Look, Up in the Sky!

THE SOLAR SYSTEM AS SEEN FROM EARTH

by Henri Picciotto

INTRODUCTION

The Solar System is our home. The Sun, the Moon and several planets are there for us to see, yet most of us have lost touch with them. This kit provides an open-eyes, hands-on, and discovery-based approach to this subject, with the help of:

* A Teacher's Manual outlining 19 lessons.
* Reproducible pages for the students.
* The materials needed to carry out the activities.

OBJECTIVES:

The objectives are clearly stated at the beginning of each lesson.

* First, through observation and record-keeping, the students become familiar with the behavior of the Solar System as seen from Earth.
* Later on, they achieve a more sophisticated understanding of the system through the building of models.

With the help of this manual, the teacher guides the students' discoveries.

GRADE LEVELS:

Most of the activities in this kit have been developed and tested in grades 4 and 5. Much of the material is unfamiliar to older students and adults, and so can be taught in middle school or junior high.

A few lessons may be too difficult for some fourth and fifth grades. There is a note at the beginning of each lesson, indicating whether it is geared to grades 4 and up, or primarily to grades 6 and up.

SCHEDULING:

The activities in this kit should be spread over seven weeks or more, with up to three lessons a week. Many activities will take a class period of approximately 45 minutes, and can happen at the time you have scheduled for science. In addition, you will need to assign a small amount of homework every day, and to allot a few minutes daily to discuss it.

The observational activities must be timed to correspond to astronomical conditions, such as the phase of the Moon or the presence of planets in the evening sky. They are also contingent on the availability of clear skies. To teach observational astronomy, you must be flexible in your scheduling!

ORGANIZATION:

The 19 lessons are spread over 7 weeks. It may be necessary to take longer to cover them, because of weather conditions or other reasons. However, do not teach any lesson too early: enough time must elapse between lessons to give the students a chance to make and record enough observations.

The Solar System is a "system" and your students will learn most if you do all the lessons in the order suggested. The skills and concepts overlap and reinforce each other. The organization of the lessons is based on an appreciation of the developmental needs of young people when grappling with the rather overwhelming concepts of astronomy. In many ways, this parallels the history of the field: from naked eye observation (Lessons 1 through 9), to optically aided observation (Lesson

11), to increasingly elaborate models (Lessons 12 through 19).

However, if you want to do less than the whole ~~unit~~ book, you can choose among the following subtopics:

* The Moon (short course): Lessons 1, 8, 13, 17.
* The Moon (full course): Lessons 1, 5, 6, 8, 9, 13, 14, 16, 17.
* The Sun (short course): Lessons 2, 4, 7.
* The Sun (full course): Lessons 2, 4, 7, 18, 19.
* The night sky: Lessons 3, 6, 9, 11.
* Making models: Lessons 12, 13, 14, 15, 18, 19.
* Astrology: Lesson 10.

PREPARATION:

Before you start teaching the units, familiarize yourself with the kit. Look over this manual and the student sheets. When possible, do the activity yourself before asking the students to do it.

To complement the observational, experimental and discovery-based learning offered by this kit, you should make relevant books and magazines available to your students. A visit to your public or school library, or to a museum bookstore will reveal many excellent children's books on astronomy. See also the bibliography at the end of this Teacher's Manual.

STUDENT SHEETS:

Twenty-four sets of the student sheets are included in each class set. If you do not purchase the set, you can duplicate the sheets included in this kit.

The student sheets do not constitute a textbook. They are just one component in an integrated package. This Teacher's Manual explains how each student sheet fits in this program.

MATERIALS:

Included in Basic Kit:

...

Included in Class Set:

...

To be provided by you:

...

REFERENCES:

To teach the observational lessons, you must have information on what's up in the sky on any given night or day. There are many ways to find out. I recommend two inexpensive tools:

* The DAILY PLANET ALMANAC is packed with astronomical information you will need, including the time of sunrise, sunset, moon rise, moon set, and the phase of the Moon for every day of the year.

* The SKY CALENDAR is designed with you, the teacher, and your students in mind. It features a beautifully simple monthly star chart and a daily description of notable celestial events, including the position of the Moon, and plenty of planet information. You will find it a tremendous help in planning your students' observational homework.

Use these references to prepare your lessons and assignments, but do not feel you need to necessarily show them to your students.

Other good sources of information on the sky are ASTRONOMY and ODYSSEY magazines. They feature monthly information on the sky, complete star charts, gorgeous photographs, interesting activities, and telescope tips. Back issues are great for students to browse through when looking for information on astronomy.

NOTE ON LATITUDE:

Many lessons in this kit, like the references mentioned above, assume that you are in the Northern hemisphere. In fact some comments are only accurate if you live between the Tropics and the Arctic Circle. (This need not~~, and should not,~~ be discussed with the students.)

The kit can be used anywhere in the contiguous 48 states.

DISCOVERY TEACHING:

In addition to learning about the Solar System, your students will be learning about the scientific method. The science of astronomy involves the interplay of observation and modeling. For this process to happen in your classroom, you will need to gather a lot of observational data, record it, save the records, discuss them, and draw conclusions. (The records of your own observations can be included among the information accumulated by the students.) Later, you will make models that will throw light on the data you accumulated.

Accept your students observations, even if they seem inaccurate. As the data accumulates, it becomes obvious that certain observations are mistaken, and the students will discard them. The following anecdote illustrates the kind of learning process that can take place while carrying out the activities.

One morning, only two students saw the Moon. Both saw it in the East, but while one of them said it was full, the other saw only a crescent. I accepted both observations, neutrally. Later, by comparing these sightings with the ones made the following and previous days, it became clear to the class that the crescent was more likely. Later still, the students realized that the Full Moon always rises when the Sun sets, and sets when the Sun rises. (In other words, it is never visible during the day -- particularly in the East.) Still later, some students saw the Sun shining through the fog during recess. It looked like the Full Moon to some of them. As the fog cleared, everyone agreed that it was the Sun and not the Moon, and someone pointed out that this may have been the source of the erroneous "Full Moon" sighting. The mystery of the two conflicting observations was solved and the students learned a lot. In contrast, not much would have been gained if I had "taken sides" with one sighting and against the other.

In the course of carrying out the activities, the students' understanding grows, and they are more open to genuine learning of concepts. The written activities at the end of the units can serve to clarify and summarize what was learned. Class discussions should also be used for the same purpose.

A lot can be learned about the Solar System using a very limited amount of instrumentation and almost no calculations. Much of that knowledge is accessible to your students. A solid grasp of "flat earth" astronomy, and then of Sun-centered astronomy, is a foundation on which to build a more sophisticated understanding.

INVOLVING GIRLS:

The activities in this kit can involve boys and girls equally. Do not assume that because boys are "into spaceships" that girls will not be interested in astronomy. In my classes I have found that some of the most enthusiastic Moon-starers are girls. While some boys are better model-builders, some girls are neater and more accurate observers and record-keepers. All these skills are important in learning astronomy --all your students can participate and contribute.

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SKY CALENDAR AUGUST 1984

An aid to enjoying the changing sky

CURRENT SKY INFORMATION: Call (517) 332-STAR

Use this scale to measure angular distances between objects on diagrams below. 0° 10° 20°

PLANETS (in evening): **VENUS** sets early, so look soon after sunset. On Aug 1 Venus is 13° upper left of setting sun and sets in WNW 40 min after sundown. By Aug 31 it improves to 21° upper left of sun and sets in W 50 min after sundown. **MERCURY** on Aug 1 is 15° upper left of Venus; use binoculars. Mercury quickly fades and gets lower each day. By Aug 10 it sets 10° to left of Venus. **THREE BRIGHT OUTER PLANETS** are easy; locations in mid-twilight, about ¾ hour after sunset: **JUPITER**, brightest, is in SSE to S. **MARS**, next in brightness, is reddish in SSW. Antares is fainter than Mars and to its left; see diagrams. **SATURN** is yellowish in SW, to right of Mars and upper left of Spica.

Wednesday 1 — Evening (mid-twilight): Spica • Moon (WSW)

Thursday 2 — Evening: • Saturn, Moon, • Spica (SW)

Friday 3 — Mars, Alpha Librae, Saturn, Moon at First Quarter. Aug 3, evening: Moon occults Saturn from southern S America. (SSW, SW)

Saturday 4 — Moon, Mars, Alpha Librae, •Saturn. Aug 4, evening: (SSW, SW)

Sunday 5 — Moon, Mars, Antares. Sunday Aug 5, evening: (SSW)

Monday 6 — Moon, Antares. Monday Aug 6, evening: (S)

Tuesday 7 — Tuesday and Wednesday evenings, Aug 7 and 8: Jupiter, Moon Tues 7, Moon Wed 8, TEAPOT (SSE)

Wednesday 8 — This morning and tomorrow, there is a brief interval of dark moonless sky, good for viewing the Perseid meteors. Look after moonset and before morning twilight, 2-3 hours before sunup today.

Thursday 9 — This is the last morning with a dark "window" for seeing the Perseid shower, without interference from moonlight or twilight. Observe from a dark site two hours before sunrise.

Friday 10 — Moon rises at about sunset tonight and remains in view until nearly sunrise tomorrow. Too bad for the Perseids!

Saturday 11 — Full Moon rises shortly after sunset. Perseid meteor shower, at maximum late tonight, will be spoiled by bright moonlight. See Aug 8 and 9.

Sunday 12 / Monday 13 — Antares, Mars, Alpha Librae, Saturn, Spica. Sunday Aug 12, evening: (SSW, SW)

Tuesday 14 — With each passing night, Mars appears ½° farther east. Look nightly, and watch for next week's interesting conjunction.

Wednesday 15 — Evening: Antares, Mars (SSW). See star map on reverse side for tonight's positions of Jupiter and Saturn.

Thursday 16 — Moon now rises after end of twilight, allowing dark evening skies and excellent Milky Way viewing.

Friday 17 — Have you seen Sirius yet in morning sky? Look very low in ESE 45 minutes before sunup, below Orion.

Saturday 18 — Evening: Antares, Mars (SSW)

Sunday 19 — Morning (mid-twilight): Pleiades, Moon approaching Last Quarter, Hyades, Aldebaran

Monday 20 — Morning: Pleiades, Moon, Hyades, Aldebaran

Tuesday 21 — Evening: Antares, Delta Sco, Mars (SSW). Mars 0.4° S of Delta Scorpii — a pretty sight for naked eye and binoculars.

Wednesday 22 — Regulus in conjunction (beyond Sun) today. In early September it will emerge into morning sky, near Mercury. See next month's *Sky Calendar*.

Thursday 23 — Morning: Castor, Pollux, Moon, Procyon (E)

Friday 24 — Morning: Castor, Pollux, Moon (ENE, E)

Saturday 25 — Morning: Old Moon (ENE, E)

Sunday 26 — New Moon Sunday Aug 26 3:26 p.m. EDT (12:26 p.m. PDT). This is the only date this month the Moon can't be seen.

Monday 27 — Monday Aug 27, evening: Spica, Venus, Young Moon (WSW, W)

Tuesday 28 — Mercury at inferior conjunction, between Earth and Sun. Evening: Moon, Venus (W)

Wednesday 29 — Evening: Moon, Spica (WSW)

Thursday 30 — Evening: Saturn, Alpha Lib, Moon, Spica (SW, WSW)

Friday 31 — Mars, Antares, Moon, Saturn, Alpha Lib. Fri Aug 31, evening: (SSW, SW)

In Sept *Sky Calendar*: Mars passes "rival of Mars" and approaches Jupiter. Venus overtakes Spica and approaches Saturn. Mercury excellent in morning. To subscribe, see information below.

Robert C. Victor, Jenny L. Pon, Robert D. Miller

Subscription: $5.00 per year, from *Sky Calendar*, Abrams Planetarium, Michigan State University, East Lansing, Michigan 48824-1324.
ISSN 0733-6314

Magnitudes: Venus −3.9; Jupiter −2.6 to −2.4; Mars −0.4 to 0.0; Mercury (Aug 1) +0.5; Saturn +0.6 to +0.7; Uranus 5.6; Neptune 7.9. **Motions Aug 1 - Sept 1:** The Sun, going 30° east, crosses from Cancer into Leo Aug 10. **Mercury** on Aug 1 is 27° E of Sun; see Aug 28. **Venus** improves from 13° to 21° E of Sun, and ends August 24° W (lower right) of Spica. **Mars** goes 16° E, from Libra through head of Scorpius (see Aug 21) into Ophiuchus. On Aug 31 Mars is 2.7° NW of Antares. The planet will pass only 2¼° N of that star Sept 3. **Jupiter** goes 1.3° W until ending retrograde 4° NW of 3rd-mag Lambda Sagittarii (the top of the Teapot) on Aug 29. **Saturn** goes 1.6° E, ending month 4° NW of 3rd-mag Alpha Librae (Zubenelgenubi). **Uranus:** Locate 4.5-mag Omega Ophiuchi 5° N of Antares. Uranus is a magnitude fainter, and within 0.5° south and slightly east of Omega all month.

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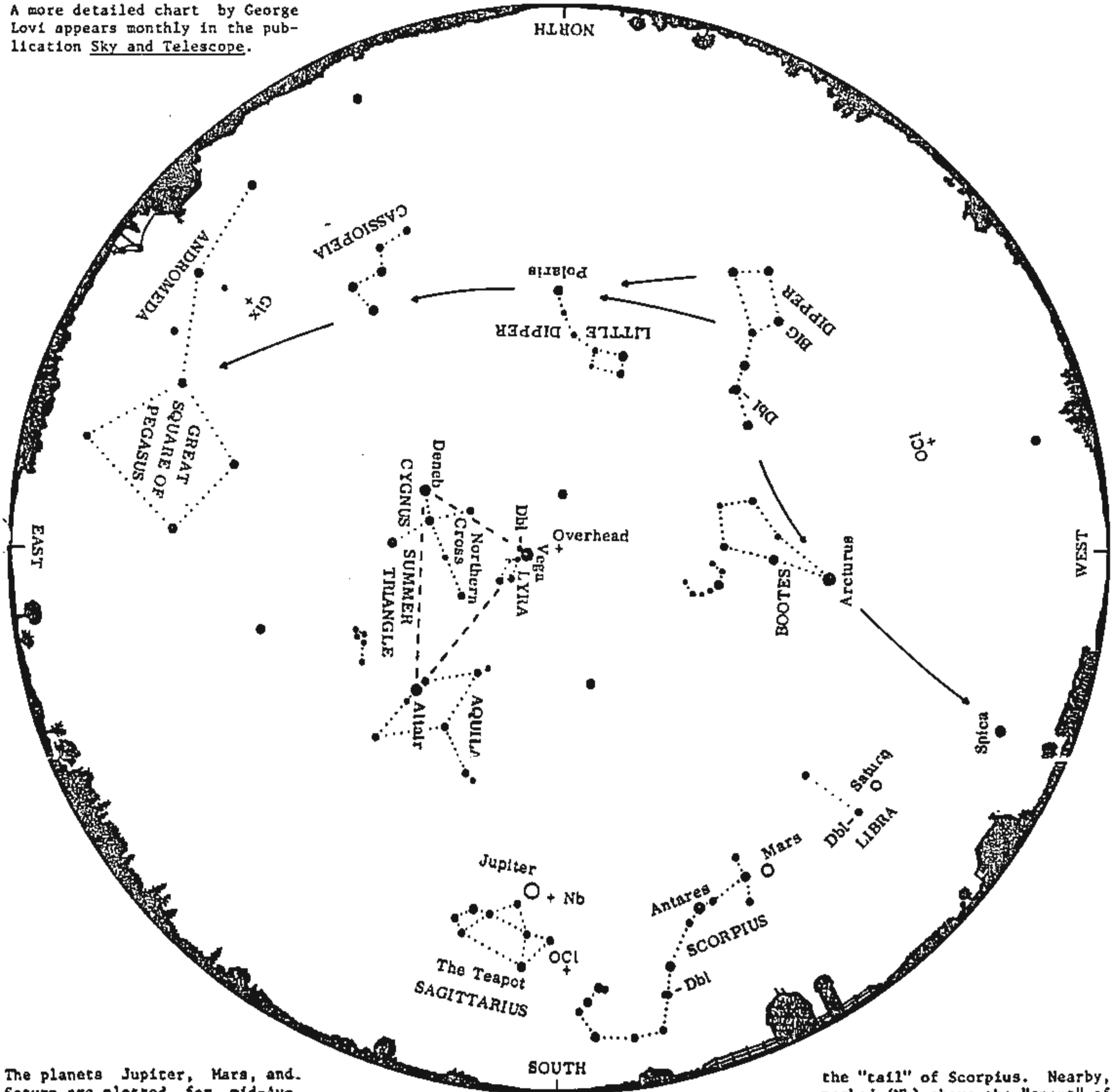
August Evening Skies

This chart is drawn for Latitude 40° north, but should be useful to stargazers throughout the continental United States. It represents the sky at the following local daylight times:

Late July	11 p.m.
Early August	10 p.m.
Late August	9 p.m.

This map is applicable one hour either side of the above times. A more detailed chart by George Lovi appears monthly in the publication Sky and Telescope.

Subscription: $5.00 per year, from *Sky Calendar*, Abrams Planetarium, Michigan State University, East Lansing, Michigan 48824-1324.



The planets Jupiter, Mars, and Saturn are plotted for mid-August, 1984. At chart time 9 objects of first magnitude or brighter are visible. In order of brightness they are: Jupiter, Mars, Arcturus, Vega, Altair, Saturn, Antares, Spica, and Deneb. In addition to stars, other objects that should be visible to the unaided eye are labeled on the map. The double star (Dbl) at the bend of the handle of the Big Dipper is easily detected. The double star in Scorpius is somewhat harder. Much more difficult is the double star near Vega in Lyra. The open or galactic cluster (OCl) known as Coma Berenices, "The hair of Berenice", is located between Leo and Boötes. A more compact open cluster is located between Sagittarius and the "tail" of Scorpius. Nearby, marked (Nb) above the "spout" of the "Teapot," is the Lagoon Nebula, a cloud of gas and dust out of which stars are forming. The position of an external star system, called the Andromeda Galaxy after the constellation in which it appears, is also indicated (Glx). Try to observe these objects with unaided eye and binoculars.

—D. David Batch

Week 1

Aside from the Earth, the Sun and the Moon are the most prominent parts of the Solar System. This week, your students start observing them, and recording their observations.

As the weeks pass, the activities will become more demanding, your students will become increasingly sophisticated, and they will add more and more depth and detail to their observations. For now, however, what matters is that they develop some curiosity, get used to keeping an eye towards the heavens, and learn good record-keeping habits.

This kit does not deal with galaxies, black holes or any of the other objects that lie beyond the limits of the Solar System. However, your students will begin star-gazing this week. This is because familiarity with the stars and constellations which serve as signposts in the night sky is needed for a good understanding of the apparent motion of the Moon and planets.

To liven up the class, read your students some stories and myths about the Sun, Moon and stars. One possible source is THE MAN IN THE MOON: SKY TALES FROM MANY LANDS, by Alta Jablow and Carl Withers (Winston, 1969). These stories show that people of many different cultures all over the world have made up wonderful stories about the sky. They are an excellent springboard for creative writing.

Before starting the first lesson, you may want to ask your students for all the words they know about the Solar System.

Write the words on a large piece of paper. If you repeat this exercise after the last lesson, your students will probably come up with a much longer list, and be conscious of how much they have learned.

Lesson 1

THE MOON CALENDAR

OBJECTIVES:

* To raise questions about the Moon and its phases.

