Static Electricity

Summer Science Fun

What We Will Explore

What happens on a dry day when you scuff across a rug and then reach out to touch a metal doorknob (or other metal object)? What happens when you place an inflated balloon against a wall? What happens if you rub the balloon briskly with a piece of carpeting or wool before you place it against the wall? Are these various observations related? What else can you do to explore these phenomena?

Who This Exploration Is For

Explorers from about kindergarten on up should find various parts of these activities and their results interesting. It's more fun to explore together in pairs or small groups, so there will be others with whom to discuss the results and decide on the next thing to try. Depending upon how the activity is structured, it can take about 15 minutes for one activity to an afternoon or more to explore questions generated by the group.

Materials Needed

Per Group

Many of the same materials are used in several different activities. Also, variations in the activities can be done by mixing and matching materials from the different activities. For example, the ping-pong ball (C), tiny pieces of paper (D), and lightweight pieces of cereal (F) all play the same role in their respective activities. Other materials that might be tried are air-popped popcorn or Styrofoam (packing material). Based on your own experiences with static electricity, you can probably think of other materials that can be substituted for those suggested here and in the activity.

A. Stuck-up Balloon

- inflated balloon
- piece of fur, wool, or clean hair from someone's head
- blank space on a nearby wall

B. Dancing Balloons

- 2 inflated balloons
- 2 lengths of thread or lightweight string a yard (a meter) or so long (exact length is not critical)
- fur, wool, or hair, as in activity A
- tape
- ping-pong balls, Styrofoam, air-popped popcorn, loosely wadded aluminum foil, etc. (optional)

C. Ping-Pong Ball Pet

- comb or inflated balloon

- fur, wool, or hair, as in activity A
- ping-pong ball
- smooth, clear area on a table or the floor
- length of thread or lightweight string a meter or so long (exact length is not critical)
- tape
- Styrofoam, air-popped popcorn, loosely wadded aluminum foil, etc. (optional)

D. Dancing Paper
- comb or inflated balloon
- fur, wool, or hair, as in activity A
- pieces of paper about the size of a small fingernail (enough pieces can be obtained by tearing up a small piece of note paper about 2 inches (5-6 cm) square)

E. Flying Newspaper
- strip of newspaper about 1 inch (3 cm) wide and 30-40 inches (75-100 cm) long

F. Snap, Crackle, and Hop!
- clear plastic box about 1-2 inches (3-5 cm) deep (a food storage box will work)
- sheet of aluminum foil larger than the opening of the box
- dry puffed rice cereal (enough to make a layer one-piece deep that covers about half the bottom of the box)
- Styrofoam, air-popped popcorn, loosely wadded aluminum foil, etc. (optional)

Safety Considerations

These vary depending upon which activities are done. The activities themselves are harmless. The amount of static electricity that can be generated by rubbing materials together like this is not nearly enough to give anyone a harmful shock. In general:

- be careful not to frighten anyone by accidentally breaking balloons,
- be careful not to let very small explorers put objects in their mouths, and
- watch out for paper cuts in activity F.

Adaptations for Explorers with Disabilities

- Explorers with hearing impairments should be able to do these activities without any modifications other than those necessary for communicating the instructions.
- Explorers with visual impairments may be able to feel some of the effects produced with their hands, especially in activities A, B, C, and E. In some cases, touching the objects may cause the electricity in them to be discharged and the effect will be lost.

Curiosity Starter

Suggestions for starting an exploration of static electricity are given under "Guiding the Exploration." Briefly, begin with a demonstration of a static electricity phenomenon (any one will probably do) followed by a discussion of other phenomena the explorers have experienced or heard about. Find out what they would like to know about static electricity phenomena and questions they have. Some of these may make good jumping off points to one or more of the suggested activities.

What to Do

Materials Preparation

- Gather the necessary materials for the activities you have chosen to do.
- Arrange a place to do the activities where the explorers will have enough room.
- Make up copies of the explorer handout.

To Prepare for Next Time

- Except for inflated balloons, which will not stay inflated, all the materials can be stored in zip-close bags or other small containers and reused.

Guiding the Exploration

(See also the questions throughout the Activity Sheet.)

The electrical nature of the phenomena your explorers will observe is not obvious. Only with very rare exceptions will anyone see an electric spark generated by any of the activities. You should attempt to make the connection through the phenomenon of getting a shock when touching a metal object after scuffing across a rug (see the first question on the Activity Sheet). Leading questions might be:

- Have you ever been shocked after walking across a carpet or pulling off a sweater?
- Have you ever found your dry hair following your comb or brush (instead of staying where you want it) when you try to comb or brush?
- Have you ever gotten a shock when you touched the door handle after getting out of a car with cloth upholstery?
- What other experiences with *static electricity* (this gives a name to the basis for the above phenomena; names don't necessarily explain anything, but they make it easier to communicate with one another) have you had?

If your exploration is carried out on a very dry day (usually only winter days are dry enough to condense most of the moisture out of the air), you can have your explorers actually do such an activity. If you hold a metal object like a key *tightly* in your hand and, after scuffing across a rug, touch the key to another metal object, you will not feel the shock, but you will be able to hear the crackle and see the spark (best in a darkened room). Thus, the shock (felt if you aren't holding the key), the spark (like a lightning bolt), and the crackle (like the sound of thunder after a lightning bolt) are all evidence (based on other experiences as well) that you are dealing with electrical phenomena.

