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INTRODUCTION

Though my soul may set in darkness, it will rise in perfect light,
I have loved the stars too fondly to be fearful of the night.

—Unknown—an old astronomer to his pupil (Galileo)

Astronomical! 44 Activities, Experiments, and Projects is a resource book for four major areas of study:

basic astronomy
a star's life
the planets
the atmosphere

The activities and demonstrations in this book can be done in a classroom setting during the day by using readily available materials.

This classroom resource also features five activities with reproducible pages:

- Make a Star Finder (planisphere): pages 9–11
- Learn the circumpolar constellations: pages 14, 15
- Learn the winter constellations: pages 18, 19
- The orbit of Halley's Comet: page 74
- Sun vocabulary and poetry: page 83

Just turn the page to embark on an exploration of the grandeur and mystery of the cosmos. With this book in hand, the universe will be your home!

CHAPTER TWO

A STAR'S LIFE

23. Star Birth

> *The heavens declare the glory of God and*
> *the firmament proclaims his handiwork.*
>
> —Psalm 19

In the constellation of Orion, a line of faint stars make up the sword hanging from the Mighty Hunter's belt. Even with the naked eye, one of the stars in the middle of the sword has a fuzzy appearance. This "star" is not a star at all; it's a huge cloud of molecules of gas and dust, some 15 light-years across, called a nebula. Star formation is actively taking place in the Great Orion Nebula and many young stars are found in this area. All are unstable, with the result that their light output varies rapidly in an irregular manner.

The problem with the molecular cloud is that the gas and dust are so dense that astronomers have not been able to see what's going on inside it. But now astronomers can see into the nebula using the light of infrared or heat radiation.

Using a new British telescope, the James Clark-Maxwell Telescope, or JCMT, astronomers have been able to tune into groups of molecules deep within the gas and dust clouds. Mauna Kea in Hawaii is at an especially high altitude—4,145 m (13,600 feet)—and the air is very dry. Since water vapor blocks infrared, the telescopes at Mauna Kea are especially suitable for infrared work.

By observing heat sources embedded within the gas and dust of the nebula, scientists have succeeded in putting together the story of star formation. Dust and gas clouds start to collapse and condense into a number of cores. Within the cores, molecules of gas and dust contract further because of the gravity pulls of the gas and dust molecules upon one another. The JCMT infrared telescope revealed these stars which become hotter and hotter as they shrink and more material clumps onto them. Temperatures at the center of the contracting masses rise to 15,000,000°K, which is high enough to start the thermonuclear or hydrogen bomb activity in the core. The ignition of the nuclear fires marks the moment of birth. The radiation pressure of the hot gases pushing outward now balances with the pull of gravity inward and the young protostar stops contracting.

Remnants of the original dust cloud still surround the young star; out of this swirling mass, planets may form. Violent winds may blow away from the young star, dispersing the remaining nebula into space.

The Power of Attraction

You can demonstrate how particles condense or clump together when an attractive force acts on them.

What you need: sodium thiosulphate (hypo); test tube; water; burner; piece of clear glass or plastic; iron filings; magnets; horseshoe magnet if available; books; plastic comb; puffed rice or puffed wheat, crushed to powder

Solidifying solution

1. Dissolve 25 grams of hypo crystals in as little water as possible. Heat to boiling, then set aside to cool. To witness molecules clumping together, give the test tube a sharp tap on the side. What do you see taking place? If the solution is truly supersaturated, it should all clump together or solidify at once. If this does not take place, your solution is too dilute and you need to reheat it to boil off some of the water.

2. Lay the piece of glass or plastic on the books as in Figure 1. Sprinkle the iron filings evenly over the glass.

   Bring one end of a magnet under the glass (Figure 2). Describe how the iron filings behave. Do they come together or condense? Do they form clumps? Try moving the magnet around. Do the clumps grow in size? How is this like the particles in nebulae far out in space forming clumps because of an attractive force acting on them? Try this using a horseshoe magnet as well.