* To start to observe the Moon in the sky and keep daily records.

GRADES: 4 and up.

SCHEDULING:

A good time to start is on the day of the Last Quarter Moon (give or take a day or two). At that time, the Moon is visible during school hours, and the first observations will happen in your presence so you can demonstrate and explain the record keeping procedure.

Of course, you must start on a clear day!

Plan to continue this activity (with various additions introduced gradually), for at least six weeks. Use the first few minutes of school every day to listen to the students comments about their observations. Try to be flexible enough to accomodate a longer discussion once in a while, should the need arise.

PREPARATION:

You may feel more comfortable teaching this lesson after having done some Moon-watching yourself for a few weeks. But this is not necessary: you can learn along with your students. However, make sure you can find the Moon on the first day of this activity, since your students may need help.

STUDENT SHEETS:

* Moon Calendar

* Moon Calendar Instructions

DISCUSSION:

There are probably many misconceptions about the Moon among your students. You should not correct them at this stage. You should even avoid praising "good" answers. Instead, tell the students that their own experiences and observations will clear up most of these questions within a few weeks. Some will be solved very quickly, others will take more time.

Write the most controversial questions on large pieces of paper, and display them on the bulletin board until the class agrees on an answer.

* Does the Moon rise whenever the Sun sets?

* Can one see the Moon in the daytime?

* Does the Moon seem to move in the sky? Does it rise and set? Where? When?

* What is the shape of the Moon? What does it seem to be? Does it change? Why?

For your reference, the answers to these questions are in the "Conclusions" section below.

ACTIVITY:

Take the class outside to look at the Moon. Make sure that they bring paper and pencils in order to draw it.

Back in the clasroom, hand out the Moon Calendars and the accompanying Instructions. Go over the instructions. Check that the students enter the dates correctly. (If the last one is incorrect, they made a mistake along the way! Make sure they know the number of days in the current calendar month. Have extra copies on hand!)

Explain that the shape of the Moon will be recorded by shading in the area you DON'T see, leaving the Moon's shape in white. Demonstrate this on the chalkboard. Have them draw the Moon in the appropriate box on the Calendar. (Allow them to go back out if necessary.)

Emphasize that they should do this every day until the calendar is full. If they forget to look or cannot find the Moon, they should NOT enter a guess in the calendar. Discourage "cheating" by looking up the shape of the Moon in the daily paper, or on a calendar or almanac: the point of the activity is to use the students' own observations as a basis for learning, so that they will be able to predict the phases of the Moon.

Sometimes, no one will be able to find the Moon for a few days. (This will always happen at the time of the New Moon, but it may happen at other times too, especially if the weather is bad.) Encourage the students to keep looking. With the help of the ALMANAC and SKY CALENDAR, you may be able to suggest a good time and direction to look for it.

CONCLUSIONS:

As the weeks go by, the following points should become clear:

* The Moon rises (roughly) in the East, and sets (approximately) in the West.

* It does not rise or set at the same time every day.

* The Moon's shape changes continuously, not suddenly.

More conclusions will become possible as the observational assignments become more sophisticated in the coming weeks.

COMMENTS:

* Some students have trouble remembering to look for the Moon, especially at first. Others become nearly fanatical about it, and go out several times a day. The morning conversations at school provide an opportunity for the enthusiasts to communicate some of their excitement to the others.

* Some students may notice differences in the color of the Moon. The Moon is often reddish when it is low in the sky, because its light must cross more atmosphere to get to us. This is analogous to the redness of the sunset. It is due to the fact that blue light gets scattered by the atmosphere, while red light does not. (It is not important for students to understand this idea.)

* The size of the Moon also seems to vary. A rising Full Moon often seems unexpectedly large, ~~Mostly~~ probably because of its apparent proximity to various landmarks.

* You may want to make a large Moon Calendar for the classroom bulletin board, and have students take turns entering their observations every morning. Such a wall calendar can help focus discussions about the Moon and its cycle.

* The Elementary Science Study unit WHERE IS THE MOON? (Webster - McGraw Hill) originally inspired me to teach astronomy to children. Read it, as well as the companion student text, WHERE

WAS THE MOON?, for a different approach to Moon-watching.

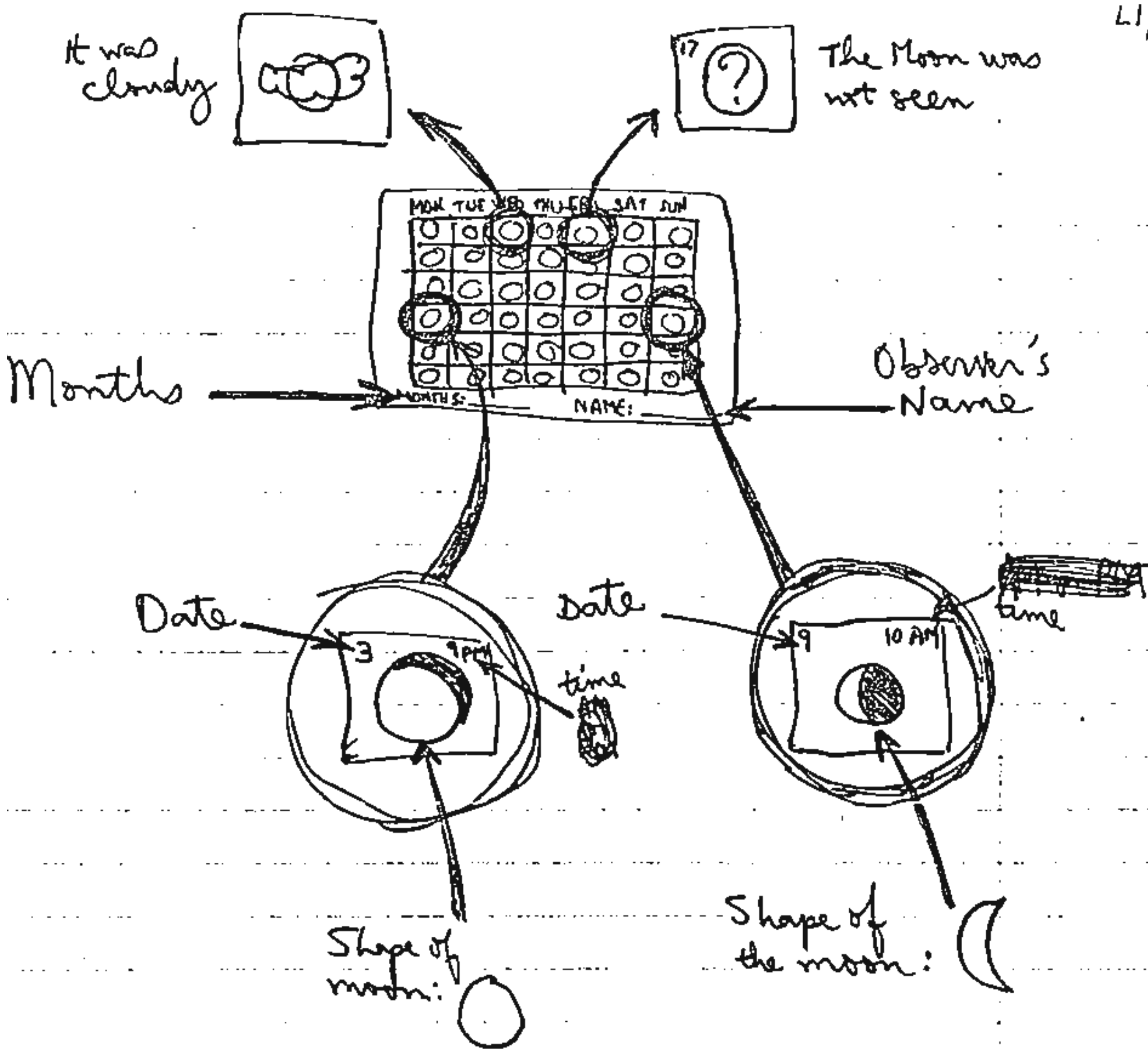
* A little puzzle: rearrange the letters of "Moon starer" to make a word with a related meaning. (Answer: "astronomer").

MOON CALENDAR INSTRUCTIONS

Write your name and the months on your Moon Calendar. Fill in all the dates.

For the next six weeks, look for the Moon every single day and night!

* If you cannot find it, or forget to look, put a question mark in the circle for that day.
* If it is cloudy all day, put a cloud over the circle.
* If you find the Moon, indicate the time in the corner. Don't forget "am" or "pm". Show the shape by shading the part of the Moon you don't see, and leaving the shape you do see unshaded. (See figure.)
* If the Moon has an unusual color, color it on the sky calendar.


It was cloudy
17
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MON TUE WED THU FRI SAT SUN
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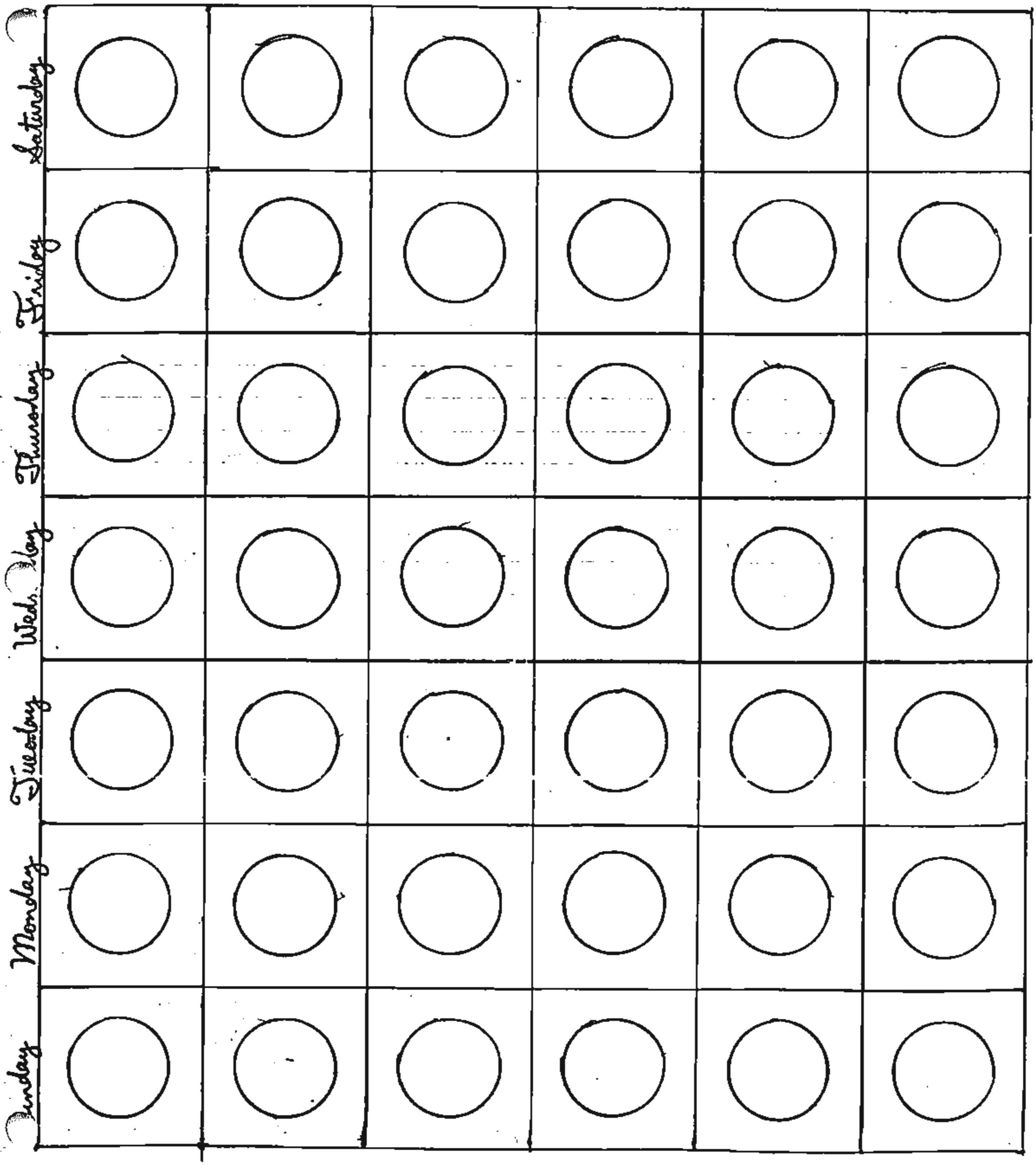
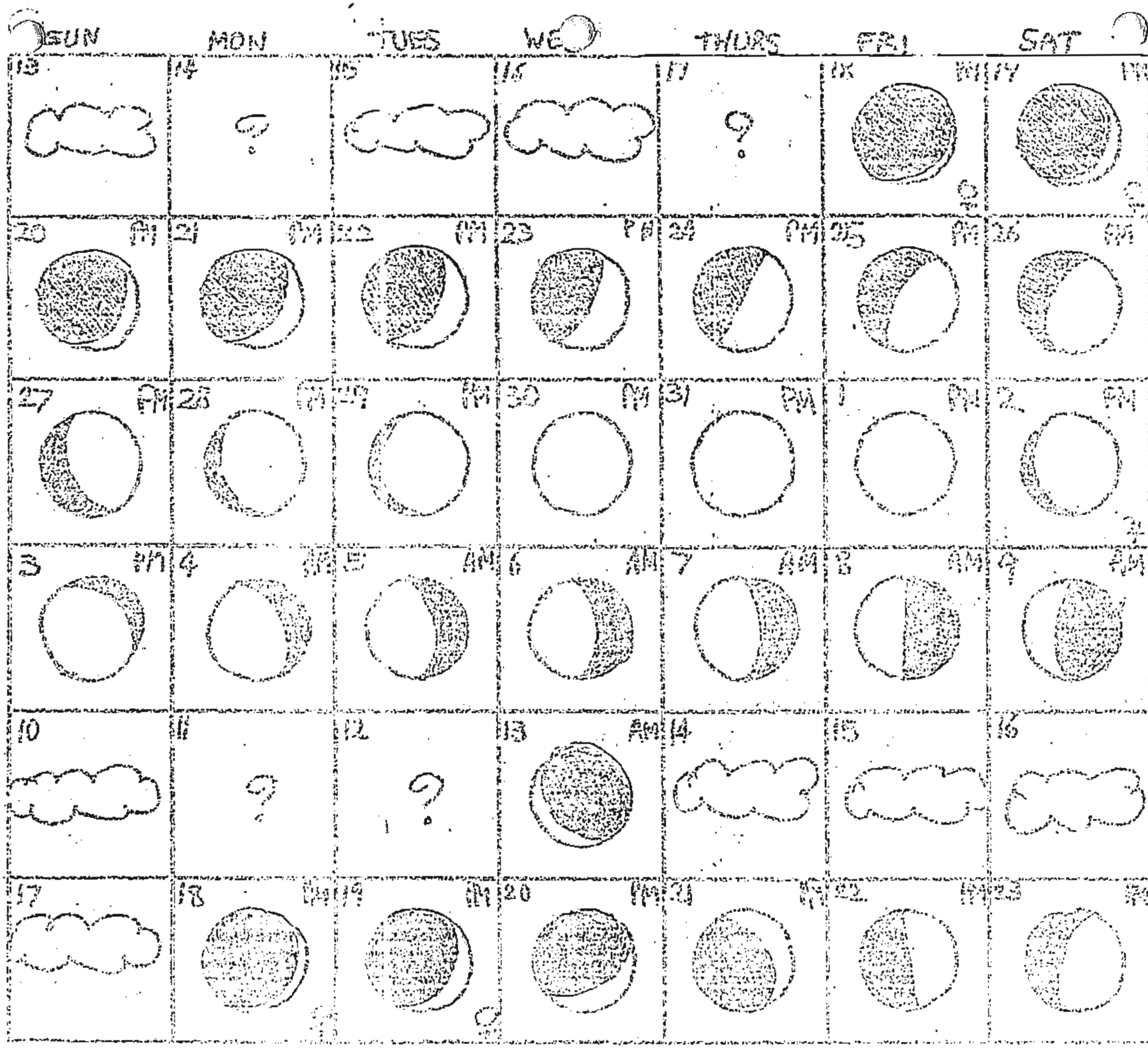
Date
9
10 AM
time
Shape of moon:
Shape of the moon:

Name:

Moon Calendar



Months of: ____________



Henri's Class

BPC

Moon Calendar

Jan & Feb 1980

Lesson 2

SHADOWS

OBJECTIVES:

* To familiarize students with the main features of the Sun's apparent motion across the sky in the course of one day.

* To teach students the cardinal points.

GRADES: 4 and up.

SCHEDULING:

A sunny day is required to carry out this all-day activity. Start out with the class discussion, and set up the experiment. Then go on with your ordinary schedule, but send students out in pairs, throughout the day, to record the shadows. Wait till the next day to hold a discussion and draw conclusions from the experiment.

PREPARATION:

Read the description of the activity carefully, and pick out an appropriate place to do the experiment.

MATERIALS:

For a gnomon (shadow stick), use:

* A 9" stick on a styrofoam stand

Tape it to a 3'x3' sheet of paper, which is itself taped to a 3'x3' masonite board (see figure 2-1)

You will also need:

* A watch or clock

* Markers

* Masking tape

* A good compass

CLASS DISCUSSION:

Show the class the gnomon, and ask them to predict the motion of its shadow during the day.

* How does the Sun move across the sky?
* Where does it rise? Where does it set?
* How does it get from here to there?
* Which way is North? East? West? South?
* Imagine yourself at home, looking out a certain window. Point in the direction you would be facing. (Some students have a strong intuitive sense of direction, and can do this without hesitation.)
* Which way do shadows point?
* When are shadows long? When are shadows short?
* At what time is there no shadow at all?
* At what time is the Sun exactly overhead?

Remember that this discussion is intended only to raise the questions investigated by the experiment, not to answer them. Accept all your students' answers without judging their correctness. The less the students worry about saying "something stupid", the more they will participate in the discussion, and the more curious they will be about the outcome of the activity.

Tell the students that to evaluate the ideas that came up during the discussion, they will record the shadow of the gnomon many times in the course of the day, and that they will finish the discussion the next day.

WARNING:

Never look directly at the Sun. You may damage your eyes permanently. The same applies to your students. Make sure they understand this.

STUDENT SHEET:

* The Sun

ACTIVITY:

Start out by synchronizing the watches or clocks that are to be used.

The basic setup is illustrated in Figure 2-1. The gnomon should be on the southern part of the sheet (this will allow the shadows to land entirely on the sheet). The sheet should be on a piece of masonite (or other flat board), to facilitate drawing on the paper. Place the whole setup in a location that gets sunlight throughout the school day.

Show the students how a slight motion of the gnomon affects the position of the shadow. Therefore emphasize that it must not be touched during the course of the day. (In fact it is preferable to keep it out of the way of playground games and other potential disturbances.) Use chalk to mark the position of the paper on the ground (paint if you are to repeat the eperiment on another day). The orientation of the paper should remain absolutely constant during the whole experiment. Using a good compass, find and mark the direction of magnetic North.

Outline the position of the gnomon's base on the paper. The gnomon should remain exactly in the same position during the whole experiment. Masking tape can be used to hold it in place. The surface beneath the setup should be as flat and horizontal as possible.

Tell the students to mark the outline of the top of the gnomon's shadow, and write the time of day next to it (Figure 2-2). Send groups of students out to repeat this every twenty to thirty minutes, and every ten to fifteen minutes around midday. Allow the students to make more frequent observations if they want.