Based on such preliminary activities or previous experience, your explorers should be encouraged to suppose (hypothesize without being told directly) that rubbing an object (like a balloon) with some soft fabric (like a piece of wool or rug) will also produce some electrical phenomenon that they can investigate. The suggested activities are designed to lead explorers to learn that charged objects attract uncharged objects and that like charged objects repel one another. Perhaps they can think up and carry out activities to try to show that objects of unlike charge attract one another. Set them free to explore the various activities, while you encourage exploration and reinforce good cooperative work and group interaction.

Where to Go from Here

For more activities, check out the following books: *Thomas Edison for Kids* by Laurie Carlson; *Exploratopia* by Pat Murphy, Ellen Macaulay, and the staff of the Exploratorium; and *Stellar Science Projects about Earth's Sky* by Robert Gardner.

Why It Happens

The phenomena associated with static electricity provide a safe and fun way to explore the electrical nature of matter. In today's model of matter, substances are composed of very tiny atoms. Each atom contains an even tinier, positively charged nucleus, in which most of the atom's mass is concentrated. Surrounding the nucleus, in a neutral atom, are just enough very light, negatively charged electrons to balance the charge on the nucleus. The light electrons are moving very fast and are whizzing about the nucleus forming a sort of “cloud” (like a swarm of bees about a hive) that makes up most of the space occupied by the atom. Each atom is held together by electrical forces. Positive and negative charges attract one another. Electrical forces also hold atoms together with other atoms to form molecules, the tiny particles that make up all of the physical substances in the universe (including us).

Almost all of the space taken up by any substance is occupied by the fast moving electrons. When we rub two different substances together, it is likely that one of the substances will hold its electrons a little more loosely than the other will. In that case, some of the electrons can get rubbed off and become attached to the second substance. The first substance will now have fewer negative charges (electrons) than it originally had and will be positively charged (an excess of nuclear charge). The second substance will now have more electrons than it originally had and will be negatively charged. Over time, the first substance will gain electrons from other substances (for example, air molecules) and the second will lose electrons to other substances, and both will once again become electrically neutral. Water vapor in the air is very effective for taking excess electrons from a negatively charged object. That's why activities with static electricity work best on a dry day (which, as mentioned above, is most likely to occur during the winter).

In most substances, electrons can't travel very far. (Metals are the exception; electrons can travel easily through metals. Metals are good *conductors* of electricity.) Therefore, when electrons are rubbed off onto a surface, they are pretty much stuck on the surface they get rubbed off onto. That is why these activities are said to involve *static electricity* (electricity that is, in some sense, "standing still").

In Activity A, the balloon will probably stick to the wall after being charged by rubbing. When the balloon is rubbed with wool, electrons are rubbed off the wool by the balloon, so the wool is left with a positive charge and the balloon with a negative charge. As the negatively charged balloon is brought up to the wall, the electrons in the wall are repelled and they tend to move back a little bit. The positively charged nuclei aren't so easily moved and, moreover, are attracted by the negatively charged balloon. The upshot is that the wall gets slightly more positive at its surface. The positive wall and the negative balloon are attracted to one another and the balloon sticks to the wall. Because of the charge it acquired when it was rubbed, the balloon can stick to a wide variety of objects (even a person). The time it takes for the charge to be lost can be determined by timing how long the balloon stays stuck to an object. Do all objects act the same?

In Activity B, when only one of the balloons is charged, it attracts the other balloon (just as above) and they should swing together and touch. It is likely that some of the electrons will get transferred from the charged balloon to the one that was initially uncharged. Now both of them have a negative charge and they should then repel one another ("like" charges repel). They should swing apart and are likely to end up trying to be further apart than they were before either was charged. In order to do this, they have to swing so their strings are no longer vertical. But gravity is trying to pull each of them back down. Any small imbalance among these forces or a draft in the room will make the situation unstable and results in the balloons “dancing” around to stay away from one another. When both balloons are negatively charged by rubbing, they repel one another immediately and try never to touch. Other very lightweight objects, such as ping-pong balls, Styrofoam, and popcorn, although themselves difficult to rub, can pick up a charge from a charged object like a balloon and then behave similarly to balloons.

In Activities C and D, you again have a situation like Activity A (or Activity B with only one balloon charged). The same sort of separation of charges occurs in the ping-pong ball (Activity C) or pieces of paper (Activity D) when a charged balloon or comb is brought near. Since these lightweight objects move easily and their positive side is attracted to the charged object, they move toward it. The ping-pong ball can be "pulled" about (very much like leading a pet on a leash) by keeping the charged object just ahead of it as it rolls along. The pieces of paper will probably jump to the charged object and stick momentarily. Some electrons are likely to be transferred to the pieces of paper to give them a negative charge and then they will jump off the negatively charged object. The same thing will happen if you let the ping-pong ball touch the charged object. Now you can move it around by "pushing" it away as it is repelled by an object with a charge of the same sign.

Activity E is similar to Activity B, in which both balloons have the same charge and repel one another.