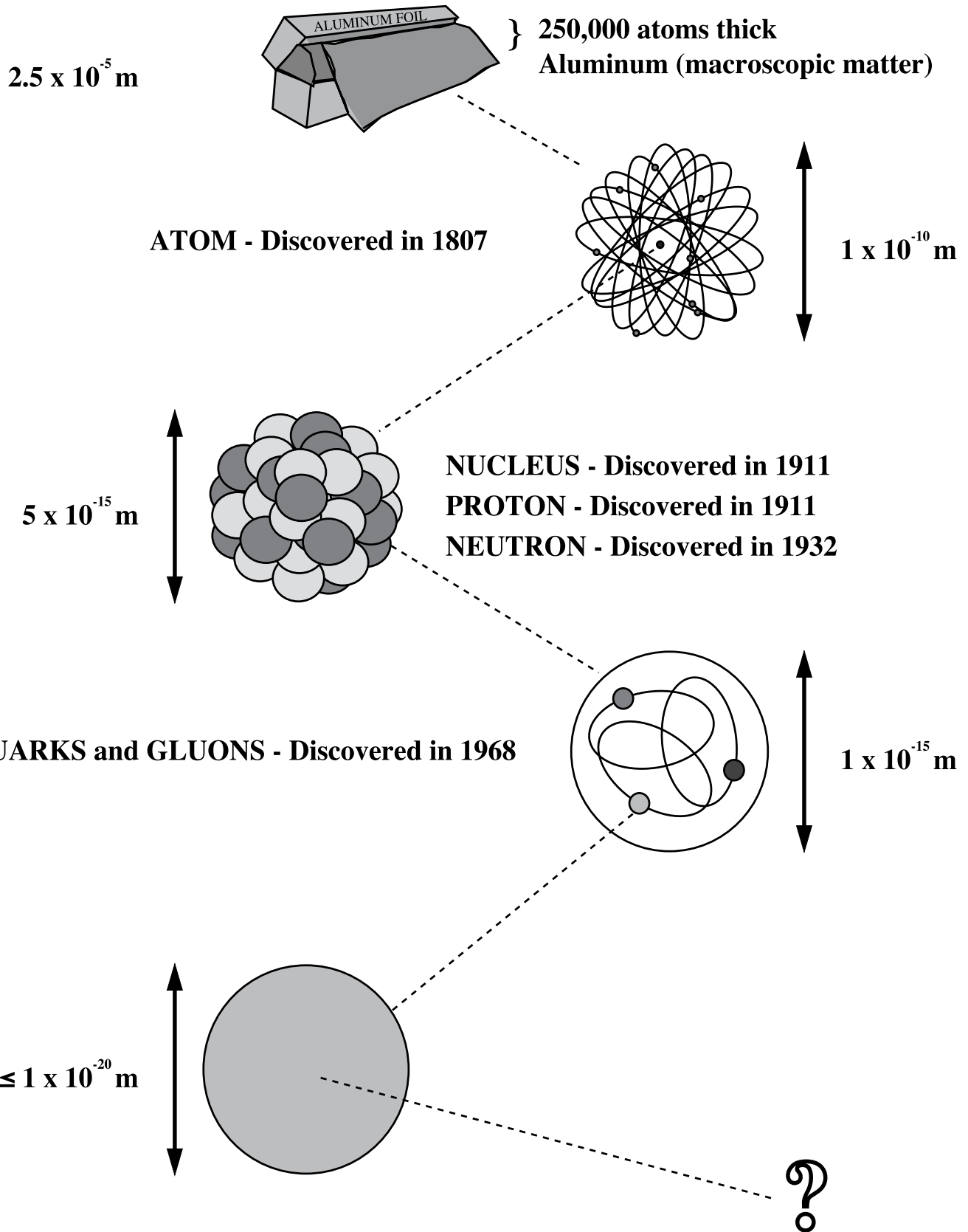
When the beam is directed through an experiment's target - typically a small, thin sheet of material whose nuclei are under study - unimaginably tiny electron-quark interactions result. The exact interactions are the 'fingerprints' of the experiment. These interactions are recorded automatically by spectrometers and detectors in the end stations. Collecting the thousands to millions of fingerprints required for each experiment may take weeks or even months. Later, aided by computers, nuclear physicists use this data to understand the mysteries of nuclear structure.

Studying the world of the very small requires equipment that is very large. Jefferson Lab's electron accelerator is 1.4 km around. The detectors used to 'watch' the experiments weigh thousands of tons each. Scientists use these huge machines to 'see' the quarks and gluons inside an atom's nucleus - particles that are less than 0.0000000000001 cm across!

The main goal of Jefferson Lab's scientific program is to understand the structure and behavior of the nucleus and its parts. Scientists use the electron accelerator to study how the nucleus and its pieces are put together and interact with each other. Jefferson Lab is like a powerful microscope used for studying the atom's nucleus.



How Scientists' Ideas About Matter Have Changed



What's next?

What is Matter?

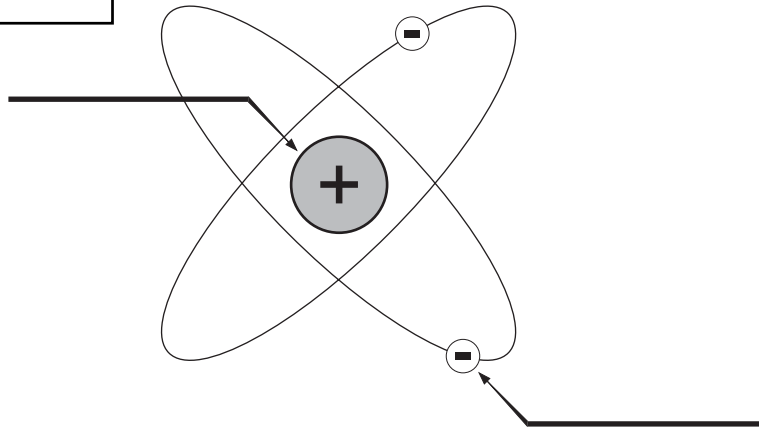
Matter is anything that has mass. All objects are made of matter. Air, water, a brick, even you are made of matter!

Matter is made up of smaller pieces.

Over ninety years ago, scientists thought that the atom was the smallest piece of matter. At that time, the atom was thought to be 'the building block of matter.'

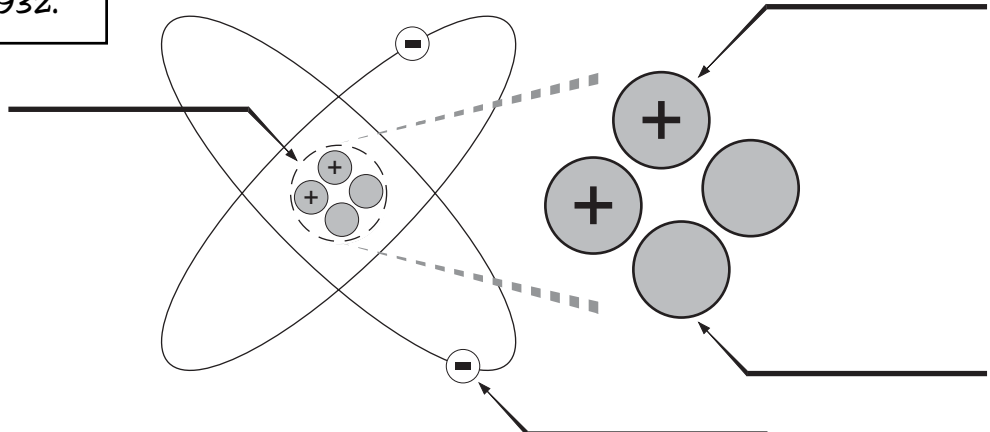
In 1911, a scientist named Ernest Rutherford discovered that atoms are really made of a positively charged center called the **nucleus** orbited by negatively charged particles called **electrons**.

Label the parts of the atom as it was known in 1911.



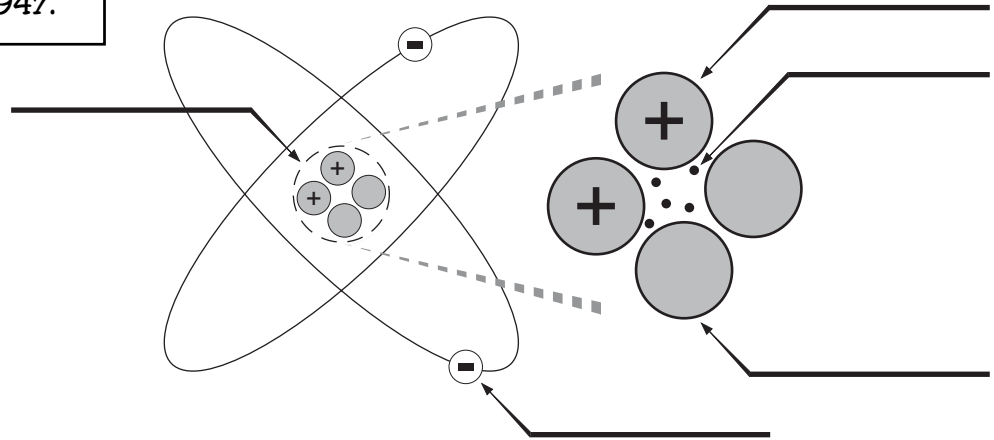
In 1932, scientists discovered that the nucleus of an atom is made of smaller particles called **protons** and **neutrons**. Protons carry a positive charge while neutrons have no charge at all. Protons and neutrons are each called nucleons since they are found in the nucleus. When they were discovered, scientists thought they were the smallest piece of matter.

Label the parts of the atom as it was known in 1932.