Model of collisions between gas clouds

1. Try using two magnets as shown in Figure 3. Bring the "clouds" together. How is this like nebulae, giant clouds of gas and dust, colliding in space? How do you think this might favor star birth?

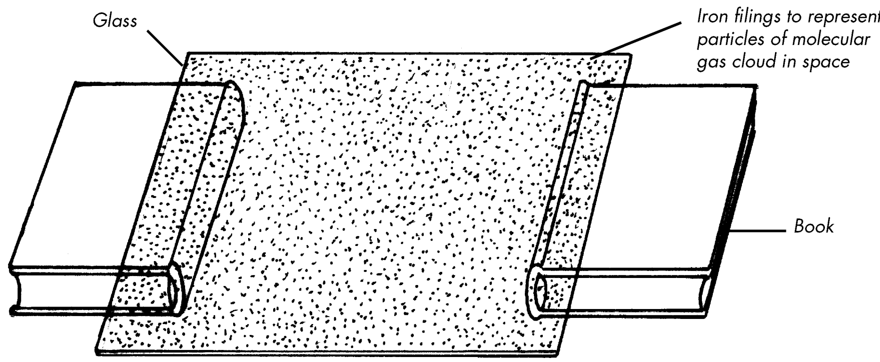

Figure 1. A model of gas clouds in space

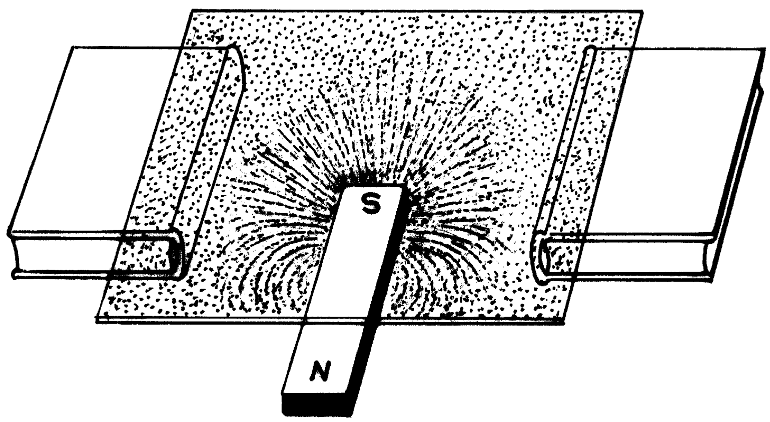

Figure 2. A demonstration of attractive forces on particles

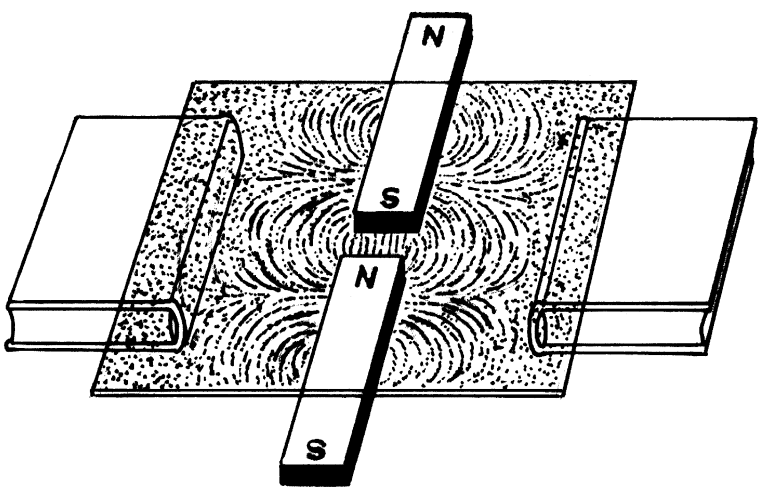

Figure 3. A model of colliding nebulae

2. Pass a comb several times through your dry, un-oiled hair, then hold it over the crushed cereal. Describe what takes place. Could this be like particles in a nebula attracted together? (Do this experiment on a dry, cold day in winter. It will not work when humidity is high.)

