Planetarium Handbook

1974

Compiled by
G. Henry Sultner
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PLANETARIUM HANDBOOK

1974

Compiled by

G. Henry Sultner

December, 1974

INTERNATIONAL SOCIETY OF PLANETARIUM EDUCATORS

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DALLASTOWN AREA SCHOOL DISTRICT

PLANETARIUM HANDBOOK

1974

Kindergarten thru Grade 12

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Superintendent

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Edited for ISPE by Robert J. Hitt
**PLANETARIUM PRESENTATIONS (K thru 12)**

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KINDERGARTEN

Introduction to the Planetarium

Time

The prime objective of the kindergarten lesson is to introduce the child to the planetarium.

I. The Planetarium
   A. Three main parts
      1. Dome
      2. Controls
      3. Projector
   B. The Day Sky
   C. The Night Sky

II. Rules for visits
   A. Simple and easy
   B. Everyone benefits

III. Time
   A. Day time sky
      1. Morning - Worktime
      2. Noon - Lunch time
      3. Afternoon - Play time, etc.
   B. Night time sky
      1. Evening - Rest time
      2. Night - Bed time

Student Objectives: - Kindergarten
1. To develop awareness of time within the child's daily environment. (Work time, play time, rest time, lunch time, bed time, etc.)

GRADE ONE

The Day and Night Sky

The prime objective of the first grade lesson is to introduce the child to what the planetarium does.

I. What is a planetarium?
   A. It is a special room where we study about the sky.
   B. It reproduces a day or a night sky on a special ceiling called a dome.

II. What happens each day in the day time sky?
   A. The sun makes our day.
      1. The sun is really a star.
      2. The sun gives us light and heat.
   B. The sun appears to move in the sky.
      1. The sun is in the eastern sky in the morning.
      2. The sun is over our heads at noon.
      3. The sun is in the western sky in the afternoon.
   C. The earth turns; the sun stays in the same place.
III. What can we see in the night time sky?

A. When the sun is not in the sky, it is night.
B. We see stars at night.
   1. The stars can be seen only after the sun disappears.
   2. Our part of the earth must turn away from the sun before we can see the stars.
   3. The stars appear to move westward only because the earth turns.
   4. Some stars seem to make pictures in the sky.
      a. The Big Dipper is sometimes called the Big Bear.
      b. The Little Dipper is sometimes called the Little Bear.
   5. Stars make their own light.
   6. Stars are far, far away.
C. Sometimes we see the moon at night.
   1. The moon is the earth's neighbor in space.
   2. The moon goes around the earth.
   3. We see the moon only because the sun shines on it.
   4. The moon does not always look the same.

GRADE ONE - Word List

Astronomy  sun  earth  day  shadows
planetarium  moon  sky  night  dark
dome  stars  space  week  light
sunrise  gravity  astronaut  telescope

Suggested Post-Visit Activities

1. Art work showing the sun, moon and stars.
2. Songs and stories about planets, stars, sun and moon, etc.
3. Spelling lesson on the easier terms.
4. Review some of the terms on the word list.
5. Ask the children to observe what happens in the real sky.
6. Have students observe the night sky at home.
7. Have students discuss the planetarium visit.
8. Discuss what they saw on the way to the planetarium.
9. Discuss how the sky as seen in the planetarium differs from the natural sky.
10. Put a piece of tape on Pennsylvania as you turn the globe from west to east to show that this causes day and night. Use a flashlight for the sun.

Student Objectives: - Grade One

1. Children should be able to describe the following results from the earth's rotation:
   a. When our side of the earth is toward the sun, we have day.
   b. When our side of the earth is away from the sun, we have night.
   c. The earth turns around once a day.
   d. The sun, moon and stars move across the sky because the earth is turning.
2. To understand that the moon looks as big as the sun because it is much closer to us.
3. To understand that the moon shines by reflected light.
4. To understand there are stars in the sky in the daytime but we cannot see them because the sun is so bright.
5. To demonstrate that when the sun is low in the sky, the shadows are long, and when the sun is high in the sky, the shadows are short.
6. To demonstrate that we can see shadows on sunny days but not on cloudy days.

GRADE TWO

The Moon and The Stars

I. We see the moon and the planets because of the sun.
   A. The moon and the planets are members of the sun's family.
      1. The planets travel around the sun.
      2. The moon travels around the earth in one month.
   B. The moon and the planets make no light of their own.
   C. The moon reflects sunlight.

II. The moon is smaller than the earth.

III. The moon does not always look the same.

   A. At new moon, the sun shines on the side of the moon that is away from us.
   B. After the new moon, the moon appears to grow larger each night.
   C. When the moon is "full", we see the entire half of the moon that is lighted by the sun.
   D. After the "full" moon, the moon appears smaller each night.

IV. The stars are not evenly placed in the sky, but seem to form patterns.

   A. The Big Dipper is part of the constellation Great Bear.
   B. The Little Dipper is part of the constellation Little Bear.
   C. The Dragon is found between the Big and Little Bears.
   D. Cassiopeia forms a "W" or "M" in the northern sky.

GRADE TWO Vocabulary

direction  | constellations  | reflected  | waning moon  
est  | south     | Big Dipper  | gravity  | waxing moon
west | year  | Dragon  | full moon | crescent moon
north | planet  | Cassiopeia  | new moon |

Suggested Post-Visit Activities

1. Art work - pictures.
2. Records, stories and poems relating to the moon and the constellations.
3. Write stories about the visit to the planetarium.
4. Review the terms in the vocabulary list.
5. Make calendars based on the moon.
6. Keep track of the moon phases for a month and note when changes occur.
7. Use balls to represent the sun, earth, moon and planets.

Student Objectives: - Grade Two

1. Explain that planets go around the sun, and moons go around planets.
2. Compare moon's size to earth's size.
3. Identify full moon, new moon, quarter moon (half moon).
4. Recognize that star patterns or groupings in familiar shapes form constellations.
5. Identify at least 4 constellations: Big Dipper, Little Dipper, Dragon, Cassiopeia.
GRADE THREE

The Solar System

I. The sun is the center of the solar system.

A. The sun rises in the east and sets in the west.
   1. The earth rotates from west to east.
   2. This rotation causes day and night.

B. The ecliptic is the apparent path of the sun in the sky in a year.

C. Living things depend on the sun's light and heat.

II. The solar system includes the sun and the nine known planets.

A. All of the planets revolve around the sun.
   1. The planets closer to the sun travel faster than those that are farther from the sun.
   2. The planets closer to the sun have a shorter year than those that are farther from the sun.
   3. The earth's year is 365-1/4 days.
   4. Other planets' years

B. Every planet rotates on its axis.
   1. Each planet rotates at a different rate.
   2. The earth rotates in 24 hours. Its day is 24 hrs. long.
   3. Rotation speeds of other planets.

III. The moon is a satellite of the earth.

A. The moon revolves around the earth once every 29-1/2 days from west to east.

B. The moon changes phases from day to day.

GRADE THREE - Vocabulary

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Suggested Post-Visit Activities

1. Art work - pictures.
2. Related stories, songs and poems.
3. Writing stories related to the planetarium visit.
4. Make pictures or models of the solar system.
5. Keep track of the moon's position for several nights at exactly the same time.
6. Notice the difference in the size and shape of the moon at the same time each night.

Student Objectives - Grade Three

1. To explain that all living things could not survive without the sun's heat and light.
   a. The sun is a star
   b. The sun is the source of our energy
   c. The sun is nearer to us than any other star
2. To be able to identify in order the planets in our solar system.
3. To demonstrate the moon's movement around the planet earth.
   a. The motion of the moon and its relative position to the earth and sun causes it to appear in phases.
4. To recognize the moon's phases.
GRADE FOUR

The Sun, the Earth and the Planets

I. The sun is the center of the solar system.
   A. The sun appears to rise in the east and set in the west because
      the earth rotates from west to east.
   B. The sun is highest in the sky at noon.
   C. The sun's family includes planets, asteroids, comets, meteors
      and satellites.

II. There are nine known planets revolving around the sun.
   A. Planets revolve in different orbits and at different speeds.
      1. The orbits of planets are nearly circles.
      2. The planets closer to the sun revolve faster than those
         farther from the sun.
      3. The earth revolves once every $365\frac{1}{4}$ days, which is one
         year.
      4. The length of a year for each planet is different.
   B. Planets rise in the east and set in the west due to the earth's
      rotation.
   C. Normally, planets move from west to east in relation to the star
      background.
   D. Occasionally, a planet travels from east to west for a short time.
   E. Planets appear very near the ecliptic.
   F. Planets rotate on their axes at different speeds.
      1. Earth rotates once every 24 hours giving us a 24-hour day.
      2. Each planet has a different length of day.

III. Some of the planets have satellites or moons.
   A. The earth has one natural satellite or moon.
   B. The moon revolves around the earth once every $29\frac{1}{2}$ days.
   C. Some planets have no moons.
   D. Planets with moons - Mars (2), Jupiter (12), Saturn (10), Uranus
      (5), Neptune (2)

IV. Some of the planets have phases as our moon does.

V. Planets vary as to size and appearance.

VI. Venus and Mercury are sometimes seen as the Evening Star or Morning Star.

GRADE FOUR - Vocabulary

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<th>Mercury</th>
<th>Neptune</th>
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Suggested Post-Visit Activities

1. Related stories, songs and poems.
2. Writing stories related to the planetarium visit.
3. Discussion of the planetarium sky as compared to the natural sky.
4. Art work and/or pictures
5. Make models of the solar system.
Student Objectives: - Grade Four

1. Explain why sun appears to rise in east and set in west.
2. Tell at what time sun is highest in the sky.
3. List six members of the sun's "family".
4. Describe shape of planet orbits.
5. Explain which planets travel faster and which travel slower.
6. Tell where to look for planets in the sky.
7. Explain that planets rotate and revolve at different speeds.
8. List planets that have no moons and those that have moons.

