DISCOVERY OF INFRARED RAYS

TOPIC:

Infrared Radiation

SCIENTIST:

William Herschel 1738–1822

INTRODUCTION:

From the earliest times, people noticed that precious stones and fragments of glass produced bright colors when sunlight shone through them. It was not until the seventeenth century that Isaac Newton (see 1.034) investigated this phenomenon with his experiments using prisms. Newton showed that white light is made up of a spectrum of seven "pure" colors—red, orange, yellow, green, blue, indigo, and violet—that could not be split up any further. William Herschel took Newton's investigations a stage further. Herschel was a well-known astronomer and scientist at the beginning of the nineteenth century. Noting that the sun produces not just light but heat as well, he suggested that some colors in the light spectrum deliver more heat than others. He tested his hypothesis by splitting sunlight into its constituent colors using a prism and measuring the temperature of each color with a thermometer. Herschel made his crucial discovery, however, at the end of the experiment. He moved the bulb of the thermometer just past the red end of the spectrum and, to his surprise, instead of the temperature going down, as he expected, it actually increased. Herschel was not sure why this invisible region of the spectrum was hot, but he named it "infrared," meaning "below red" (in Latin, *infra* means below or farther down). It was another fifty years before scientists showed that infrared rays were very similar to light rays but did not produce the same image on the retina of the eye.

TIME NEEDED:

1 hour

MATERIALS:

Note: This experiment must be performed in a room that can be darkened, with a south-facing window; the bottom of the window should be no more than 3 ½ ft. above floor level.

- table, approximately 2 ½–3 ft. high, placed next to window
- glass prism, approximately 7 cm long x 4 cm wide x 3 cm high
- few styrofoam chips (as used for packaging goods)
- black construction paper (sufficient to cover any area of the window not covered by drapes or blinds)
- piece of white paper or cardboard approximately 30 cm x 20 cm
- masking tape
- thermometer (-10–100°C)
- metric ruler
- graph paper
- sharp pencil
- 2 ring stands with clamps
- convex lens, 5–6 cm diameter

Original Materials:

Herschel would have used a more primitive form of thermometer, probably one filled with alcohol.

Safety Precautions

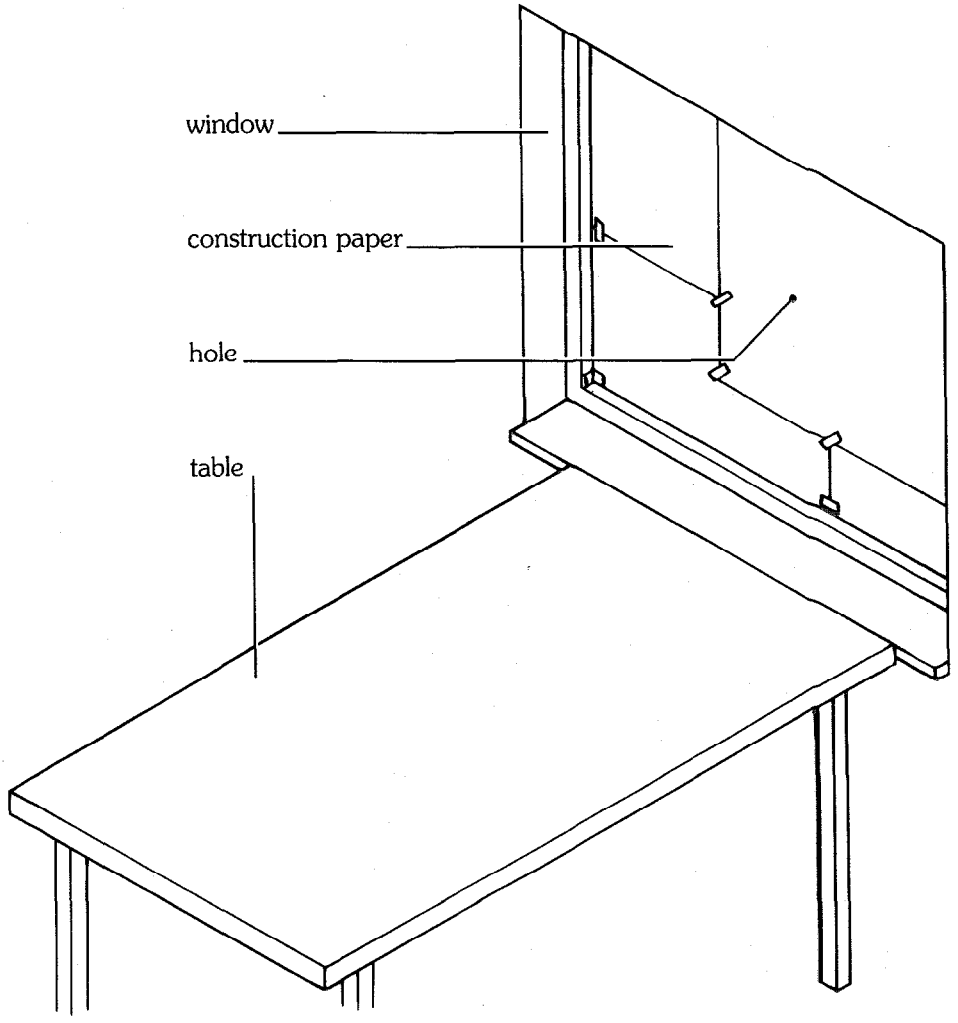
Please read and copy the safety precautions at the beginning of this book.