3. How do your experiments help you to picture star birth when clouds of gas and dust condense far out in space due to gravity?

24. The Sun As a Star

The sun is a great sphere of glowing gases at very high temperature (Figure 4). It is the source of all life. Without its light and heat, nothing would grow, not a creature could exist.

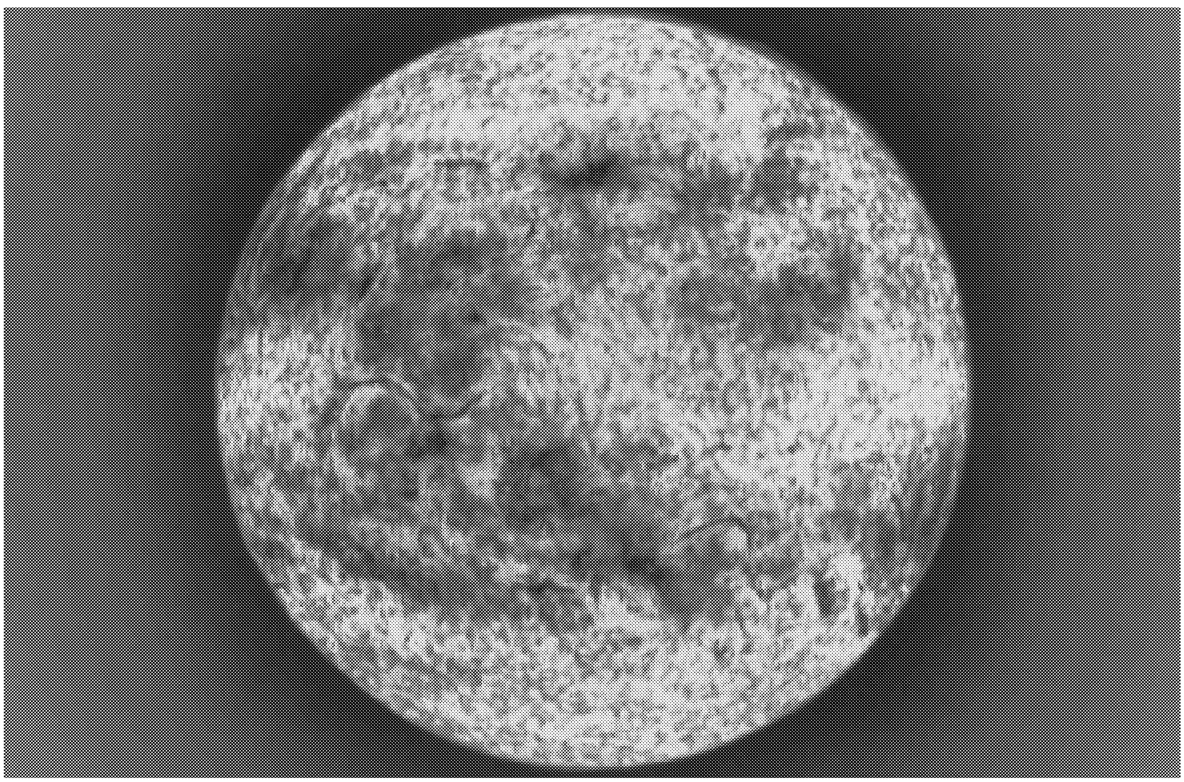

Figure 4. Although the chemical constitution of the sun is similar to that of Earth, it is so hot that it remains completely gaseous.