GRADE FIVE

The Coordinate System

I. We can easily locate positions on the earth.
   A. Latitude measures positions north and south of the equator.
   B. Longitude measures distance east and west of the prime meridian through Greenwich, England.

II. The North Star can be used to determine latitude.
   A. Latitude is the number of degrees that the North Star is above the horizon.
   B. At the North Pole, the North Star is directly overhead and the latitude is 90°.

III. The elevation of the sun is also used to determine latitude.
   A. To do this we must know the time of the day.
   B. We must also know the day of the year.

IV. Longitude can be determined by time difference between local time and Greenwich time.
   A. There are 24 time zones around the earth.
   B. There is a difference of one hour for each 15° of longitude.

V. There are several systems of determining positions in space.
   A. One method is locating specific stars or constellations as guideposts for travel.
   B. Another method is that of giving the two coordinates of a star in the horizon system, called the azimuth and the altitude.
      1. The azimuth is the number of degrees from the north along the horizon, eastward to the point directly under the star.
      2. The altitude is the number of degrees above the horizon.

VI. Navigation in space poses many problems.
   A. Parallax is the apparent shift in the position of a star.
   B. Geometry can be used to calculate the distance to a star.
   C. The light year is used to measure astronomical distances.

GRADE FIVE - Vocabulary

| navigation | azimuth | magnetic compass | concave | radar | light year |
| converge   | sextant | latitude         | diverge | altimeter | geometry  |
| Zenith     | meridian| altitude         | magnetic north | parallax | astronomical |
| radio compass | convex | dead reckoning | longitude | distance | mile |
Suggested Post-Visit Activities

1. Related stories, songs and poems.
2. Art work and/or pictures.
3. Writing stories about the planetarium visit.
4. Discussions relating to the planetarium visit.

Student Objectives - Grade Five

1. Measure latitude and longitude correctly for earth measurements.
2. Read observer's latitude from altitude of Polaris.
3. Explain what needs to be known to figure latitude by the sun.
4. Calculate width of a "time zone".
5. Describe at least 2 ways of determining positions in the sky.
6. Define altitude and azimuth.
7. Demonstrate parallax using a pencil in front of observer's face.
8. Identify the light-year as a measure of large astronomical distance.

GRADE SIX

The Stars, Constellations and Galaxies

I. Stars appear to move.
   A. Stars appear to rise in the east and set in the west because of the earth's rotation.
   B. Circumpolar stars never rise or set, but revolve around the north star.

II. Stars vary as to color.
   A. The color of a star is determined by its temperature.
   B. Red stars are the coolest stars.
   C. Blue-white stars are the hottest stars.

III. The magnitude of a star refers to its observed brightness.
   A. The lower the magnitude, the brighter the star.
   B. Stars fainter than the sixth magnitude cannot be seen with unaided eyes.

IV. Stars vary greatly in size.
   A. Our sun is a medium-sized star.
   B. The red giants are the largest stars.
   C. The white dwarfs are the smallest stars.

V. Stars vary greatly in distance from the earth.
   A. The sun is our closest star.
   B. The stars are so far away that we cannot measure the distance in miles.
   C. If you travel 1000 miles an hour, it would take you 3 million years to reach the nearest star except the sun.
   D. The distance to stars is measured in "light years".

VI. Constellations and stars can be recognized.
   A. Constellations are star patterns.
      1. The most familiar are the circumpolar constellations which can be seen at all times.
2. Other common constellations can be seen only during certain times of the year.

B. Some large, bright stars are easily seen.
   1. Betelgeuse and Rigel are part of the constellation Orion.
   2. Sirius is a part of Canis Major.
   3. Spica is a part of Virgo.
   4. Vega, Deneb, and Altair form the summer triangle.

VII. A galaxy is a great system of stars in space.

A. Our galaxy is the Milky Way.
   1. A side view is disc shaped.
   2. A top view has a spiral structure.
B. The Whirlpool Galaxy is another spiral type.
C. The Barred Spiral Galaxy is so far away, it requires the largest telescope to see it.
D. The famous Andromeda Galaxy is similar to our own Milky Way.

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**GRADE SIX - Vocabulary**

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<td>Barred Spiral</td>
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<td>Andromeda</td>
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**Suggested Post-Visit Activities**

1. Related stories, songs and poems.
2. Art work and/or pictures.
3. Writing stories related to the planetarium visit.
4. Discussions relating to the planetarium visit.

**Student Objectives:** Grade Six

1. Explain difference between circumpolar stars and "seasonal" stars.
2. List 5 star colors.
3. Match hot stars with proper color; "cool" stars with proper color.
4. Given 2 magnitude numbers, tell which star is brighter, which one dimmer.
5. List 3 star size classes.
6. Explain that sun is closest star; other stars very far away.
7. Identify Rigel, Betelgeuse, Sirius, Spica, Vega, Deneb and Altair as bright stars and their respective constellations.
8. Describe shape of the Milky Way galaxy; 2nd, list at least two other galaxies.

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**GRADE SEVEN**

**The Sun as Related to The Earth**

I. The sun can be used to tell directions.

A. The sun seems to rise in the east.
B. The sun seems to move from east to west.
   1. The sun is not moving; it only appears to move.
   2. The earth is rotating from west to east.

II. The sun is a star.

A. The sun is like all other stars in its general characteristics.
1. The sun makes its own light and heat.
2. This is the source of energy for photosynthesis.
3. The sun is always shining.
B. The sun looks larger than other stars.
1. The sun is the closest star.
2. The sun is a medium-sized star.

III. We can tell time by the sun.
A. We cast a shadow when the sun is shining.
1. Our shadows change their length.
2. At noon our shadows are almost gone.
B. We can tell time by the position of the sun in the sky.
1. When the sun is in the east it is morning or A.M.
2. When the sun is at its highest point in the sky it is noon.
3. The sun "sets" in the west in the evening or P.M.

IV. The sun helps us determine the seasons.
A. We have more hours of sunlight in the summer.
1. The sun rises north of east in the summer.
2. The sun rises farther in the sky above us in the summer.
3. The sun sets north of west in the summer.
B. We have fewer hours of sunlight in the winter.
1. The sun rises south of east in the winter.
2. The sun is lower in the sky in the winter.
3. The sun sets south of west in the winter.
C. In spring and autumn, the hours of day and night are nearly equal.
1. The sun rises in the east.
2. The sun sets in the west.
D. The ecliptic is the annual path of the sun.
1. The summer solstice.
2. The winter solstice.
3. The vernal equinox.
4. The autumnal equinox.

GRADE SEVEN - Vocabulary

| north | west | time | autumnal equinox | summer solstice | ecliptic  |
| south | east | P.M. | vernal equinox | winter solstice | rotation |
| sun   | star | A.M. | revolve         | photosynthesis | energy   |

Suggested Post-Visit Activities

1. Related stories, songs and poems.
2. Art work and/or pictures.
3. Writing stories related to the planetarium visit.
4. Discussions relating to the planetarium visit.

Student Objectives: Grade Seven

1. Explain how sun can be used to tell direction during all four seasons.
2. Explain that the sun is always shining, generates its own heat and light energy, and is the energy source for photosynthesis.
3. Explain how to tell time by the sun.
4. Given number of hours of daylight and dark in Northern Hemisphere, identify the season.
5. Define: summer solstice, winter solstice, vernal equinox, autumnal equinox.
ALTERNATE, ADDITIONAL OR ENRICHMENT PROGRAMS

Time

I. We can tell time by the sun.
   A. The sun appears to rise in the east and set in the west due to the rotation of the earth.
      1. This gives us a 24 hour period.
      2. The earth is divided into 24 time zones.
      3. The continental 48 states are divided into 4 time zones.
      4. The earth rotates through 15° longitude each hour.
   B. When the sun is at the meridian and is highest in the sky, it is noon.
      1. The meridian divides the sky in half.
      2. A.M. occurs when the sun is in the eastern half.
      3. P.M. occurs when the sun is in the western half.

II. When the sun is shining, we can use our shadows to tell the time of day.
   A. In the morning and evening our shadows are long.
   B. At noon our shadows are shortest, close to our feet, and point north.
   C. A sundial may be used to tell time during the day.
   D. The solar day is the period of time between the highest position of the sun at noon until it reaches this same position again the following day.
   E. The calendar day is from midnight to midnight.

III. The revolution of the moon around the earth gives us our month.
   A. The moon revolves around the earth in 29-1/2 days.
   B. The moon appears to move from east to west due to the earth's rotation.
   C. The moon actually moves from west to east 13° each day.

IV. The earth revolves around the sun once every 365-1/4 days.
   A. On or about March 21 and September 22, the sun rises in the east and sets in the west, causing equal day and night, or the vernal and autumnal equinoxes.
   B. On or about June 21, the sun rises north of east and sets north of west, causing the summer solstice.
   C. On or about December 21 the sun rises south of east and sets south of west, causing the winter solstice.

Vocabulary

<table>
<thead>
<tr>
<th>summer solstice</th>
<th>rotation</th>
<th>autumnal equinox</th>
<th>shadow</th>
<th>midnight</th>
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<tr>
<td>winter solstice</td>
<td>meridian</td>
<td>longitude</td>
<td>time</td>
<td>degrees</td>
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<tr>
<td>vernal equinox</td>
<td>latitude</td>
<td>solar day</td>
<td>A.M.</td>
<td>zenith</td>
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<tr>
<td>calendar day</td>
<td>sun dial</td>
<td>time zone</td>
<td>P.M.</td>
<td>equator</td>
</tr>
</tbody>
</table>

Suggested Post-Visit Activities

1. Make a sundial and other timing device such as a marked candle and an hour glass, etc.
2. Related stories, songs and poems.
3. Discussion of time zones.
4. Make a map of time zones.
5. Art work and/or pictures.
Student Objectives: Grade Eight

1. List: how many time zones there are on the earth; how many in continental U.S.; how many degrees longitude there are per zone; at what time sun is highest in the sky.
2. Name several instruments for measuring time.
3. Explain how lengths of shadows tell time.
4. Explain how the moon can be used to tell time.
5. Tell where the sun rises and sets on the summer solstice, winter solstice, vernal equinox, autumnal equinox.
6. Explain the relationship of the meridian to A.M. and P.M.