By the end of the day, you will have a record of the shadow's movement. Save it. If you want to repeat the experiment on another day, try to place the setup in exactly the same orientation, and the gnomon in the same place so that comparisons of the records are meaningful. However, be aware that changes in the tilt of the gnomon dramatically affect the length of the shadow.

CONCLUSIONS:

The next day, hand out the student page "THE SUN". The students should find it relatively easy to answer the questions.

Post the gnomon shadow records in a visible place in the classroom. Discuss the ideas that were raised in the DISCUSSION above, and those on the student sheet.

At this point, you can be more of a guide in helping the students make sense of the information they gathered. Don't rush or force conclusions, but reinforce the correct comments made by the students, by repeating and rephrasing the best formulations.

The following conclusions may be reached as a result of the lesson:

* Between sunrise and sunset, the Sun travels across the Southern sky, from East to West (left to right).

* Shadows point in the direction opposite to where the Sun is. They are longer in the morning and evening, and shorter at midday.

Also, make sure that the students have a clear knowledge of the cardinal points.

COMMENTS:

* For more on this activity, see DAYTIME ASTRONOMY (Elementary Science Study, Webster / Mcgraw Hill)

* The following are alternative gnomons for the experiment:

.A flag or tether ball pole (use chalk to mark the shadow)

.A golf tee, glued to an 8 1/2x11 sheet of paper, on an 8 1/2x11 piece of stiff cardboard

.A thumbtack, poking through an index card

The shadow of a larger gnomon (say a flagpole) moves faster and allows more accurate readings. The records of the shadow of a 9" gnomon can conveniently be seen by the whole class. On the other hand, smaller gnomons allow children to have their own individual gnomon and record.

* It is commonly believed that there is no shadow at noon, because the Sun is exactly overhead. This only happens below the tropics -- this will be discussed in Lesson 19.

* If some students want to use the gnomon and its shadow record sheet as a sundial, encourage them to try it. However they will probably find that this kind of a sundial becomes inaccurate

after a few days. This can serve to interest the students in the seasonal variations in the Sun's path (which will be discussed in Lessons 6, 7, 8, 19 and 20), and in the design of sundials.

* It is especially interesting to do the gnomon experiment on or near the dates of the Solstices (December and June 21) and one of the Equinoxes (March or September 21). Differences in the shadow's path are most dramatic between those dates.

* It is interesting to compare compass North to "gnomon North". Keep in mind that inexpensive compasses are often inaccurate, and that good compasses point to Magnetic North. The DAILY PLANET ALMANAC features a map showing magnetic declination, the difference in degrees between magnetic and actual North. "Gnomon North" is true North.

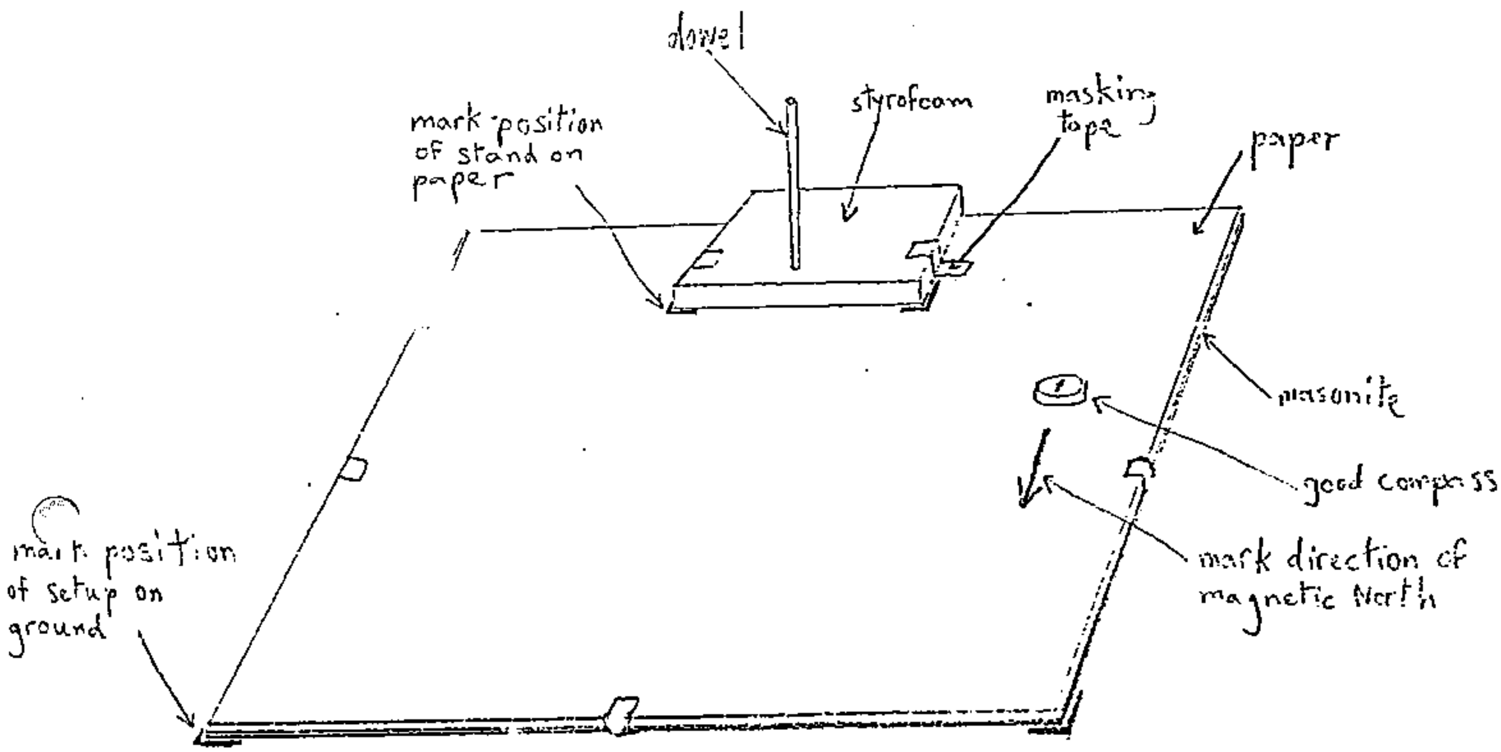
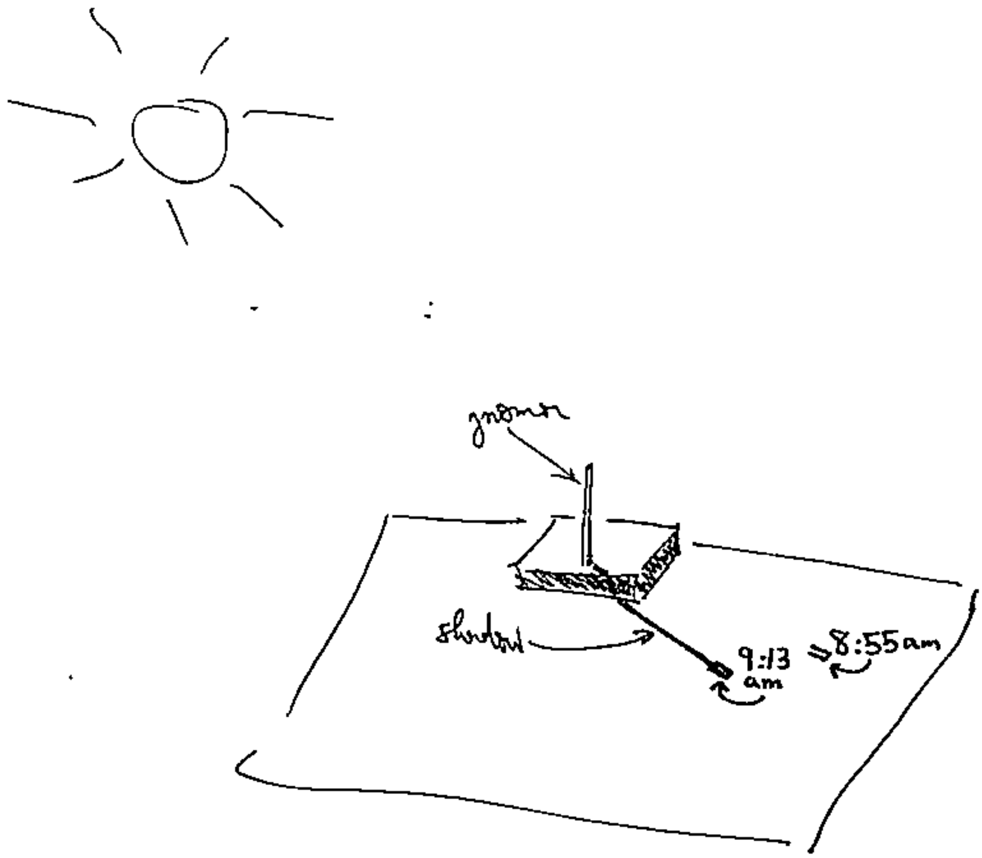

dowel
styrofoam
masking tape
mark position of stand on paper
paper
masonite
good compass
mark direction of magnetic North
mark position of setup on ground

Fig 2-1

Fig 2-2.



THE SUN

1. Fill in all the directions on the compass below. Some have been done to get you started. (Fig. 1)

2. The gnomon (pronounced know-mon) is the world's oldest scientific instrument. It is a vertical stick. By watching and measuring its shadow, people learned about the Sun's motion in the sky.

* When the Sun is low, the gnomon's shadow is (short, long).
* If the gnomon's shadow is short, the Sun is ______.
* When the Sun is in the East, the shadow points ________.
* If the shadow points North West, the Sun is ________.
* When the Sun is South South East, the shadow points ________.

3. Around what time of day are shadows shortest?

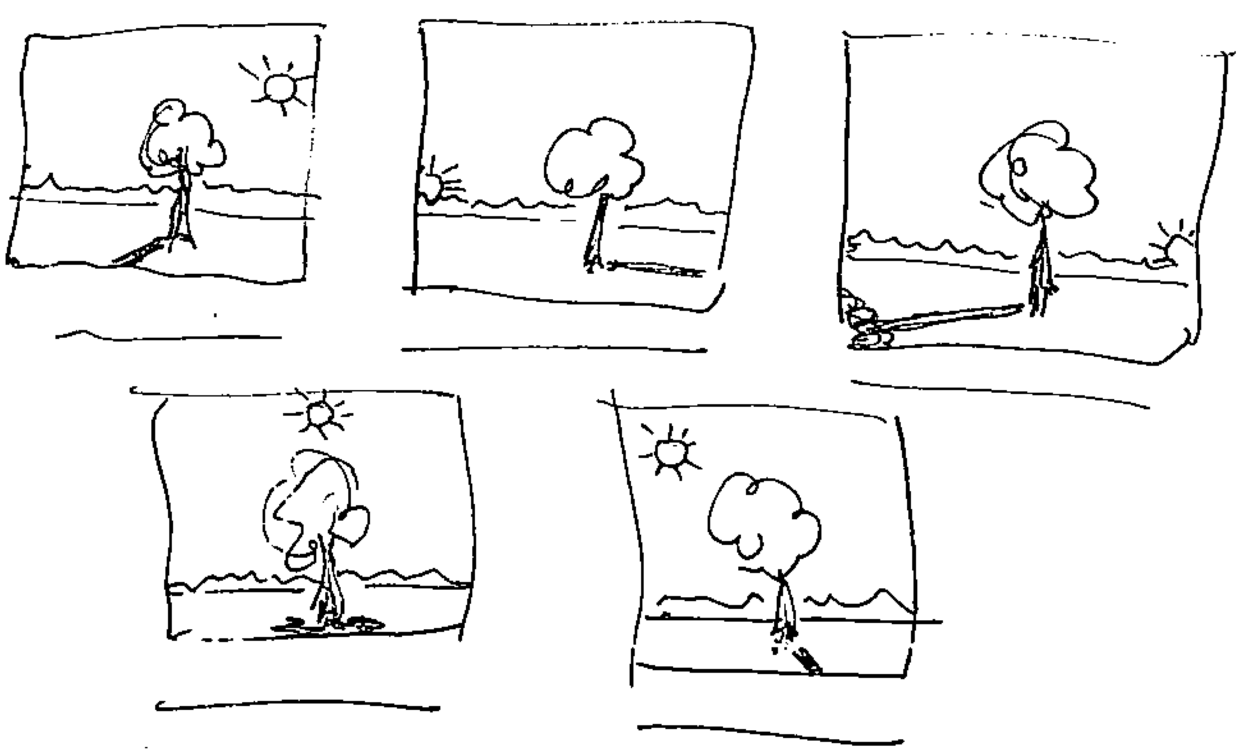
* At that time, which direction do they point to?

4. These pictures were taken (facing South) (a) at sunrise, (b) in the middle of the morning, (c) at midday, (d) in the afternoon, and (e) in the evening. Unfortunately, they have been mixed up. Under each one, write the correct letter (a-e). (Fig. 2)

WARNING: NEVER LOOK DIRECTLY AT THE SUN. YOU COULD DAMAGE YOUR EYES PERMANENTLY.

Fig 1 :

Fig 2 :



Lesson 3

THE NORTH STAR

OBJECTIVES:

* To start looking at the night sky.

* To teach students the cardinal points at home.

GRADES: 4 and up.

SCHEDULING:

This assignment requires a short introduction at school, and a clear night to do the homework.

PREPARATION:

Using the student sheet, find the North Star yourself.

STUDENT SHEET:

* Finding North

INTRODUCTION:

Explain that sailors in the ocean cannot use landmarks to help them find their way. How do they find directions? One way is by using the North Star.

ACTIVITY:

Hand out the student sheet. Explain that most stars in the sky are always in motion. However, they remain in constant patterns, as shown on the illustrations. Make sure they can recognize which star is the North Star on each one. Warn them that the Big Dipper may be considerably bigger than they expect.

Also encourage them to use other methods for finding North: an approximate knowledge of North may help find the Big

Dipper.

This first star-gazing assignment may be difficult for some students. Be sure to discuss their experiences at school the next day, as early in the day as possible. If some students do not succeed, encourage them to try again, with the help of a classmate, parent or older sibling.

COMMENTS:

* The EDMUND SKY GUIDE, by Terence Dickson and Sam Brown, is a fine introduction to the night sky, with outstanding illustrations. In particular, it uses the Big Dipper as a guide to several constellations. (Edmund Scientific Co., Barrington, N.J. 08007.)

FINDING NORTH

There are many ways to find out where North is at your house or apartment building. You can ask someone who knows, or use a map.

At night, you can use the North Star. The North Star is not very bright. To find it, use the Big Dipper's pointer stars as a guide. The Big Dipper is a large group of stars that is easy to find. (See Figure 1.)

* When you face the North Star, you are facing North. South is behind you. East is to your right. West is to your left.

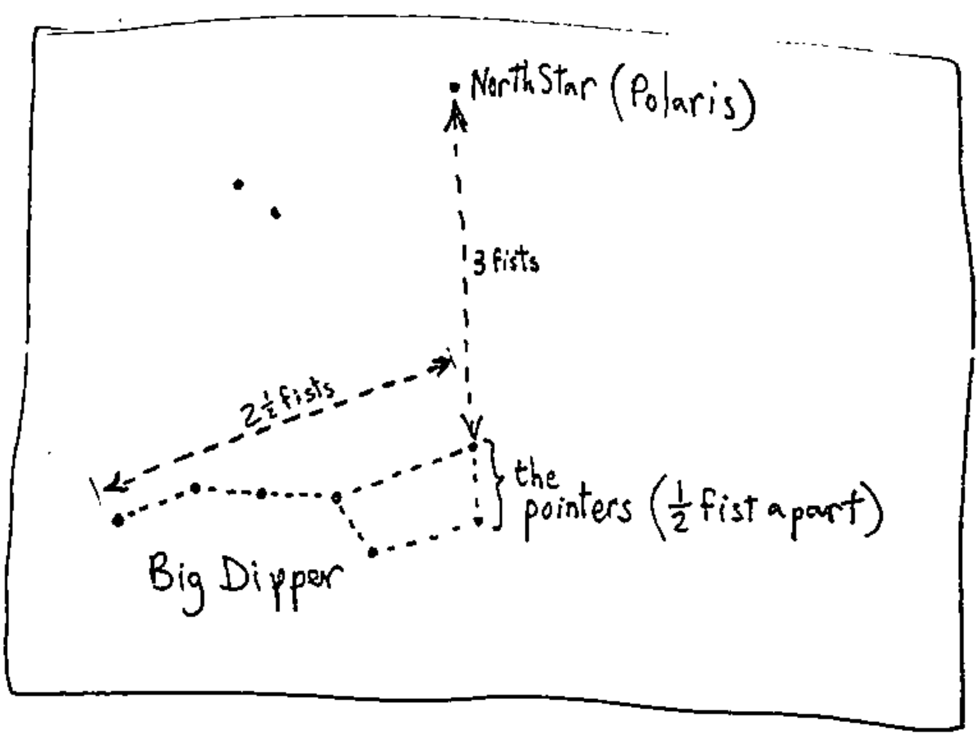
* If you face South, is East is to your left or right? What about West?

* When standing at your front door, which direction are you facing?

* When looking out your bedroom window, which direction are you facing?

* Choose one other place away from school, and describe how you would stand to face North there.

FINDING THE NORTH STAR



Week 2

This week, your students will continue to observe the Sun and the Moon. In addition to daily entries in the Moon Calendar, they will keep track of the relative positions of Sun and Moon, and of the location and time of sunset. At night, they will look for bright stars and planets, and record the Moon's position with respect to them.

Make sure your students continue to enter daily records on the Moon calendar. Remember to discuss their observations daily, first thing in the morning if possible. A few minutes a day is all it takes, ~~but~~ and it ~~can~~ helps keep the interest level high.

While this kit does not primarily rely on "book learning", you should complement it with some research projects for your students. Ask a few students each week to prepare oral reports and/or bulletin board displays on various topics related to the Solar System. At the beginning of each week, a research topic will be suggested.

* Research topic: the Sun, sun spots.

Lesson 4

SUNSET

OBJECTIVES:

* To start noticing seasonal variations in the Sun's path.

GRADES: 4 and up.

SCHEDULING:

This activity needs a clear sky (though a few clouds can make for a more dramatic sunset.) It is a good idea to schedule it two or three days after the New Moon. This would help the students find the Moon after its monthly disappearance.

Students should make a weekly drawing of the location of the sunset until Lesson 19.

Only a few minutes of class time are required to introduce the activity, and a little more to discuss it the next day.

DISCUSSION:

Motivate the homework with a discussion of the following questions:

* Where does the Sun set (rise)? At what time does the Sun set (rise)?

* Does the Sun set in the same place every night? Does it set at the same time?

* Are days getting longer? shorter?

Some students may be aware of seasonal changes in the times of sunrise and sunset, but it is a widely held misconception that the Sun rises exactly due East, and sets exactly due West. (In fact, this only happens on the day of the

Equinox. Do not reveal this to your students: it will be made clear by their own observations and by the activitiy in Lesson 18.)

STUDENT SHEET:

* Sunset

ACTIVITY:

Every week, remind the students to mark the location of the sunset on their drawing. The intervals do not need to be exactly one week: if you forget to remind them on a certain day, or if it is cloudy, the observation should be done on the following day.

Explain that it is best to watch the sunset from a place that has a wide view with many distant landmarks near the horizon. Using nearby landmarks is misleading, because standing in a different spot makes the Sun appear to set at a different spot.

Early risers should be encouraged to carry out the activity at sunrise.