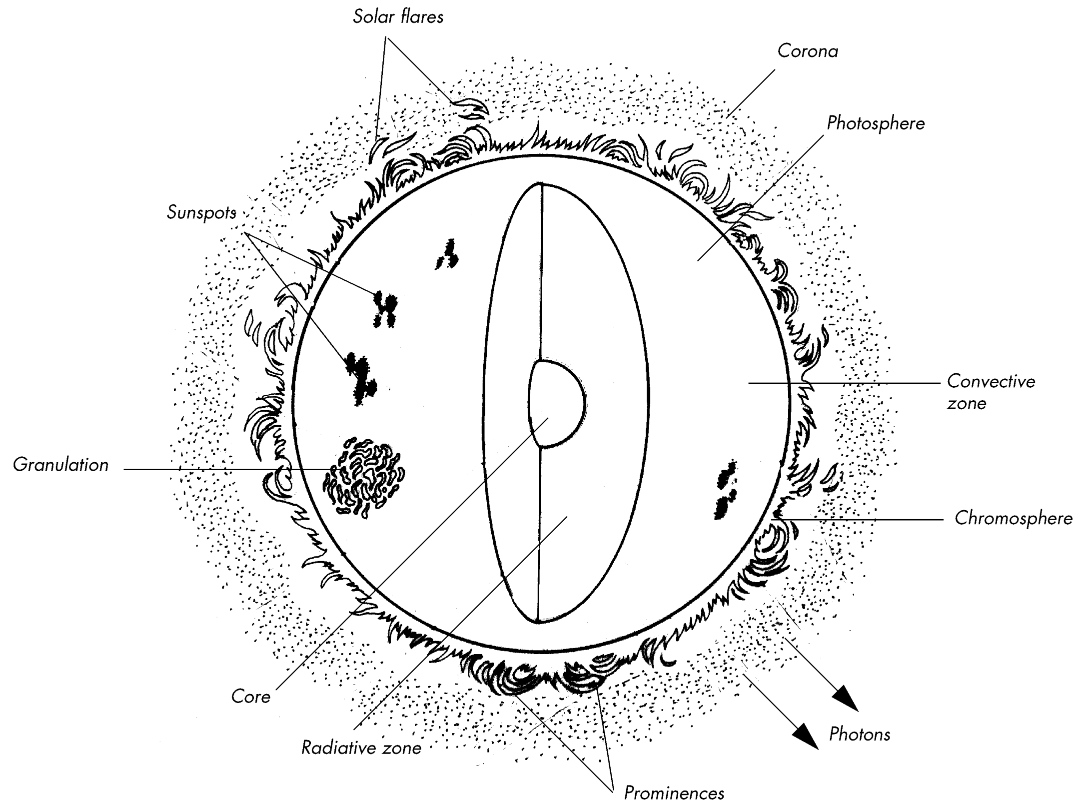

Figure 5. The sun's structure

Using an instrument known as a spectroscope, scientists have discovered the presence of enormous quantities of hydrogen and helium in the sun. When four hydrogen atoms fuse together, a helium atom is formed. The mass of the helium atom so formed is slightly less than that of the four parent hydrogen atoms. The mass that seems to be lost changes into energy. This is the source of the sun's tremendous energy. Measurements show that, during nuclear explosions, the temperatures developed are the same as those of the sun. In this furious process, scientists estimate the sun's loss of mass at over four million tons per second. Yet the sun is likely to maintain its temperature for another 35 billion years without noticeable loss.

The corona is the outer part of the sun's atmosphere (Figure 5). Seen during an eclipse, it reaches millions of kilometers into space. Its temperatures are about 2,000,000°K, the hottest observable temperatures in the universe. The chromosphere lies below the corona and can be seen during solar eclipse. It is red in color and is mainly hydrogen gas. The photosphere is the bright surface of the sun. Its temperature is 6,000°K. In the convective zone, gases whirl about. In the sun's core at temperatures near 15 million°K, nuclear reactions take place, the energy passing outward through the radiative zone.