ALTERNATE, ADDITIONAL OR ENRICHMENT PROGRAM

The Seasons

I. The position of the sun at sunrise and sunset changes during the year.
II. The ecliptic is the apparent path of the sun in the sky during the year.
   A. The ecliptic appears to move westward as does the sun.
   B. The sun does not change its position on the ecliptic during daily motion.
III. The tilt of the earth on its axis, and the revolution of the earth around the sun cause the seasons.
   A. Earth is inclined 23° on its axis.
   B. If the earth were not tilted, there would be no seasons.
   C. The earth revolves once every 365-3/4 days.
   D. At the equinoxes, March 21 and September 22, the periods of day and night are equal.
      1. The equinox on March 21 is called the vernal or spring equinox.
      2. The equinox on September 22 is called the autumnal equinox.
   E. The sun is 23° north of equator on June 21.
      1. This is the summer solstice.
      2. At this time the sun is directly over the Tropic of Cancer.
   F. The sun is 23° south of the equator on December 22.
      1. This is the winter solstice.
      2. At this time the sun is directly over the Tropic of Capricorn.
   G. The altitude of the sun on the meridian changes during the year.
      1. The zenith is the point in the sky directly overhead.
      2. The meridian is a vertical line passing through the zenith to the horizon at the south.
      3. A.M. time occurs when the sun is east of the meridian.
      4. P.M. time occurs when the sun is west of the meridian.

Vocabulary

autumnal equinox  summer solstice  ecliptic  degrees  revolution
winter solstice    Tropic of Capricorn  meridian  equator  vernal equinox
Tropic of Cancer  rotation               axix  zenith  horizon

Suggested Post-Visit Activities

1. Related stories, songs and poems.
2. Art work and/or pictures.
3. Write stories about the seasons.
4. Discuss how the sun and other factors produce the seasons.
Student Objectives: The Seasons

1. Explain at least two major causes of seasons.
2. Relate length of day and night to different seasons.
3. Locate Tropic of Cancer, Equator, and Tropic of Capricorn and tell during which season(s) sun is directly over these imaginary lines.
4. Explain effect of sun's changing altitude on the seasons.

ALTERNATE, ADDITIONAL OR ENRICHMENT PROGRAM

The Motion of Stars and Constellations

I. Circumpolar stars are located in the northern sky.
   A. The North Star is always above the North Pole.
      1. The North Star does not move.
      2. It can be found by using the pointer stars of the Big Dipper.
   B. The circumpolar stars do not rise and set, but are always visible.

II. Stars appear to move rapidly in the night sky due to the rotation of the earth.
   A. Circumpolar stars revolve counterclockwise around Polaris.
      1. The position of the stars changes about 15° each hour.
      2. They make a complete revolution every 24 hours.
   B. In the southern sky, the stars move from east to west.
      1. The stars rise in the east and set in the west.
      2. This movement simulates that of the sun.

III. The motion of the stars is also due to the revolution of the earth.
   A. This motion is very slow.
      1. The earth revolves around the sun in 365\(\frac{1}{4}\) days.
      2. The star's apparent motion to the west is about 1° each day.
   B. Constellations move to the west when observed at the same time each night.
      1. Orion is seen in the southeast sky at 8 P.M. on January 1.
      2. Orion is in the southern sky at 8 P.M. in the middle of February.
      3. Late in March, Orion is in the western part of the sky at 8 P.M.

IV. The sky is divided into areas by groups of stars known as constellations.
   A. There are 88 constellations in the entire sky.
   B. These can be used to locate position in the sky.

Vocabulary

epicycle  solstice  circumpolar  retrograde motion  inertia  light year
parallax  Polaris  relativity  triangulation  equinox

Suggested Post-Visit Activities

1. Related stories, songs and poems.
2. Art work and/or pictures.
3. Write stories about the motion of stars.
4. Discuss the motion of stars and constellations.
Student Objectives: - The Motion of stars and constellations
1. Observe that during rotation, Polaris stands still.
2. Explain why seasonal stars rise and set and circumpolar stars do not.
3. Tell which direction circumpolar stars appear to move around Polaris.
4. Calculate how fast in degrees per hour stars appear to move.
5. Recall how many constellations are known today.

ALTERNATE, ADDITIONAL OR ENRICHMENT PROGRAM

Navigation - Latitude and Longitude

I. The earliest navigators.
   A. The caveman used natural landmarks.
   B. Later hunters, nomads, farmers and herdsmen developed trails.
   C. Trails developed into established trade routes.

II. Polaris, the voyagers' star.
   A. In the southern sky, stars appear to rise in the east and set in the west.
   B. In the northern sky, stars seem to revolve around the north star or pole star.
   C. The pole star is so close to the celestial pole that it appears stationary. (70 away 3,000 years ago; 10 today)
   D. Polaris is the star at the end of the handle of the Little Dipper.
   E. The pointer stars of the bowl of the Big Dipper lead to Polaris. (Demonstrate night sky with daily motion)

III. Determining position.
   A. By taking "sights" on numerous heavenly bodies. (Even man-made ones)
   B. The two which were of particular use to early seamen were the star nearest the celestial north pole and the sun.

IV. Latitude (lines parallel to the equator)
   A. To find latitude by Polaris, it is only necessary to measure the angular distance of this star above the equator. (not exactly at the celestial north pole) (Demonstrate meridian, zenith, celestial north pole)
   B. The sun does not maintain a constant course.
      1. The ecliptic is the apparent annual path of the sun on the celestial sphere. (Demonstrate ecliptic)
      2. The earth's axis is tilted at 23 1/20. The celestial equator is also tilted. (Demonstrate equator)
      3. Vernal equinox (March 21) and autumnal equinox (September 23) are the only two days of the year when the ecliptic and the equator meet or cross or are in the same plane. (Demonstrate with annual motion)
      4. At other times, allowance must be made for the sun's declination.
      5. Tables showing the sun's declination for each day have been worked out since the fifteenth century. (Ephemeris, Nautical Almanac)
      6. Instruments for measuring angles evolved from a simple post to a cross staff to a ring to the quadrant to the sextant.

V. Longitude (north to south lines converging at the poles)
A. Lines are called meridians.
B. The prime meridian (0°) passes through Greenwich, England.
C. We can translate time into degrees of longitude because of the earth's rotation. (one hour equals 15°)
D. Dallastown is at 75° 40' longitude or about 5 hours later than Greenwich time.
E. Exact times for Greenwich and unknown meridian are necessary for these calculations.

VI. Modern navigation aids.

A. Sextant, magnetic compass, gyrocompass, radios, chronometer, radar, radio direction finder, LORAN (Long range navigation - radio), navigation satellites, SINS (ships inertial navigation system - computerized for all devices)

Vocabulary

Polaris equinox declination longitude latitude Equator gyrocompass

equinox navigation ecliptic latitude meridian sextant chronometer

Suggested Post-Visit Activities

1. Related stories, songs and poems.
2. Art work and/or pictures.
3. Write stories about navigation.
4. Build a device to take angular readings in the real sky.
5. Discuss latitude and longitude.

Student Objectives: Navigation - Latitude and Longitude

1. Recite how early navigators traveled from place to place.
2. Recognize the absence of a pole star in the Southern Hemisphere.
3. Recognize motion of stars around Polaris.
4. Demonstrate that Polaris is actually 1° away from the true pole.
5. Polaris located by Big Dipper's Pointer stars.
6. Determine latitude from altitude of Polaris.
7. Explain use of an Ephemeris in determining latitude by the sun.
8. List instruments used for measuring angles: post, cross staff, quadrant, sextant.
9. List 6 modern navigation aids.

Planetarium Curriculum Outline

The following is the curriculum of planetarium activities to be experienced by 8th Grade students at Dallastown Area Middle School. All areas are to be presented through Spitz A-4 Planetarium instrument application unless other wise noted. Approximate program length is indicated from trial experience.

GRADE 8 - Astronomy Experience

I. Introduction to the Planetarium and the celestial sphere (40 min.)
A. Definition of astronomy
B. Cardinal points - N, E, S, and W
C. Sky at North Pole 1. Note positions of Big & Little Dipper
D. Sky at our latitude (40°N.) 2. North Star to tell latitude
E. Stars - note brightness and color differences
F. Locating simple constellations with overlay Orion & Cassiopeia
G. Identify visible planets (inferior & superior)
A. Lines are called meridians.
B. The prime meridian (0°) passes through Greenwich, England.
C. We can translate time into degrees of longitude because of the earth's rotation. (one hour equals 15°)
D. Dallastown is at 75° 40' longitude or about 5 hours later than Greenwich time.
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Vocabulary

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<tr>
<td>Polaris</td>
<td>Declination</td>
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<td>Navigation</td>
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<td>Sextant</td>
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<tr>
<td>chronometer</td>
<td>Gyrocompass</td>
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Suggested Post-Visit Activities

1. Related stories, songs and poems.
2. Art work and/or pictures.
3. Write stories about navigation.
4. Build a device to take angular readings in the real sky.
5. Discuss latitude and longitude.