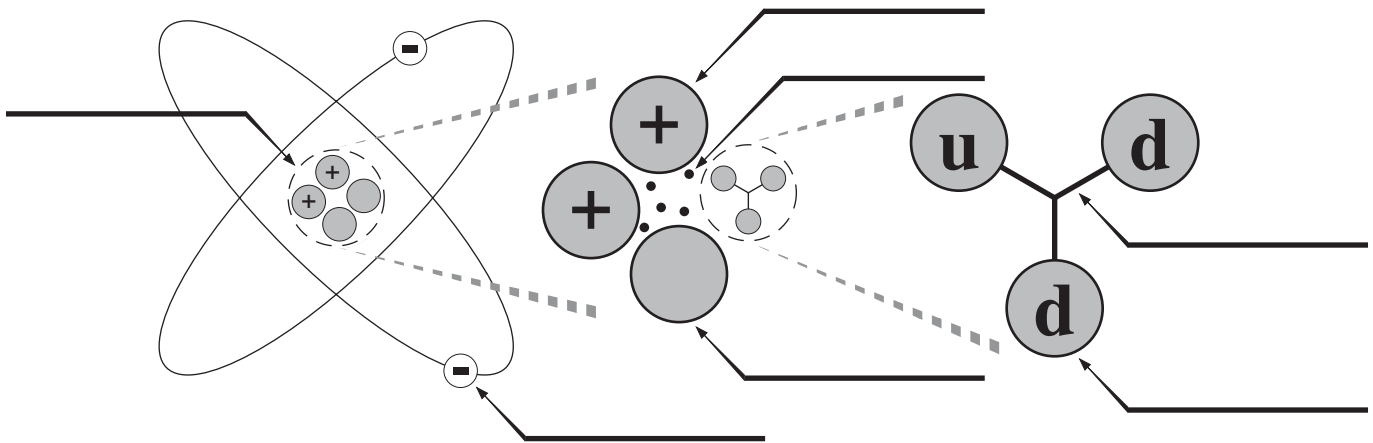
Scientists know that opposite charges attract and like charges repel, so they wondered why the protons in the nucleus didn't fly apart. They found the answer in 1947 when they discovered other particles that they named **mesons**. Mesons hold the protons and neutrons together to form the nucleus.

Label the parts of the atom as it was known in 1947.



As scientists did more experiments, they began to realize that there was something funny about protons and neutrons. In 1968 they discovered that protons and neutrons are made up of smaller particles they called **quarks**. Scientists discovered six different types of quarks: Up, Down, Strange, Charm, Top and Bottom. Protons have two Up quarks and one Down quark while neutrons have two Down quarks and one Up quark. Quarks are held to each other by particles scientists called **gluons**.

Label the parts of the atom as it was known in 1968.



Some scientists now think that the quark is the smallest piece of matter. Scientists used to think that atoms were the smallest bit of matter, but they discovered that it wasn't. Do you think that the quark is the smallest piece of matter or do you think that there might be something smaller inside the quark?

Career Opportunities at Jefferson Lab

You might be interested to know more about high-technology jobs with scientific organizations like Jefferson Lab.

These jobs can be very rewarding in job satisfaction, pay and benefits. In the years ahead, many more well trained people will be needed for technical and scientific jobs. These people will earn more dollars per hour than they would in minimum wage jobs or many nontechnical jobs.

Several hundred people work at Jefferson Lab. About 650 are Lab employees and many more are visiting scientists. People working at Jefferson Lab got their technical or scientific training, education and experience in many different ways. But they all have one thing in common; they all studied math and science in school.

Early in their careers, many found jobs that gave them valuable experience. They knew that a person's first job often isn't what one ends up doing later on. Some Lab employees started out doing simple jobs for little pay. They learned more and more about the things they worked with and gradually gained technical experience. Often they continued their education after work by going to college or by taking special classes.

Formal education is important for some jobs. A scientist, for instance, almost always earns both a four-year college degree and a doctorate, or Ph.D., degree. A Ph.D. can take several years to earn. You have to do research to find new knowledge that no one already knew.

Most other technical and scientific professionals have four-year degrees and many have master's degrees. A master's degree may take an additional year or two to earn.

Still other technical professionals and highly skilled workers have community college two-year associate degrees or other special training. Most such workers at Jefferson Lab also have a good deal of practical work experience. Even as early as high school, they may have studied computers, electronics, machine tools or other technical equipment. Many of them take more courses from time to time after they 'finish' school to improve or update their skills and knowledge. They know they must always be learning if they want to be successful.

In addition to scientific and technical education, training and experience, employees of organizations like Jefferson Lab need to be able to read and write effectively, communicate well and work cooperatively with others.

They also need to be able to adapt old knowledge and skills to new job demands. Many Jefferson Lab employees had to learn on the job. They were able to do so because they prepared themselves to be flexible and to take on new kinds of technical challenges. Often, these challenges make their work interesting and exciting.

Any large organization needs accountants, bookkeepers, maintenance workers, secretaries and others who help keep the organization going. There are many nonscientific jobs at Jefferson Lab. These workers need good math, reading, writing, speaking and teamwork skills and a general appreciation of science to succeed at Jefferson Lab.

Here are some examples of technical and scientific jobs at Jefferson Lab:

Drafters and Designers

Drafters and designers use computer equipment to make drawings of high-technology equipment and components. Some drafters learn their trade mainly through experience after they leave high school. But many, especially those who become designers, have a formal technical education from a two-year community college.

Engineers

Mechanical, electrical, electronic and civil (construction) engineers are important technical managers and decision makers in an organization that builds and operates complex equipment. Often, an engineer gets to build something no one has ever built. At a minimum, an engineer usually has an engineering degree from a four-year college or university.

Electricians

Much of the equipment at Jefferson Lab is electrical. Although engineers and physicists may be responsible for the equipment, trained electricians install, operate and maintain it. A typical electrician might have a two-year degree, lots of practical experience or both.

Physicists

Nuclear physicists study the atom's nucleus. An important job for them is preparing and operating the equipment used in accelerator experiments. Accelerator physicists design, build and operate the accelerator. Physicists have Ph.D. degrees.

Health Physicists and Safety and Environmental Specialists

Operating an accelerator requires good safety. Health physicists and safety and environmental specialists make sure that the people who operate the machine are protected from the dangers that can be involved if people are not careful. They also make sure the operation of Jefferson Lab does not harm the public and the environment. Formal education for these kinds of jobs can range through and beyond a four-year college degree.

Electronics and Mechanical Technicians

Skilled technicians build, operate and maintain equipment. Many are graduates of apprentice schools or special programs at community colleges. Often they have substantial college-level education.

Computer Systems Technicians and Programmers

The scientists use computers to do much of their work. Computer systems technicians make sure all the computer hardware runs smoothly and programmers help the scientists use computers. Most computer workers have college education through the four-year level and beyond.

Electrostatics

WHAT HAPPENS TO DIFFERENT OBJECTS WHEN THEY ARE ELECTRICALLY CHARGED?

1. In this experiment, a device called a Van de Graaff generator will be used to place extra electrons on different objects, giving them a negative charge. Use the **Electrostatics Data Chart** to predict the outcome of some of the experiments.
2. Watch what actually happens and record the outcome on the **Electrostatics Data Chart**.
3. Ask bunches of questions and have fun!

Electrostatics Data Chart

The Experiment: A container full of packing foam is placed on the Van de Graaff generator.

Your Hypothesis:

What happened?

Why did this happen?

The Experiment: A bunch of string is placed on the Van de Graaff generator.

Your Hypothesis:

What happened?

Why did this happen?

The Experiment: A person touches the Van de Graaff generator.

Your Hypothesis:

What happened?

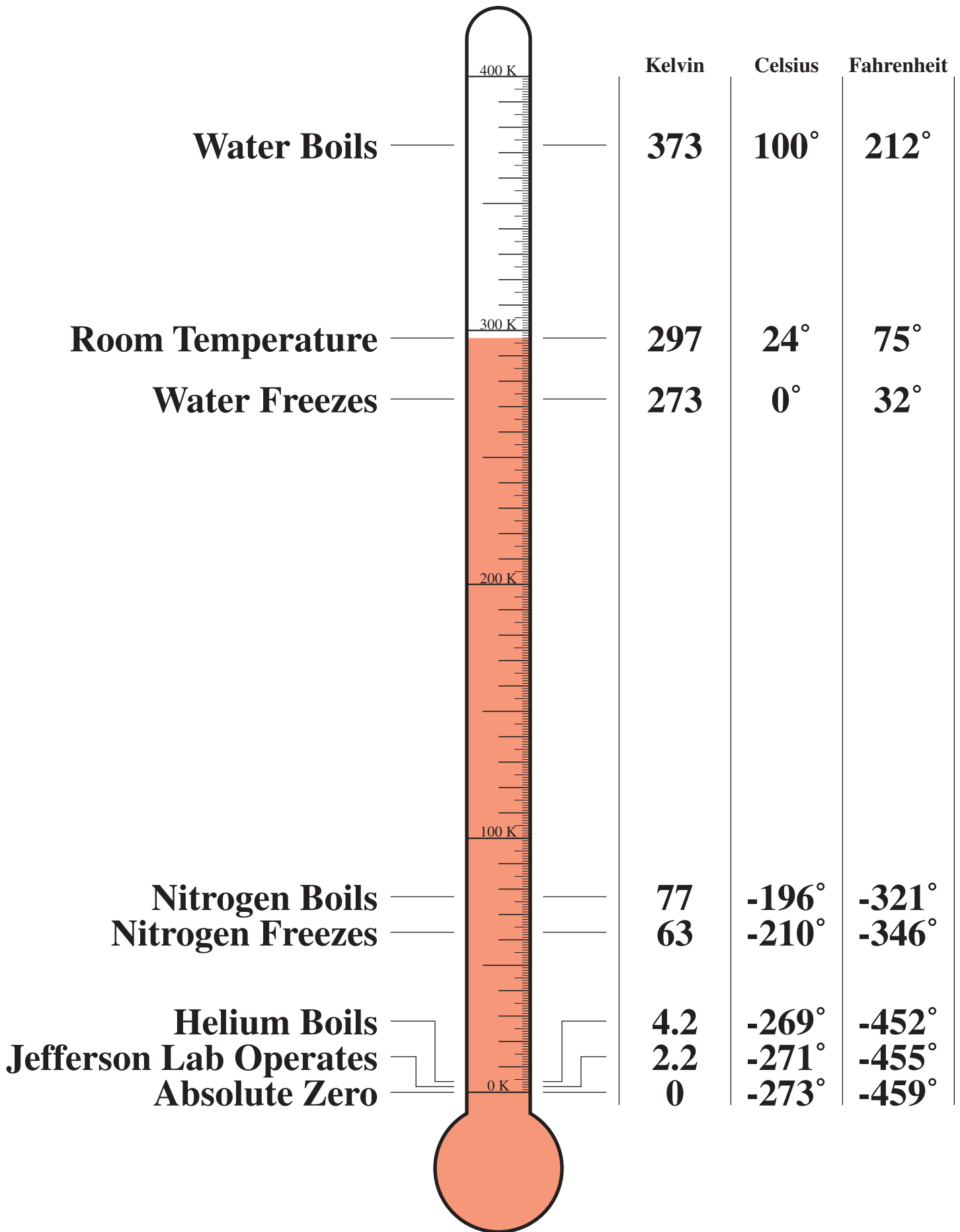
Why did this happen?