Sunspots are great storms that rage furiously on the sun. They usually appear first in pairs towards the high latitudes, then more appear closer and closer to the sun's equator. With time the spots begin to die away; then the next cycle begins again in the higher latitudes. On an average the complete cycle takes about $11\frac{1}{2}$ years. Sunspots are related to periods of increased solar activity, which have a marked effect on the earth's environment. Solar prominences are great clouds of incandescent gas that shoot out 300,000 km from the sun's surface, then curve gracefully back into the sun's disc. Strong magnetic fields may be involved. Solar flares, sudden brilliant outbreaks that occur near sunspots, are also related to the sunspot cycle. From the flares, great eruptions shoot out 500,000 km from the sun at speeds of 400,000 km per hour.

Seen through a modern solar telescope, the sun's surface appears grainy, the granules changing in brilliance as you watch them. Each granule is about 1,000 km across and represents gas bubbling up over the sun's surface like water boiling in a kettle. Great outbursts on the sun—sunspots and solar flares—result in increased output of X-ray and ultraviolet radiations. These enter our atmosphere and interfere with long-distance communications. Scientists today are sending instruments aloft in rockets and satellites in order to solve some of these problems of electrical communication. The signals radio telescopes receive from the sun may reveal some of the sun's secrets and how it is able to influence the earth.

Radiation as a Source of Energy

What you need: hand magnifier; sheet of paper; fruit can; camphor or candle; three pots with potting soil; peas

1. Hold the hand magnifier in bright sunlight with a sheet of paper behind it. Move the paper to and fro until there is a bright spot on it. All the sunlight which falls on the lens is brought to this spot. Try using a bigger hand magnifier. Is the spot brighter? Explain why. What happens to the paper? What rays of the sunlight does the lens concentrate at the spot?

2. Take the fruit can and hold it over a piece of burning camphor, which burns with a very smoky flame (or use a burning candle). In this way, coat the sides of the can with soot. Then add water to fill the can and place in the sunshine. After an hour or so, put your hands in the water. What can you say about the temperature? How has heat been gained? Repeat the experiment using a shiny can. Which can is the better absorber of the sun's heat? Explain why.

3. Plant five or six pea seeds in the soil of each pot. Put one pot where it gets sunlight, stand a second in a dark corner, and put the third in a cupboard where it gets no light at all. Which seeds show the best growth? What do you notice about the ones in the dark corner?

Name ______________________________ Date ______________________

Talking About the Sun

1. Choose the correct words from the list to complete the paragraph about sunspots; write them in the spaces provided.

ultraviolet	eleven	dark
high	equator	long-distance
eruptions		

Sunspots are giant ____________________ on the sun's surface. Being less bright than the rest of the sun's disc, they appear as __________________ areas. Sunspots generally appear in the sun's ________________________ latitudes. Then more appear toward the sun's ____________________. They occur in cycles every ____________________ years or so. Sunspots shoot into space vast quantities of charged particles called ions and electrons, as well as _________________ radiation. Sunspots interfere with ________________ communication. They also cause the aurora of the polar regions.

2. "Give me the splendid silent sun with all his beams full-dazzling,
Give me juicy autumnal fruit ripe and red from the orchard."

These lines are by the poet Walt Whitman. He sees the majesty of the sun in the sky. To him the sun meant life and light and the wonder of all growing things.

Write some lines of your own in which you express the same ideas.

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25. Hot Breath of a Red Giant

In about five billion years the sun will have used up the hydrogen at its core and will enter the red giant stage of its life history. As the core compresses due to gravity, heat will be generated. This will set the hydrogen in the surrounding layers burning. The sun will balloon out into a bloated red giant 40 times its present size. Mercury, Venus, and Earth will be destroyed as the sun swells to beyond Earth's orbit.

The hot breath of the red giant will affect the outer planets and their moons. Europa, Callisto, and Ganymede, orbiting Jupiter 770,000,000 kilometers from the sun, will have kept their frozen cover during the sun's colossal outpouring of energy. But as the sun enters the red giant stage, the ice-covered moons will begin to melt. If the ice of Europa is pure water-ice, it will take hundreds of millions of years to melt. If the ice is a water-ammonia mix, it will melt sooner as its melting point will be lower. Once the ice crust on Europa has melted, the moon will be covered by fog and cloud drifting across a vast expanse of water.