Student Objectives: Navigation - Latitude and Longitude

1. Recite how early navigators traveled from place to place.
2. Recognize the absence of a pole star in the Southern Hemisphere.
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C. Sky at North Pole
   1. Note positions of Big & Little Dipper
D. Sky at our latitude (40°N.)
   2. North Star to tell Dipper latitude
E. Stars - note brightness and color differences
F. Locating simple constellations with overlay Orion & Cassiopeia
G. Identify visible planets (inferior & superior)
H. Journey to center of "geocentric" earth
I. Moon - rapid phasing and relate to lunar month
J. Sunrise, moon sets, twilight

Student Objectives

During and following this program of instruction, students will be able to perform the following tasks:
A. Student will be able to recognize and identify the Cardinal Points N, E, S, W.
B. Student can locate the Big and Little Dipper at the North Pole and at our latitude - 40° N.
C. Student will be able to explain that the height of Polaris above the horizon in degrees is equal to an observer's latitude in N. Hemisphere.
D. Student will be able to orally distinguish between star brightness and colors.
E. Students will be able to locate and identify the following additional constellations: Orion and Cassiopeia
F. Students will be able to explain the difference between terms inferior and superior planets.
G. Students can recognize and name earth's equator and poles
H. Students will be able to identify a full moon, new moon and quarter phase moon.
I. Students will successfully locate the cardinal points N, E, S & W.

II. Celestial Sphere Relationships (40 min.)
A. Earth as a sphere; divided into hemispheres; has poles
B. Celestial sphere orientation
C. All objects in sky seen against celestial sphere (sun, moon, planets, stars)
D. Earth's poles; rotates about these poles
E. Sky poles; sky appears to turn about celestial poles
F. Earth's equator; divides into N and S hemispheres
G. Celestial equator; divides sky into N and S hemispheres
H. Ecliptic - sun's apparent path against star background in the course of a year
   1. Ecliptic's relation to celestial equator during the year
   2. Used for setting planetarium
   3. All planets and moon near ecliptic
   4. 12 Zodiac constellations along ecliptic
I. Local points of reference
   1. Horizon
   2. Zenith
   3. Meridian

Student Objectives

Following this program of instruction students will be able to perform the following tasks:
A. From diagram of celestial sphere student will be able to recognize, identify and name: celestial sphere, North and South Celestial Poles, earth's equator, North and South poles of earth, ecliptic and celestial equator.
B. From diagram of a local point of observation student will be able to recognize, identify and name: horizon, meridian, and zenith.
C. Student will be able to recall or look up astronomical definitions for the points in A and B above.
D. Student will be able to identify at what two times during the year the ecliptic and celestial equator cross.
E. Using appropriate reference material, student will be able to write a 300-350 word research essay on the topic "Planetarium".
F. Student can explain along which line are located the planets, moon, sun and Zodiac.

III. Relating celestial sphere concepts (student activity) - (50 min.)

A. From diagram of celestial sphere student will be able to recognize, identify and name: Celestial sphere, North and South Celestial Poles, earth's equator, North and South poles of earth, ecliptic and celestial equator.
B. From diagram of a local point of observation student will be able to recognize, identify and name: horizon, meridian, and Zenith
C. Student will be able to recall or look up astronomical definitions for the points in A and B above.
D. Student will be able to identify at what two times during the year the ecliptic and celestial equator cross.
E. Using appropriate reference material, student will be able to write a 300-350 word research essay on the topic "Planetarium".
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A. From diagram of celestial sphere student will be able to recognize, identify and name: Celestial sphere, North and South Celestial Poles, earth's equator, North and South poles of earth, ecliptic and celestial equator.
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E. Using appropriate reference material, student will be able to write a 300-350 word research essay on the topic "Planetarium".
F. Student can explain along which line are located the planets, moon, sun and Zodiac.

IV. Time (40 min.)

A. Attempts at definitions - difficulty!
B. Timekeeping in nature (trees, plants, etc.)
C. Ancient timekeeping methods
D. Stonehenge
E. Modern timekeeping
F. Earth as a timekeeper
   1. Rotation - solar and sidereal day; time zones
   2. Revolution (the year) - Julian and Gregorian calendars; leap year
G. Precision of timekeeping devices
H. The earth as a 1-day clock throughout history
I. Time as a relative concept

Student Objectives

During and following this program of instruction, students will be able to perform the following tasks:
A. Attempt to define "time" and express difficulty in trying to do so
B. Recognize and identify ancient timekeeping devices (sundial, hourglass, knotted rope, water clocks)
C. Explain the difference between the earth's motions rotation and revolution
D. Given a year, identify it as a leap year or not
E. Explain the rule governing leap years
F. Suggest ways "Stonehenge" may have been a type of clock
G. Distinguish between a guided time exposure and a trailed time exposure and explain why the difference.
H. Identify Einstein as person introducing time as a relative concept

V. The Seasons (45 min.)

A. Review earth-celestial sphere relationships
B. The autumnal equinox; def., day and night equal, position of sunrise and set, sun at noon; relate ecliptic and celestial equator
C. Winter solstice - same as B activities
D. Vernal equinox - Same as B activities
E. Summer solstice - same as B activities
F. Relate sun's position to rate of heating; obliquity of rays; etc.
G. Southern hemisphere seasons compared to Northern
H. Land of the "Midnight Sun" - causes and appearance

Student Objectives

During and following this program, students will be able to perform the following tasks:
A. Recognize earth's equator and N, E, S, W directions
B. Match up names of vernal equinox, summer solstice, autumnal equinox, and winter solstice with their appropriate dates
C. Measure and read sun's height in degrees along meridian for noon on 4 times in "B"
D. Observe and tell sun's precise direction of rising and setting for the 4 times of the year in "B"
E. Identify meaning of equinox and solstice
F. Relate sun's position in sky to rate of heating, obliquity of rays, surface area covered
G. Observe and explain cause of Land of the Midnight Sun

VI. What to do on an evening when it's cloudy -- a trip through the solar system by way of introduction (45 min.)

A. Cloudy and thunderstorm
B. The moon close-up - craters, "seas", mountains
C. Venus close-ups - cloud cover, phases
D. Mercury and the sun - close to sun, transit
E. Mars close-up - coloring, ice caps
F. Pass through asteroids
G. Jupiter, Saturn, Uranus, Neptune, Pluto - surface features
H. Look beyond solar system: nebulae and galaxies
I. Return trip - pass a comet
J. Splash-down

Student Objectives

During and following this program of instruction, students will be able to perform the following tasks:
A. Distinguish among moon craters, seas and mountains from telescopic pictures and planetarium moon
B. Identify and name the planets Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto
C. Identify and point out Jupiter's Great Red Spot, Saturn's Rings, Mar's ice cap and green and red markings, Venus' phases, Mercury in a transit
D. Locate the asteroids
E. Explain what a transit is
F. Recognize at least one galaxy, one nebula and one comet
VII. Many phases of the moon (40 min.) Introduction with astronaut "exercises"

A. Closest space neighbor; same side always toward earth; revolves around earth once every month
B. Full moon - "man-in-the-moon", rises as sun sets, moon orbit tilted
C. Waning phases - last gibbous, quarter, crescent
   1. Terminator
   2. "Cusps" always point away from sun
D. New moon
E. Waxing phases - new crescent, 1st quarter, gibbous
   1. Earthshine
   2. 1st day crescent
F. Two kinds of month - lunar - 29-1/2 days and sidereal - 27-1/3 days
G. Misc. - lunar halo, "moon dog"

Student Objectives

During and following this program of instruction, students will be able to perform the following tasks:
A. Explain why moon keeps same side toward the earth
B. Explain which lunar feature responsible for "man-in-the-moon"
C. Shown a lunar phase, can identify it
D. Locate sun from position of "cusps" of moon
E. Explain difference between waxing and waning
F. Recognize and identify "earthshine", "lunar halo", "moon dog", 1st day crescent
G. Point out the terminator and explain what it is
H. Observe tilted orbit of moon around the earth and explain this is why there aren't two eclipses every month
I. Perform at least one astronaut "exercise"

VIII. Pocket Planetarium Construction (student activity) (50 min.)

A. Student will be able to follow directions and construct working model of earth-moon-sun system
B. Once constructed, student will be able to demonstrate the following positions of earth-sun-moon system following pocket planetarium instructions: autumnal equinox, winter solstice, vernal equinox, summer solstice, full moon, new moon, 1st quarter, last quarter, lunar eclipse, solar eclipse.

Student Objectives

During and following this program of instruction, students will be able to perform the following tasks:
A. Student will be able to follow directions and construct working model of earth-moon-sun system
B. Once constructed, student will be able to demonstrate the following positions of earth-sun-moon system following pocket planetarium instructions: Autumnal equinox, winter solstice, vernal equinox, summer solstice, full moon, new moon, 1st quarter, last quarter, lunar eclipse, solar eclipse.

IX. Tides (35 min.)

A. Causes of tides - gravitational effect of moon and sun
B. Relation of moon's phase to tides (Spring and Neap Tide)
C. New moon, quarter phases, full moon
D. Predicting tide times
E. Explaining tide lag
F. The tides of the Bay of Fundy
Student Objectives

During and following this program of instruction, students will be able to perform the following tasks:

A. Identify from a prepared slide the direction of the sun's and moon's gravitational pull on the earth's water.
B. Recite which phases of the moon are responsible for spring and neap tides, and be able to recite from a prepared slide of earth-moon-sun relationship which tide situation it represents.
C. Predict how many times a day the tide changes at a given point.
D. Explain using a prepared slide why there is a "tide lag".
E. Locate the Bay of Fudy and observe causes for the extreme tides.
F. Recall and discuss events relating to high and low tide from experiences while at a beach.

X. Lunar Eclipse (35 min.)

A. Mechanics of eclipses
B. Conditions for a lunar eclipse
C. Lunar eclipse sequence presentation
D. Totality - copper color, white crescent
E. Importance of lunar eclipses
F. Recent and future lunar eclipses

Student Objectives

During and following this program of instruction, students will be able to perform the following tasks:

A. With the pocket planetarium, set up the proper earth-moon-sun relationship in order to have a lunar eclipse.
B. Recall and explain the moon's tilted orbit reason for eclipses not occurring every month.
C. Recite which phase moon must be in order to have a lunar eclipse.
D. Observe lunar eclipse sequence and relate to actual observations.
E. Suggest causes for the varying degree of copper color during totality.
F. List or recite at least two reasons why lunar eclipses are important to study.
G. Request information about date, time and location of next lunar eclipse.
H. Given a length of time totality of an eclipse lasts, tell whether eclipse was solar or lunar.