Hot and Cold

DO THINGS ACT DIFFERENTLY WHEN THEY GET REALLY HOT OR REALLY COLD?

1. In this experiment, some things will be made very hot and some things will be made very cold. Use the chart on the next page to predict the outcome of some of the experiments. When a scientist makes an educated guess about an experiment, it is called a **hypothesis**.
2. Watch what actually happens and record the outcome in the chart.
3. Ask bunches of questions and have fun!

Experiment	What's your hypothesis?	What happened?	Why did it do this?
A balloon is filled with air and then made very cold. What will it do?			
A ping-pong ball is made very cold and then bounced. How will it bounce?			
A super ball is made very cold and then bounced. How will it bounce?			
A racquetball is made very cold and then bounced. How will it bounce?			
A burning match is slowly lowered into the vapor of a very cold substance. What will happen?			
A tube of Helium gas is heated to 3000° Centigrade (~5000° Fahrenheit). What will it look like?			



Vocabulary List

Accelerate - to speed up

Accelerator - a machine which accelerates charged particles to high energies

Antimatter - matter that is exactly the opposite in every way from its matter counterpart: antiquark/quark; positron/electron

Atom - the smallest unit of a chemical element, made up of a nucleus surrounded by electrons

Atomic Number - the number of protons in the nucleus of an atom

Atomic Weight - the average mass of an atom of an element measured relative to the mass of an atom of carbon-12

Beam - a ray of light; a group of particles traveling together along a well-defined path

BEAMS - the acronym for Becoming Enthusiastic About Math and Science

Boiling Point - the temperature at which a substance changes from a liquid to a gas

CEBAF - former name of Jefferson Lab; stands for Continuous Electron Beam Accelerator Facility

Celsius - a temperature scale on which water freezes at 0° and boils at 100°

Charge - the amount of electricity carried by a body (A charge can be negative, like an electron, or positive, like a proton. Objects with opposite charges attract one another, while objects with like charges repel one another.)

Chemical Change - a change in the chemical composition of a substance to produce a new material with new properties (An example of a chemical change is wood turning to ash and smoke when it burns.)

Chemical Property - a characteristic of a substance that determines how it will react with other substances

Chemical Reaction - a chemical change in which one or more substances are changed into one or more new substances

Circuit - a closed path through which an electric current flows

Colloidal Suspension - a material that has properties of more than one state of matter, such as Jell-o

Compound - a substance composed of two or more elements, such as water (H₂O), carbon dioxide (CO₂), or table sugar (C₁₂H₂₂O₁₁)

Computer - a programmable machine that inputs, processes and outputs data

Coordinate - a set of numbers that determines the location of a point in space

Condensation - the process by which a gas changes to a liquid

Conduction - the transportation of heat or electricity from one place to another directly through an object (A frying pan is warmed by a hot stove due to conduction.)

Conductor - a material (like a metal) through which electricity and heat flow easily

Continuous - steady; uninterrupted

Convection - the transportation of heat from one place to another by the movement of a liquid or gas (A classroom is warmed by a hot air blower due to convection.)

Cryogenics - the science of very low temperatures, far below the freezing point of water

Data - a group of measurements, facts or statistics

Density - the amount of mass per unit volume (An object's density is calculated by dividing the object's mass by the object's volume. For example, a 10 gram object that occupies 2 cubic centimeters of space has a density of 5 g/cm³.)

Dependent Variable - the responding variable; the variable that may change as a result of a change in the independent variable

Dew Point - the temperature at which a gas condenses to form a liquid

Electric Current - movement of electricity, measured in charges per second (just as river current is measured in liters per second)

Electromagnet - a wire coil around a metal core (usually iron) that acts like a magnet when an electric current flows through it

Electron - a tiny particle with a negative charge which orbits an atom's nucleus

Element - any substance that cannot be broken up into simpler substances by chemical means (Currently 115 elements have been observed and are displayed on the Periodic Table of Elements. Gold, silver, iodine, oxygen and nickel are examples of elements.)

Energy - the capacity to do work

Engineer - a person who uses science and math to design, build or operate equipment, structures and systems (A person who receives a college degree in engineering might be an electrical, mechanical, industrial, chemical, environmental, biochemical or aeronautical engineer.)

Evaporation - the process by which a liquid changes to a gas

Experiment - a series of actions carried out to test a theory, demonstrate a fact or find out what happens

FEL - stands for Free Electron Laser; a tunable laser made by wiggling a beam of electrons (Jefferson Lab's FEL is the most powerful in the world.)

Fahrenheit - a temperature scale at which water freezes at 32° and boils at 212°

Force - a push or pull (There are four basic forces: gravitational, electromagnetic, strong nuclear and weak nuclear.)

Freezing Point - the temperature at which a substance changes from a liquid to a solid

Gas - a state of matter with no definite shape or volume, like air

Gluons - particles that hold quarks together

Graph - information represented in the form of a picture, diagram or drawing

Grid - a pattern of horizontal and vertical lines forming squares of uniform size on a map or chart

Heat - energy in the form of the random motion of an object's molecules

Helium - a colorless, odorless, tasteless gas (Helium becomes a liquid near absolute zero. Liquid helium is used to cool Jefferson Lab's accelerator components.)

HTML - an acronym for HyperText Markup Language; the programming language or code used for the creation of internet web pages

Hypothesis - an educated guess that can be tested or investigated

Independent Variable - the manipulated variable; the variable that is changed on purpose in an experiment

Injector - the first section of an accelerator, where electrons are torn away from atoms and accelerated to an energy sufficient for them to be injected into the cavities of the accelerator

Insulator - a material through which electricity or heat does not flow easily (like many plastics, glasses and ceramics)

Interact - act with each other

Internet - a worldwide network of computers linked together for the purpose of exchanging information (also sometimes called the Information Superhighway or Cyberspace)

Ion - an atom or molecule that has an electric charge because it has either gained or lost electrons

Jefferson Lab - a nuclear physics research facility built to explore quarks in the nucleus of the atom, located in Newport News, Virginia

Kelvin - a temperature scale that begins at absolute zero, where there is no molecular movement (Water freezes at 273 K and boils at 373 K.)

Laboratory - a place equipped for scientific research, experiments or testing

Lepton - one of the two basic building blocks of matter (An electron is a lepton.)

LINAC - an abbreviation for Linear Accelerator

Linear Accelerator - a machine used in physics experiments that makes particles go faster in a straight line

Liquid - a state of matter with definite volume but no definite shape, like water

Magnet - a piece of iron or other material that attracts other pieces of iron or steel

Magnification - the process of making something look bigger

Mass - the measure of the amount of matter an object has in it; measured in grams or kilograms

Mass Number - the total number of protons and neutrons in an atom's nucleus

Matter - something that has mass which can exist in the form of a solid, liquid, gas or plasma

Mean - the sum of the items in a set of data divided by the number of items in the set; the average (The mean of {1,1,1,2,4,6,6} is 3 since $(1 + 1 + 1 + 2 + 4 + 6 + 6) \div 7 = 3$.)

Median - the middle number in a set of ordered data (The median of {1,1,1,2,4,6,6} is 2 since 2 is the middle number when all of the numbers are placed in order. If there are an even number of numbers, the median is the mean of the two middle numbers.)

Melting Point - the temperature at which a substance changes from a solid to a liquid

Meson - particle made of a quark and an antiquark that is thought to bind protons and neutrons together inside the nucleus of an atom

Microscope - an optical instrument that uses a combination of lenses to produce magnified images of very small objects

Mixture - a substance composed of two or more components, each of which retain its own properties (A salad is a mixture of vegetables.)

Mode - the data item that occurs the most often in a set of data (The mode of {1,1,1,2,4,6,6} is 1 since 1 is the number that appears most often.)

Molecule - two or more elements that are chemically joined (Water is a molecule made from two atoms of Hydrogen and one atom of Oxygen.)

Negative - having a minus charge (Negative charges are attracted to positive charges and are repelled by other negative charges.)

Neutral - having no charge

Neutron - a neutral particle made of three quarks found in the nucleus of an atom

Nitrogen - a colorless, odorless, tasteless gas which makes up 78% of the air (Nitrogen is a gas at room temperature and becomes a liquid at about 77 K, -196°C or -321°F.)

Nuclear Physics - the science of studying the nucleus of the atom

Nucleon - a proton or a neutron

Nucleus - the central part of an atom, which makes up 99.9% of the atom's mass

Observation - the use of one's senses to learn something new

Orbit - the path an object follows as it travels around another object

Particle - a very small piece or part; an indivisible object

Physical Change - a change that affects the size, shape or color of a substance but does not affect its composition

Physical Property - a characteristic of a substance that can be observed with the senses, such as size, weight, color or odor, without altering the substance's molecular make-up

Physics - the study of matter, energy and force

Plasma - a very hot, gas-like state of matter

Pole - the place on a magnet where the magnetic field is strongest

Positive - having a plus charge (Positive charges are attracted to negative charges and are repelled by other positive charges.)

Probe - an object or device used to investigate the unknown

Property - any characteristic or attribute of an object or substance

Proton - a positively charged particle found in the nucleus of an atom

Prototype - an original type that serves as a model for later examples

Quadrant - one quarter of the coordinate plane (The x- and y-axes divide the coordinate plane into four quadrants.)

Qualitative - observations that do not involve measurements and numbers ("My brother is shorter than my sister," is a qualitative observation.)

Quantitative - observations that involve measurements and numbers ("My brother is 30cm shorter than my sister," is a quantitative observation.)

Quark - one of the two basic building blocks of matter (Scientists have discovered six different kinds of quarks: Top, Bottom, Up, Down, Strange and Charm.)

Radiation - the transportation of heat from one place to another by waves or particles (The Earth is warmed by the Sun due to radiation.)

Resistance - a measurement of how much a material opposes the flow of electricity (Wood has high resistance so it is a poor conductor of electricity. Copper has low resistance, so it is a good conductor of electricity.)