PROCEDURE:

Note: This experiment should be done on a warm, sunny day when the sun is shining through the chosen window. Because all rooms are different, the experimenter should use her/his common sense in applying the general instructions below to the particular room chosen for the experiment.

1. Take a sheet of black construction paper and lay it flat on the table. Make a small hole with the pencil point near the center of the sheet.
2. Hold the construction paper against your chosen window and secure it in position using masking tape at the corners (see figure 1). Apply the masking tape to the window lightly so that it can be removed easily later.

Figure 1



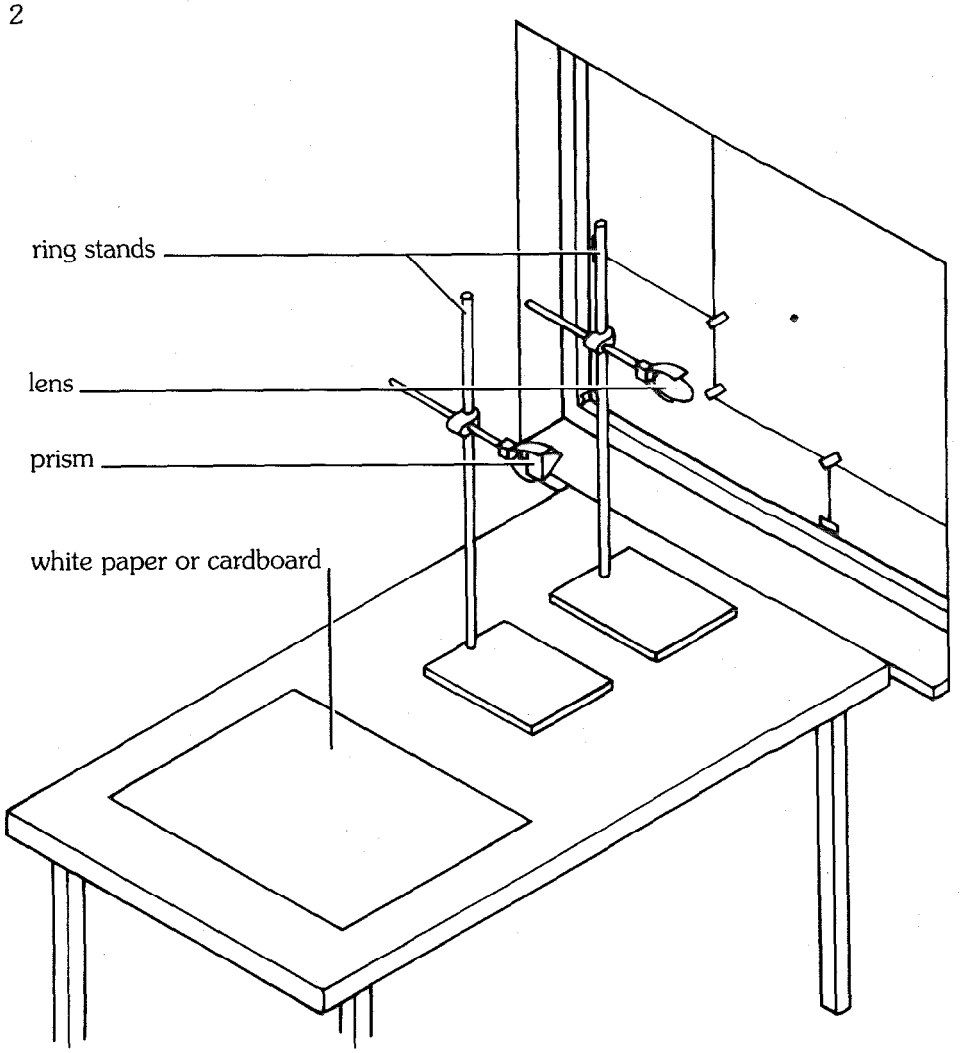
3. Cover the rest of the window with black construction paper, gently taped to the edges of the window and to the sheet of paper with the hole. Close any blinds or drapes so that the only light that can come through that window is through the hole in the paper.
4. Put one of the ring stands on the table next to the window. Adjust the clamp so that it is level with the hole. Carefully clamp the convex lens in the upright position.
5. Put the second ring stand next to the first with its clamp at the same level. The first ring stand should be between the window and the second ring stand.
6. Carefully clamp the prism in place so that its apex is pointing vertically. Use small styrofoam chips in the jaws of the clamp to ensure that the prism is not damaged when the clamp is tightened.