XI. Solar eclipse (45 min.)

A. Mechanics of solar and annular eclipses
B. Conditions for a solar or annular eclipse
C. Eclipse sequence presentation
   1. Pre-totality - include Bailey's Beads, shadow bands, "Diamond Ring effect"
   2. Totality - corona, prominences, chromosphere, intra-mercurial planet search
   3. Post totality - reverse sequence from pre-totality
D. Annular eclipse
E. Predicting eclipses
F. Importance of solar eclipses
G. Recent and future solar eclipses

Student Objectives

During and following this program of instruction, students will be able to perform the following tasks.
A. With the pocket planetarium set-up proper earth-sun-moon relationship in order to have a solar eclipse.
B. Recall and explain the moon's tilted orbit reason for eclipses not occurring every month.
C. Recite which phase moon must be in order to have a solar eclipse.
D. Observe lunar eclipse sequence and relate to actual observations.
E. Explain why some solar eclipses are annular and others total.
F. List or recite at least two reasons why solar eclipses are important to study.
G. Identify and name: corona, Bailey's Beads, "diamond-ring effect", prominences.
H. Request information about date, time and location of next solar eclipse.
I. Given a length of time of totality of an eclipse, tell whether eclipse was solar or lunar.
J. Given date of an eclipse, predict next eclipse in that cycle.
K. Cite precautions to be followed when viewing a solar eclipse.

XII. Mapping the lunar surface (student activity) (50 min.)
A. Using appropriate reference material student will be able to locate and neatly and accurately place on a blank moon map at least: 15 large craters, 10 "seas", 1 "ocean", 10 mountain ranges, 3 ray systems, 1 rill, the straight wall, and sites of Apollo 11, 12, 14, 15, and 16 U.S. manned moon landings.
B. Evaluation will be based on neatness and accuracy of placing features.

XIII. The Lunar Surface (45 min.)
A. "First man on the moon" (Live tape of Apollo 11 - 15 min.)
B. Trip to the moon - countdown and blast-off
C. Preliminary look at mountains, craters, "seas", rays, rills
D. Close-up survey of the lunar surface - maria, craters, rays, mountains, straight wall, rills
E. Return to earth

Student Objectives

During and following this program of instruction, students will be able to perform the following tasks:
A. Quietly listen to a tape of Apollo 11 highlights and be able to recite the date of the 1st manned moon landing and the 3 men on the flight, and what their look at the moon was like.
B. Differentiate by naming: "seas", mountains, craters, rills, straight wall
C. Recite at least 5 reasons why it is necessary to explore the moon.

XIV. The terrestrial planets (40 min.)
A. Mercury - location, position and physical characteristics
B. Venus - location, position and physical characteristics
C. Mars - location, position and physical characteristics
D. Earth - location, position and physical characteristics; also the use of the earth's distance from the sun as basis for the astronomical unit (1 A.U. = 93,000,000 miles)
E. Why called "terrestrial" planets; 4 closest planets to sun
F. Possibilities of life on these planets
Student Objectives:

During and following this program of instruction, students will be able to perform the following tasks:

A. Locate in the planetarium sky and name these planets: Mercury, Venus, and Mars
B. Explain why these planets change in apparent size as they change phases
C. Explain why called "terrestrial"
D. Recite the meaning of A.U. and what it's equivalent to
E. Discuss possible causes for Mars' color changes
F. Using 2-3 grams of CuSO4, NiCl2 and CoCl2 separately, heat slowly and observe color changes in these hygroscopic chemicals and record; explain where water droplets come from; suggest ways to return chemicals to original colors; evaluate orally how such a process could account for Mars' color changes
G. Point out ice caps of Mars
H. Evaluate physical conditions of terrestrial planets and conclude which one most like earth
I. Evaluate possibilities of life on these 4 planets

XV. The Giant Planets and Pluto (45 min.)

A. Jupiter - location, position, and physical characteristics
B. Saturn - location, position and physical characteristics
C. Uranus - location, position, and physical characteristics
D. Neptune - location, position, and physical characteristics
E. Pluto - location, position, and physical characteristics
   (C, D, & E - only telescopic objects)
F. Why called giant planets; which group Pluto best fits into
G. Possibilities of life on these planets

Student Objectives

During and following this program of instruction, students will be able to perform the following tasks:

A. Locate in the planetarium sky and name: Jupiter and Saturn; identify and name from telescopic slides: Uranus, Neptune and Pluto
B. Explain why called "giant"; which group does Pluto best fit into
C. Locate and identify Jupiter's Great Red Spot, Saturn's four rings and Cassini's division, Jupiter's four Galilean moons from telescopic slides
D. Evaluate Pluto's characteristics and place it in terrestrial or giant planet group
E. Evaluate possibilities of life on these five planets
F. Express a difficulty in observing Uranus, Neptune and Pluto
G. Explain the basis for grouping planets into inferior and superior planets as opposed to terrestrial and giant planets

XVI. Planets in Motion (40 min.)

A. Early Greek theories about organization of the solar system and universe
   1. Eudoxus and Plato
   2. Aristotle
   3. Heraclides and Aristarchus
   4. Apollonius and Hipparchus
B. The Ptolemaic system - geocentric
   1. Epicycles and deferents
   2. Retrograde motion - define, demonstrate and show how Ptolemy explained it
   3. Inadequacies which lead to its discarding
C. The Copernican revolution - heliocentric
1. Demonstrate with orrery
2. Show how retrograde motion explained
3. Held correct because explains all observations

D. Work of Kepler
1. 1st Law - planets orbits are ellipses, not circles; parts of an ellipse
2. 2nd Law - planets travel faster when close sun, slower when farther away.
3. 3rd Law - used to calculate planet distances and period of revolution

XVI. During and following this program of instruction, students will be able to perform the following tasks:

A. Suggest orally several different systems of organization of the planet, moon, star system
B. Observe and evaluate the theories of the universe of the early Greeks and Ptolemy
C. Observe retrograde motion of a planet
D. Observe and evaluate Copernican system
E. Recognize an ellipse shape and name the foci and place the sun at one focus
F. Explain why planets travel faster when close sun and slower when farther from sun
G. Recite season earth travels faster and slower
H. Observe method for calculating planet distances and periods of revolution using Kepler's 3rd Law

XVII. Asteroids, Meteors, Comets (40 min.)

A. Asteroids - location, numbers, sizes, names of largest, possible origins, other names (planetoids, minor planets)
B. Meteors - mis-named "falling and shooting stars", description, cause, fireballs, bolides, observation, meteor showers (important ones, radiant), composition, size; Meteorites - craters on earth and moon, sizes, viewing samples, Arizona Crater, name given to meteorites that hit the earth

XVII. Student Objectives
During and following this program of instruction, students will be able to perform the following tasks:

A. Locate the asteroids in the solar system
B. List or recite at least two possible origins of the asteroids
C. List or recite at least two alternate names for asteroids
D. Differentiate among meteor, fireball and bolide, and meteor showers
E. List or recite two mis-used names for meteors
F. Compare and contrast orally earth meteorite craters with large moon craters
G. Record dates of at least 4 prominent meteor showers
H. Observe at least 4 comets and locate and name the head, coma and tail
I. Locate the sun from direction of comet tail
J. Recall and recite the composition of comets and how they get their light

XVIII. Light in Astronomy Demonstrations I (50 min.) (student involvement)

A. Light and sound
B. Dispersion of white light into spectrum (R-O-Y-G-B-P-V)
   1. Prism
   2. Diffraction grating
C. Polarizing light
   1. Light from source vibrating in all directions
   2. Passing through single polarizer emits only light vibrating
      in one plane; passing through second at right angle cuts
      off all light
   3. Double polarizer to demonstrate
D. Fluorescence and phosphorescence
   1. Light emission from ultraviolet stimulation (long and short
      wave); use chalk, ink, minerals, that fluoresce under U-V
      light, relate to fluorescent lighting
   2. Phosphorescent minerals and paint - gives off light with
      no external stimulation
E. Light from an electric arc -- carbon arc demonstration
F. Light from a sound-modulated light generator

XVIII. Student Objectives
During and following this program of instruction, students will be able
   to perform the following tasks:
A. Disperse light into a spectrum with a prism and a diffraction grating
B. Recall and recite the exact order of colors in the spectrum
C. Observe a prepared slide on the theory of polarizing light
D. Using a variable density filter, polarize light and relate observations to prepared slide
E. Distinguish between and identify fluorescent minerals from phosphorescent minerals
F. Relate observations to fluorescent lighting and explain how a fluorescent light works
G. Collect carbon rods and observe operation of a carbon-arc lamp taking necessary precautions to protect eyes
H. Question the operation of a sound-modulated light generator

XIX. Light in astronomy demonstrations II (50 min.) (student involvement)
A. Light and sound II
B. The spectroscope -- using student-made shoe-box spectroscopes
   observe 3 types of spectra: continuous from projector bulb,
   bright-line from fluorescent lights; dark-line from sunlight
   reflected off a light object
C. Fiber optics - "crofon" used to bend light around corners; light
   passes in and out of ends only
D. Reflections - flat mirrors, concave, convex (relate to telescopes)
E. Refraction (lenses) - convex - converge and magnify; concave -
   divergent and reduce
F. Light versus distance - use light meter to measure footcandles at
   1, 2, 3, 4, and 5 ft. from light source (hopefully develop a good
   approximation of Inverse Square Law Relationship
G. Effects of U-V light on fluorescent paint, chalk, posters

XIX. Student Objectives
During and following this program of instruction, students will be able
   to perform the following tasks:
A. Using student-made shoe-box spectroscopes observe continuous, bright-
   line and dark-line spectra and differentiate among them.
B. Demonstrate ability of fiber optics material to bend light around
   corners.
C. Experiment with and describe differences between reflections off of
   flat, concave and convex mirrors.
D. Experiment with and describe effects convex and concave lenses have on light
E. Use light meter and read intensity in foot-candles and draw conclusions about how intensity of light falls off with distance.
F. Observe effects of ultraviolet light on fluorescent paint, chalk, posters.

