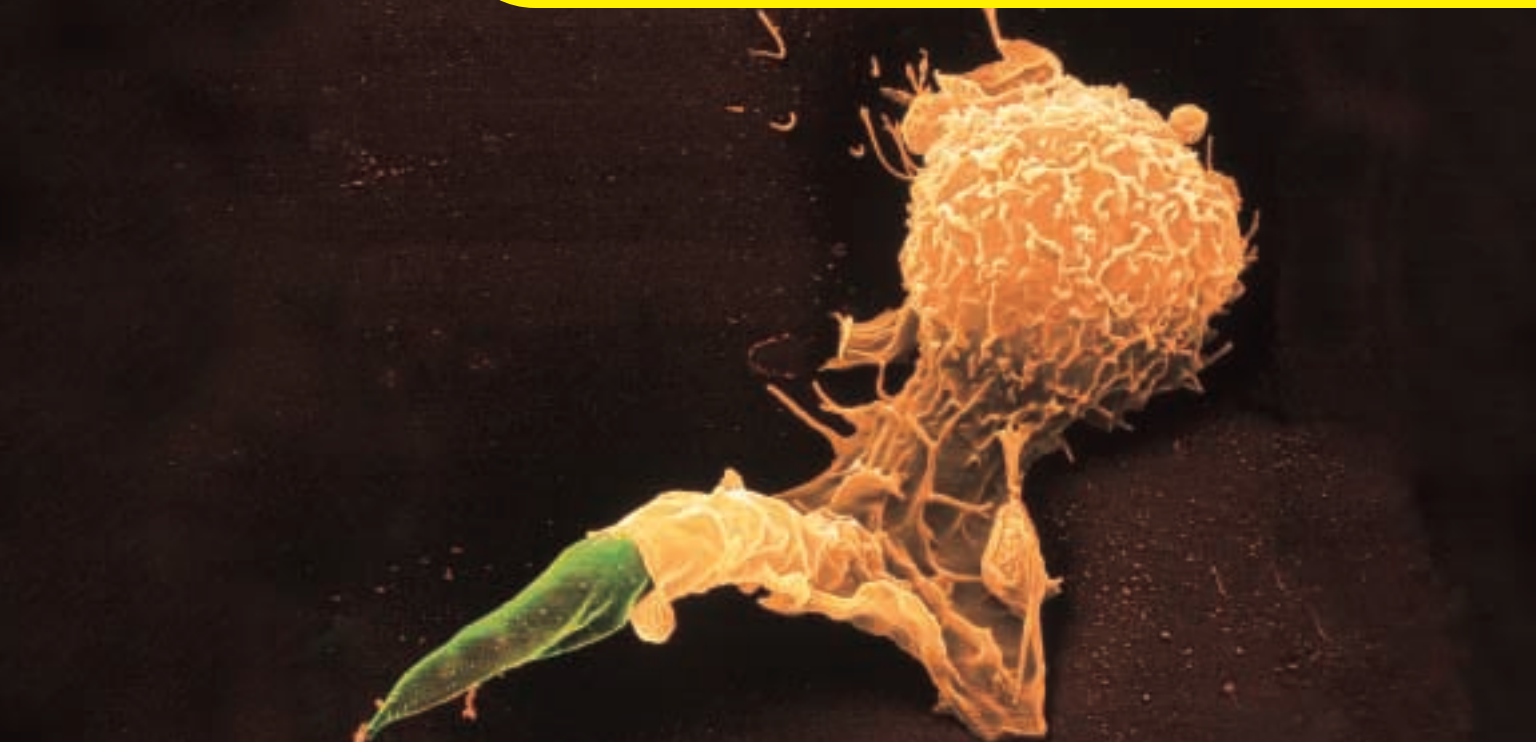
CHAPTER 18

Early Quantum Theory



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In the photograph above, a white blood cell is engulfing and destroying a parasite. This process, called "phagocytosis," is one way in which your immune system protects you from disease. The image of the white blood cell was formed not by light waves, but by electrons. Previously, you learned how light waves form images. You discovered that the wave properties of light made image formation possible. It would seem logical then, that in order for electrons to form images, they must behave like waves.

The idea that electrons, and all forms of matter, have wavelike properties was one of the concepts that shook the world of physics in the early 1900s. This discovery, along with the observation that light behaves like particles, helped form the basis of quantum theory — a theory that has permanently changed scientists' perception of the physical world. The early observations and concepts seemed so theoretical and distant from the everyday world that it was difficult to see any potential impact on the daily lives of non-scientists. However, out of quantum theory grew such technologies as electron microscopes, lasers, semiconductor electronics, light meters, and many other practical tools. In this chapter, you will follow, step by step, how and why quantum theory developed and how it influenced scientists' concept of the atom.

INVESTIGATION 18-A

Discharging an Electroscope

TARGET SKILLS

- **Hypothesizing**
- **Performing and recording**
- **Analyzing and interpreting**

In this investigation, you will use an electroscope to analyze the interaction between ultraviolet light and a zinc plate.

Problem

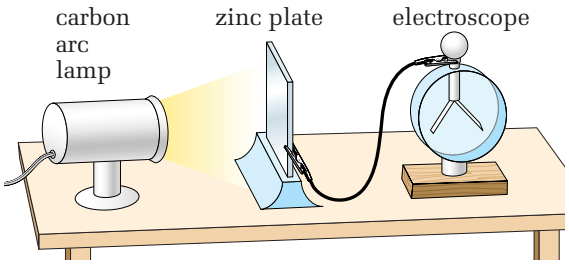
How can you discharge an electroscope when it is isolated from any source of electric grounding?

Equipment

- metal leaf electroscope
- carbon arc lamp (or source of intense ultraviolet light)
- insulating stand
- conducting wire with alligator clips
- zinc plate
- ebonite rod
- glass rod
- emery paper
- fur
- silk

Procedure

1. Polish the zinc plate with the emery paper until the plate shines.
2. Assemble the apparatus as shown in the diagram, leaving the lamp turned off. Ensure that the shiny side of the zinc plate faces the lamp.



3. Rub the ebonite rod with the fur to give the rod a negative charge.
4. Touch the ebonite rod to the sphere of the electroscope. Record the appearance of the electroscope.
5. Observe and record any changes in the electroscope over a period of 2 to 3 min.
6. Turn on the carbon arc lamp and observe and record any changes in the electroscope over a 2 to 3 min period.

CAUTION When the carbon arc lamp is on, do *not* look directly at the light or any reflected light. Ultraviolet light could damage your eyes.

7. Turn the lamp off. Touch the sphere of the electroscope with your hand to fully discharge the leaves.
8. Rub the glass rod with the silk to give it a positive charge. Touch the rod to the sphere of the electroscope.
9. Turn on the carbon arc lamp and observe and record any changes in the electroscope over a period of 2 to 3 min.
10. Turn the lamp off and discharge the electroscope.

Analyze and Conclude

1. Describe the exact conditions under which the electroscope discharged. For example, did it discharge when it was carrying a net negative charge or net positive charge? Was the carbon arc lamp on or off when this occurred?
2. Describe the conditions under which the electroscope did not discharge.
3. What entity had to escape from the electroscope in order for it to discharge?
4. Formulate a hypothesis about a mechanism that would have allowed the entity in question 3 to escape.
5. As you study this chapter, compare your hypothesis with the explanation given by physicists.