7. Position the sheet of white paper or cardboard flat on the table next to the second ring stand so that paper, ring stands, and window are in a straight line.

8. Darken the room by turning off any lights and closing the drapes or blinds on any other windows.

9. Adjust the clamps and ring stands so that light is focused by the lens onto the prism, which in turn projects a concentrated spectrum onto the white paper (see figure 2).

Figure 2



10. Hold the bulb of the thermometer in the violet band of the spectrum. When the temperature has stabilized, record the color of the band and its temperature.

11. Repeat step 10 for the other bands—blue, green, yellow, orange, and red—of the spectrum.

12. Now move the thermometer beyond the red end of the spectrum and repeat step 10.

ANALYSIS:

1. Make a graph plotting color (including beyond red, or infrared) along the horizontal axis against temperature along the vertical axis.

2. Describe what the graph shows. Is there any evidence for a band of "invisible radiation" beyond the red end?

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO EXPERIMENTERS

Each experiment includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are performing the experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each experiment you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not say BE CAREFUL WITH HOT LIQUIDS or DON'T CUT YOURSELF WITH THE KNIFE does not mean that you should be careless when simmering water or stripping an electrical wire. It does mean that when you see a special note to be careful, it is extremely important that you pay attention to it.

If you ever have a question about whether a procedure or material is dangerous, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:
—Clear all surfaces before beginning experiments
—Read the instructions before you start
—Know the hazards of the experiments and anticipate dangers

PROTECTING YOURSELF:
—Follow the directions step-by-step; do only one experiment at a time
—Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eye wash, and first-aid kit
—Make sure there is adequate ventilation
—Do not horseplay
—Wear an apron and goggles
—Do not wear contact lenses, open shoes, loose clothing, or loose hair
—Keep floor and work space neat, clean, and dry
—Clean up spills immediately
—Never eat, drink, or smoke in laboratory or work space
—Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

USING EQUIPMENT WITH CARE:
—Set up apparatus far from the edge of the desk
—Use knives and other sharp or pointed instruments with caution
—Pull plugs, not cords, when removing electrical plugs
—Don't use your mouth to pipette; use a suction bulb
—Clean glassware before and after use
—Check glassware for scratches, cracks, and sharp edges
—Clean up broken glassware immediately
—Do not use reflected sunlight to illuminate your microscope
—Do not touch metal conductors
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders

USING CHEMICALS:
—Never taste or inhale chemicals
—Label all bottles and apparatus containing chemicals
—Read labels carefully
—Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves)
—Do not touch chemical solutions
—Wash hands before and after using solutions
—Wipe up spills thoroughly

HEATING SUBSTANCES:
—Use goggles, apron, and gloves when boiling water
—Keep your face away from test tubes and beakers
—Never leave apparatus unattended
—Use safety tongs and heat-resistant mittens
—Turn off hot plates, bunsen burners, and gas when you are done
—Keep flammable substances away from heat
—Have fire extinguisher on hand

FINISHING UP:
—Thoroughly clean your work area and glassware
—Be careful not to return chemicals or contaminated reagents to the wrong containers
—Don't dispose of materials in the sink unless instructed to do so
—Wash your hands
—Clean up all residue and put in proper containers for disposal
—Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES