INTRODUCTION

FUNDAMENTAL FORCES OF NATURE (CERN)

Exploring Fundamental Particles and Forces of Nature

What are fundamental particles and fundamental forces of nature?

A longstanding goal of physics has been to discover the fundamental particles and forces of nature. A fundamental particle is one that cannot be broken down into small particles. Fundamental particles are the building blocks of all matter. Likewise, the fundamental forces are the building blocks of all forces in nature. The fundamental particles interact with each other via the fundamental forces. For example, one of the fundamental particles is called the electron. Two electrons repel each other by the fundamental force called the electrical force.

Brief History of the Discovery of Fundamental Particles and Forces

The ancient Greeks proposed that all matter is made of fundamental particles called atoms. Then, in the twentieth century, we learned that atoms are not fundamental. They are made of smaller particles called quarks and electrons.

Gravity was the first fundamental force known. We are all familiar with gravity. It is the force that causes a dropped ball to fall to the ground. The ancient Greeks discovered two other fundamental forces: electricity and magnetism.

In the twentieth century, scientists discovered two more fundamental forces: the strong nuclear force, which holds the centers of atoms together, and the weak nuclear force, which causes certain particles to disintegrate. The discovery of these forces required large machines.

In the nineteenth century, scientists discovered that the electrical and magnetic forces — once thought to be different fundamental forces — were actually part of the same force, called the **electromagnetic force**. Electricity can generate magnetism, and vice versa.

In the 1960s and 1970s, again using large machines, scientists discovered that the electromagnetic and weak nuclear force are part of a more fundamental force called the electro-weak force. At the present time, we believe there are three fundamental forces: gravity, the strong nuclear force, and the electro-weak force.

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KEY CONCEPTS AND VOCABULARY

Electric field: a region where a test charge experiences an electric charge

Magnetic field: region where a magnetic force can be detected

Electromagnetic force: the physical interaction that occurs between charged particles

Electromagnetic induction: the process of creating a current in a circuit by changing magnetic field

Amperes: the SI unit of electric current, defined as the flow of one coulomb of charge per second

Note: Definitions are derived from Houghton Mifflin Harcourt Physics, Tennessee Edition textbook

What is the role of particle accelerators (like CERN) in the discovery of the properties of fundamental particles and forces?

Aside from the gravitational force, the fundamental forces have been discovered by accelerating fundamental particles to very high energies and then making them collide with each other. By studying these collisions and the way that the fundamental particles interact with each other, scientists are able to discover the properties of fundamental particles and fundamental forces.

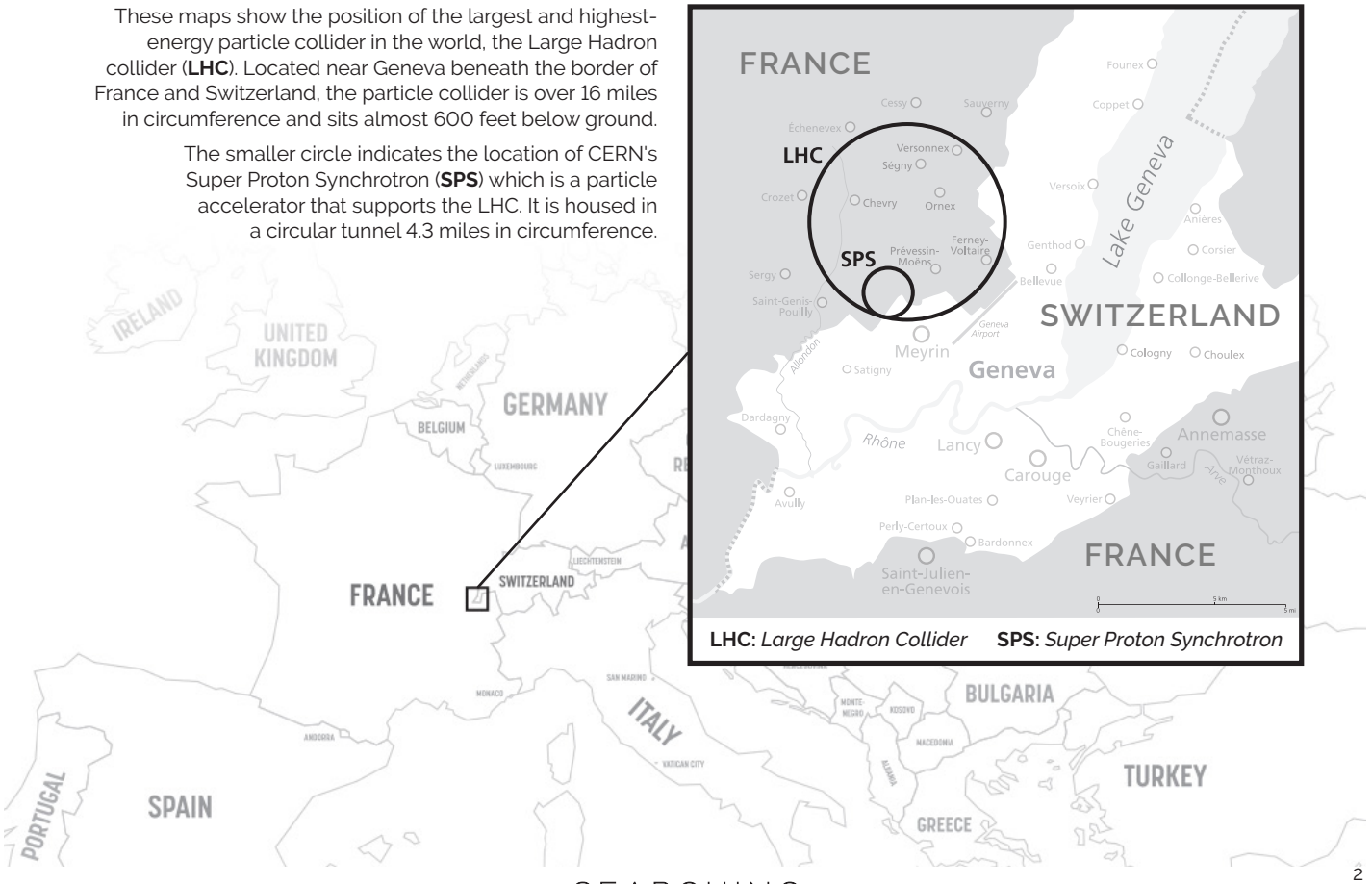
The machines that accelerate particles to high energies are called "atom smashers" or sometimes "particle accelerators." The first particle accelerator was built in the 1930s.

The largest particle accelerator in the world is called CERN and is located in Geneva, Switzerland. CERN was built in 1954. About a hundred physicists, plus about 2000 support staff, work at CERN and come from all over the world. Scientists hope to learn more about the fundamental particles and forces of nature by experiments at CERN.

The circular tunnel at CERN – an impressive 27 kilometers in circumference – accelerates charged subatomic particles up to 99.999999% the speed of light!

These maps show the position of the largest and highest-energy particle collider in the world, the Large Hadron collider (**LHC**). Located near Geneva beneath the border of France and Switzerland, the particle collider is over 16 miles in circumference and sits almost 600 feet below ground.

The smaller circle indicates the location of CERN's Super Proton Synchrotron (**SPS**) which is a particle accelerator that supports the LHC. It is housed in a circular tunnel 4.3 miles in circumference.



LHC: *Large Hadron Collider* **SPS:** *Super Proton Synchrotron*