TRANSFER OF ELECTRIC CHARGE

When a balloon and your hair are charged by rubbing, only the rubbed areas become charged, and there is no tendency for the charge to move into other regions of the material. In contrast, when materials such as copper, aluminum, and silver are charged in some small region, the charge readily distributes itself over the entire surface of the material. For this reason, it is convenient to classify substances in terms of their ability to transfer electric charge.

Materials in which electric charges move freely, such as copper and aluminum, are called **electrical conductors.** Most metals are conductors. Materials in which electric charges do not move freely, such as glass, rubber, silk, and plastic, are called **electrical insulators.**

Semiconductors are a third class of materials characterized by electrical properties that are somewhere between those of insulators and conductors. In their pure state, semiconductors are insulators. But the carefully controlled addition of specific atoms as impurities can dramatically increase a semiconductor's ability to conduct electric charge. Silicon and germanium are two well-known semiconductors that are used in a variety of electronic devices.

Certain metals and compounds belong to a fourth class of materials, called *superconductors.* Superconductors have zero electrical resistance when they are at or below a certain temperature. Thus, superconductors can conduct electricity indefinitely without heating.

electrical conductor

a material in which charges can move freely

electrical insulator

a material in which charges cannot move freely

Insulators and conductors can be charged by contact

In the experiments discussed above, a balloon and hair become charged when they are rubbed together. This process is known as *charging by contact.* Another example of charging by contact is a common experiment in which a glass rod is rubbed with silk and a rubber rod is rubbed with wool or fur. The two rods become oppositely charged and attract one another, as a balloon and your hair do. If two glass rods are charged, the rods have the same charge and repel each other, just as two charged balloons do. Likewise, two charged rubber rods repel one another. All of the materials used in these experiments—glass, rubber, silk, wool, and fur—are insulators. Can conductors also be charged by contact?

If you try a similar experiment with a copper rod, the rod does not attract or repel another charged rod. This result might suggest that a metal cannot be charged by contact. However, if you hold the copper rod with an insulating handle and then rub it with wool or fur, the rod attracts a charged glass rod and repels a charged rubber rod.

In the first case, the electric charges produced by rubbing readily move from the copper through your body and finally to Earth because copper and the human body are both conductors. The copper rod does become charged, but it soon becomes neutral again. In the second case, the insulating handle prevents the flow of charge to Earth, and the copper rod remains charged. Thus, both insulators and conductors can become charged by contact.

Why it Matters

Conceptual Challenge

1. Plastic Wrap

Plastic wrap becomes electrically charged as it is pulled from its container, and, as a result, it is attracted to objects such as food containers. Explain why plastic is a good material for this purpose.

2. Charge Transfer

If a glass rod is rubbed with silk, the glass becomes positively charged and the silk becomes negatively charged. Compare the mass of the glass rod before and after it is charged.

3. Electrons

Many objects in the large-scale world have no net charge, even though they contain an extremely large number of electrons. How is this possible?