Scatter - to go in many directions

Science - the study of the natural world

Scientific Method - the 'tool' that scientists use to find the answer to questions (The Scientific Method allows scientists to solve complicated problems by taking a series of smaller steps:

- **identify the problem** - a scientific problem to be solved
- **research** - the process of collecting information and data about a topic being studied
- **hypothesis** - an idea about the solution to a problem, based on knowledge and research
- **experimentation** - the process of testing a hypothesis by collecting data under controlled, repeatable conditions
- **data analysis** - organizing and examining the collected data using narratives, charts, graphs or tables
- **conclusion** - a summary of the results of the experimentation and a statement of how the results relate to the hypothesis

Scientist - a person who uses observation, experimentation and theory to learn about a subject (Biologists, physicists, chemists, geologists and astronomers are all scientists.)

Solid - a state of matter with definite shape and volume, like ice

Speed - a measurement of distance traveled over time (example: 100 kilometers per hour)

Spreadsheet - a computer program used for organizing and analyzing data (Spreadsheets are arranged in **rows** and **columns**. A **cell** is a box in a spreadsheet where a row and column meet. The names of the row and column determine the name of the cell. For example, in the spreadsheet shown below, column C and row 2 meet at cell C2, the shaded box. The value in C2 is 1.23.)

	A	B	C	D	E
1	0.71	0.70	0.52	1.12	4.01
2	0.02	4.45	1.23	0.74	3.11
3	9.58	1.87	6.19	3.13	0.93

Static Electricity - a collection of unbalanced charges on an object

Superconductivity - the flow of electric current without any resistance in certain metals at temperatures near absolute zero (The superconductors used at Jefferson Lab are cavities made of niobium that are cooled to 2 K by liquid Helium.)

SURA - the acronym for Southeastern Universities Research Association (Jefferson Lab is managed by SURA.)

Teamwork - joint action by a group to complete a given task

Technician - a person who is an expert in doing certain technical jobs

Temperature - a measure of heat energy in an object, body or environment (Temperature can be measured using Fahrenheit, Celsius or Kelvin scales.)

Theory - a general principle that explains or predicts facts or events

Theory - a general principle that explains or predicts facts or events

Variable - something that does not remain constant (In an experiment, a variable is something that can change. Usually, an experimenter will change only one variable in an experiment while keeping everything else the same.)

Voltage - electrical force or pressure (measured in volts)

Volume - the amount of space an object occupies (The volume of a rectangular box can be found by multiplying the box's length, width and height together. For example, a box that is 8 cm long, 3 cm wide and 2 cm high has a volume of 48 cm³. Other formulas exist for calculating the volumes of objects with other shapes.)

Weight - a measure of the gravitational force pulling objects to the earth, moon or other celestial body (The more mass a planet has, the greater the gravitational pull of that planet will be. An object weighs more on the earth than it does on the moon because the earth has more mass than the moon.)

Directions: Fill in each space with a different term from the vocabulary list. As definitions or examples are given, cover each term until you have five in a row diagonally, horizontally or vertically. The first person to call out "BEAMS!" and have five matching terms wins!

B					
E					
A			FREE SPACE		
M					
S					

B					
E					
A			FREE SPACE		
M					
S					

Directions: Fill in each space with a different element from the list. When an element's chemical symbol is called out, cover that element until you have five in a row diagonally, horizontally or vertically. The first person to call out "BEAMS!" and have five matching elements wins!

B					
E					
A					
M			FREE SPACE		
S					

**Choose 24 different elements
from the following list:**

- | | |
|-----------|------------|
| ALUMINUM | NIObIUM |
| ANTIMONY | NITROGEN |
| ARGON | OXYGEN |
| BERYLLIUM | PALLADIUM |
| BORON | PHOSPHORUS |
| CALCIUM | PLATINUM |
| CARBON | PLUTONIUM |
| CHLORINE | POTASSIUM |
| COPPER | RADIUM |
| GOLD | RADON |
| HELIUM | SILICON |
| HYDROGEN | SILVER |
| IODINE | SODIUM |
| IRON | SULFUR |
| KRYPTON | TIN |
| LEAD | TITANIUM |
| LITHIUM | TUNGSTEN |
| MERCURY | URANIUM |
| NEON | ZINC |
| NICKEL | ZIRCONIUM |

Directions: Fill in each space with a different chemical symbol from the list. When an element's name is called out, cover that chemical symbol until you have five in a row diagonally, horizontally or vertically. The first person to call out "BEAMS!" and have five matching chemical symbols wins!

B				
E				
A				
M			FREE SPACE	
S				

Choose 24 different chemical symbols from the following list:

Ag Nb
 Al Ne
 Ar Ni
 Au O
 B P
 Be Pb
 C Pd
 Ca Pt
 Cl Pu
 Cu Ra
 Fe Rn
 H S
 He Sb
 Hg Si
 I Sn
 K Ti
 Kr U
 Li W
 N Zn
 Na Zr

Directions: Fill in each space with a different math term from the list. As definitions or examples are given, cover each term until you have five in a row diagonally, horizontally or vertically. The first person to call out “BEAMS!” and have five matching terms wins!

B					
E					
A					
M			FREE		
S			SPACE		

Choose 24 different terms from the following list:

- | | |
|----------------------------------|---------------------|
| ANGLE | NUMERATOR |
| AREA | ORDERED PAIR |
| ASSOCIATIVE PROPERTY OF ADDITION | ORIGIN |
| BINOMIAL | PARALLEL LINES |
| CIRCLE | PERCENT |
| COMMUTATIVE PROPERTY OF ADDITION | PERIMETER |
| COMPOSITE NUMBER | PERPENDICULAR LINES |
| DENOMINATOR | PLANE |
| DIAMETER | POINT |
| DISTRIBUTIVE PROPERTY | POLYNOMIAL |
| FACTOR | PRIME NUMBER |
| HYPOTENUSE | PROBABILITY |
| IDENTITY PROPERTY OF ADDITION | PRODUCT |
| INTEGERS | PYTHAGOREAN THEOREM |
| IRRATIONAL NUMBER | QUADRANT |
| LEAST COMMON MULTIPLE (LCM) | QUOTIENT |
| LINE | RADIUS |
| MEAN | RATIO |
| MEDIAN | RATIONAL NUMBER |
| MIDPOINT | RECIPROCAL |
| MIXED NUMBER | SEGMENT |
| MODE | SQUARE ROOT |
| MULTIPLE | VERTICAL ANGLES |
| | VOLUME |
| | WHOLE NUMBER |
| | X-AXIS |
| | Y-AXIS |

Scrambled Science Words

Directions: Use the **Vocabulary List** to help you unscramble the words below.

1. LSODI _____
2. AMOT _____
3. CEISNEC _____
4. MABE _____
5. RAKUQ _____
6. LECEORTN _____
7. ORTOPN _____
8. PCEUORTM _____
9. IUDLQI _____
10. NCESULU _____
11. MENELTE _____
12. UOENRNT _____
13. GTNAME _____
14. EEXMPTNEIR _____
15. TRTAEM _____

BEAMS Crossword Puzzle

Directions: Complete the puzzle using terms from the vocabulary list.

ACROSS

2. Anything that has mass
4. Holds quarks together
6. What the B in CEBAF stands for
7. Positively charged particle found in the nucleus of an atom
8. Orbit the nucleus
12. Made of protons and neutrons
13. Uncharged particle found in the nucleus of an atom
15. A material through which electricity and heat cannot move easily
18. The study of the nucleus is called nuclear _____.
21. A wire coil that acts like a magnet when electric current flows through it
22. Electrons have a _____ charge.
23. The laboratory in Newport News used to study the nucleus

DOWN

1. A material through which electricity and heat can move easily
3. Made up of a nucleus with electrons orbiting around the nucleus
5. Piece of iron, steel or other material that attracts other pieces of iron or steel
9. Family of particles that electrons belong to
10. How far an object goes in an amount of time is a measurement of the object's _____
11. Holds together protons and neutrons in the nucleus
14. Excited about, or what the E in BEAMS stands for
16. To change in velocity or energy
17. Basic building block of matter which cannot be detected in isolation
19. Uninterrupted or steady
20. Having no charge

East Arc

North Linear Accelerator

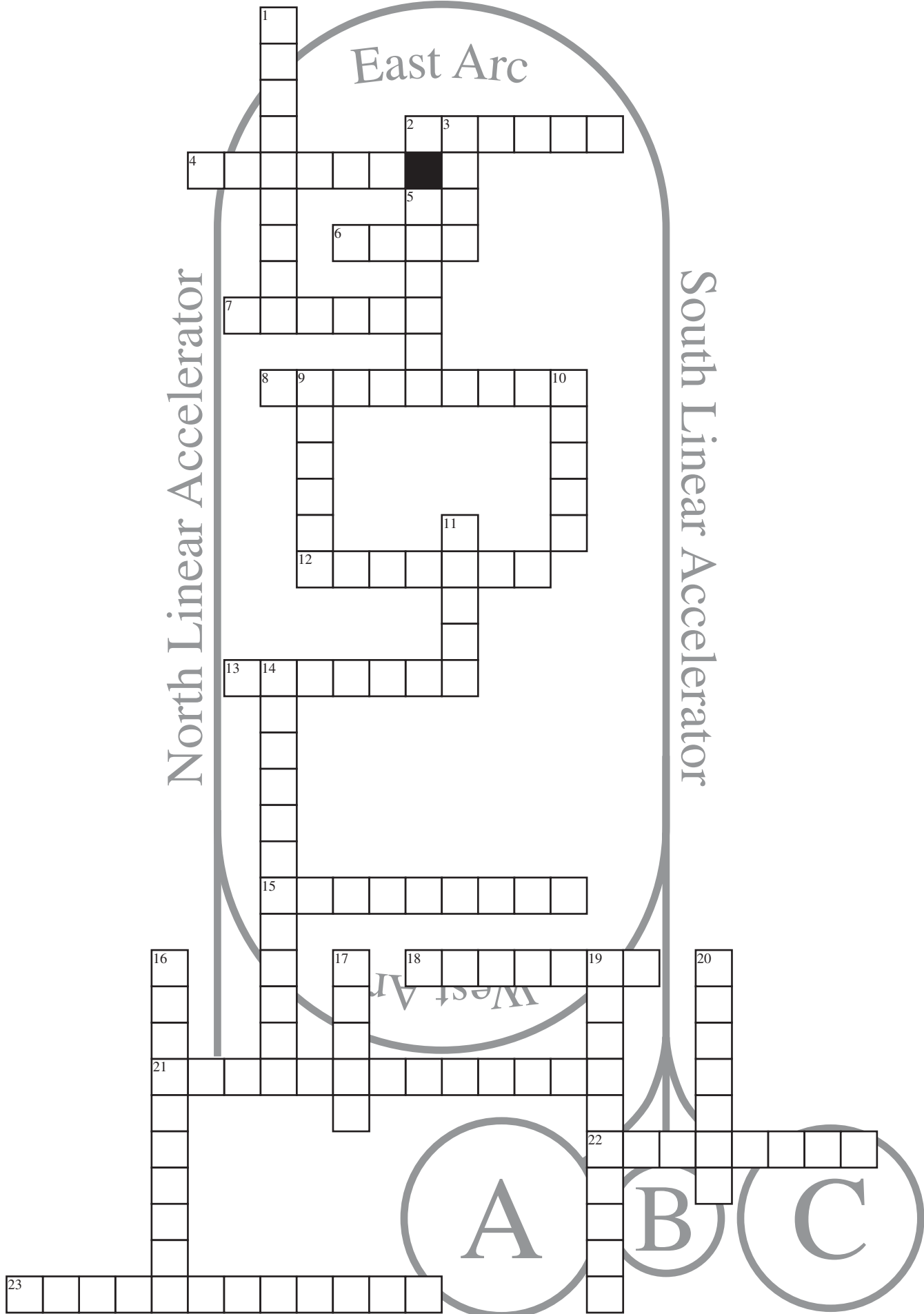
South Linear Accelerator

West Arc

A

B

C



1
2
3
4
5

6

7

8
9
10

11
12

13
14

15

16
17
18
19
20

21
22

23

BEAMS Cryptograph

Directions: Use the code below to find the secret words.

A	B	C	D	E	F	G	H	I	J	K	L	M
1	2	3	4	5	6	7	8	9	10	11	12	13

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
14	15	16	17	18	19	20	21	22	23	24	25	26

1. $\frac{\quad}{5}$ $\frac{\quad}{12}$ $\frac{\quad}{5}$ $\frac{\quad}{3}$ $\frac{\quad}{20}$ $\frac{\quad}{18}$ $\frac{\quad}{9}$ $\frac{\quad}{3}$ $\frac{\quad}{3}$ $\frac{\quad}{21}$ $\frac{\quad}{18}$ $\frac{\quad}{18}$ $\frac{\quad}{5}$ $\frac{\quad}{14}$ $\frac{\quad}{20}$

2. $\frac{\quad}{3}$ $\frac{\quad}{5}$ $\frac{\quad}{12}$ $\frac{\quad}{19}$ $\frac{\quad}{9}$ $\frac{\quad}{21}$ $\frac{\quad}{19}$

3. $\frac{\quad}{9}$ $\frac{\quad}{15}$ $\frac{\quad}{14}$

4. $\frac{\quad}{2}$ $\frac{\quad}{5}$ $\frac{\quad}{1}$ $\frac{\quad}{13}$ $\frac{\quad}{19}$

5. $\frac{\quad}{11}$ $\frac{\quad}{5}$ $\frac{\quad}{12}$ $\frac{\quad}{22}$ $\frac{\quad}{9}$ $\frac{\quad}{14}$

6. $\frac{\quad}{22}$ $\frac{\quad}{15}$ $\frac{\quad}{12}$ $\frac{\quad}{20}$ $\frac{\quad}{1}$ $\frac{\quad}{7}$ $\frac{\quad}{5}$

7. $\frac{\quad}{13}$ $\frac{\quad}{1}$ $\frac{\quad}{19}$ $\frac{\quad}{19}$

8. $\frac{\quad}{3}$ $\frac{\quad}{8}$ $\frac{\quad}{5}$ $\frac{\quad}{13}$ $\frac{\quad}{9}$ $\frac{\quad}{3}$ $\frac{\quad}{1}$ $\frac{\quad}{12}$

9. $\frac{\quad}{7}$ $\frac{\quad}{12}$ $\frac{\quad}{21}$ $\frac{\quad}{15}$ $\frac{\quad}{14}$

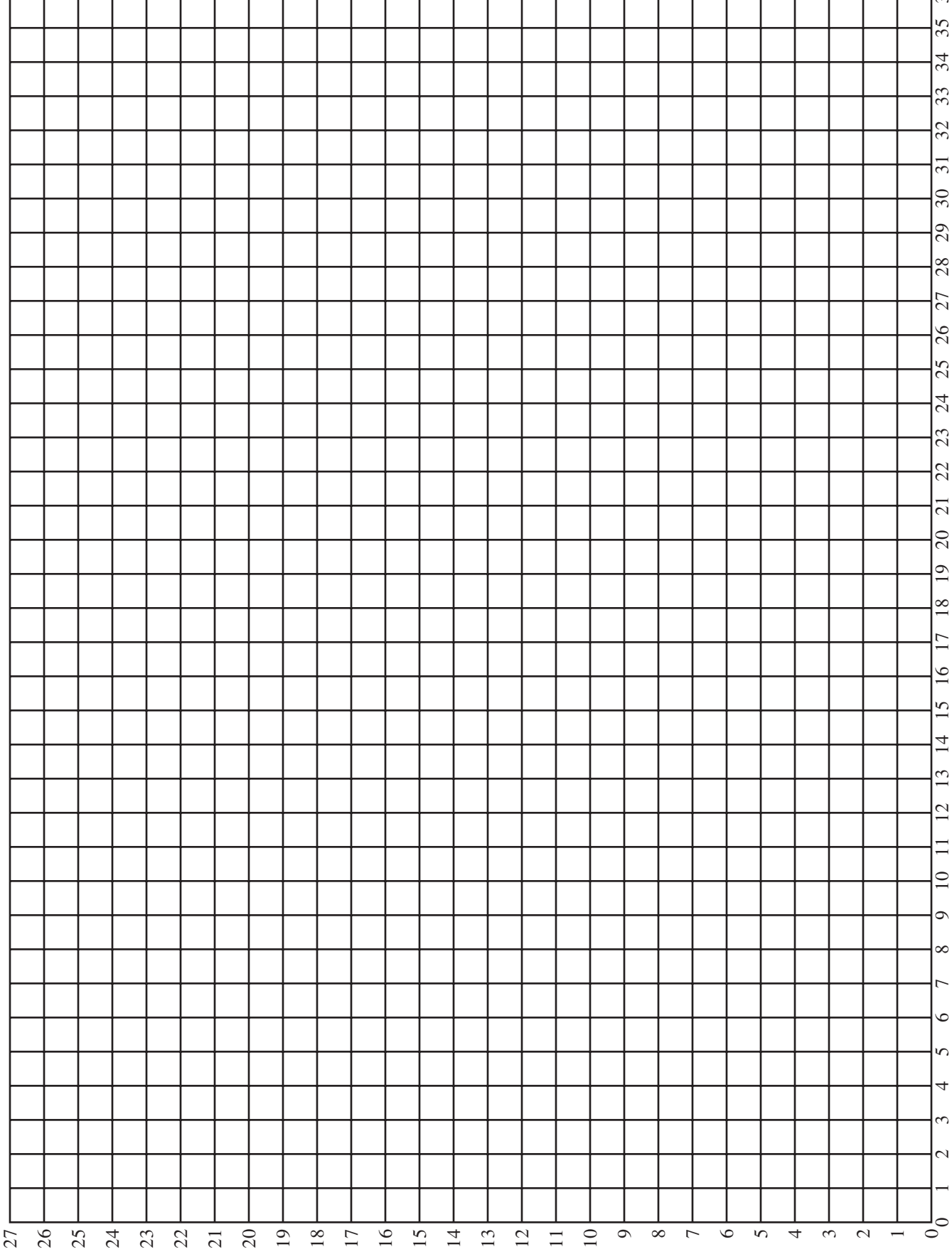
10. $\frac{\quad}{16}$ $\frac{\quad}{18}$ $\frac{\quad}{15}$ $\frac{\quad}{16}$ $\frac{\quad}{5}$ $\frac{\quad}{18}$ $\frac{\quad}{20}$ $\frac{\quad}{25}$

11. $\frac{\quad}{14}$ $\frac{\quad}{21}$ $\frac{\quad}{3}$ $\frac{\quad}{12}$ $\frac{\quad}{5}$ $\frac{\quad}{1}$ $\frac{\quad}{18}$ $\frac{\quad}{16}$ $\frac{\quad}{8}$ $\frac{\quad}{25}$ $\frac{\quad}{19}$ $\frac{\quad}{9}$ $\frac{\quad}{3}$ $\frac{\quad}{19}$
12. $\frac{\quad}{14}$ $\frac{\quad}{21}$ $\frac{\quad}{3}$ $\frac{\quad}{12}$ $\frac{\quad}{5}$ $\frac{\quad}{15}$ $\frac{\quad}{14}$
13. $\frac{\quad}{14}$ $\frac{\quad}{5}$ $\frac{\quad}{7}$ $\frac{\quad}{1}$ $\frac{\quad}{20}$ $\frac{\quad}{9}$ $\frac{\quad}{22}$ $\frac{\quad}{5}$
14. $\frac{\quad}{7}$ $\frac{\quad}{18}$ $\frac{\quad}{1}$ $\frac{\quad}{16}$ $\frac{\quad}{8}$
15. $\frac{\quad}{20}$ $\frac{\quad}{8}$ $\frac{\quad}{5}$ $\frac{\quad}{15}$ $\frac{\quad}{18}$ $\frac{\quad}{25}$
16. $\frac{\quad}{16}$ $\frac{\quad}{8}$ $\frac{\quad}{25}$ $\frac{\quad}{19}$ $\frac{\quad}{9}$ $\frac{\quad}{3}$ $\frac{\quad}{1}$ $\frac{\quad}{12}$ $\frac{\quad}{3}$ $\frac{\quad}{8}$ $\frac{\quad}{1}$ $\frac{\quad}{14}$ $\frac{\quad}{7}$ $\frac{\quad}{5}$
17. $\frac{\quad}{19}$ $\frac{\quad}{16}$ $\frac{\quad}{5}$ $\frac{\quad}{5}$ $\frac{\quad}{4}$
18. $\frac{\quad}{18}$ $\frac{\quad}{5}$ $\frac{\quad}{19}$ $\frac{\quad}{9}$ $\frac{\quad}{19}$ $\frac{\quad}{20}$ $\frac{\quad}{1}$ $\frac{\quad}{14}$ $\frac{\quad}{3}$ $\frac{\quad}{5}$
19. $\frac{\quad}{22}$ $\frac{\quad}{5}$ $\frac{\quad}{12}$ $\frac{\quad}{15}$ $\frac{\quad}{3}$ $\frac{\quad}{9}$ $\frac{\quad}{20}$ $\frac{\quad}{25}$
20. $\frac{\quad}{19}$ $\frac{\quad}{21}$ $\frac{\quad}{16}$ $\frac{\quad}{5}$ $\frac{\quad}{18}$ $\frac{\quad}{3}$ $\frac{\quad}{15}$ $\frac{\quad}{14}$ $\frac{\quad}{4}$ $\frac{\quad}{21}$ $\frac{\quad}{3}$ $\frac{\quad}{20}$ $\frac{\quad}{9}$ $\frac{\quad}{22}$ $\frac{\quad}{9}$ $\frac{\quad}{20}$ $\frac{\quad}{25}$

Mystery Picture

Directions: Plot the coordinates to find the mystery picture.