XX. The Sun (45 min.)

A. Classification as a star - color, size, temp., distance, gravity
B. Makes energy by changing \( H_2 \) to He via thermonuclear fusion - 564 million tons \( H_2 \) changed to 560 tons He every second, rest goes into energy
C. How long has sun been doing this? How long can it continue?
D. Parts and descriptions and viewing these parts
   1. Photosphere
   2. Granules
   3. Chromosphere
   4. Corona
   5. Prominences - types
   6. Sunspots - parts and cycle
   7. Flares - associated aurora on earth, cosmic rays

E. Misc.: uneven rotation of sun at equator and poles, precautions used to view sun, terrestrial effects of solar activity - the aurora, tree-ring relationship to sunspot cycle; sun directly or indirectly responsible for nearly all energy in our solar system; barring catastrophe sun has enough fuel for 4 to 5 billion more years

XX. Student Objectives
During and following this program of instruction, students will be able to perform the following tasks:

A. Classify the sun according to color, size, distance, temperature, age
B. Recite source of sun's fuel and main product
C. Identify these solar parts: photosphere, granules, chromosphere, corona, prominences, sunspots, flares
D. Point out precautions to be taken when viewing the sun
E. Observe at least 3 types of aurora and explain which solar activity causes them
F. Predict age of sun and life remaining

XXI. To the land of the midnight sun and the northern lights (35 min.)

A. Review sun's position at noon; 23-\( \frac{1}{2} \)° tilt of earth's axis
B. Move from latitude 40°N. to 66-\( \frac{1}{2} \)°N.; run diurnal - sun never sets in summer
C. Change annual to winter and run diurnal - sun never rises
D. Scientific terminology for Northern Lights and Southern Lights
E. Causes: solar flare ejections and particle gathering around magnetic poles
F. Colors, forms

XXI. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Explain the causes of the land of the midnight sun
B. Tell above which latitudes the midnight sun can be observed
C. Relate to similar conditions in southern hemisphere and explain that same phenomena occurs there
D. Explain why 6 months of darkness follows the 6 months of midnight sun
XXII. Milky Way, Here We Come (45 min.)

A. Classifying stars
   1. Distance - miles, A.U., light-years, parsecs
   2. Magnitude - lower number, brighter; higher number, dimmer
   3. Size - dwarfs, middle-sized, giants, supergiants
   4. Color & temperature - blue-white hottest; white, yellow, orange, red the least hot
   5. Relate 1 to 4 above by showing example stars and classifying them

B. Unusual types of stars
   1. Multiple stars - binaries, triple-stars; give examples
   2. Nova & supernova - examples & results
   3. Variables - Delta Cephei classic example (value in determining stellar distances)

C. Relate types of stars to inclusion in Milky Way Galaxy and other galaxies

XXII. Student Objectives
During and following this program of instruction, students will be able to perform the following tasks:

A. Cite at least 3 units for measuring stellar distances
B. Given several magnitude numbers of stars, compare their brightness
C. Shown a prepared slide of different star sizes, classify as dwarf, middle-sized, giant, supergiant
D. Observe and identify the color of at least 12 bright stars
E. Locate, point out, and observe at least one binary star
F. Locate, point out, and observe at least one variable, pulsating star
G. Locate, point out, and observe at least one supernova in planetarium sky
H. Locate, point out, and observe Milky Way in planetarium sky; and observe sun's position in Milky Way from a prepared slide

XXIII. Surveying the Sky (40 min.)

A. Surveying the earth - review of latitude and longitude
   1. Latitude measured in degrees N & S of earth's equator
   2. Longitude measured in degrees E & W of prime meridian

B. Surveying the sky
   1. Horizon System
      a. Altitude - number of degrees above horizon; not good because changes with latitude and time
      b. Azimuth - number of degrees measured E of N end of meridian; not good because changes with time
   2. Equatorial System
      a. Declination - number of degrees above or below celestial equator; remains constant
      b. Right Ascension - hours and minutes east of vernal equinox; remains constant with time

C. Locating objects using the equatorial system (dec. & R.A.)
   1. Andromeda galaxy, Crab-nebula, Orion Nebula, Ring nebula

D. Surveyors use horizon system; astronomers usually use equatorial system - telescopes usually fitted with equatorial mountings
XXIII. Student Objectives
During and following this program of instruction, students will be able to perform the following tasks:

A. Measure one location for N & S latitude, and E & W longitude
B. Measure height of at least 4 objects above horizon in degrees along meridian
C. Measure height of at least 4 objects above celestial equator along meridian
D. Measure azimuth of at least 4 objects east from N. star Polaris
E. Measure Right Ascension of at least 4 objects east from vernal equinox
F. Locate these objects using declination and right ascension equatorial coordinates: Crab Nebula, Orion Nebula, Andromeda Galaxy, Ring Nebula
G. State which coordinate system surveyors use and astronomers use

XXIV. Constellations - Circumpolar (40 min.)

A. Definition of constellation; numbers recognized in ancient times (48); numbers recognized today (88)
B. Circumpolar constellations (why called circumpolar)
   1. Ursa Major
      a. Other names for constellation - Big Bear, Big Dipper
      b. How to locate - look north for large dipper shape
      c. Important stars - Mizar-double star next to last star in handle: "Pointer Stars" Dubhe & Merak
      d. Other important objects:
         1. Galaxy M-81 Spiral
         2. Galaxy M-82 Irregular
   2. Ursa Minor
      a. Other names: Little Bear, Little Dipper
      b. How to locate: Follow "Pointer Stars" of Big Dipper to North Star
      c. Important stars: Polaris, North Star; sky appears to turn around this star which is last star in handle
      d. Other important objects: NONE
   3. Cassiopeia
      a. Other names: The queen, The lazy "M" or "W"
      b. How to locate: Look on opposite side of Little Dipper from Big Dipper; look for "M" or "W" shape
      c. Important stars: NONE
      d. Other important objects: Great Nova in 1572 in Cassiopeia could be seen in daylight
   4. Cepheus
      a. Other names: The King, "Little House"
      b. How to locate: Line drawn from "Pointer Stars" through Polaris brings you to star at top of little house shape; next to Cassiopeia, the Queen
      c. Important star: Delta Cephei, first Cepheid variable star discovered just below base of house shape
      d. Other important objects: Galaxy between Cepheus and Cygnus
   5. Draco
      a. Other names: The Dragon
      b. How to locate: Tail between dippers, swings around Little Dipper, 4 stars form head
      c. Important star: Thuban, former North Star 2000 years ago used by Egyptians to orient the pyramids; 3rd star from end of tail
      d. Other important objects: NONE
C. Review the 5 major circumpolar constellations; note the absence of very bright stars in this region of the sky.
XXIV. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Define "constellation"; circumpolar
B. Recite how many constellations ancients named; how many named today
C. Students will be able to name and locate features under a, b, c, and d for each constellation.

XXV. Fall constellations (40 min.)

A. Poorest season for observing bright stars, but good for viewing other astronomical objects
B. Review circumpolar constellations
C. Constellations of fall
1. Pegasus
   a. Other name: Winged Horse
   b. How to locate: Line drawn from Polaris through west end of Cassiopeia hits the "Great Square" of Pegasus
   c. Important star: Alpheratz - a triple star common to Pegasus and Andromeda
   d. Other important objects: Galaxy in Pegasus
      NGC-7331
      Galaxy in Pegasus
      NGC-7217
2. Andromeda
   a. Other name: Chained Lady
   b. How to locate: Same as Pegasus, connects to "GREAT SQUARE" at Alpheratz; lazy "V" shape
   c. Important star: Alpheratz - a triple star common to Andromeda and Pegasus
   d. Other important objects: M-31 Great Andromeda Galaxy, brightest galaxy to unaided eye; much like our Milky Way except slightly larger; about 2-½ million light years away; note satellite galaxies; Satellite Galaxy left of M-31, Satellite Galaxy right of M-31 (M32)
3. Auriga
   a. Other names: The Charioteer, The "Big House"
   b. How to locate: Line drawn from top stars of Big Dipper's bowl points to Capella; look for "Big House" shape
   c. Important star: Capella - a bright, yellow star
   d. Other important objects: Nebula IC405 in Auriga, the "Kids" star clusters near Capella
4. Perseus
   a. Other name: Lazy "H" or "K"
   b. How to locate: Look close to Cassiopeia, one leg of "K" points to Pleiades, another to Auriga
   c. Important star: Algol - eclipsing binary (double star with the 2 stars 13 million miles apart; changes in brightness; called the "Demon" star since ancient times.
   d. Other important objects: Double star cluster
5. Point our Cetus

XXV. Student Objectives
During and following this program of instruction, the students will be able to perform the following tasks:

A. Recognize and indicate poorest season for observing bright stars, but good for viewing deep-sky objects
B. Can review and locate the 5 major circumpolar constellations in the sky
C. Students will be able to name and locate features under a, b, c, and d for each constellation.