Because a red giant is so swollen, the outer layers of gases are very thin and the surface density is very low. By contrast, the core of a red giant is very dense and hot. Gases escape from the surface of the red giant and drift off into space. Red giants are cool stars with surface temperatures of around 3,000°K (Figure 6).

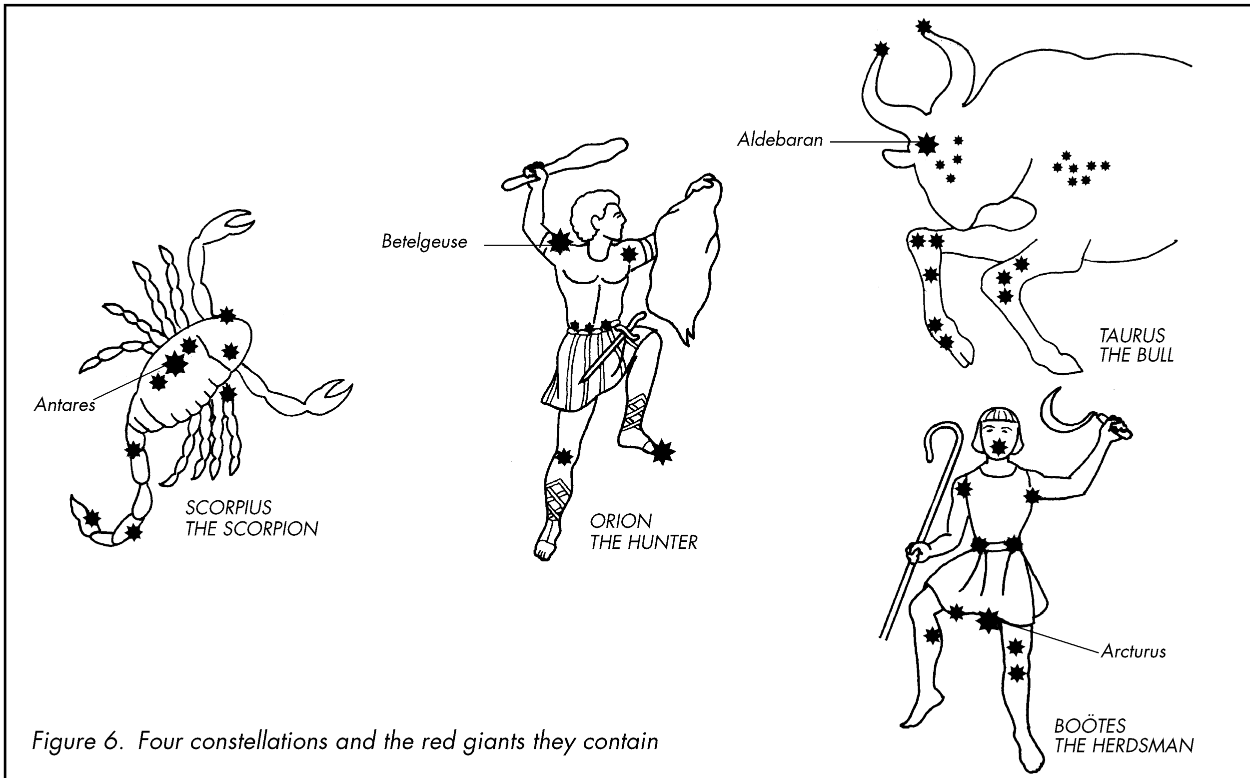

Figure 6. Four constellations and the red giants they contain

Expanding Gas

In this experiment you will show how heat expands gases and sets up movements in gases, and you will see how this is important in the red giant stage of a star's life.