CONCLUSIONS:

* After a few weeks, your students should be able to see that while the statement that "The Sun rises in the East and sets in the West" is basically true, it is not usually exact. Depending on the season, your students may have seen the sunset North or South of due West, and will have noticed changes from week to week.

* They will also become aware of the time of sunset changes.

* The most observant may notice that the location and time are

related: when the Sun sets further South, it sets earlier. When it sets further North, it sets later. This will be clearer after the experiment in lesson 18.

COMMENTS:

* The location and time of sunset change fastest around the time of the Equinox, slowest around the time of the Solstice. (In fact solstice means "still sun".) In other words, this Lesson would be most effective in March or September, least effective in December or June.

* Be aware of Daylight Savings Time. If your students' observations span a period that includes a time change, convert all clock times to Standard Time in order to facilitate comparisons.

* Students enjoy noticing the large number of colors that become visible in the sky during some sunsets.

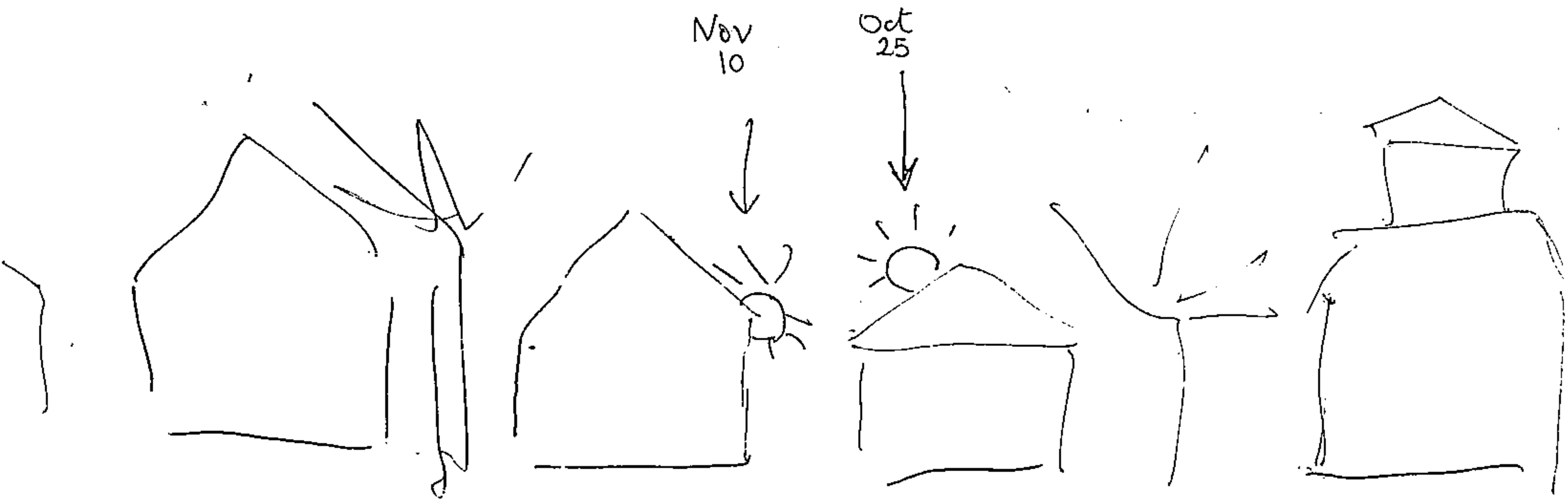
SUNSET

* Go where you can see the Sun set. People often say the Sun sets in the West. Is this exactly true?

* Describe the sunset in a short paragraph. Be sure to pay close attention to any colors you may see in the sky. How many different colors do you notice? (You may be surprised!) Also notice how stars start appearing as the sky darkens.

* Make a simple drawing of the western horizon, and on it, mark where the Sun sets. Do it again, on the same drawing, every week. Be sure to write the date and time each time.

* Extra: If you can get up early enough, repeat these activities at sunrise.


Nov
10
Oct
25

Lesson 5

THE SUN AND THE MOON

OBJECTIVES:

* To become aware of the relative positions of Sun and Moon in the sky.

* To learn the "fist" method of measurement.

GRADES: 4 and up.

SCHEDULING:

This activity should continue for as long as the students continue Moon-watching. A good time to start is three to ten days after the New Moon. (Of course, start on a clear day!)

STUDENT SHEETS:

* Moon Position

* Sun-Moon

ACTIVITY:

The idea presented in this lesson is simple, yet powerful. The Sun-Moon record sheet allows the students to concentrate on the one variable that is most significant in understanding the phases of the Moon: the relative position of the Sun and Moon in the sky. However, you should let the students discover this from the records of their observations.

Hand out the "Moon Position" sheet. Explain that the students will record the Moon's position with respect to the Sun. The "fist" system will be used for measurement. Astronomers use more precise methods, but with practice, fist measurements can be accurate to 10 degrees. This is quite adequate for the purposes of this unit. Emphasize that the method works only if your arms are always completely stretched out. Practice by trying to measure the angle from the horizon to overhead: you should get approximately nine fists (Figure 5-1).

For more accuracy, suggest the students make each measurement two or more times and use the average -- or the most frequent result. There will be differences between measurements obtained by different students. (They are usually due more to wobbly arms and bent elbows than to differences in body size.) In any case, what is important is that each student's measurements are consistent.

From now on, remind your students daily that in addition to entering their Moon observations on the Moon Calendar, they should also enter any daytime observation of the Moon on the Sun/Moon sheet.

The Moon is often hard to find during the day. In order to get many entries on their Sun-Moon sheets, encourage your students to look for it shortly before sunset, or for early risers, shortly after sunrise.

CONCLUSIONS:

As the weeks go by, the following conclusions can be reached:

* The Moon's position with respect to the Sun changes from day to day.

* The Moon's motion with respect to the Sun is from West to East (right to left).

* The Moon's shape is related to its position with respect to the Sun: the further it gets from it, the fuller it is.

Do not rush students to these conclusions. They are ideas that most adults are not familiar with, and only prolonged observation makes them easy to grasp.

COMMENTS:

* A single record sheet for the daytime position of the Moon should not be used for more than one cycle of the Moon (four weeks). Give out a new copy every four weeks, or every New Moon.

* Alternate scheduling: this activity can be started on any clear day that the Moon is visible in the daytime. (Consult the ALMANAC for time of moonrise and moonset).

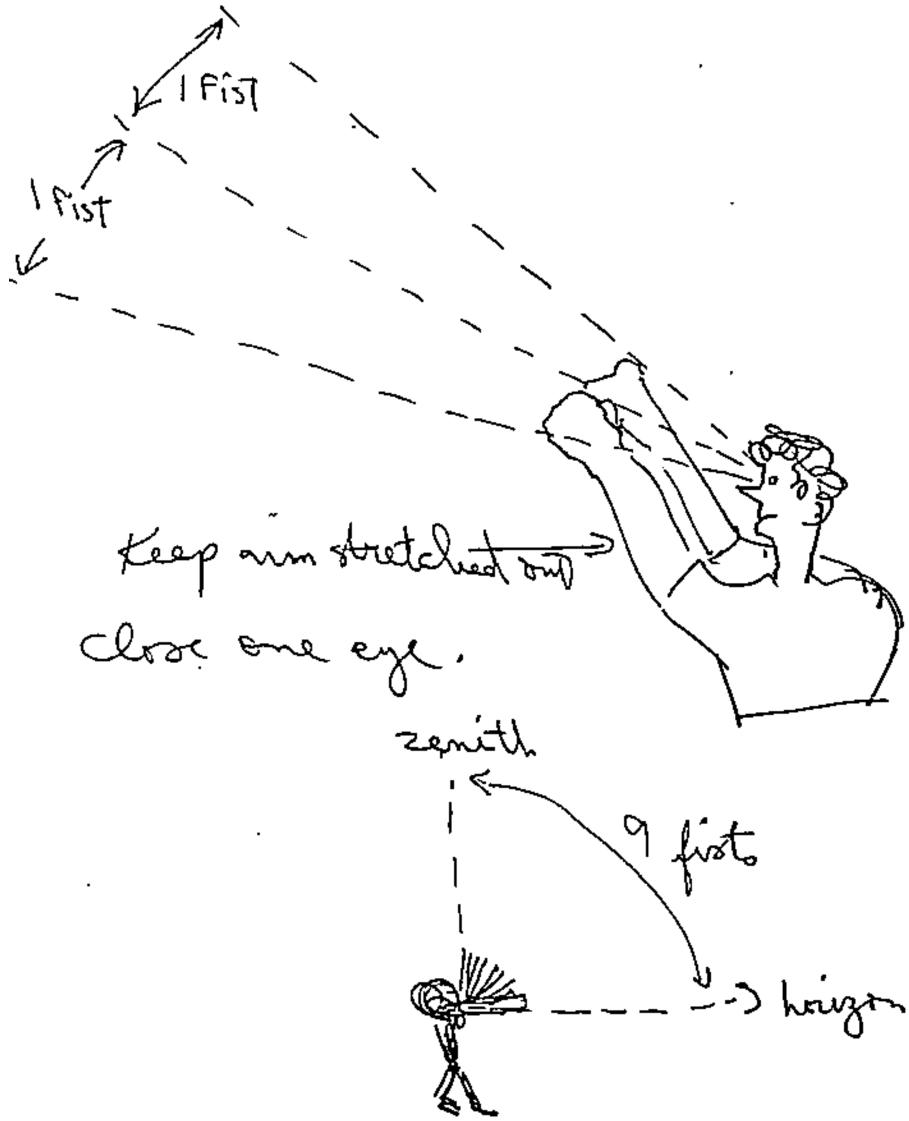

1 fist
1 fist
Keep arm stretched out
Close one eye.
zenith
9 fists
horizon

Fig 5-1

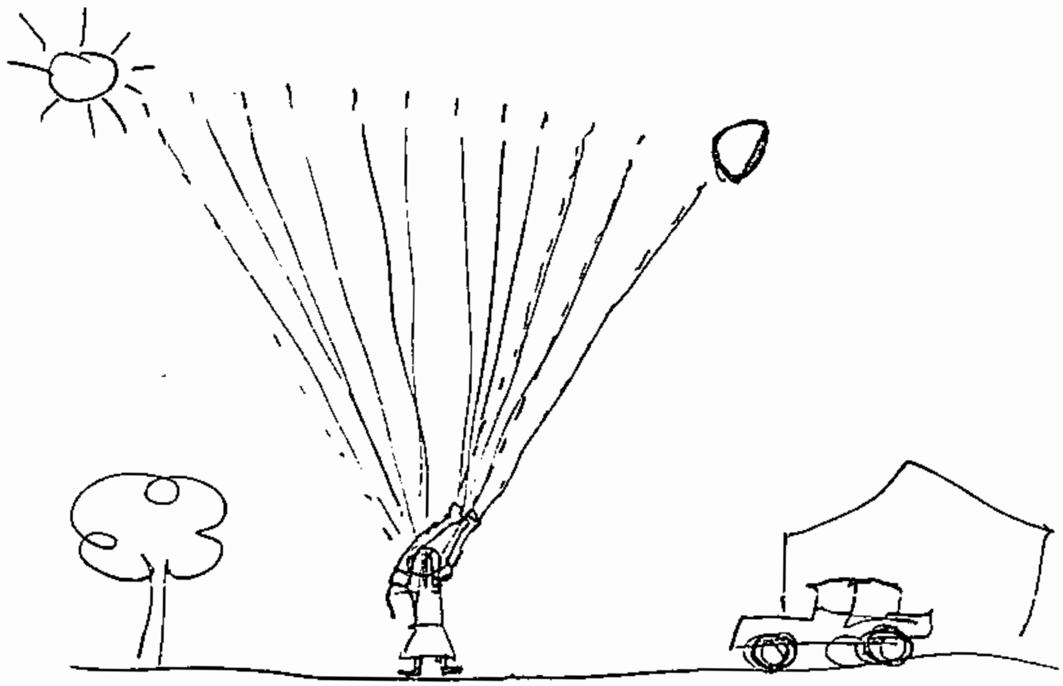
THE MOON'S POSITION
(DAYTIME)

If you find the Moon in the daytime, notice its position with respect to the Sun.

Face South when making your observation. First note whether the Moon is to the East (left) or West (right) of the Sun. Measure the distance between the Sun and the Moon by counting fists: stretch out your arms, close your fists, close one eye. The width of your fist, when seen at arm's length, is your unit. Use your fists to measure distances in the sky (See Figure 1.)

Once you have measured the distance, draw the Moon on the Sun-Moon sheet. Write the date next to it. Be sure you are drawing on the correct side of the Sun, and that your Moon faces the same way (left or right) as the one in the sky! (See Figure 2.)

From now on, whenever you see both the Sun and the Moon at the same time, use the Sun-Moon sheet to record your observation.



The Moon is 11 fists West of the Sun.

Fig 1

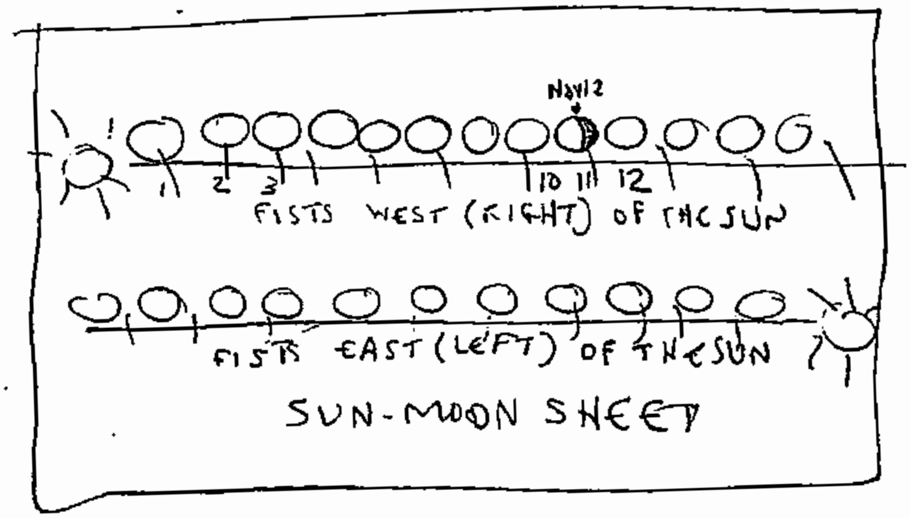
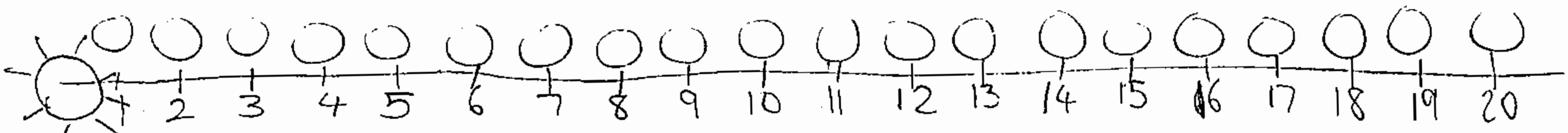
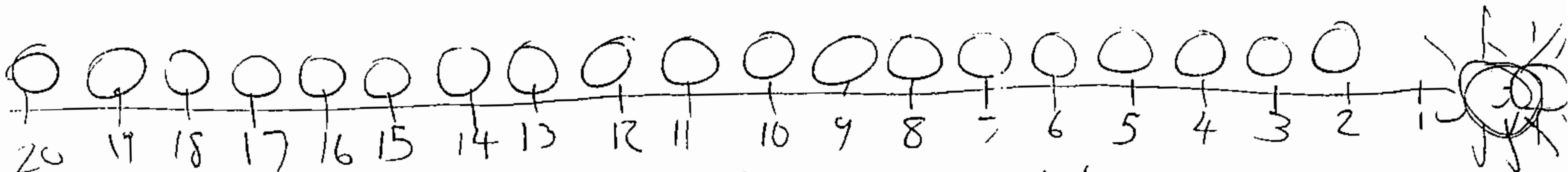

Nov12
1
2
3
10
11
12
FISTS WEST (RIGHT) OF THE SUN
FISTS EAST (LEFT) OF THE SUN
SUN-MOON SHEET

Fig 2



FISTS WEST (RIGHT) OF THE SUN



FISTS EAST (LEFT) OF THE SUN

SUN-MOON SHEET

Lesson 6

THE MOON AND THE STARS

OBJECTIVES:

* To follow the Moon's motion in the night sky.

* To find the planets and brightest stars.

GRADES: 4 and up.

SCHEDULING:

This activity should be started on a clear day, when the Moon is visible in the evening sky, near a bright star or planet. It should be repeated as often as possible, until your students are able to find all bright objects in the night sky.

Because they are so easy to find, this activity is most effective when Jupiter and/or Venus are in the sky.

PREPARATION:

Using the SKY CALENDAR or ALMANAC, find out what bright stars and/or planets are near the Moon, on what night. Write a short "reminder" telling your students to look for the Moon, and what bright star or planet will be near it. Select the appropriate star chart(s).

STUDENT SHEETS:

* Reminder (written by you)

* Star chart(s)

* Planets and Stars

DISCUSSION:

* What can be seen in the night sky besides the Moon? (Accept all answers -- including "airplanes", "clouds", "the North

Star", etc.)

* What is a planet? Have you ever seen one?

ACTIVITY:

Hand out the star charts and the Planets and Stars sheet. Explain how to use the star charts. (The ones included in this kit depict the Southern part of the sky.) Explain that the students will gradually learn to find more and more of the stars displayed on the chart.

If there are planets in the night sky, tell the students to find them, with the help of the Moon and your "reminder". Then, they should mark their location on the star chart and to write the date next to it. If Mars or Venus are visible, check their positions weekly. Your students should be able to notice a change in their positions after a few weeks.

Tell your students to draw the Moon right onto the star chart, taking care to place it correctly in relation to the bright stars. They should indicate the date next to it. This will be the evening equivalent of the daytime Moon position sheets.

Repeat this activity every time the Moon is near a bright planet or star, until they know all the bright objects in that part of the night sky.

When the Moon is near another object in the sky, it is called a conjunction. Conjunctions can be recorded in the Moon Calendar by writing the name of the star or planet at the bottom of the box. Make clear to your students that from now on, night-time sightings of the Moon should lead to a record of the Moon's position with respect to stars and planets.

CONCLUSIONS:

After the activities in this lesson, your students should be able to understand the following concepts:

* The planets look like stars in the night sky.

* The Moon moves daily against the background of the stars and planets.

COMMENTS:

* A field trip to a planetarium is an excellent idea before (or after) starting this activity. Planetariums almost always have a show about "The Sky Tonight".

* If there are no planets visible with the naked eye in the night sky, you may consider early morning assignments.

* The Lawrence Hall of Science SKY CHALLENGER, is an excellent source of night-time observational activities. It consists of five different star charts, each one with a different suggested activity. All can be set to show the sky at any time, on any date.

THE PLANETS

When Venus is in the evening sky, it is in the general direction of the sunset. People call it "the Evening Star" even though it is far brighter than any star. As it gets dark in the evening, Venus is the first to appear.

Jupiter -though not as bright as Venus- is also brighter than any star. When Jupiter is visible, it too appears in the sky before the stars as the sky darkens. However, it can be in the East, South, or West.

Saturn is yellowish and Mars is reddish. They are harder to find because they are dimmer.