XXVI. Winter Constellations (45 min.)

A. Late winter best for observing bright stars; also excellent for viewing deep-sky objects
B. Review fall constellations
C. Constellations of winter
1. Orion
   a. Other name: The Great Hunter
   b. How to locate: Look south for 3 bright stars in row close together forming belt with 4 other bright stars making a rectangle around the 3.
   c. Important stars:
      (1) Betelgeuse - a red supergiant
      (2) Rigel - a blue-white giant, brightest in Milky Way, one foot
      (3) Bellatrix
      (4) Mintaka - on celestial equator
   d. Other important objects (Note Trapezium)
      (1) Great Orion Nebula M-42, small, dim
      (2) Great Orion Nebula M-42, large, bright
      (3) Horsehead Nebula NGC-2024, dim
      (4) Horsehead Nebula NGC-2024, bright
2. Taurus
   a. Other name: The Bull
   b. How to locate: Line drawn north through Orion's belt brings you to bright star Aldebaran in Taurus.
   c. Important star: Aldebaran, orange-red giant at Bull's eye.
   d. Other important objects:
      (1) The Pleiades - star cluster (wound on shoulder)
      (2) Pleiades with nebulosity
      (3) Hyades - star cluster around bull's eye
      (4) Crab Nebula M-1 between horns which is result of a supernova explosion in 1054 recorded by Chinese astronomers
3. Canis Major
   a. Other name: The Big Dog (hunting dog of Orion)
   b. How to locate: Line drawn southeast through Orion's belt brings you to Sirius (brightest star in the sky)
   c. Important star: Sirius - brightest star in the sky at magnitude - 1.6; one of closest to earth 8.8 light years away; actually a double star (small companion): blue-white star; called "Dog Star" (Explain Dog Days).
   d. Other important objects: NONE
4. Canis Minor
   a. Other Name: Little Dog (Hunting dog of Orion)
   b. How to locate: Line drawn directly east from Betelgeuse in Orion takes you to Procyon
   c. Important star: Procyon - white star and bright, only one other star in this constellation.
   d. Other important objects: NONE
5. Point out minor constellations Lepus, Columba and Monoceros

XXVI. Student Objectives:

During and following this program of instruction, the students will be able to perform the following tasks:

A. Recognize and indicate best season for observing bright stars, deep-
sky objects, but poor for observing Milky Way.
B. Can review and locate the 4 major fall constellations in the sky.
C. Students will be able to name and locate those features under a, b, c, and d for each constellation.

XXVII. Mapping The Stars I (student activity) Circumpolar, Fall and Winter (50 min.)
A. Given a star map containing circumpolar, fall and winter constellations, student will be able to recognize at least Ursa Major, Ursa Minor, Cassiopeia, Cepheus, Cetus, Orion, Taurus, Canis Major, Canis Minor, Lepus, Monoceros, circle them and give the correct name and one nickname for them (drawing lines to make the figures optional).
B. Student will be able to locate those bright stars in each constellation which were pointed out and name them, recognizing names from a prepared list.
C. Student will also be able to locate other important objects (galaxies, nebulae, and star clusters) which were pointed out in above constellations and label them, recognizing names from a prepared list.

XXVII. Student Objectives
During and following this program of instruction, the students will be able to perform the following tasks:
A. Given a star map containing circumpolar, fall and winter constellations, student will be able to recognize at least Ursa Major, Ursa Minor, Cassiopeia, Cepheus, Cetus, Orion, Taurus, Canis Major, Canis Minor, Lepus, Monoceros circle them and give the correct name and one nickname for them.
B. Student will be able to locate those bright stars in each constellation which were pointed out and name them, recognizing names from a prepared list.
C. Student will also be able to locate other important objects (galaxies, nebulae, and star clusters) which were pointed out in above constellations and label them, recognizing names from a prepared list.

XXVIII. Spring Constellations (45 min.)
A. Early Spring excellent for observing bright stars; not as rich in deep-sky objects
B. Review winter constellations
C. Constellations of spring
1. Gemini
   a. Other name: The Twins
   b. How to locate: Line drawn through Rigel and Betelgeuse north and east brings you to Castor and Pollux
   c. Important stars: Pollux, a bright red-yellow star (left) Castor, a green double-triple star (6 in all!)
   d. Other important objects: Several star clusters; Two clusters, one is M-35
2. Leo
   a. Other name: The Lion
   b. How to locate: Draw line through back stars of Big Dipper's bowl south to Regulus and the "sickle-shape"
   c. Important stars: Regulus, blue-white giant about on ecliptic Denebola
   d. Other important objects: Very dim galaxy clusters
3. Bootes
   a. Other name: The Herdsman
   b. How to locate: follow curve of Big Dipper's handle to bright star Arcturus and look for "kite" shape
c. Important star: Arcturus, very bright orange giant star at base of "kite"
d. Other important objects: NONE

4. Virgo
a. Other name: The Virgin
b. How to locate: Follow curve of Big Dipper's handle through Arcturus and on to bright star Spica; look for "Y" shape opening toward Denebola
c. Important star: Spica - blue-white 1st magnitude star
d. Other important objects: Cluster of galaxies, Sombrero Galaxy

5. Cancer
a. Other name: The Crab
b. How to locate: Look between Gemini and Leo, small and dim
c. Important stars: No bright ones; all quite dim
d. Other important objects: Beehive or Praesepe Cluster M-44

6. Locate minor constellations Coma Berenices and Canes Venatici between Leo and Bootes below Big Dipper.

XXVIII. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Recognize and indicate excellent season for observing bright stars; not as rich in deep-sky objects; better for observing Milky Way.
B. Can review and locate the 4 major winter constellations in the sky.
C. Students will be able to name and locate those features under a, b, c, and d for each constellation.

XXIX. Summer Constellations (45 min.)

A. Summer sky rich in bright stars; best for observing Milky Way; sometimes obscured by smog, haze, etc.
B. Review spring constellations
C. Constellations of summer
1. Corona Borealis
   a. Other name: The Crown
   b. How to locate: Find Bootes, "U" shape just east of Bootes
   c. Important stars: NONE
   d. Other important objects: NONE

2. Hercules
   a. Other name: The Kneeler; Strong Man
   b. How to locate: locate Corona, just east lies the keystone shape of center of Hercules with sprawling arms in 4 directions
   c. Important stars: NONE
   d. Other important objects: M-13 Globular Cluster (black & white) along western side of keystone 2/3 of the way up M-13 in color

3. Lyra
   a. Other name: The Lyre
   b. How to locate: continue eastward line from Hercules and look for very bright star Vega and diamond shape
   c. Important star: Vega - brightest star in summer sky; blue-white giant; forms part of summer triangle of Vega, Deneb, Altair
   d. Other important objects: M-57 Ring Nebula between bottom stars of diamond; small and dim; M-57 large and bright

4. Cygnus
   a. Other names: The Swan; Northern Cross
   b. How to locate: Continue eastward line from Lyra and look conspicuous cross shape.
c. Important stars: Deneb - bright, white star at tail; forms part of summer triangle Vega, Deneb, Altair; Albireo - spectacular orange and blue double at head of swan
d. Other important objects: 4 nebulae in Cygnus; Veil Nebula NGC-6992; Milky Way appears to split in 2 here

5. Aquila
   a. Other names: The eagle; The anchor
   b. How to locate: Line drawn just south and east of Cygnus brings you to anchor shape
   c. Important star: Altair - bright white star near head of eagle forming part of summer triangle of Vega, Deneb, Altair
   d. Other important objects (small nearby constellations): Sagitta - the arrow; Delphinus - the dolphin

6. Scorpius
   a. Other name: The Scorpion
   b. How to locate: look in southern sky for giant fishhook shape, three stars in row for front, bright red star
   c. Important star: Antares - red supergiant at heart of scorpion
   d. Other important objects: several star clusters

7. Sagittarius
   a. Other names: The Archer; The Teapot
   b. How to locate: Look just east of Scorpius; small milk dipper shape
   c. Important stars: NONE
   d. Other important objects: Milky Way rich here - this direction is looking toward center of our galaxy!!!

D. Summer triangle of Vega, Deneb, Altair

XXIX. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Recognize and indicate season rich in bright stars; best for observing Milky Way; skies of summer frequently obscured by smoke, smog, haze.
B. Can review and locate the 5 major spring constellations in the sky.
C. Students will be able to name and locate those features under a, b, c, and d for each constellation.

XXX. Mapping the stars II (student activity) (50 min.)

A. Given a map containing Circumpolar, Spring and Summer constellations, student will be able to recognize at least Ursa Major, Ursa Minor, Cassiopeia, Cepheus, Draco, Gemini, Leo, Bootes, Virgo, Cancer, Coma Berenices, Canes Venatici, Corona Borealis, Hercules, Lyra, Cygnus, Aquila, Scorpius, Sagittarius, Vega, Deneb, Altair, circle them and give the correct name and one nickname for them (drawing lines to make the figure Optional).
B. Student will be able to locate those bright stars in each constellation which were pointed out and name them, recognizing names from a prepared list.
C. Student will also be able to locate other important objects (galaxies, nebulae, and star clusters) which were pointed out in above constellations and label them, recognizing names from a prepared list.

XXX. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:
A. Given a map containing Circumpolar, Spring and Summer constellations, student will be able to recognize at least Ursa Major, Ursa Minor, Cassiopeia, Cepheus, Draco, Germinii, Leo, Bootes, Virgo, Cancer, Coma Berenices, Canes Venatici, Corona Borealis, Hercules, Lyra, Cygnus, Aquila, Scorpius, Sagittarius, Vega, Deneb, Altair, circle them and give the correct name and one nickname for them (drawing lines to make the figure optional).

B. Student will be able to locate those bright stars in each constellation which were pointed out and name them, recognizing names from a prepared list.

C. Student will also be able to locate other important objects (galaxies, nebulae, and star clusters) which were pointed out in above constellations and label them, recognizing names from a prepared list.