(4,20)	(1,1)	(20,20)	(26,24)	(10,23)	(2,11)	(22,21)
(13,19)	(12,16)	(22,24)	(30,25)	(16,22)	(22,5)	(1,10)
(4,21)	(32,14)	(20,21)	(12,5)	(7,19)	(1,8)	(22,23)
(14,25)	(8,24)	(17,25)	(5,2)	(12,19)	(4,7)	(2,0)
(11,6)	(34,10)	(19,25)	(26,22)	(10,21)	(9,13)	(2,3)
(5,19)	(2,7)	(3,7)	(29,19)	(4,5)	(8,6)	(32,21)
(10,19)	(1,2)	(23,24)	(31,22)	(16,24)	(13,25)	(8,11)
(4,19)	(34,11)	(10,22)	(26,23)	(22,20)	(3,11)	(26,21)
(7,22)	(4,11)	(22,25)	(31,19)	(16,23)	(24,5)	(10,14)
(4,24)	(4,23)	(9,5)	(1,9)	(12,25)	(6,9)	(24,16)
(8,10)	(31,6)	(18,22)	(26,19)	(6,3)	(5,8)	(3,0)
(5,22)	(11,25)	(22,19)	(6,5)	(11,22)	(28,20)	(30,5)
(10,24)	(18,16)	(2,5)	(28,23)	(4,2)	(16,5)	(3,6)
(11,19)	(10,16)	(11,15)	(24,23)	(31,25)	(17,22)	(28,5)
(33,13)	(9,8)	(32,7)	(18,25)	(26,20)	(14,19)	(5,9)
(30,16)	(10,7)	(33,8)	(19,22)	(6,16)	(3,4)	(10,20)
(5,10)	(7,25)	(5,25)	(20,16)	(4,1)	(29,22)	(28,16)
(14,5)	(16,19)	(6,22)	(16,16)	(22,22)	(30,19)	(7,4)
(18,5)	(5,5)	(4,22)	(3,3)	(20,22)	(32,20)	(10,25)
(12,22)	(16,20)	(8,16)	(8,23)	(8,21)	(26,5)	(31,15)
(26,16)	(8,20)	(22,16)	(25,24)	(26,25)	(20,23)	(6,19)
(7,5)	(20,24)	(11,5)	(6,25)	(7,7)	(14,16)	(30,22)
(16,21)	(20,5)	(20,19)	(4,25)	(29,25)	(32,24)	(28,24)



BEAMS Word Search

Directions: Hidden in the puzzle below are 32 words that are frequently used at Jefferson Lab. The words may be spelled vertically, horizontally, backwards or diagonally. Some letters may be used in more than one word.

ACCELERATOR

ATOM

BEAM

CEBAF

CHARGE

COMPOUND

CURRENT

ELECTROMAGNET

ELECTRON

ELEMENT

ENERGY

FEL

FIELD

FORCE

INJECTOR

INSULATOR

INTERNET

IRON

JEFFERSON LAB

LABORATORY

MATTER

METER

MOLECULE

NUCLEUS

PHYSICIST

PROTON

QUADRANT

QUALITATIVE

QUARK

SCIENCE

SPEED

WEIGHT

S C I A N C E I C S A T M M A T S E R H P I
 C M A C C E L E R A T O R S A T N E M E L E
 I O F E L E L E C T R O N O H T I C A R E L
 E L I O T P R O T O N S L H E N T E M E L E
 N E D N C I R O N O S S E T G T O E I N N C
 C C D O T O E T S I C I S Y H P T F R I U T
 T U M N O E M A Z F O E T I H K A D H R O R
 W L A N B E R P L D I U A N R O R L R N R O
 O E K H I V T N O I L L T A Q E E E T S E M
 S I I O T A L H E U T P U U D T N I L U A A
 G N C G S E E A N T N Q A Q H T E F K W S G
 F U S E H P R S C H R D U H T E C M A R P N
 H E R N T T L A B O R A T O R Y C T S B A E
 A T O M T W O I T A L U W V E E B Q D U E T
 E T T S N I E A N I E T F O R C E G R A H C
 Y W C L D E L T T S Z T E O B S H E M E O A
 N D E A P U L A S O U L E A E H T H E A B N
 B U J T S R T F T L M E T T A R H I T U P S
 J S N N A I O L O N D O L F M O E S E C H P
 I B I Q V I R G K A R T I C S Y A S R Y I E
 C C K E Q W P I E P L T L U U C Y G R E N E
 S C I E N C E J E F F E R S O N L A B P Q D

Element Word Search

Directions: Hidden in the puzzle below are the names of 40 common elements. The names may be spelled vertically, horizontally, backwards or diagonally. Some letters may be used in more than one name.

ALUMINUM
ANTIMONY
ARGON
BERYLLIUM
BORON
CALCIUM
CARBON
CHLORINE
COPPER
FLUORINE

GOLD
HELIUM
HYDROGEN
IODINE
IRON
KRYPTON
LEAD
LITHIUM
MERCURY
NEON

NICKEL
NITROGEN
OXYGEN
PALLADIUM
PHOSPHORUS
PLATINUM
PLUTONIUM
POTASSIUM
RADIUM
RADON

SILICON
SILVER
SODIUM
SULFUR
TIN
TITANIUM
TUNGSTEN
URANIUM
ZINC
ZIRCONIUM

C I D L A B I R A G I K P O T A S S I U M B
C N I Z I C N S R X Z R C L N I U M D A E L
P I T I A O O H O O X Y O U I M O D A R B F
Z T I R A D R E L D M P U N R X C P Y A A I
C I B C K G O L D E I T G R Y Y H L I D B V
I O D O X O B I M P A O N E A G L U V I Y E
N A Z N I L Y U K E L N M L N I O T A U L X
Y C I I O M O M E R C U R Y U R R O N M O Y
N K M U N I T A L P V I R M N O I N O I N H
O L C M G K A R F P I S M U I O N I V L I Y
M N I T R O G E N L T O U T I X E U A O R D
I I I T K O S H M U I D A L L A P N O D A R
T I B I H L Y T A T U I V A F R R S D F S O
N C A L C I U M G O R U O R R U R H E L U G
A L U M I N U M N N A M R G A R R E L U R E
W A R G D O E M E I N L L O N A N R E O O N
I O D E R N R S D U I R B N K L I I N R H Z
R A G S I R E E R M U C N W E N A D N I P A
P E K D P U V N O M M N E T S G N U T N S H
N V O I S I L V E R E I N N E L Y R I E O A
N I C K E L I M U I N A T I T O T X S F H X
S I L I C O N S W O D A H S R E P P O C P Y

Reading About Looking for Quarks Inside the Atom

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

About thirty years ago, three scientists ran some accelerator experiments to study the nucleus at the 1 of the atom. They ran the experiments because they wanted to know more about the structure of the 2. They found that the protons and neutrons in the nucleus are made of quarks. The discovery of 3 raised new questions about the nucleus.

The three scientists are Richard Taylor, Henry Kendall and Jerome Friedman. They did their experiments from 1967 to 1973 in California at the Stanford Linear Accelerator Center, called SLAC for short. These scientists won the 1990 Nobel Prize in Physics, one of the world's greatest honors for 4.

In the 1960's some scientists, like Murray Gell-Mann, were beginning to think that each nucleon might really be made up of even smaller particles. Gell-Mann even had a name for the smaller 5. He called them quarks.

Taylor, Kendall and Friedman used beams of high-energy electrons at SLAC to explore deep inside atoms. Inside the two mile long accelerator the electrons gained energy as they moved along in a beam almost as fast as light. At the end of the accelerator, some hydrogen was the target for the electrons. Sometimes an electron would 6 into the proton inside of the hydrogen atoms. These crashes were far too tiny to see directly or even with a microscope. The three experimenters used spectrometers to 7 what happened.

Each spectrometer consisted of huge electromagnets, about the 8 of a bus, and some detectors. When electrons crash into a target nucleus, a spectrometer measures their angles and energies as they bounce away. The electrons were not striking solid protons. They were striking vibrating clusters of quarks. Each proton is a cluster of three 9; each neutron is too.

This new discovery led to new questions. Experiments at Jefferson Lab will answer new 10 about quarks and nuclei. That's how scientific research works. There is always something new to find out!

In fact, that's why Alfred B. Nobel started the Nobel 11 in 1901. In December, 1990, Taylor, Kendall and Friedman went to Stockholm, Sweden, to receive their Nobel Prize in Physics. The three winners shared not only the honor of the Nobel, but the 12 that comes with it: \$710,000.

Directions: Choose the word that fits the context of the passage.

1. a. outside b. edge c. center d. perimeter
2. a. nucleus b. accelerator c. electromagnet d. spectrometer
3. a. alpha b. quarks c. nuclei d. electron
4. a. teachers b. engineers c. farmers d. scientists
5. a. nucleon b. quarks c. particles d. gell
6. a. crash b. glide c. slip d. fall
7. a. wonder b. observe c. question d. argue
8. a. size b. color c. purpose d. strength
9. a. quarks b. bounces c. clusters d. protons
10. a. inventions b. questions c. discoveries d. statements
11. a. medals b. trophies c. prizes d. certificates
12. a. book b. certificate c. paper d. money

Reading About Ernest Rutherford

Directions: Read the passage. Locate the paragraph that contains the answer to each question on the next page.

1. Ernest Rutherford (1871-1937) was a scientist who wanted to learn about atomic structure. The best way to learn about the inside of the atom, he decided, was to blow it apart.
2. Rutherford chose the nucleus of the helium atom as the bullet to shoot at the atom. The helium nucleus, which is called an alpha particle, contains two protons and two neutrons. The "gun" to fire the alpha particle was the element radium. Radium is radioactive. It is continually shooting out atomic particles. He placed the radium in a heavy lead container with just a small opening to direct the escaping alpha particles.
3. The target for the alpha particles was a very thin sheet of gold foil, less than 1/100,000 of an inch thick. This is even thinner than the aluminum foil you use to cover food. Yet atoms are so small that the gold foil still had a thickness of more than 2,000 atoms.
4. For his first experiment, he set the foil in front of the radium container. Behind the foil, he placed a fluorescent screen. The screen would show a spark of light whenever it was struck by an alpha particle. Thus, he could see whether any alpha particles were able to pass through the atoms in the gold foil.
5. The actual results were amazing. Rutherford got flashes of light from the screen. Somehow the alpha particles were able to get through.
6. The scientist moved the screen to the sides and even in front, facing the foil. To his amazement he found light flashes at all angles. Some particles were even bouncing off to the side as well as straight back at the radium.
7. In 1911, Rutherford explained what had happened. He suggested that the atom consists of a very small, heavy central core called the nucleus. Very far out from the nucleus are the rapidly swirling electrons.
8. The atom was largely an empty shell. That explained how the alpha particles were able to get through the gold foil. Within the shell, there was a small but heavy nucleus with a positive charge. That is what deflected some of the positive alpha particles and bounced back the few that actually hit the nucleus of the gold atoms.
9. Rutherford performed another experiment similar to the first to check his picture of the atom. This time he used nitrogen as a target. Most of the particles went straight through the empty space of the nitrogen atoms. A few bumped into the nucleus and bounced off. He also discovered the presence of hydrogen nuclei (more than one nucleus) that had a positive charge. Then he realized that the hydrogen nuclei had to come from within the nitrogen atoms. Rutherford concluded that the atoms of every element contain one or more of these positively charged nuclei. These positive hydrogen nuclei are called protons.

11. On the basis of these results, he set forth a complete model of the atom. The nucleus is made up of heavy, positively charged protons. It has a positive electrical charge. Very far out from this nucleus are the much lighter electrons. Their negative charge balances the positive charge of the nucleus.

Directions: Read each question carefully. Locate the paragraph that contains the information needed to answer each question. Write the number of the paragraph on the blank.

- _____ 1. What is an alpha particle?
- _____ 2. What was the thickness of the gold foil?
- _____ 3. What was the target for the alpha particle?
- _____ 4. How did Rutherford conduct his first experiment to study the inside of an atom?
- _____ 5. Why did Rutherford put a fluorescent screen behind the foil?
- _____ 6. What happened when Rutherford moved the screen to the side?
- _____ 7. What did Rutherford discover when he used nitrogen as a target?
- _____ 8. Why did the nucleus deflect some of the alpha particles?
- _____ 9. What does the word "nuclei" mean?
- _____ 10. How did Rutherford check his picture of the atom?
- _____ 11. What are positive hydrogen nuclei called?

BEAMS Fractions

Directions: Reduce each fraction to its lowest terms. Then use the code to find the names of the 6 quarks.

$1/2 = A$	$1/4 = D$	$3/4 = G$	$1/3 = N$	$2/5 = P$	$2/9 = S$
$1/8 = U$	$1/7 = B$	$1 = E$	$1/6 = M$	$3/8 = O$	$0 = R$
$1/5 = T$	$1/9 = Y$	$2/7 = W$	$4/5 = H$	$7/9 = C$	

$$\frac{5}{25} \quad \frac{6}{16} \quad \frac{20}{50}$$

$$\frac{8}{36} \quad \frac{9}{45} \quad \frac{0}{5} \quad \frac{50}{100} \quad \frac{4}{12} \quad \frac{75}{100} \quad \frac{12}{12}$$

$$\frac{12}{48} \quad \frac{15}{40} \quad \frac{8}{28} \quad \frac{9}{27}$$

$$\frac{8}{56} \quad \frac{21}{56} \quad \frac{3}{15} \quad \frac{10}{50} \quad \frac{12}{32} \quad \frac{7}{42}$$

$$\frac{14}{18} \quad \frac{16}{20} \quad \frac{14}{28} \quad \frac{0}{65} \quad \frac{9}{54}$$

$$\frac{6}{48} \quad \frac{12}{30}$$

Reading About Superconductivity

In 1911 Heike Onnes, a Dutch scientist, was conducting experiments to learn how metals were affected by very cold temperatures. While working with the metal mercury, he discovered something new. When mercury was cooled to the extremely cold temperature of liquid helium, it allowed electricity to flow through it without any loss of energy.

Onnes and other scientists continued investigating other metals to learn if they would react the same as the mercury to the extremely cold temperature. They found that many of the metals had the same reaction. In one experiment, a metal wire loop was cooled in liquid helium and electricity was allowed to flow into the loop. When the source of the electricity was removed, the current continued to flow. Onnes was not able to explain this discovery, but he called it *superconductivity*.

In a normal conductor, the current stops flowing when the source of electricity is removed. If a superconducting metal is kept at the supercool temperature of liquid helium, the current can flow for years without becoming weaker.

It was many years before the discovery of superconductivity could be used in practical ways, because liquid helium and the equipment needed to cool superconducting materials are very expensive and difficult to handle. Today, the use of superconducting technology is being researched and applied in such fields as medicine, physics, transportation, communication and the military.

Directions: Answer the questions in complete sentences.

1. How many years ago was superconductivity discovered?

2. How could you test a metal to see if it is a superconductor?

3. How does a superconductor differ from a normal conductor?

Bonus Question: How are superconductors used in the cryomodules at Jefferson Lab?

Reading About Properties and Changes

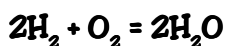
Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

Matter can be described and identified by physical and chemical properties. Physical 1 have to do with appearance. You can observe many physical properties with your senses and by measuring the length, 2, height, mass and density of a substance. 3 properties include color, shape, smell, texture, taste and size. The state of matter (whether its a solid, 4, or gas) and the 5 at which the substance boils, melts or freezes are also physical properties. Magnetic properties are physical properties as well.

6 properties, on the other hand, have more to do with the atomic or molecular composition of matter. Chemical properties deal with how substances react with other 7 such as water, air or fire.

A physical change has occurred when a substance changes color, size, shape, temperature or state. A 8 change has occurred when a substance has changed into something new or 9 so that the original substance is gone. Digestion, combustion and radioactive decay are examples of chemical changes. A chemical change takes place in a 10 to produce electricity when you turn on a flashlight.

Chemical changes are sometimes represented by a chemical formula:



This formula states that two hydrogen gas molecules react with one oxygen gas molecule to produce two molecules of water.

Directions: Choose the word that fits the context of the passage.

- | | | | | |
|-----|----------------|----------------|---------------|---------------|
| 1. | a. chemicals | b. properties | c. substances | d. textures |
| 2. | a. width | b. density | c. height | d. property |
| 3. | a. chemical | b. matter | c. described | d. physical |
| 4. | a. water | b. molecule | c. liquid | d. atom |
| 5. | a. time | b. temperature | c. design | d. cylinder |
| 6. | a. chemical | b. physical | c. substance | d. gaseous |
| 7. | a. properties | b. physicals | c. degrees | d. substances |
| 8. | a. temperature | b. physical | c. chemical | d. color |
| 9. | a. similar | b. different | c. familiar | d. original |
| 10. | a. battery | b. bulb | c. change | d. switch |

Reading About Changes


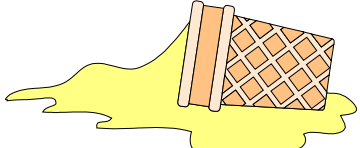

Look at the picture of the candle burning. The wax of a candle burns and changes into ash and smoke. The original materials are changing into something different. Changes that create a new material are called **chemical changes**.



Look at the picture of water boiling and changing into steam. Steam is another form of water. Heating the water did not create a new material. In changing the water from a liquid to a gas, only the state of the water changed. Changes in the shape, size or state of a material are called **physical changes**.



Directions: Study the changes that are occurring in each picture below. Tell what is changing. Then decide if the change is a chemical change or a physical change.

	What is changing?	What kind of change?
 A car wreck		
 Melting ice cream		
 Wood burning		

Challenge! List three changes you observe at home. Tell what is changing and what kind of change is occurring in each. Can some changes be both physical and chemical?

Reading About Charges and Electricity

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

Atoms, the basic building blocks of matter, are made of three basic components: protons, neutrons and electrons. The protons and neutrons cluster together to form the nucleus, the central part of the atom, and the 1 orbit about the nucleus. Protons and electrons both carry an electrical charge. The charges they carry are opposite to each other; protons carry a 2 electrical charge while electrons carry a negative electrical charge. Neutrons are 3 charged - they carry no charge at all.

Electricity is the movement of charged particles, usually electrons, from one place to another. Materials that electricity can move through easily are called conductors. Most metals, such as iron, copper and 4 , are good 5 of electricity. Other materials, such as rubber, wood and glass, block the flow of electricity. Materials which 6 the flow of electricity are called insulators. Electrical cords are usually made with both conductors and 7 . Electricity flows through a 8 in the center of the cord. A layer of insulation 9 the conductor and 10 the electricity from 'leaking' out.

Objects usually have equal numbers of positive and negative charges, but it isn't too hard to temporarily create an imbalance. One way scientists can create an imbalance is with a machine called a 11 generator. It creates a large static charge by placing electrons on a metal dome using a motor and a big rubber band. Since like charges 12 , the electrons push away from each other as they collect on the dome. Eventually, too many electrons are placed on the dome and they leap off, creating a spark that looks like a bolt of lightning.

Have you ever received a 13 after having walked across a carpet? This shock was caused by extra electrons you collected while walking across the carpet. Your body became like the dome of the Van de Graaff generator, full of extra electrons looking for a way to get away. The path back to the carpet was blocked by the 14 you were wearing, but they were able to move through your hand and into the object that you touched, causing the shock. So, the next time you shuffle across a carpet and shock your friend on the ear, tell them you were just trying to be a Van de Graaff generator!

Directions: Choose the word that fits the context of the passage.