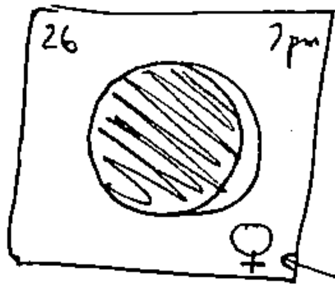
The planets move very slowly, so that they seem in pretty much the same place every night. Look for them every week, and see if you notice any change in their positions.

CONJUNCTIONS

Draw the Moon (not too big!) at the right place on your chart, and write the date you saw it right next to it. Do this every evening, and you will see which way the Moon moves from day to day.

When the Moon appears very close to a planet or star in the sky, it is called a conjunction. If you see a conjunction, put the symbol for the planet, or the name of the star on your Moon Calendar. (See Figure 1.)

Conjunctions



Moon is near Venus

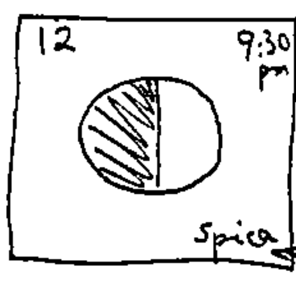
Planet symbols

♀ Venus

♃ Jupiter

♂ Mars

♄ Saturn



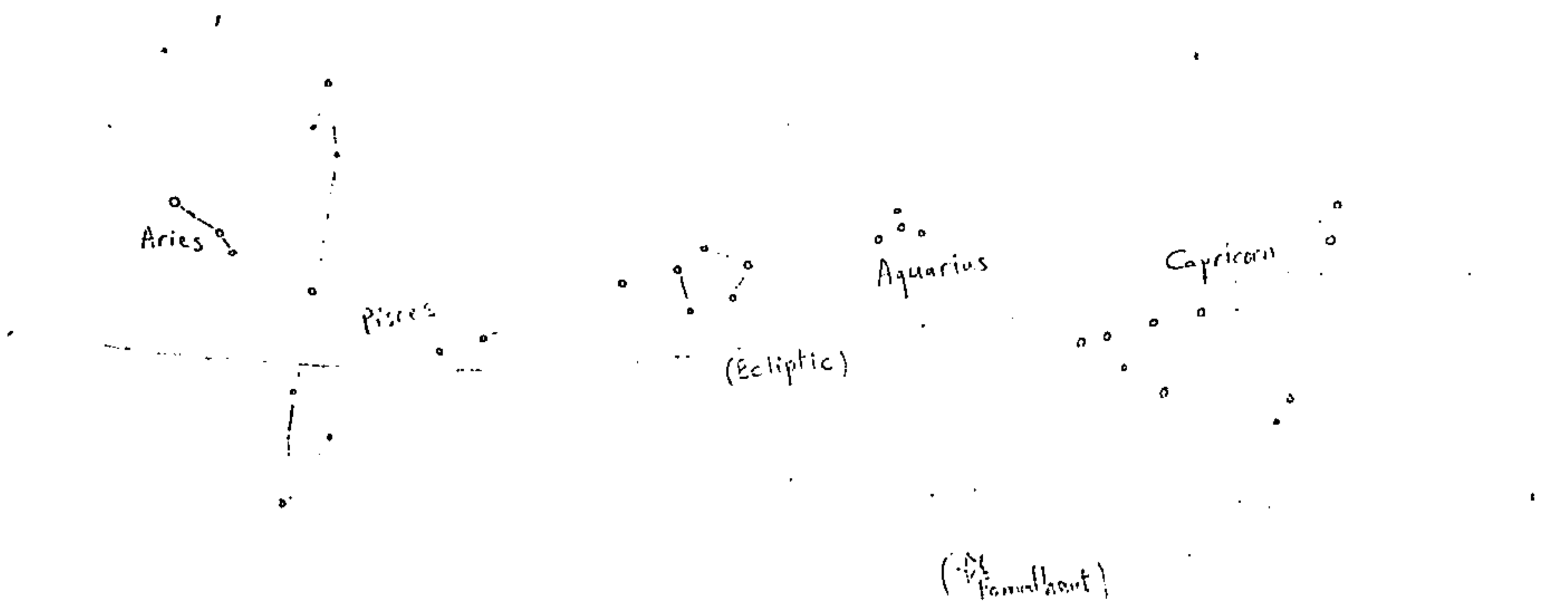
Moon is near Spica

THE STAR CHARTS

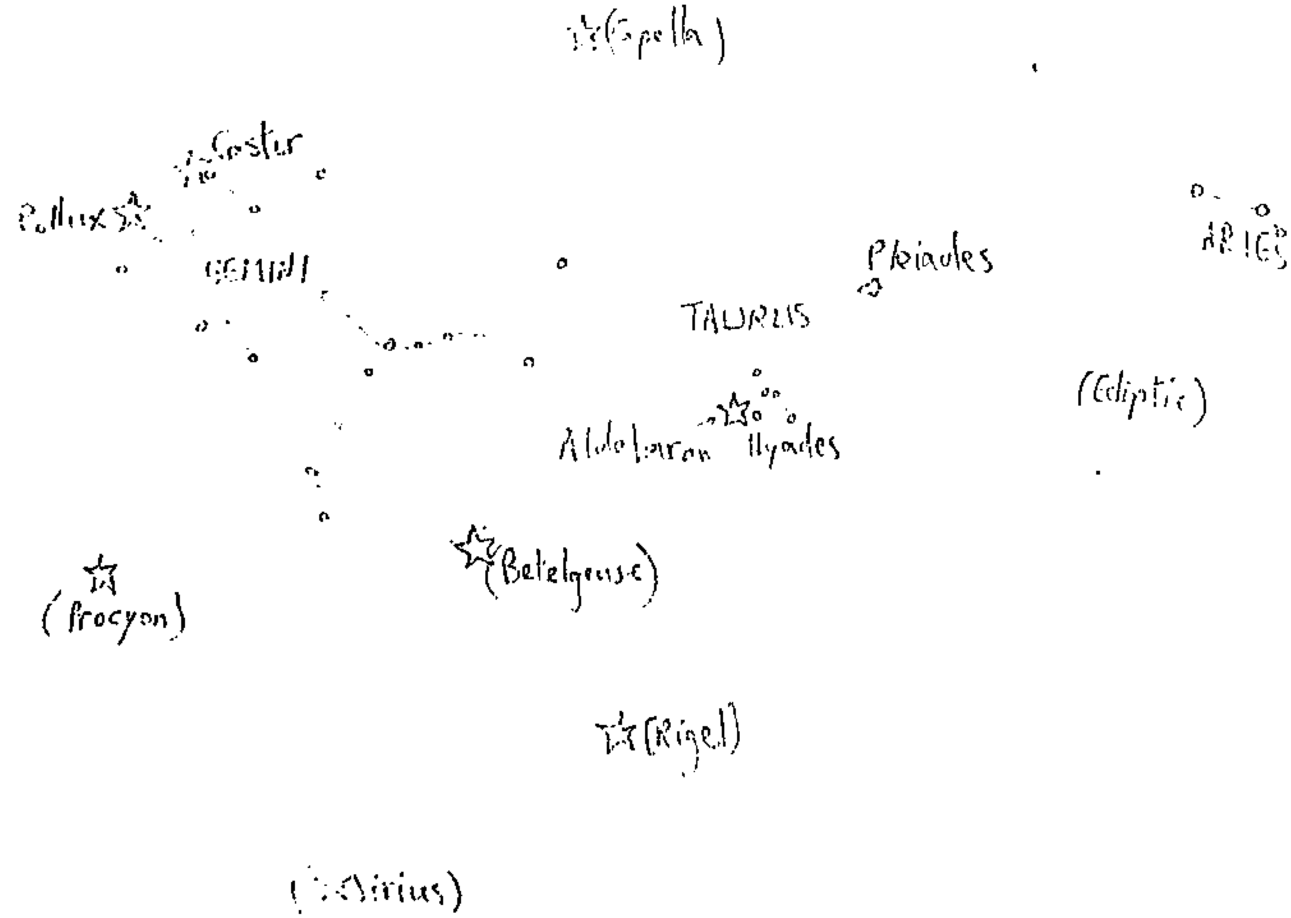
Only some of the stars in the sky are represented on the chart. To find them:

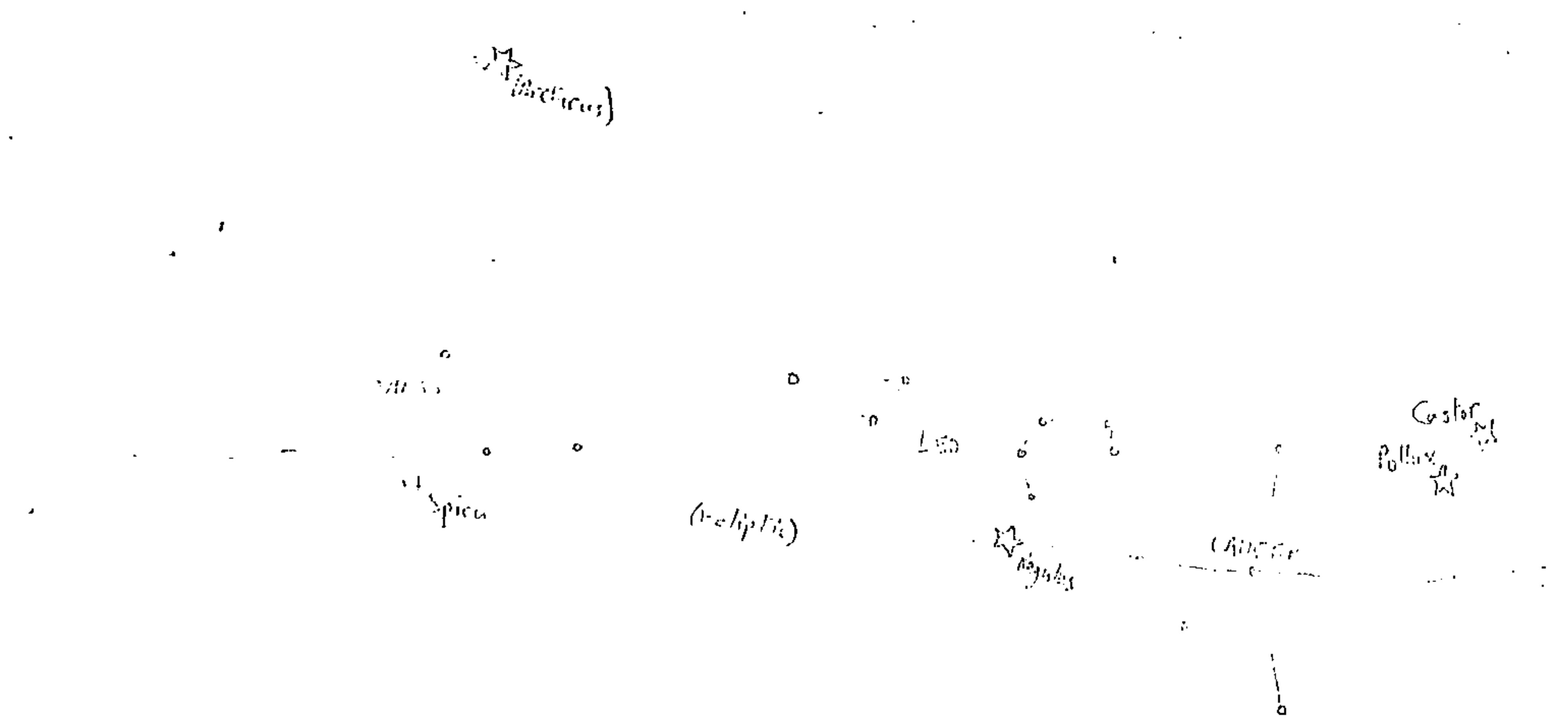
* Face South.
* Hold the chart over your head.
* Look for the brightest stars and try to match them to the ones on the chart.
* Use the bright stars as a guide to the faint ones.

ZODIAC CONSTELLATIONS
(FALL)



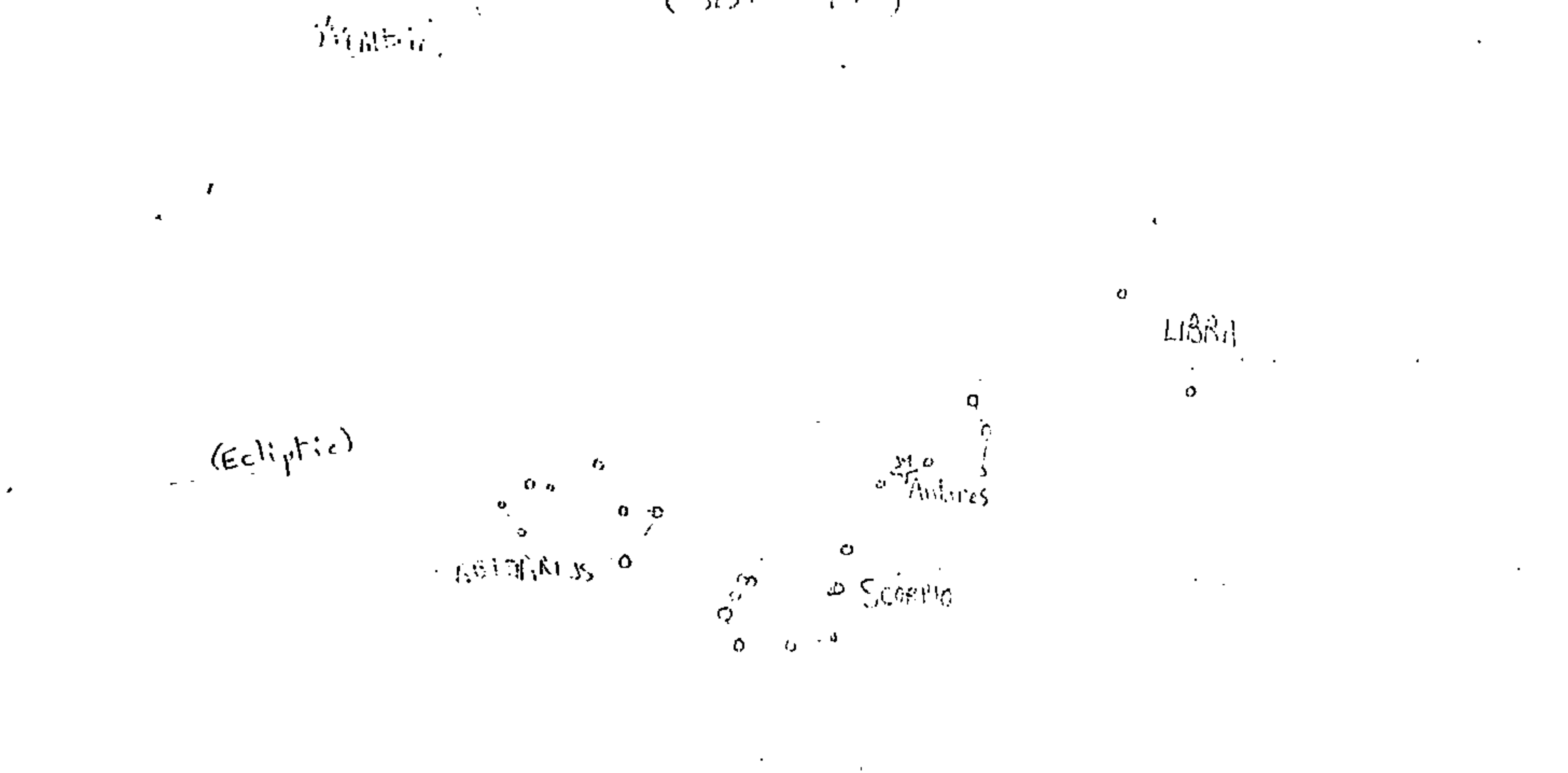
ZODIAC CONSTELLATIONS (WINTER)





Zodiac Constellations (Spring)

ZODIAC CONSTELLATIONS (SUMMER)



Week 3

This week, your students will look for other changes in the sun's daily path. At this half-way point in the Moon-watching, they will learn some interesting Moon vocabulary, and discuss the Moon data accumulated so far. Finally, they will learn to recognize the zodiac constellations.

Continue the activities started in the previous weeks:

* Daily: .Moon Calendar

  .Moon position records (in relation to the Sun and/or stars or planets)

* Once this week: .Sunset

* If your students have not yet found all the bright objects (stars and planets) in the Zodiac, continue working on that, using the Moon as a guide. In either case, if planets are in the sky, have your students find them and indicate their positions on the star chart.

* Research topics: planets, moons, rings, asteroids, the Viking and Voyager missions.

Lesson 7

MIDDAY

OBJECTIVES:

* To understand the midday shadow.

* To start looking for seasonal changes in it.

GRADES: 4 and up.

SCHEDULING:

This lesson will require one class period on a sunny morning, and a few minutes around midday for some shadow observations. It will be followed up with a weekly noon shadow observation.

PREPARATION:

Use the ALMANAC to find out the times of sunrise and sunset on the day of the lesson, and on the day that you performed the gnomon experiment.

STUDENT SHEETS:

* Midday

* Noon Shadow Record Sheet

MATERIALS:

* The record sheet from the gnomon experiment.

* The whole gnomon setup. (See Lesson 2.)

DISCUSSION:

Put the gnomon shadow record sheet where all can see it. Ask the class:

* What would happen if we repeated the gnomon experiment today?

* Would the shadows point in the same direction?

* What time would the shortest shadow be? Where would the Sun be, then?

ACTIVITY:

Tell the students that you will not repeat the whole gnomon experiment, but that you will investigate the day's shortest shadow. It happens when the Sun is highest. It is reasonable to assume that the highest point is halfway between sunrise and sunset. That time is called midday.

Hand out the Midday sheets. Tell the students the times of sunrise and sunset on the day of the gnomon experiment, and show them on the chalkboard how to calculate midday for that day. On the gnomon record sheet, look for the shadow closest to midday, measure it, and note the general direction it is pointing to. (Use the "magnetic North" arrow as a reference.) Note the shadow closest to noon, measure it, and see which direction it is pointing to. Compare the results with the Midday shadow.

Give them today's times of sunrise and sunset. Ask them to calculate the time of midday. (Allow them to do the calculations "their own way" if they want.)

Once the time has been calculated, assign some students to set up the gnomon and compass, so that two shadow observation can be made: one at midday, and one at noon (or as close to noon as practical, e.g. five minutes before lunch recess). Compare the length of the two shadows. (Midday should be shorter.) Compare the direction of the midday shadow with magnetic North. Tell the students that the midday shadow points to the North pole, while the compass points to the magnetic North pole. (If you have access to a globe, show them the North Pole and the magnetic North pole on it.) In other words, gnomon North is true North, while compass North is only an approximation.

From now on, make a weekly measurement of the noon shadow, and enter it on the Noon Shadow Record Sheet. If you miss it on one day, do it the next, as a difference of a day or two is not significant, because changes are slow.

To keep students interested in this weekly activity, ask for predicitions: will the shadow be shorter today? longer? can you predict its length?

CONCLUSIONS:

* Midday is not usually at clock noon.

* The midday shadow points North. In other words, the midday Sun is due South.

* The midday shadow is the shortest shadow of the day.

After a few weeks, it should be apparent that:

* The length of the noon shadow changes from week to week.

COMMENTS:

* If you or your students are interested in the outcome, you can repeat the whole gnomon experiment. You will observe more obvious changes around the Equinoxes (late September or March) than around the Solstices (late December or June).

* Tell the students they can find "gnomon North" at home and compare it to "North Star" North. They should match. If any students want to do this, they will need the time of midday on

a week-end day. Provide them with the times of sunrise and sunset so they can make the calculation.

