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will soon decrease because of air humidity. (It also decreases if the “nonconducting surface” actually conducts somewhat.) However, if the powder mixture is dusted lightly over the region so that the grains drift down onto the charged regions, the negative grains will collect in the positive patches and the positive grains will collect in the negative patches. If the powders have different colors (such as black toner and brown cinnamon), the patches are visible. Some powder mixtures work better than others. For example, crushed paprika and photocopier toner work well together, but paprika and flour attract each other so strongly that they virtually ignore the charged patches on the dusted site and settle out uniformly.

When a spark jumps between a fingertip and Mylar that is stuck on a large conductor (such as a metal shelf), the charge flow leaves charged regions in the Mylar, at least until air humidity neutralizes those regions. If a mixture of cumin and toner powder is blown lightly over the Mylar, it will reveal one of two general types of patterns, called *Lichtenberg patterns* after George Christoph Lichtenberg, who discovered them in 1777.

If the person has become negatively charged by walking on the carpet and thus has an excess of electrons, electrons jump from the fingertip to the Mylar and produce a circular spot of negative charge on the Mylar, centered on the spark (fine radial lines might be visible). If, instead, the person has become positively charged and has too few electrons, electrons break away from atoms in the Mylar, flow along forked lines to the spark point, and then jump from that point to the fingertip. The forked lines are left positively charged. So, if dusting the Mylar reveals a negatively charged circular spot, the person was negatively charged, and if it reveals positively charged forked lines converging to a point, then the person was positively charged. Some lightning victims have the forked-lines version burnt into their skin by the lightning.

Some scientific supply stores sell beautiful forked-line patterns that have been produced in small cylinders or slabs of Plexiglas. To produce the pattern, the Plexiglas sample is moved through the beam of an *electron accelerator* (a device that electrically accelerates electrons to a fairly high speed); the electrons stop within the Plexiglas and are trapped there. The Plexiglas is then (immediately) put on a grounded plate while a grounded, pointed conductor is pressed against the opposite side of the Plexiglas. The high concentration of electrons within the Plexiglas produces a fairly large electric field, especially at the pointed conductor where a spark occurs. The high temperature produced by the spark carbonizes the Plexiglas along the spark path, creating a conducting path. The electric field then extends from this path out into the rest of the Plexiglas. Sparking occurs along these new lines of electric field, producing more carbonized paths, until the electrons left by the accelerator are drained to the pointed conductor. The collection of carbonized paths forms the tree-like, branching structure seen inside the Plexiglas.

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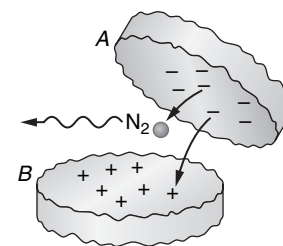
### 5.19 • Wintergreen glow in the closet

You and a friend first adapt your eyes to darkness for about 15 minutes in a closet or outside on a moonless night. Then have your friend chew a wintergreen LifeSaver candy (a candy in the shape of a marine lifesaver and infused with the oil of wintergreen) with the mouth as open as possible so that you can see inside. Why does each bite initially produce a faint flash of blue light, and why do later bites fail to produce the light? (If you don't want to eat the candy, squeeze it with a pair of pliers until it fractures.)

Why does tonic water have a faint blue tint?

**Answer** Whenever a bite breaks one of the mint's sugar crystals into pieces, the pieces will probably end up with different charges. Suppose a crystal breaks into pieces *A* and *B*, with *A* negatively charged and *B* positively charged (Fig. 5-3). Some of the electrons on *A* will then jump across the gap to reach *B*. Because air has moved into the gap after the crystal breaks, these electrons jump through air. Those that collide with nitrogen molecules in the air transfer energy to the molecules, exciting them. When the molecules de-excite, they emit in the ultraviolet range, which you cannot see. However, the wintergreen molecules on the surface of the candy pieces absorb ultraviolet light and then emit blue light, which you *can* see—it is the blue light coming from your friend's mouth. This process of absorbing light in one wavelength range (here, in the ultraviolet) and then emitting light in a longer wavelength range (here, blue light) is called *fluorescence*.

The quinine in tonic water is like wintergreen oil in that it absorbs ultraviolet light and then emits blue light, giving tonic water its faint blue tint. You can see the tint better if the tonic water is near a fluorescent bulb in an otherwise dark room. The quinine will then convert some of the ultraviolet light from the bulb into blue light. The effect is decreased if the illumination is through a plastic or glass wall such as with a bottle of tonic water, because plastic and glass absorb ultraviolet light. The effect is increased if you illuminate the tonic water with a black light (ultraviolet) lamp.



**Figure 5-3 / Item 5.19** Two pieces of a wintergreen LifeSaver candy as they fall away from each other. Electrons jumping from the negative surface of piece *A* to the positive surface of piece *B* collide with nitrogen molecules ( $N_2$ ) in the air.