What you need: medicine dropper or small bottle; wood ash, chalk dust, or talcum powder; hot water; convector heater or reading lamp; two paper bags; thread; stick; adhesive tape; candle; matches; wire

1. Make a wire holder for the dropper and place it under hot water, or use the small bottle (Figure 7). What do you see? What is the effect of heat on the gases of air in the dropper or bottle? Is the density of the gas different? If so, how?

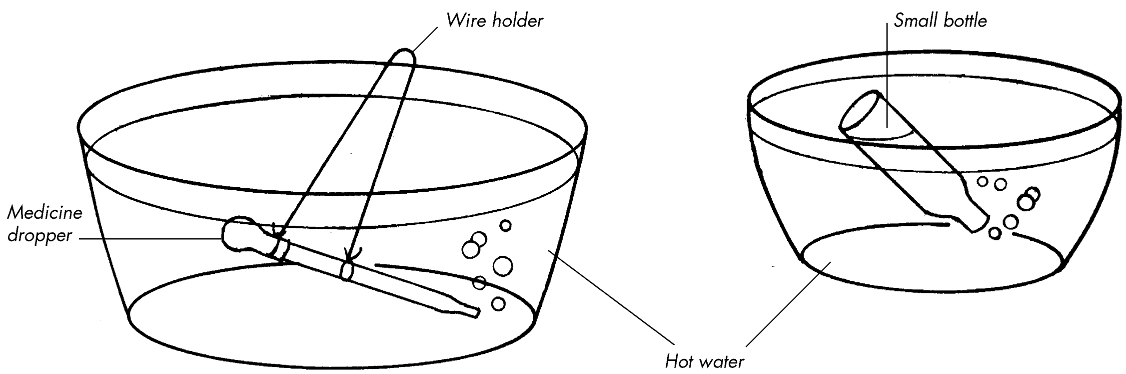

Figure 7. Heat expands gases

2. Sprinkle some wood ash, chalk dust, or talcum powder above a convector heater or reading lamp. Watch the tiny particles; what do you see them doing? What does this tell you about the effect of heat on particles of air (Figure 8)? How could this be like the particles in the outer layers of gases in a red giant?

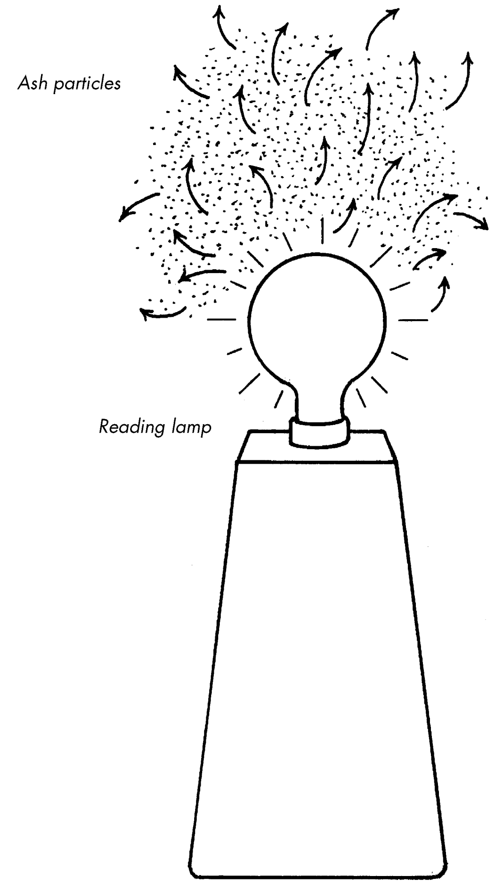

Figure 8. Heat sets up movement in gases

3. Arrange the stick and paper bags as in Figure 9, making sure they balance.

4. Hold one bag steady and bring the lighted candle below it. What does the heat of the candle do to the gases of air in the bag?

5. Now take away the candle and release the bag. What happens? How is the bag able to overcome gravity? How has heat affected the air in the bag? Can you relate this to what happens in a red giant?