* In this lesson, your students will learn that calculations are essential to astronomy. Astronomers do use a lot of mathematics, and most of it is beyond the reach of your students. This kit will teach them much of what can be learned without accurate measurements and complex calculations.

MIDDAY

At midday, the Sun is halfway across the sky, on its path from sunrise to sunset. Many people think midday is at noon. You will find out what time midday is today.

To do that, you will need to find the time that is exactly half way between sunrise and sunset. In other words, the time at midday is the average of the time at sunrise and the time at sunset (their sum divided by 2).

HOW TO CALCULATE IT:

The following example is worked out for San Francisco, October 14, 1984. Read it, then use the same method to find midday today in your town. Or, work out your own method for finding midday.

1. Time at sunrise: 7:18 (am)

2. Time at sunset: 18:34 (i.e. 6:34 pm).

3. Average of the hours: (7 + 18) / 2 = 12.5 or 12 1/2. In other words, 12:30 .

4. Average of the minutes: (18 + 34) / 2 = 26

5. Time at midday: 12:30 + :26 = 12:56. The answer is 12:56 pm

* Be sure to use a 24-hour clock! (In other words, if the time you have for sunset is less than 12, add 12 hours to it.)

* Remember that half an hour is 30 minutes (see #3 in the example above).

* If you get an answer like 11:71, with a number of minutes greater than 60, subtract 60 from the minutes, and add 1 to the hours. (In the case of 11:71, you get 12:11.)

Noon shadow record sheet

Date	Time	Length of shadow

Try to measure the gnomon's shadow at the <u>same time</u> every day.

Lesson 8

MOON WORDS

OBJECTIVES:

* To learn some useful Moon vocabulary.

* To start analyzing the Moon data collected so far.

GRADES: 4 and up.

SCHEDULING:

This discussion will take one class period.

STUDENT SHEETS:

* Moon Vocabulary

* Moon Questions (a reference for you - do not hand it out)

DISCUSSION:

Tell the students to take out all their Moon records (Calendars, Sun-Moon, and star charts). Hand out the Moon Vocabulary sheet. Have the students take turn reading it aloud. Stop after each definition for any discussion your students want to have about the word.

Continue the discussion with the questions on the student sheet titled "Moon Questions". (Do not hand out the sheet, which will be used as one of the concluding activities in Week 6.) You can also use the questions below, as well as any raised by your students.

Some questions will probably be answered correctly today. Others won't. Do not provide any answers at this stage. Instead, record the students' conjectures (perhaps on large sheets of paper that all can see) and say that the accuracy of the answers will be tested by further observations and record keeping. The main point of raising them is to make the students more observant and analytical in the remaining weeks of Moon-watching, so that they are able to answer the questions themselves by the end of the observing period.

If your students do not reach a certain conclusion at the end of a certain lesson, it probably means that they were not ready for it. Be patient: they will probably figure it out before long. Further observations and experiments can be used to resolve differences, or to propel discussion further.

* Why is the First Quarter Moon called that even though it is a half-moon? (Because it takes place one-quarter of a moon cycle after New Moon.)

* Why is the New Moon called that? (Because the "old" Moon gradually got smaller and disappeared, and a new Moon cycle is starting.)

* How can the Moon be invisible sometimes? (Because it is in the general direction of the Sun. It is lost in its glare, and only the side of the Moon furthest from us is illuminated.)

* How can you tell First from Last Quarter? (A First Quarter Moon is to the left of the Sun, it looks like a capital "D", and can be seen in the evening. A Last Quarter Moon is to the right of the Sun, it looks like a backwards "D", and can be seen in the morning.)

COMMENTS:

* What Moon word can be changed into its opposite by changing one letter? (Answer: "waxing" and "waning".)

MOON VOCABULARY

CRESCENT: less than a half-moon

FIRST QUARTER: the half-moon that follows the New Moon

FULL MOON: you already know this one

GIBBOUS: more than a half-moon

LAST QUARTER: the half-moon that follows the Full Moon

NEW MOON: Moon that is invisible, no matter when or where you look, or what the weather is like

WANING: getting smaller

WAXING: getting bigger

Lesson 9

The Ecliptic

OBJECTIVES:

* To recognize the brighter Zodiac constellations.

* To understand that the Moon and planets travel along the Ecliptic.

SCHEDULING:

You will need a clear night. Do the activity at least twice: once when the Moon is visible in the evening sky, and once when the Moon is not. (A moonless night affords the best chance to see the fainter constellations.)

Note: The Zodiac constellations that are visible in the evening in Winter, Spring, and Summer, are easier to find and identify than the ones visible in the early Fall, which consist exclusively of faint stars.

PREPARATION:

Use the SKY CALENDAR (or ALMANAC) to find the best nights for this assignment.

STUDENT SHEETS:

* Star charts

* The Zodiac

* Symbols

DISCUSSION:

* What is a constellation? (A group of stars.)

* What is the meaning of the words "Gemini", "Taurus", etc.? (They are the names of constellations.)

ACTIVITY:

Hand out the star charts and the Zodiac and Symbols sheets. Review how to use the star charts.

Have the students find the various Zodiac constellations on the chart. Ask them which constellation each planet is in. (The planets should have been drawn into the star charts during Lesson 6.) Explain that the reason the planets and Moon are not usually shown on star charts is that they are not always in the same place in the sky.

If the Moon is to be in the sky, remind the students to draw it at the right place on the star chart, and mark the date next to it. Also show them how to enter the symbols on the Moon Calendar to show which constellation the Moon is in.

CONCLUSIONS:

After they can recognize the Zodiac constellations, and when they have several observations of the Moon in various constellations, your students are ready for the following ideas:

* The Moon moves from one Zodiac constellation to the next.
* This motion is from West to East (right to left).
* Planets also move among the Zodiac constellations, but it takes them much longer. (Actually, Venus and Mars move faster than Jupiter or Saturn.)
* The Moon and planets never move very far from an imaginary line called the Ecliptic. (The Ecliptic is shown on the Star Charts, but it is not visible in the sky.)

COMMENTS:

* You may choose to introduce your students to more than just the Zodiac constellations. In fact some other constellations are often easier to find and can be used as a guide to the ones in the Zodiac. See for example THE STARS: A NEW WAY TO SEE THEM, by H.A.Rey.

* As new Zodiac constellations appear in the evening sky, you should repeat this activity in order to introduce it to your students.

* Some students may enjoy memorizing the symbols for the planets and constellations, or making a bulletin board display of them.

* It is not advisable to teach lessons in this kit earlier than scheduled. However, an exception can be made: Lesson 11 (telescopes) can be taught this week, in conjunction with this lesson.

* In addition to the star charts supplied among the Student Sheets, you may want to reproduce the SKY CALENDAR monthly EVENING SKIES chart, or some other. You can also make your own charts by tracing. This allows you to add stars, planets and constellations gradually. If you use a whole-sky chart, remember to explain to your students how to hold it: the direction you are facing should be at the bottom, and overhead is in the center.

THE ZODIAC

Just like the Sun and the Moon, the stars in the sky are constantly moving. But they move together: they are arranged in patterns that do not change. People often "connect the dots" in their mind and imagine that the stars make up different shapes in the sky. These are called constellations. The ancient Greeks named many constellations. We still use these names today.

The Zodiac is a group of constellations in the sky. You can only see three or four up at any given time, but there are twelve of them. What makes these constellations special is that they are located along an imaginary line in the sky, called the Ecliptic (which is indicated on your star chart). The Sun, the Moon, and the planets are always near this line. They appear to travel along the Ecliptic, from one Zodiac constellation to the next.

If you see the Moon at night, it will be in one of the Zodiac constellations. Try to figure out which constellation it's in, and write the symbol for that constellation at the right place on your Moon Calendar. The planets too are always in the Zodiac.

Zodiac constellations symbols

♈ Aries

♉ Taurus

♊ Gemini

♌ Leo

♍ Virgo

♎ Libra

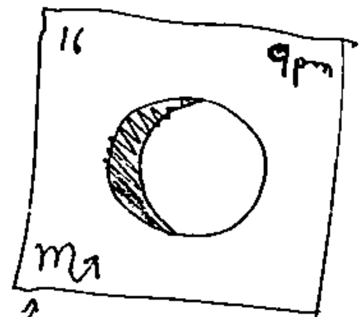
♏ Scorpius

♐ Sagittarius

♑ Capricorn

♒ Aquarius

♓ Pisces



The Moon is in Scorpius

Week 4

In the first three weeks of this unit, you have set up a complete program of naked-eye observation of the Solar System. By now, the observational work should be routine, and while your students should be reminded to keep it up, the main focus of the lessons will shift to activities that will give the students a broader and deeper view.

This week, for example, your students will evaluate the claims of those who believe in astrology; they will look at the night sky through a telescope, and they will make a model of planetary orbits.

Continue the activities started in the previous weeks:

* Daily: .Moon Calendar

  .Moon position records (in relation to the Sun and/or the stars and planets)

* Once this week: .Sunset

  .Noon shadow

* If your students have not yet identified all the Zodiac constellations, continue working on that until they have.

* Research topic: Comets. (This should be done before Lesson 12.)

Lesson 10

ASTROLOGY

OBJECTIVES:

* To evaluate the accuracy of astrological predictions.

* To do this by way of a statistical approach.

GRADES: 6 and up.

SCHEDULING:

This unit will take two class periods.

PREPARATION:

The activity will be a testing of the accuracy of a given horoscope through interviews conducted by your students. Interviewees will be asked to say which of two horoscopes applies to them. One will actually be theirs, and the other not. The question is how often the correct guesses will be made. (Approximately 50 % can be expected by chance alone.)

* Decide who will be interviewed: your own students? students in other classes? students and teachers in the playground? family and neighbors of your students? some combination of these? For the results to mean anything, you would have to interview at least 50 people. (Interviewing exactly 100 people would make for easy calculations.)

* Randomly pair the horoscopes and number the pairs. (Example: #1: Sagittarius & Pisces; #2: Capricorn & Virgo, etc.)

* Within each pair, decide which sign will be "a" and which sign will be "b". Do not tell anyone which is which until all the interviews have been completed (Example: #1a:Sagittarius,

#1b: Pisces, #2a: Virgo, #2b: Capricorn, etc.)

* Choose the horoscope from some publication. The best is probably to use the daily paper from the day preceding the activity.

* Delete the signs, and replace them with the number and letter you selected for each. Rearrange the horoscopes in numerical order. (Example: #1a: "This is an opportune time for making important financial decisions. Problems will befall one of your loved ones.". #1b: "You have a tendency to take on too much. Concentrate on improving your communication with others." etc.) Duplicate the resulting sheet for your students.

STUDENT SHEETS:

* Yesterday's horoscopes (see above)

* Astrology Survey

* Astrology Survey Instructions

DISCUSSION:

Tell the students that the Sun also travels along the Ecliptic. However, since the stars are not visible in the daytime, it is not obvious which of the Zodiac constellations it is in. However by watching the sky at sunrise and sunset, it is possible to find out which constellation the Sun is in. According to astrologers, "your sign" is the constellation the Sun was in on the day of your birth.

* What is the difference between astronomy and astrology?

* What is a horoscope?

* Can the future be predicted?

ACTIVITY:

Hand out the reproduction of the horoscope, and the student sheets.

Explain the design of the experiment. Have the students enter the numbers (1 through 6) into the first "Code" column on the Astronomy Survey sheet.

Tell your students to conduct the interviews as follows:

* Ask the subject for his or her birthday.
* Look up the appropriate sign and find out its number.
* Read both horoscopes that carry this number to the subject. Ask him or her which of the two horoscopes most accurately applied to him or her on the previous day.
* Put a check mark on the survey sheet under "a" or "b", depending on the subject's answer.

(It is important that the students NOT know which horoscope is which, in order to prevent their behavior from affecting the subject. For the same reason, they should not show their tally to the subject.)

Discuss the criteria of your study with the students BEFORE starting the interviews. Ask them how many of the subjects can be expected to identify their horoscopes correctly by chance alone. Since this is clearly 50 %, agree on a greater percent of correct identifications that would make the horoscopes "pass" the test. 67 % ("2 to 1")? 75 % ("3 to 1")? 80 % ("4 to 1")? 90 % ("9 to 1")? A higher number is of course a more stringent requirement. What is important is that the class agree to the number ahead of time.

The next day, when the interviews are completed, reveal the correct letter (a or b) for each sign, and have the students enter it in the second "Code" column. Tell them to count the correct guesses, and the total guesses and to enter the numbers on the right. Each column should be added up, and the total entered at the bottom.

Finally, all the students' results should be combined. Divide the total number of correct guesses by the total number of interviews, and multiply by 100. This is the percentage of correct guesses. Did the horoscopes pass the test?

CONCLUSIONS:

Belief or non-belief in astrology is not likely to be changed by this experiment. For one thing, "serious" believers in astrology reject newspaper horoscopes as crude. Nevertheless, since newspaper astrology has the broadest audience, it is interesting to discuss it critically.

* Would the results have been different if the horoscope from another publication had been used?

* Why are horoscopes often vague?

* Should one trust horoscopes when making important decisions?

You may want to make clear that few, if any, astronomers believe in astrology, even though some astrologers use accurate astronomical data.

COMMENTS:

* Try to pick up a copy of the NATIONAL ENQUIRER near the beginning of the calendar year. They often feature astrologers' predictions for the coming year. It is interesting to check on the accuracy of the predictions. (All the ones I ever saw were

quite far off the mark, but see for yourself.)

* For ideas on a scientific appraisal of astrology and other paranormal claims, you may want to read various issues of THE SKEPTICAL INQUIRER (BOX 229, Central Park Station, Buffalo, New York, 14215), or write the Astronomical Society of the Pacific.

ASTROLOGY SURVEY

Sign	Dates	Code		Tally of Guesses		Number of guesses	
		1-6	a-b	a	b	Correct	Total
Capricorn	Dec22-Jan19						
Aquarius	Jan20-Feb19						
Pisces	Feb20-Mar21						
Aries	Mar22-Apr20						
Taurus	April 21-May21						
Gemini	May22-Jun22						
Cancer	Jun23-Jul23						
Leo	Jul 24-Aug23						
Virgo	Aug24-Sep23						
Libra	Sep24-Oct23						
Scorpio	Oct24-Nov22						
Sagittarius	Nov23-Dec22						
					TOTAL		

ASTROLOGY SURVEY

Sign	Dates	Code		Tally of Guesses		Number of guesses	
		1-6	a-b	a	b	Correct	Total
Capricorn	Dec 22 - Jan 19	2					
Aquarius	Jan 20 - Feb 19	3					
Pisces	Feb 20 - Mar 21	1					
Aries	Mar 22 - Apr 20	3					
Taurus	April 21 - May 21						
Gemini	May 22 - Jun 22						
Cancer	Jun 23 - Jul 23						
Leo	Jul 24 - Aug 23						
Virgo	Aug 24 - Sep 23						
Libra	Sep 24 - Oct 23						
Scorpio	Oct 24 - Nov 22						
Sagittarius	Nov 23 - Dec 22						
					TOTAL		

Before the survey

ASTROLOGY SURVEY

Sign	Dates	Code		Tally of Guesses		Number of guesses	
		1-6	a-b	a	b	Correct	Total
Capricorn	Dec 22 - Jan 19	2		||	~~||||~~ |		
Aquarius	Jan 20 - Feb 19	3		|	|||		
Pisces	Feb 20 - Mar 21	1			||		
Aries	Mar 22 - Apr 20	3		||||	||||		
Taurus	April 21 - May 21						
Gemini	May 22 - Jun 22						
Cancer	Jun 23 - Jul 23						
Leo	Jul 24 - Aug 23						
Virgo	Aug 24 - Sep 23						
Libra	Sep 24 - Oct 23						
Scorpio	Oct 24 - Nov 22						
Sagittarius	Nov 23 - Dec 22						
					TOTAL		

The survey

L10/P

ASTROLOGY SURVEY

Sign	Dates	Code		Tally of Guesses		Number of guesses	
		1-6	a-b	a	b	Correct	Total
Capricorn	Dec 23 - Jan 19	2	b	||	~~||||~~ |	6	8
Aquarius	Jan 20 - Feb 19	3	a	|	|||	1	4
Pisces	Feb 20 - Mar 21	1	b		||	2	2
Aries	Mar 22 - Apr 20	3	b	||||	||||	4	8
Taurus	April 21 - May 21						
Gemini	May 22 - Jun 22						
Cancer	Jun 23 - Jul 23						
Leo	Jul 24 - Aug 23						
Virgo	Aug 24 - Sep 23						
Libra	Sep 24 - Oct 23						
Scorpio	Oct 24 - Nov 22						
Sagittarius	Nov 23 - Dec 22						
					TOTAL		

Survey results.

Lesson 11

TELESCOPES

OBJECTIVES:

* To learn the features of the Moon and planets that can be seen with the help of binoculars or a small telescope.
* To review the stars and planets as learned in previous observational homework.

GRADES: 4 and up.

SCHEDULING:

This unit requires an evening or overnight field trip on a clear night. It is preferable to get as far away from city lights as possible. Do it a few days after the New Moon. The small crescent Moon sets early, leaving a dark sky.

MATERIALS:

You will need a pair of binoculars on a tripod, or preferably a small telescope. Of course more instruments are better if you have enough adults to supervise their use.

If you don't have access to any such equipment, contact the closest planetarium and inquire about groups of amateur astronomers in your area. Such groups are usually eager to introduce new people to their hobby and show off their equipment.

PREPARATION:

Practice finding the planets in the telescope or binoculars in the days preceding the outing.

Duplicate a star chart that includes both familiar and new material.

ACTIVITY:

Start out by finding the constellations studied previously. Use this opportunity to help any student who has not yet found the Zodiac constellations or the naked-eye planets. Introduce any new objects you want to.

Aim the telescope or binoculars towards the objects that are visible this evening. Warn the students not to kick the tripods. In fact it is best for them not to touch the instruments, so that these remain aimed to their targets. You will need to periodically adjust the aim, since everything is constantly moving westward.

With good binoculars, you can usually see one or two of Jupiter's moons, and craters on the Moon.

With almost any telescope, you can see up to four of Jupiter's moons, stripes on Jupiter's surface, the rings of Saturn, the phases of Venus, and a lot of detail on the Moon's surface.

CONCLUSIONS:

It is by looking in a telescope that was probably not as good as the one your class used that Galileo concluded:

* The Moon has mountains and "seas" (flat areas). In some ways, it is a world like the Earth.

* Venus has phases like the Moon.

* Jupiter has moons that orbit around it. (Therefore, since some heavenly bodies travel around another world than the Earth, the Earth can no longer be considered the center of the

Universe.)

* Saturn has ears (at least that's what they look like in a tiny telescope.)

* The planets are much closer than the stars. Stars just look like stars in the telescope. Planets actually look closer, revealing an actual disk to the telescope.

Lesson 12

ORBITS

OBJECTIVES:

* To understand elliptical orbits.

GRADES: 6 and up.

SCHEDULING:

This lesson will take one class period.

MATERIALS:

* String, marking pens of various colors

* A bulletin board

* A large piece of paper

* Pins

DISCUSSION:

Tell the students that people used to think that the Sun, the Moon, the planets, and the stars all went around the Earth in circles.

* To what extent were they right? (The Moon orbits around the Earth)

* How were they wrong? (The planets, including Earth, orbit around the Sun)

* What is a comet? What is an asteroid? (Have students give reports on their research.)

