Connection to Physics

Have interested students research the physics of the piezoelectric response, focusing on the history of its discovery. Encourage them to relate discoveries to the questions scientists were asking. For instance, scientists wondered why quartz crystals were able to generate an electric potential, so they examined quartz's structure and discovered that stresses on the structure caused an electrical response.

Tips from the Trenches

Piezoelectric materials are perfect for inspiring students to use both chemistry and physics. They can't understand how PVDF works without building a model (or models) of the molecule, and that teaches some fantastic chemistry. As soon as they see what this stuff can do, students want to use it in a circuit. Presto, physics!

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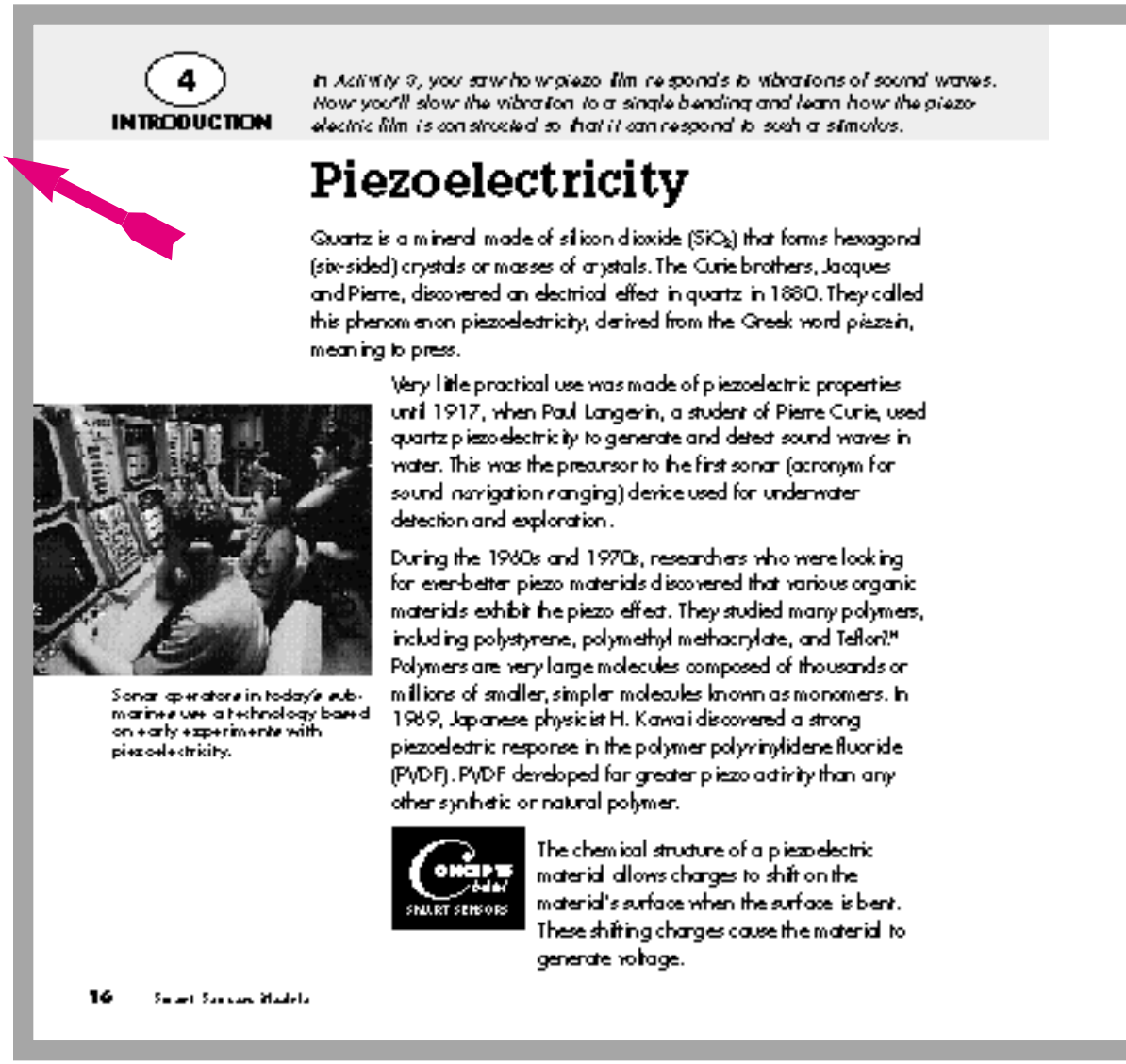

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INTRODUCTION

In Activity 9, you saw how piezo film responds to vibrations of sound waves. Now you'll slow the vibration to a single bending and learn how the piezoelectric film is constructed so that it can respond to such a stimulus.

Piezoelectricity

Quartz is a mineral made of silicon dioxide (SiO_2) that forms hexagonal (six-sided) crystals or masses of crystals. The Curie brothers, Jacques and Pierre, discovered an electrical effect in quartz in 1880. They called this phenomenon piezoelectricity, derived from the Greek word piezein, meaning to press.

Very little practical use was made of piezoelectric properties until 1917, when Paul Langevin, a student of Pierre Curie, used quartz piezoelectricity to generate and detect sound waves in water. This was the precursor to the first sonar (acronym for sound navigation ranging) device used for underwater detection and exploration.

Sonar operators in today's submarines use a technology based on early experiments with piezoelectricity.

During the 1960s and 1970s, researchers who were looking for ever-better piezo materials discovered that various organic materials exhibit the piezo effect. They studied many polymers, including polystyrene, polymethyl methacrylate, and Teflon®. Polymers are very large molecules composed of thousands or millions of smaller, simpler molecules known as monomers. In 1969, Japanese physicist H. Kawai discovered a strong piezoelectric response in the polymer polyvinylidene fluoride (PVDF). PVDF developed far greater piezo activity than any other synthetic or natural polymer.

The chemical structure of a piezoelectric material allows charges to shift on the material's surface when the surface is bent. These shifting charges cause the material to generate voltage.

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To Inspire Questioning and Learning

Ask students what they have learned in their science classes about the effects of molecular structure on a molecule's behavior. Encourage them to recall what they know about bonding and how it is influenced by molecular architecture and polarity. Have several students sketch common types of bonds—hydrogen, covalent, ionic, and polar covalent—on the board. Lead a brief discussion on the role of electrons in bonding, and ask students to contrast ions and polar molecules.