1. a. neutrons b. protons c. electrons d. quarks
2. a. negative b. positive c. neutral d. strong
3. a. negatively b. positively c. neutrally d. strongly
4. a. wood b. paper c. nitrogen d. aluminum
5. a. keepers b. protectors c. insulators d. conductors
6. a. allow b. create c. help d. prevent
7. a. conductors b. insulators c. metals d. plugs
8. a. conductor b. insulator c. neutron d. cord
9. a. surrounds b. warms c. looks at d. hears
10. a. speeds up b. replaces c. prevents d. allows
11. a. Rube Goldberg b. Van de Graaff c. Big Bad d. Einstein
12. a. jump b. join c. repel d. attract
13. a. dollar b. book c. shock d. cat
14. a. freckle b. shirt c. pants d. shoes

The Periodic Table of Elements

1 H HYDROGEN 1																	2 He HELIUM 4															
3 Li LITHIUM 7	4 Be BERYLLIUM 9																	5 B BORON 11	6 C CARBON 12	7 N NITROGEN 14	8 O OXYGEN 16	9 F FLUORINE 19	10 Ne NEON 20									
11 Na SODIUM 23	12 Mg MAGNESIUM 24																	13 Al ALUMINUM 27	14 Si SILICON 28	15 P PHOSPHORUS 31	16 S SULFUR 32	17 Cl CHLORINE 35	18 Ar ARGON 40									
METALS																		NON-METALS														
19 K POTASSIUM 39	20 Ca CALCIUM 40	21 Sc SCANDIUM 45	22 Ti TITANIUM 48	23 V VANADIUM 51	24 Cr CHROMIUM 52	25 Mn MANGANESE 55	26 Fe IRON 56	27 Co COBALT 59	28 Ni NICKEL 59	29 Cu COPPER 64	30 Zn ZINC 65	31 Ga GALLIUM 70	32 Ge GERMANIUM 73	33 As ARSENIC 75	34 Se SELENIUM 79	35 Br BROMINE 80	36 Kr KRYPTON 84															
37 Rb RUBIDIUM 85	38 Sr STRONTIUM 88	39 Y YTTRIUM 89	40 Zr ZIRCONIUM 91	41 Nb NIOBIUM 93	42 Mo MOLYBDENUM 96	43 Tc TECHNETIUM 98	44 Ru RUTHENIUM 101	45 Rh RHODIUM 103	46 Pd PALLADIUM 106	47 Ag SILVER 108	48 Cd CADMIUM 112	49 In INDIUM 115	50 Sn TIN 119	51 Sb ANTIMONY 122	52 Te TELLURIUM 128	53 I IODINE 127	54 Xe XENON 131															
55 Cs CESIUM 133	56 Ba BARIUM 137																	72 Hf HAFNIUM 178	73 Ta TANTALUM 181	74 W TUNGSTEN 184	75 Re RHENIUM 186	76 Os OSMIUM 190	77 Ir IRIDIUM 192	78 Pt PLATINUM 195	79 Au GOLD 197	80 Hg MERCURY 201	81 Tl THALLIUM 204	82 Pb LEAD 207	83 Bi BISMUTH 209	84 Po POLONIUM 209	85 At ASTATINE 210	86 Rn RADON 222
87 Fr FRANCIUM 223	88 Ra RADIUM 226																	104 Rf RUTHERFORDIUM 267	105 Db DUBNIUM 268	106 Sg SEABORGIUM 271	107 Bh BOHRIUM 272	108 Hs HASSIUM 277	109 Mt MEITNERIUM 276	110 Ds DARMSTADIUM 281	111 Rg ROENTGENIUM 280	112 Cp COPERNICIUM 285	113 Uut UNUNTRIUM 284	114 Uuq UNUNQUADIUM 289	115 Uup UNUNPENTIUM 288	116 Uuh UNUNHEXIUM 291	117 Uus UNUNSEPTIUM NOT YET OBSERVED	118 Uuo UNUNOCTIUM 294

6 ← **Atomic Number** = Number of Protons = Number of Electrons

C ← **Chemical Symbol**

CARBON ← **Chemical Name**

12 ← **Atomic Weight** = Number of Protons + Number of Neutrons*

KEY	
	= Solid at room temperature
	= Liquid at room temperature
	= Gas at room temperature
	= Radioactive
	= Artificially Made

57 La LANTHANUM 139	58 Ce CERIUM 140	59 Pr PRASEODYMIUM 141	60 Nd NEODYMIUM 144	61 Pm PROMETHIUM 145	62 Sm SAMARIUM 150	63 Eu EUROPIUM 152	64 Gd GADOLINIUM 157	65 Tb TERBIUM 159	66 Dy DYSPROSIUM 163	67 Ho HOLMIUM 165	68 Er ERBIUM 167	69 Tm THULIUM 169	70 Yb YTTTERBIUM 173	71 Lu LUTETIUM 175
89 Ac ACTINIUM 227	90 Th THORIUM 232	91 Pa PROTACTINIUM 231	92 U URANIUM 238	93 Np NEPTUNIUM 237	94 Pu PLUTONIUM 244	95 Am AMERICIUM 243	96 Cm CURIUM 247	97 Bk BERKELIUM 247	98 Cf CALIFORNIUM 251	99 Es EINSTEINIUM 252	100 Fm FERMIUM 257	101 Md MENDELEVIUM 258	102 No NOBELIUM 259	103 Lr LAWRENCIUM 262

* The atomic weights listed on this Table of Elements have been rounded to the nearest whole number. As a result, this chart actually displays the **mass number** of a specific isotope for each element. An element's complete, unrounded atomic weight can be found on the It's Elemental web site: <http://education.jlab.org/itselemental/index.html>

Science Education Web Resources

<http://education.jlab.org/>

It's Elemental

An easy to understand Table of Elements listing basic physical and historical data.

All About Atoms

A very basic overview of atomic structure.



Element Games

Games based on the Table of Elements! Featuring:

- Element Flash Cards
- Element Crossword Puzzles
- Element Math Game
- Element Concentration
- Element Hangman
- Element Matching

Who Wants to Win \$1,000,000?

A science and math quiz game where you could become a (pretend!) millionaire!

Internships

Summer programs for students and teachers!

Hands-on Activities

Experiments from Jefferson Lab's BEAMS program that you can do at home! Featuring:

- Magnets and Electromagnets
- Oobleck
- Cold Stuff
- The Shape of Things
- Design and Engineering
- And More!

Science Series

Lectures on a variety of science-related topics. Videotapes of previous lectures are available!

Virginia State SOL Practice Tests

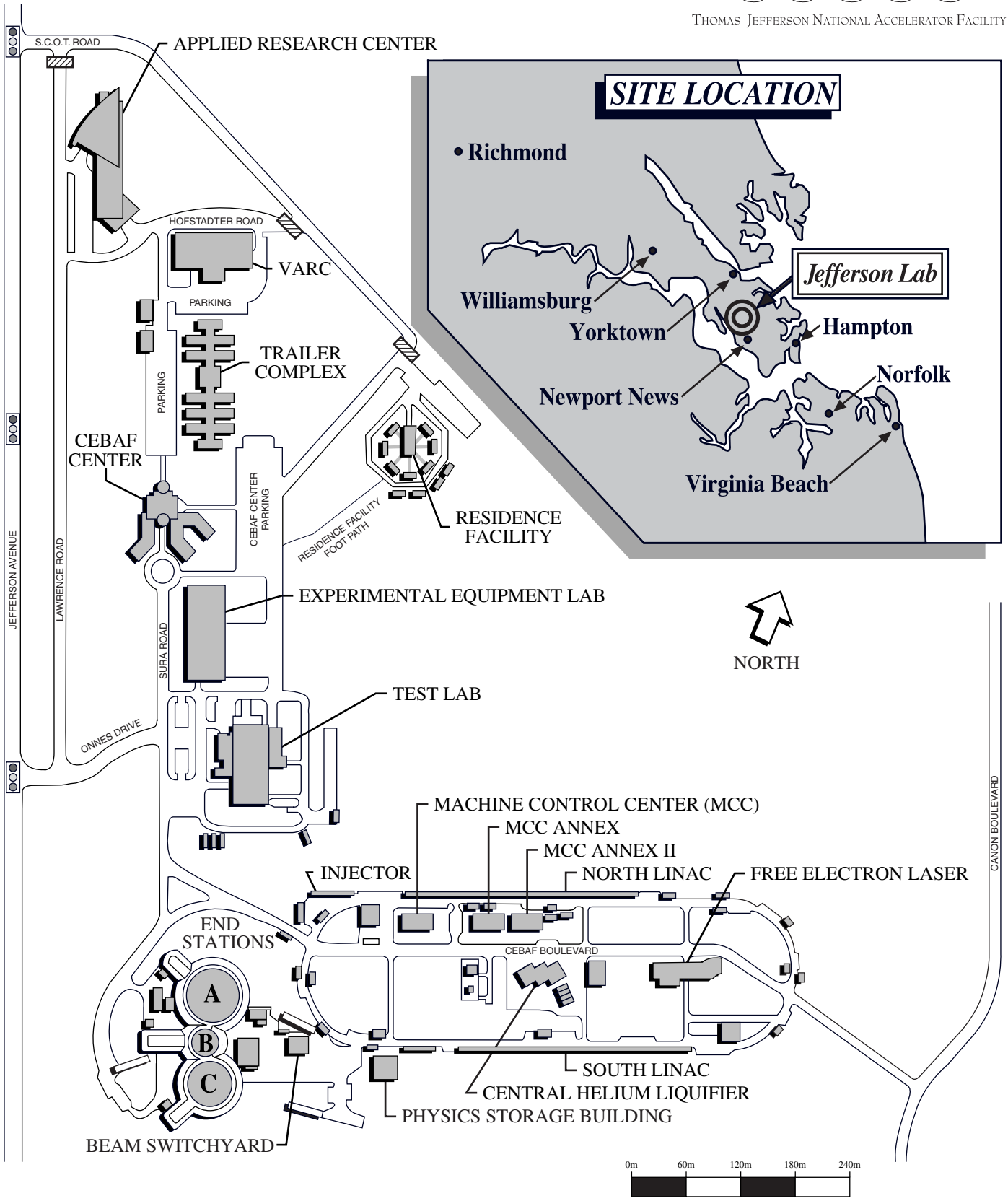
Practice the Virginia Standards of Learning tests on-line! Available tests include:

- 3rd Grade Science and Math
- 5th Grade Science, Math and Technology
- 8th Grade Science, Math and Technology
- Earth Science
- Chemistry
- Geometry
- Algebra I
- Algebra II





SITE PLAN



SITE LOCATION