ACTIVITY:

Place the large piece of paper on the bulletin board. Draw a Sun near the center, and place a pin at the Sun's center. Make a loop of string, and draw a circle centered at the Sun as shown in Figure 12-1.

Then, draw an ellipse by putting the loop around two pins (one at the Sun, and the other elsewhere). Show the class that if the two pins are close, the ellipse resembles a circle. Otherwise, it is very elongated. Explain that most planets travel around the Sun in fairly circular orbits but that comets travel in excentric orbits, which is why they are only visible to us for a short time, and then disappear for long periods.

Tell the students that the point of the orbit where the planet is nearest the Sun is called "aphelion". The point where it is furthest from the Sun is called "perihelion". Discuss how to find these points on the ellipses on the bulletin board. (They are at the points where the orbit meets the straight line that passes through the pins.)

COMMENTS:

* The students can draw their own ellipses if you provide them with cardboard to put under their papers, so that the pins do not damage their desks.

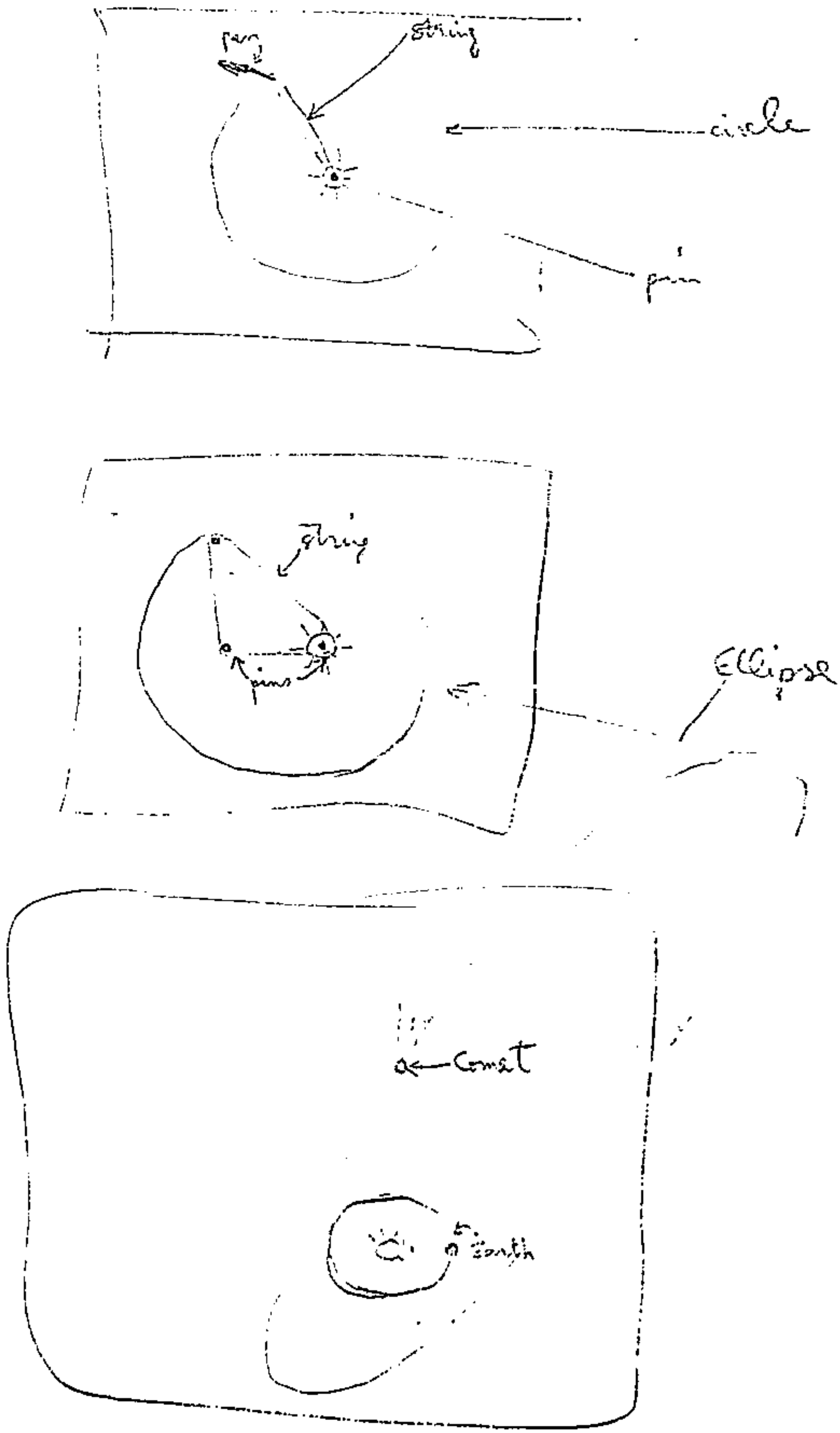


Fig 12-1

Week 5

By now, your students should have seen the Moon in all its phases. They know that the Moon orbits the Earth. They are ready to make more sophisticated models of the Moon / Earth / Sun system. This will help improve their understanding of the phases of the Moon and of the occurence of eclipses.

Having seen some of the components of the Solar System, and read about the rest, they are ready for a scale model of the entire system. This will give them a sense of the proportions of the various planets, and the vastness of the empty space between them.

The hands-on experiments are most effective if you allow each student to carry them out, as part of a small group. The materials in the Science Shelf kit are enough for one experimental setup. Small groups of students can take turns using it. If you want all of them to work on the experiments simultaneously, you may purchase the materials at dime or hardware stores, or order the Class Set, which includes twelve setups.

Now is a good time to review the spelling of the all the words learned so far.

Continue the activities started in the previous weeks:

* Daily: .Moon Calendar

.Moon position records (in relation to the Sun and/or the stars and planets)

* Once this week: .Sunset

.Noon shadow

* Research topic: Eclipses (before Lesson 14.) A good source is ECLIPSE! by ...

Lesson 13

MOON MODEL

OBJECTIVES:

* To explain the phases of the Moon with the help of a model.

* To figure out in which direction the Moon orbits the Earth.

GRADES: 4 and up.

SCHEDULING:

This lesson takes one class period.

MATERIALS:

* A bright light

For each student:

* A 3" diameter styrofoam ball

* A 9" long, 1/16" diameter dowel

DISCUSSION:

Have the students take out their Moon Calendars as a reference.

* What have we learned about the Moon?

* When was the First Quarter Moon? the Full Moon? The Last Quarter Moon?

* How many days elapsed beween them? (Approximately seven days from phase to phase.)

Make sure the students understand the sequence of the Moon's phases. In particular, make sure they can distinguish a First Quarter Moon from a Last Quarter Moon. (The Last Quarter Moon is the one that FOLLOWS the Full Moon. The First Quarter Moon precedes it. They are mirror images of each other, with the First Quarter looking like a capital "D".)

ACTIVITY:

Place the bright light at the height of an average student's head. Make the room as dark as possible, and turn on the light. The light represents the Sun. Put the sphere on the dowel (it represents the Moon). Have a student hold the dowel at arm's length, standing as far as possible from the light. The student's head represents the Earth. Point out that the part of the "Moon" that is illuminated by the light, changes shape AS SEEN BY THE STUDENT as he turns and the relative positions of "Sun", "Moon" and "Earth" change. The changing shapes correspond to the phases of the Moon.

Discuss whether the student should turn clockwise or counterclockwise for a correct simulation. (This can be determined by noticing which direction yields a Last Quarter Moon after the Full Moon.Turning counterclockwise simulates the Moon's "right to left" motion.)

Of course, students will learn most by carrying out this activity themselves. Watching it demonstrated by someone else is not particularly helpful since you cannot see the "Moon" as they see it.

CONCLUSIONS:

The following conclusions should be possible at this stage:

* The Moon's cycle is related to the Moon's motion around the Earth.

* The Moon's phases are caused by the varying shape of the part

of the Moon that is illuminated by the Sun, as seen from Earth.

* The Moon moves from right to left in relation to the Sun.

COMMENTS:

* This activity was inspired by "Moons of the Solar System" a show at the Holt Planetarium, Lawrence Hall of Science, in Berkeley, California. The show, in turn, was inspired by Lawrence Moscotti of the Como Planetarium, St-Paul, Minnesota.

Lesson 14

ECLIPSES

OBJECTIVES:

* To get a sense of the relative size and distance between the Moon and the Earth.

* To simulate solar and lunar eclipses.

GRADES: 6 and up.

SCHEDULING:

This lesson requires one class period on a sunny day.

MATERIALS:

For each group of two:

* One 3" diameter styrofoam ball

* One 3/4" diameter white bead

* One 7 1/2' length of string

* Two 1/16" diameter, 9" long dowels

STUDENT SHEET:

* Eclipses

DISCUSSION:

Hold up the styrofoam ball. Ask the class:

* If the Earth was this size what size would the Moon be?

After hearing some answers, hold up the bead, and tell the class that the Moon would be this size. Now ask:

* How far apart would they be?

Again, after hearing some answers, tell the class the answer is 7 1/2 feet.

* How large and how far would the Sun be? (The Sun would be

more than 27 feet in diameter, at a distance of more than half a mile.)

ACTIVITY:

Tell the students that the dowels will be used to hold the spheres. Have them follow the instructions on the student sheet. Help them answer the questions.

CONCLUSIONS:

During a Solar Eclipse:

* The Moon is New.

* The Moon's shadow covers only a small area of the Earth. Since most people are not in that area, very few people experience total eclipses of the Sun.

During a Lunar Eclipse:

* The Moon is Full.

* It is eclipsed as long as it is in the Earth's shadow.

* You do not have to be any particular place to see a Lunar eclipse -- just look up at the Moon.

ECLIPSES

In this activity, the Earth and the Moon will be represented by spheres of the appropriate sizes, held on thin dowels by two people. Tie the dowels to each other with an appropriate length of string. (See Figures 1 and 2. For the Sun, use the real Sun.)

SOLAR ECLIPSE:

During a solar eclipse, the Moon's shadow falls onto the Earth. Use your model to show this, and try to answer the questions.

* What phase is the Moon in during a solar eclipse?

* Notice the size of the Moon's shadow. For people who are standing in the shadow, the Sun is completely hidden by the Moon. This is called a total eclipse of the Sun. The area on Earth over which the Moon's shadow passes is called the "path of totality". Explain why most people do not see a total eclipse.

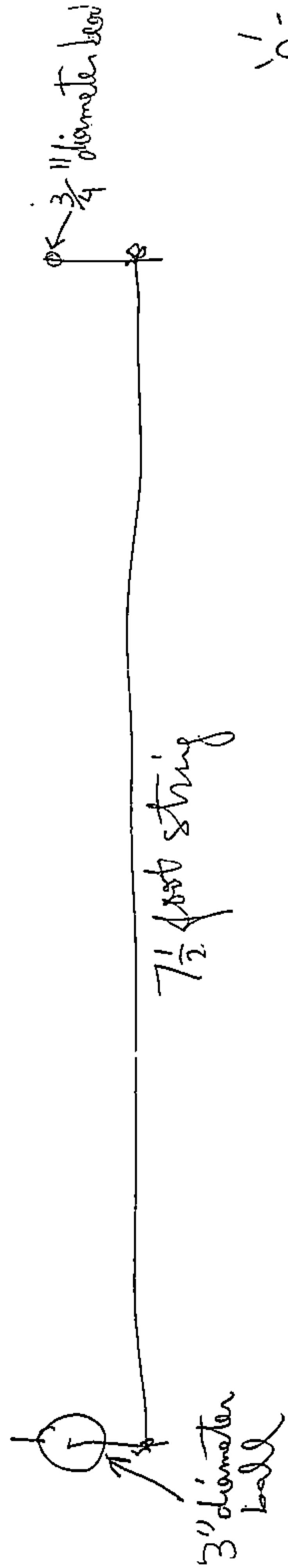
LUNAR ECLIPSE:

During a lunar eclipse, the Earth's shadow falls onto the Moon. Use your model to show this, and try to answer the questions.

* What phase is the Moon during a lunar eclipse?

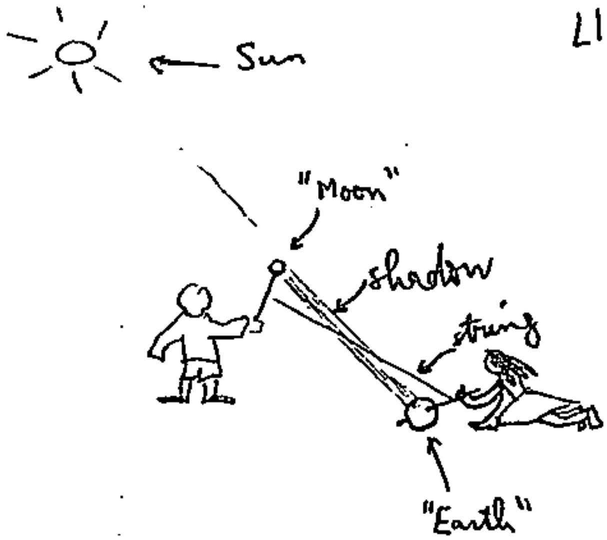
* Notice the size of the Earth's shadow. It covers an area greater than that of the Moon. Explain why a lunar eclipse lasts longer than a solar eclipse.

* Explain why everybody who can see the Moon can see a lunar eclipse.



3/4'' diameter ball
7½ foot string
3'' diameter ball

Fig 1



Sun
"Moon"
shadow
string
"Earth"

Fig 2.

Lesson 15

SCALE MODELS

OBJECTIVES:

* To give students a sense of the relative sizes of the various components of the Solar System.

* To give students a sense of the relative distances between them.

GRADES: 6 and up.

SCHEDULING:

This lesson requires one or two class periods.

MATERIALS:

* As many spheres of various sizes as possible. (The ones provided in this kit are sufficient, but if you have more spheres, use them. Or, you could ask your students to bring spheres of various sizes to school.)

* String

* A measuring tape

* A transparent ruler, or (if available) a caliper

STUDENT SHEETS:

* Scale Models

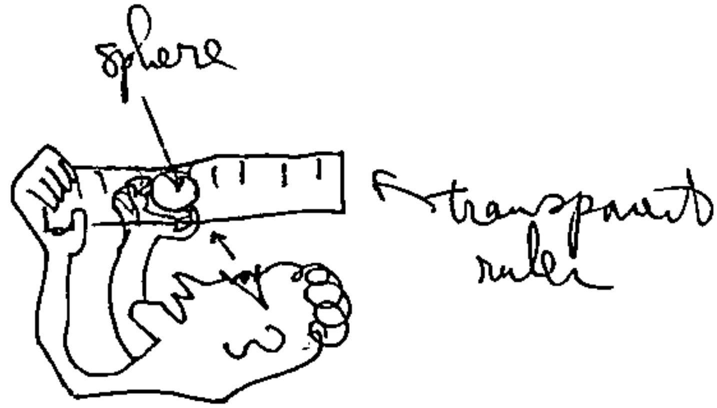
ACTIVITY:

Hand out the Scale Model student sheets, and discuss how to make each of the two models. Your students should be able to figure out that while the planets for the first model can be represented by some of the spheres included in this kit, the Sun would be difficult to show, and the distances required would spread the model all over a medium-sized town. On the other hand, the second model can fit in the playground, but the planets would be so small as to be invisible.

For the first model, show the students how to measure the diameters of spheres by looking though a transparent ruler. Of course, if you have a caliper, encourage them to use it.

For the second model, use the measuring tape to measure lengths of string for each distance. Assign a student to each planet and have them hold one end of the string. Then, on the playground, tie the other end to a flagpole. You may want the children to wear signs bearing the planet's names. (See Figure.)

You can combine the two models into one, using the scale from the first model for the sizes, and the scale from the second model for the distances. However, the result would not convey clearly the immensity of the empty space between planets.



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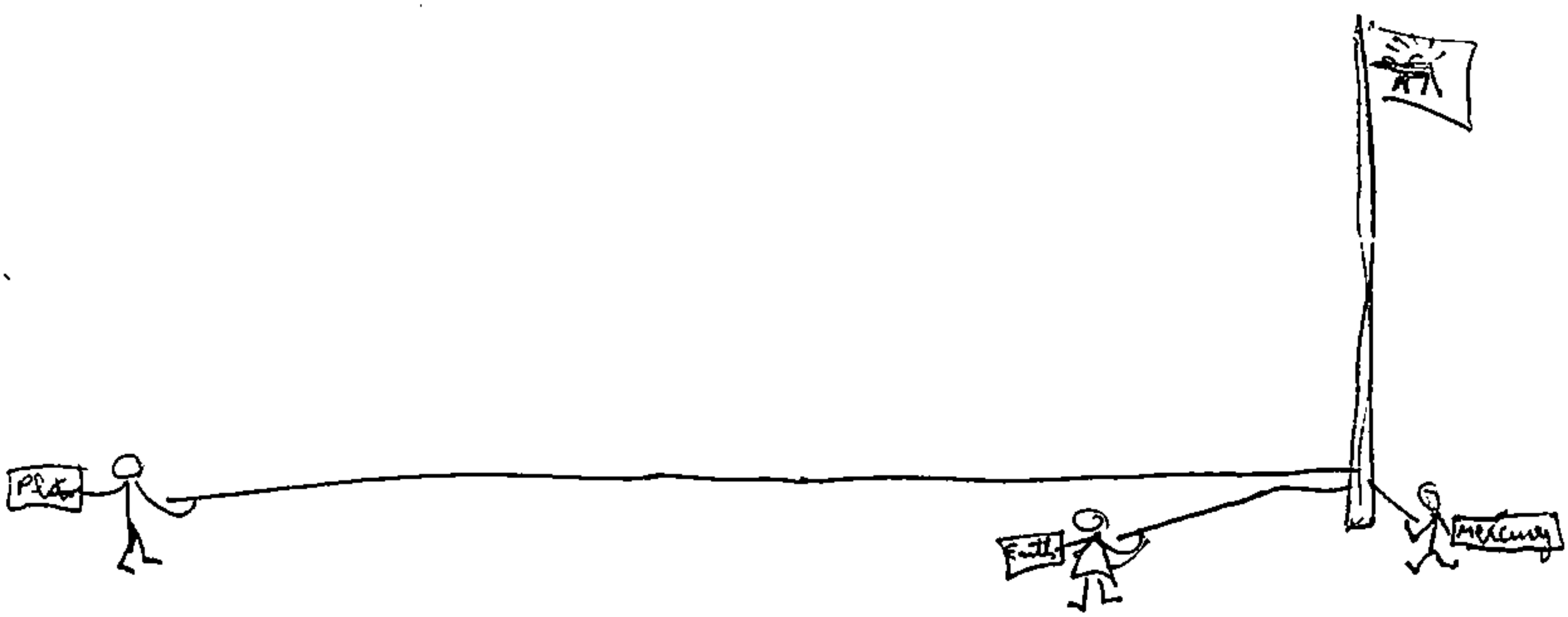


Solar System Model
Henri's class, 1979.

Scale: one billionth (1/1,000,000,000)

Planet	Diameter (mm)	Distance (When furthest from Sun) Aphelion (m)	Distance from (When closest to Sun) Perihelion (m)
Sun	1,392	—	—
Mercury	4.88	69.7	45.9
Venus	12.1	109	107.4
Earth	12.76	152.1	147.1
Mars	6.79	249.1	206.7
Jupiter	142.8	815.7	740.9
Saturn	120	1,507	1,347
Uranus	51.8	3,004	2,735
Neptune	49.5	4,537	4,456
Pluto	6	7,375	4,425

Solar System Model

Scale: One hundred billionth (1/100,000,000,000)

Planet	Diameter (mm)	Aphelion (m)	Perihelion (m)
Sun	13.92	–	–
Mercury	0.05	.697	.459
Venus	.1	1.090	1.074
Earth	.1	1.521	1.471
Mars	.07	2.491	2.067
Jupiter	1.4	8.157	7.409
Saturn	1.2	15.07	13.47
Uranus	.5	30.04	27.35
Neptune	.5	45.37	44.56
Pluto	.06	73.75	44.25

Week 6

This week, your students round up their study of the Moon with a "test" and an attempt at predicting the Moon's behavior in the next few weeks.

Continue the activities started in the previous weeks:

* Daily (until Lesson 17):

.Moon Calendar

.Moon position records (in relation to the Sun and/or the stars and planets)

* Once this week: .Sunset

.Moon shadow

* Research topics: the Moon, its craters, the Apollo program.

Lesson 16

THE MOON'S CYCLE

OBJECTIVES:

* To draw conclusions from the Moon Calendar and other records of Moon observations.

SCHEDULING:

This lesson will take one or two class periods.

PREPARATION:

If you have not kept a class Moon Calendar on the wall, collect the students' Moon Calendars. Compile the information gathered into one master calendar. Do not "edit" the data. On days where no observation was made, put a question mark. On days where the observations disagree, put the majority observation. There may be a day where you only have one observation, and it is inaccurate -- include it anyway. (Your students will be able to spot poor observations by noting that they do not fit in the patterns that emerge when looking at the "big picture" obtained from most of the data.)

Do the same with the daytime and nighttime records of Moon position.

STUDENT SHEET:

* Moon Questions

ACTIVITY:

Hand out copies of the Master Moon Calendar, other master Moon records, and the "Moon Questions" student sheet. Tell the students that they can use their own records and their memories as well as the master records when answering the questions. Tell them the questions are very difficult and that most adults would not be able to answer all of them. Have the students write down their answers to the questions.

(If you are using these questions as a test, collect them and continue the next day. You will find that the most serious moon-starers will also be the ones with the most correct answers. Do not be surprised if some students only get a few correct answers.)

Next, allow the students to discuss the answers with each other, and to modify or add to their written answers. Finally, have a class discussion of the questions.

CONCLUSIONS:

Some of the following conclusions should be possible:

* The Moon's cycle takes approximately 28 days.

* While the Moon's daily motion is from East to West across the Southern sky, its monthly motion against the background of the other celestial bodies is from West to East (i.e. from right to left).

* The Full Moon rises when the Sun sets, and sets when the Sun rises.

* The waxing crescent first appears in the West at sunset.

* Because of its month-long journey to the East, the Moon appears to move more slowly than the Sun. As a result, the Moon rises later each day.

* A waning crescent looks like a "c". You see it in the morning.

* A waxing half-moon looks like a capital "D". You see it in the evening.

MOON QUESTIONS

1. Does the Full Moon always appear to be the same size? If not, when does it appear larger or smaller?

2. Does the Moon always appear to be the same color? If not, what colors have you noticed? When do they happen?

3. On which side of the horizon does the Moon rise? set?

4. About what time does the Full Moon rise? set?

5. Sometimes you see a thin sliver of the Moon shining brightly, while the rest shines dimly. This is called "Earthshine" or "the old Moon in the New Moon's arms". What time of day is it when you see it? Where in the sky is it? What do you think causes it?

6. If you see the Moon at a certain time, and then again a few hours later, has it moved? and if so, which way?

7. If you see the Moon at a certain time one day, and again at the same time the next day, is it in the same place in the sky? and if not, which way did it move?

8. Each day, the Moon rises (later or earlier?) than the day before?

9. Which moves faster across the sky, the Sun or the Moon?

10. The Moon is never in the (East? South? West? North?)

11. Figure 1: Which drawings are impossible and why?

12. Figure 2: Which drawing is impossible? Which drawing takes place in the morning? in the evening?

13. Draw a First Quarter Moon. A Last Quarter Moon. Which one is called an "evening half moon"? a "morning half moon"? Why is a half moon usually called a quarter moon?

14. How many days are there between one Full Moon and the next?

Fig 1:

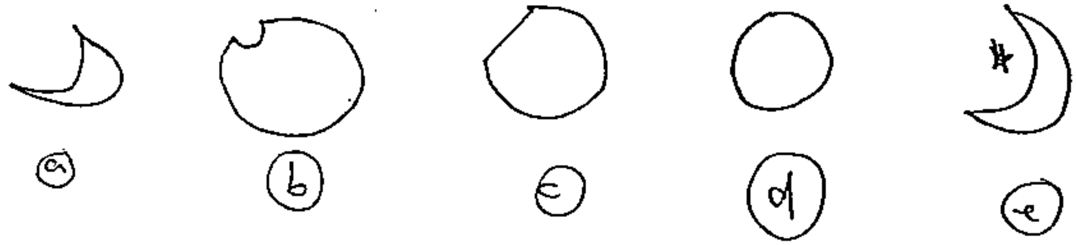
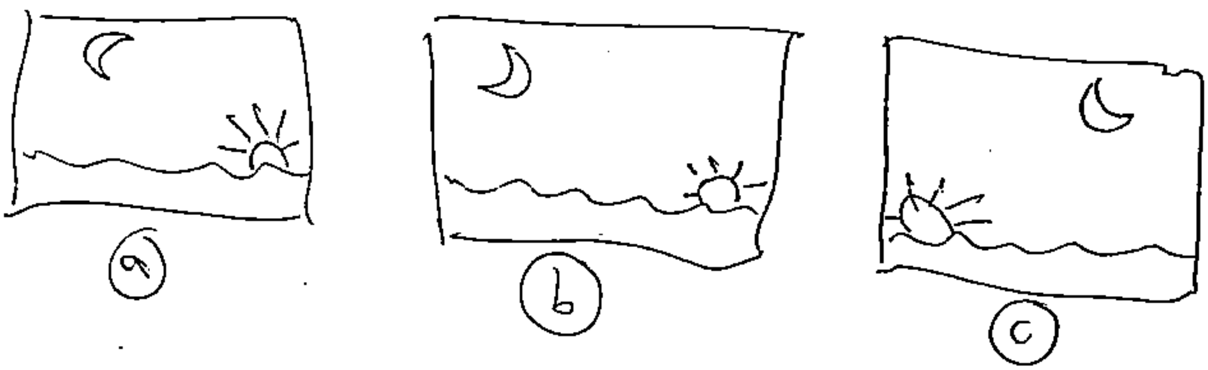


Fig 2:



Lesson 17

MOON PREDICTIONS

OBJECTIVES:

* To use what has been learned about the Moon to predict its behavior in the next few weeks.

GRADES: 4 and up.

SCHEDULING:

This lesson will take one class period.

DISCUSSION:

* Is it possible to predict the future?

* Is it possible to predict what the Moon will do in the next few weeks?

* How would you make such predictions?

ACTIVITY:

Ask the students to predict the dates of the following for the coming six weeks:

* New Moon, First Quarter, Full Moon, Last Quarter.

* Conjunctions of the Moon with the planets or first magnitude stars.

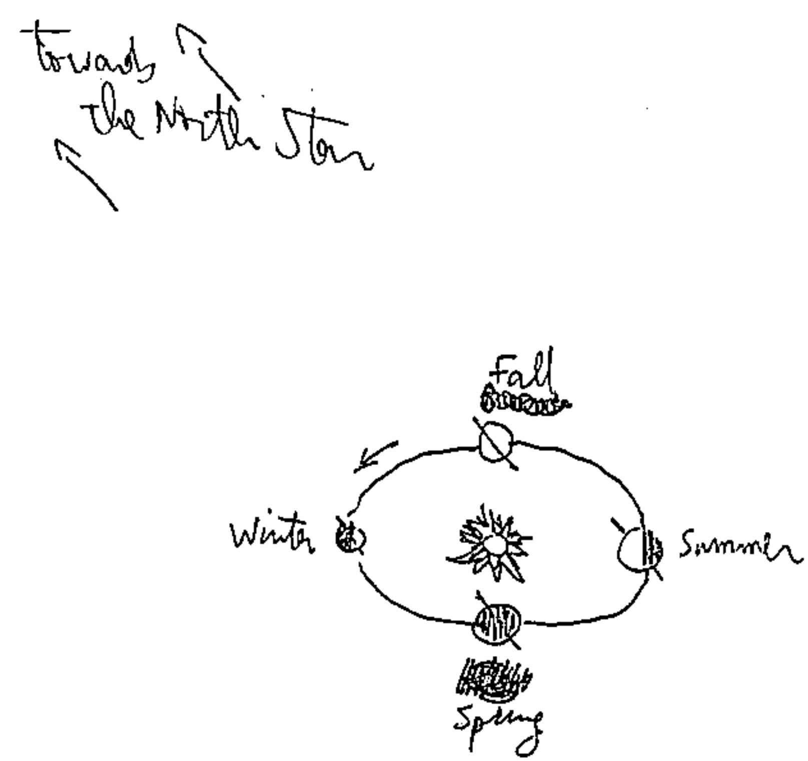
Allow them to use their own Moon records, or the master class records. An answer should be considered correct if it is within a day of the right date. Partial credit should be given for being only two days off. Answers can be checked by looking in the ALMANAC or SKY CALENDAR.

COMMENTS:

* Students are justifiably very proud of any correct

predictions they make. Congratulate **them!**

* You may take this opportunity to compare the reliability of predictions made by astrologers as compared to those made by astronomers.


towards the North Star
Fall
Winter
Summer
Spring

Week 7

This week, your students round up their study of the Sun with an experiment which explains the seasonal and geographic variations in the Sun's path.

Continue the activities started in the previous weeks:

* Once this week (before Lesson 18):

.Sunset

.Moon shadow

As their study of the Solar System draws to a close, your students should be made aware that the universe is much larger than the Solar System.

* Research topics: stars, galaxies, black holes, quasars, ...

After the last lesson, ask the students for all the words they can think of that have something to do with the Solar System. They should be able to come up with a very long list. If you kept the list made before the first lesson, comparing the lists should make clear how much was learned.

Lesson 19

A TILTED PLANET

OBJECTIVES:

* To account for seasonal variations in the Sun's path with the help of a model.

GRADES: 6 and up.

SCHEDULING:

This lesson will take one class period.

PREPARATION:

Use the ALMANAC to find the times of sunrise and sunset at one week intervals for the past several weeks (starting on the day of the gnomon experiment).

A day or two before doing this activity, ask the students to check whether the North Star is still in the same place in the night sky. (It will be.)

DISCUSSION:

Start out by discussing all the records you have of the Sun's motion: sunset drawings, noon shadow records.

* How has the Sun's path changed in he past few weeks? (Inspecting the records should reveal that the time and direction of sunset has changed; that the length of the noon shadow has changed.)

Write the times of sunrise and sunset for the past weeks on the chalkboard.

* How long was the day each time? How has it changed?

MATERIALS:

* A bright light

* A 9" x 9" styrofoam stand

* A 1/16" diameter dowel, 9" long

* A styrofoam ball, 3" diameter

* A straight pin

* A 1" square of thin cardboard, marked with the compass directions (Figure 9-1)

* A protractor

* Some cellophane tape

STUDENT SHEETS:

* Tilted Planet

ACTIVITY:

Because this experiment is complicated and requires a lot of space, it is best for you topo demonstrate it while your students watch. Encourage them to ask questions and to comment on the experiment.

By pressing firmly down, place the protractor vertically into the styrofoam stand, so its center and zero degree line are level with the surface of the stand.

Poke the dowel through the styrofoam ball. Be careful to go as nearly through the center of the sphere as possible.

The basic setup of the experiment is illustrated in Figure 9-2. Poke the dowel into the styrofoam stand near the center of the protractor, at an angle of 65 to 70 degrees (this will give your globe the same tilt as the Earth.) Tape the dowel to the protractor for stability. Slide the sphere on the dowel so that its center is at the same height as the light source. (This is essential for the experiment to work.)

Poke the pin through the dot at the center of the cardboard square, and place it on the sphere, at a point approximately half way between the pole and the equator. The North mark on the square should be directly North of the pin (i.e. between the pin and the North Pole).

Make the room as dark as possible, so that the bright light is the only source of light and that the shadow of the pin is clearly visible on the cardboard. The pin represents a gnomon on the Earth's surface, and the light represents the Sun.

Explain that the Earth's axis always points to the North Star. This can be verified by the fact that Polaris does not move in the night sky, while all the other stars appear to turn around it. Tell your students that while carrying out this experiment, the axis should always point to the North. On the other hand, the Earth travels around the Sun, which leads to the different positions shown on the student sheet.

Discuss in which direction the globe should rotate around its axis in order for the Sun to "rise" roughly in the East. (In other words, when the pin comes into the light, its shadow should point in a generally Westerly direction.)

Hand out the Tilted Planet student sheet. Place the Earth model in various positions around the "Sun", always making sure the axis points to the North. Show the students what happens with the gnomon shadow as the Earth rotates around its axis. Repeat the experiment as often as necessary for the students to be able to answer the questions.

CONCLUSIONS:

The conclusions for this lesson and the next are summarized on the student sheet titled "The Year".

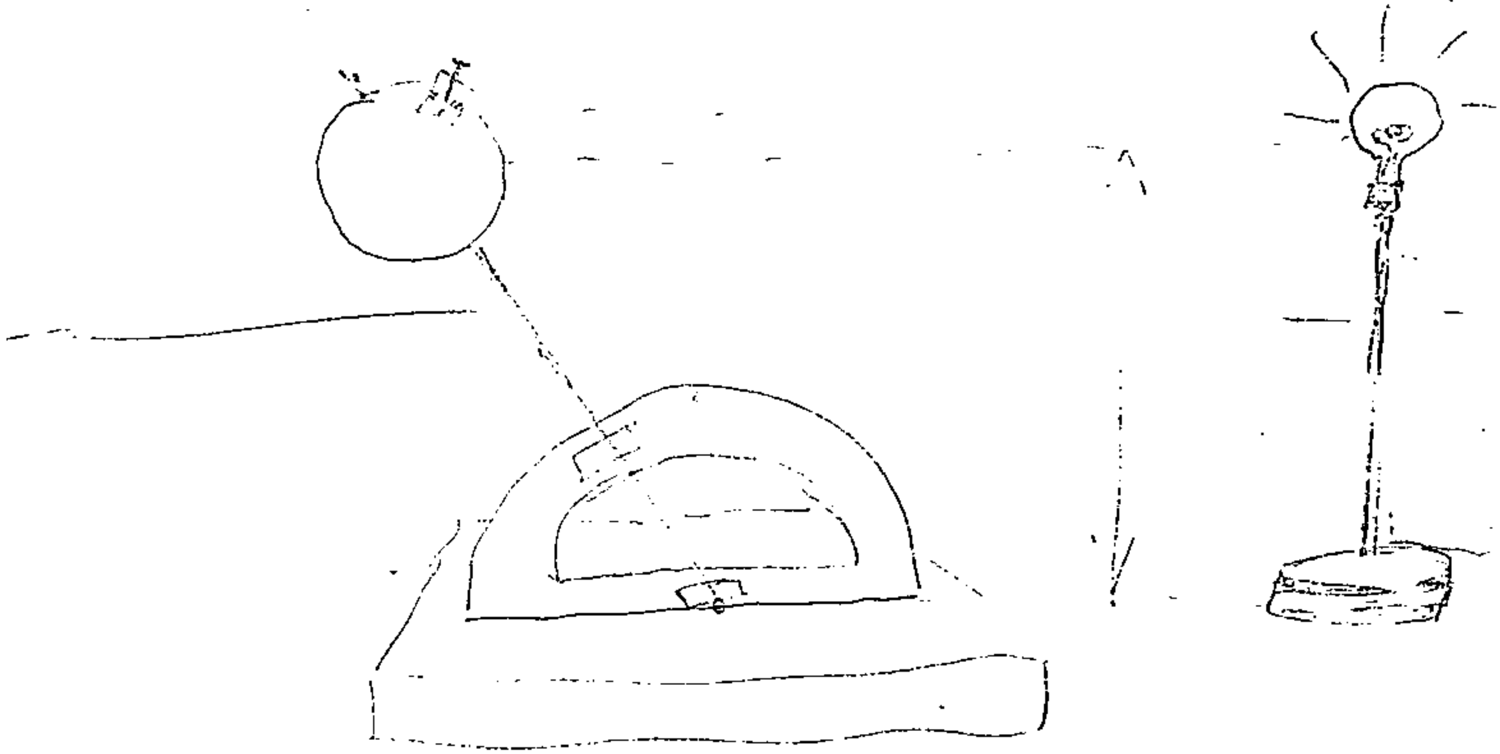


Fig 9-2

Fig 9-1

A TILTED PLANET

The figure shows three possible ways to place the Earth in relation to the Sun. Experiment with each position, and answer the questions below. (Remember that the gnomon shadow points in the direction opposite to that of the Sun.)

* In which position does the Sun rise in the North East? the East? the South East?

* In which position is the midday shadow the longest? the shortest? Is there a position where the gnomon has no shadow?

* In which position does the Sun set in the North West? the West? the South West?

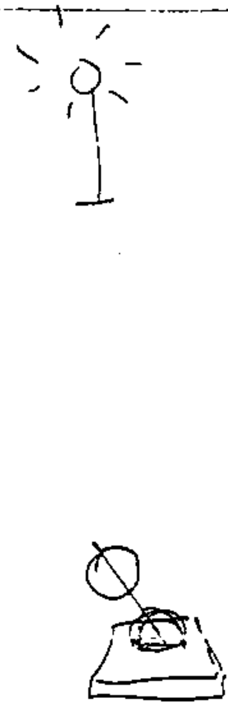
* In which position is the day longer than the night? the night longer than the day? in which position are they equal?

* Which position corresponds to winter? summer? spring? autumn?

Position 1 :

(top of axis points to "Sun")

Position 2



(top of axis at right angles to "Sun")

Position 3

(top of axis points away from light)

THE YEAR

WINTER SOLSTICE: December 21. The Sun rises and sets at its furthest South position. Midday shadows are the longest of the year. Shortest day of the year. Longest night.

SPRING EQUINOX: March 21. The Sun rises due East, sets due West. Night and day are of equal duration.

SUMMER SOLSTICE: June 21. The Sun rises and sets at its furthest North position. Midday shadows are the shortest of the year. Longest day, shortest night.

FALL EQUINOX: September 21. The Sun rises due East, sets due West. Night and day are of equal duration.

Lesson 24

LATITUDE

OBJECTIVES:

* To understand how latitude affects the Sun's path.

* To learn about the Tropics, and the Arctic and Antarctic Circles.

GRADES: 6 and up.

SCHEDULING:

This lesson will take one class period.

PREPARATION:

You will use essentially the same experimental setup as in the last lesson.

STUDENT SHEET:

* Where on Earth?

ACTIVITY:

Run through the experiment of Lesson 18, with the following change: place the gnomon very near the North Pole. (This will help answer the questions about the Arctic Circle.)

Then, place the gnomon very near the Equator. (This should help answer the questions about the tropics.)

With each position of the gnomon, place the Earth at the various positions around the Sun, until the students can answer the questions on the sheet.

CONCLUSIONS:

The conclusions to this Lesson and the previous one are summarized on the student sheet titled "The Year". Hand out the sheet and discuss it.

WHERE ON EARTH?

* In which position does the area around the North Pole have constant daylight? constant night? a night and a day?

* Try to place the gnomon so that it has no shadow. Where on the globe is this possible?