XXXI. The Age of Aquarius (50 min.)

A. Compare definitions of astronomy and astrology
B. Define Zodiac and where it is located, and how it was set up and is currently changing
C. The 12 Houses of the Zodiac - for each the following will be demonstrated:
   1. The Zodiac sign in stars and picture, period of the year it governs, the brief legend about it, qualities of persons born under sign (according to legend), and national or world figures to exemplify the sign's characteristics.
   2. Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Pisces
D. Conclusion
   1. Review manner in which Zodiac was set up
   2. Importance of astrology versus astronomy - ancient times and present
   3. The future of astronomy as an outgrowth of astrology

XXXI. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Compare definitions of astronomy and astrology and cite which was derived from which.
B. Define Zodiac, where it is located, how it was set up and currently changing.
C. Observe 12 signs of the Zodiac, period of year it governs, brief legend about it, qualities of persons born under sign according to legend.
D. Give examples of national and/or world figures to exemplify the signs' characteristics.
E. State importance of astronomy versus astrology in ancient times and today.
F. Speculate on the future of astronomy over the next couple of decades and centuries.

XXXII. Rambling through Southern Skies (35 min.)

A. Introduction
   1. Cannot see stars of southern sky from our location.
   2. Southern sky not nearly as rich in bright stars as northern sky.
   3. Change latitude to southern location and note unfamiliarity.
B. Constellations of the southern hemisphere
   1. Carina
      a. Other name: Keel of the ship Argo
      b. How to locate: line drawn directly south from Sirius brings you to Canopus, 2nd brightest star in sky.
c. Important star: Canopus, second brightest star in sky at magnitude -0.9.
d. Other objects:
   (1) Galaxy Large Magellanic Cloud about 20° south of Canopus (one of closest galaxies to Milky Way).
   (2) Small Magellanic Cloud about 4 hrs. east of Large Cloud.

2. Centaurus
a. Other name: The Centaur
b. How to locate: line south and a little west from Antares about 35° south to Alpha & Beta Centauri
c. Important stars
   (1) Alpha Centauri - also called Rigil Kent; closest star to us after the sun (its companion Proxima Centauri once thought to be closer is actually about same distance)
   (2) Beta Centauri - slightly dimmer than Alpha but 150 times farther away
d. Other objects: Southern Cross nearby

3. Crux
a. Other name: Southern Cross
b. How to locate: line drawn from Alpha to Beta Centauri will bring you to northern most star in Cross.
c. Important stars: 2 bright first magnitude stars, one is Alpha Crucis - splendid sight
d. Other Objects: NONE

C. Conclusion
1. Adjust latitude to show there is NO south pole star
2. Southern skies far less spectacular than northern
3. Slowly return to 40° N. latitude and observe southern stars disappear and more familiar northern stars reappear.

XXXII. Student Objectives:
During and following this program of instruction students will be able to perform the following tasks:

A. Recognize and state can't see southern hemisphere stars from our latitude.
B. Recognize southern sky not as rich in bright stars
C. Observe latitude change to southern hemisphere and cite unfamiliarity
D. Observe and identify: Carina, Centaurus, Crux (Southern Cross)
E. Observe no south pole star
F. Review 3 brightest southern constellations and observe slow latitude change back to 40° N. and cite familiarity.

XXXIII. Use of the telescope (50 min.)

A. Care of the telescope
B. Set-up for equatorial mount system (compare to altazimuth mount)
C. Focusing
D. Adjusting declination
E. Adjusting right ascension
F. Purpose of the sun filter
G. Magnification versus light-gathering power
H. Use of the finder scope and cross-hairs
I. Observing sunspots outside (daytime viewing) or moon, stars, and selected seasonal deep-sky objects (if nighttime viewing can be arranged.)

XXXIII. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:
A. Accurately set up telescope according to equatorial system  
B. Can focus accurately on an object using finder scope to locate object first.  
C. Can adjust declination (height) using setting circles  
D. Can adjust right ascension using setting circles  
E. Will demonstrate respect for and care of instrument during all use  
F. Carefully attach sun filter and explain its importance and uses  
G. Can argue that light-gathering power is more important than magnification and explain why and show why  

XXXIV. Flying Saucers - Hoax or Hardware (50 min.)  

A. History of flying saucer sightings  
B. Meaning of U.F.O. and I.F.O.  
C. Hoax sightings, photographs and publications  
D. Attempts to observe and explain U.F.O.'s scientifically  
E. Non-hoax sightings, photographs and publications  
F. Speculations as to origins, meanings, and destiny of U.F.O.'s  

XXXIV. Student Objectives:  
During and following this program of instruction students will be able to perform the following tasks:  
A. Relate a brief history of U.F.O. sightings  
B. Define U.F.O. and I.F.O.  
C. List at least 6 hoax sightings  
D. Explain what scientific attempts have been made to observe and explain U.F.O.'s  
E. List at least 6 non-hoax sightings  
F. Distinguish between a hoax and non-hoax U.F.O. sighting and report  
G. Cite a few speculations as to possible origins, meanings and destiny of U.F.O.'s  

The following is a suggested sequence of planetarium visits for Dallastown Area Senior High School students to be experiences as follow-up to the Elementary and Middle School astronomy-planetarium experiences. Basic outlines are indicated for these programs with encouragement being extended to teachers visiting to contact the planetarium director prior to a visit to more closely correlate the program to his teaching experience, unit, etc.  

GRADE 9 - Elective - Earth-Space Science; General Science  

I. Visit 1: "Introduction to the Planetarium and Orientation"  

A. Definition of astronomy versus astrology  
B. Direction orientation - cardinal points  
C. Sky at N. Pole  
D. Latitude by altitude of Polaris; azimuth  
E. Geocentric earth to locate equator, poles and recall how latitude is measured  
F. Relate "E" to celestial equator and poles and measuring astronomical latitude (declination)  
G. Geocentric earth to recall longitude measurement  
H. Relate "G" to celestial longitude (right ascension)  
I. Measure several earth locations in latitude and longitude  
J. Measure several celestial objects in declination and right ascension  

I. Student Objectives:  
During and following this program of instruction, students will be able to perform the following tasks:  
A. Student will be able to recognize and identify the Cardinal Points N, E, S, W.
A. Accurately set up telescope according to equatorial system
B. Can focus accurately on an object using finder scope to locate object first.
C. Can adjust declination (height) using setting circles
D. Can adjust right ascension using setting circles
E. Will demonstrate respect for and care of instrument during all use
F. Carefully attach sun filter and explain its importance and uses
G. Can argue that light-gathering power is more important than magnification and explain why and show why

XXXIV. Flying Saucers - Hoax or Hardware (50 min.)

A. History of flying saucer sightings
B. Meaning of U.F.O. and I.F.O.
C. Hoax sightings, photographs and publications
D. Attempts to observe and explain U.F.O.'s scientifically
E. Non-hoax sightings, photographs and publications
F. Speculations as to origins, meanings, and destiny of U.F.O.'s

XXXIV. Student Objectives:
During and following this program of instruction students will be able to perform the following tasks:

A. Relate a brief history of U.F.O. sightings
B. Define U.F.O. and I.F.O.
C. List at least 6 hoax sightings
D. Explain what scientific attempts have been made to observe and explain U.F.O.'s
E. List at least 6 non-hoax sightings
F. Distinguish between a hoax and non-hoax U.F.O. sighting and report
G. Cite a few speculations as to possible origins, meanings and destiny of U.F.O.'s

The following is a suggested sequence of planetarium visits for Dallastown Area Senior High School students to be experiences as follow-up to the Elementary and Middle School astronomy-planetarium experiences. Basic outlines are indicated for these programs with encouragement being extended to teachers visiting to contact the planetarium director prior to a visit to more closely correlate the program to his teaching experience, unit, etc.

GRADE 9 - Elective - Earth-Space Science; General Science

I. - Visit 1: "Introduction to the Planetarium and Orientation"

A. Definition of astronomy versus astrology
B. Direction orientation - cardinal points
C. Sky at N. Pole
D. Latitude by altitude of Polaris; azimuth
E. Geocentric earth to locate equator, poles and recall how latitude is measured
F. Relate "E" to celestial equator and poles and measuring astronomical latitude (declination)
G. Geocentric earth to recall longitude measurement
H. Relate "G" to celestial longitude (right ascension)
I. Measure several earth locations in latitude and longitude
J. Measure several celestial objects in declination and right ascension

I. - Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Student will be able to recognize and identify the Cardinal Points N, E, S, W.
B. Student can locate the Big and Little Dipper at the North Pole and at our latitude - 40° N.
C. Student will be able to explain that the height of Polaris above the horizon in degrees is equal to an observer's latitude in N. Hemisphere.
D. Students will be able to orally distinguish between star brightness and colors.
E. Students will be able to locate and identify the following additional constellations: Orion and Cassiopeia
F. Students will be able to explain the difference between terms inferior and superior planets.
G. Students can recognize and name earth's equator and poles
H. Students will be able to identify a full moon, new moon and quarter phase moon.
I. Students will successfully locate the cardinal points N, E, S, & W.

II. Visit 2: "Rocket Travel"
A. Blast-off (with prior discussion of rocketry, fuels, types, etc.)
B. Basic motions of a rocket demonstrated
C. Roll, pitch, yaw
D. Short journey through space--suggested "stopping" points: moon (locating Apollo landing sites), sun, Venus, Mars.
E. Brief history of rocketry
F. Landing

II. Student Objectives:
During and following the program of instruction, students will be able to perform the following tasks:
A. Name and define each of the 3 basic motions of a rocket-roll, pitch, yaw
B. Can name and identify from pictures several different types of rockets.
C. Can list several types of rocket fuel
D. Give a brief history of rocketry
E. List the steps and precautions to be taken in soft-landing

III. Visit 3: "Light in the Universe"
A. Poemer's light speed determination
   1. Observe Jupiter's moons telescopically
   2. Note error in predicting eclipse times depending on orbital position
   3. Relate orbital dimensions to amount of error in prediction
   4. Rough calculation
B. Michelson's experiment
C. Fizeau's experiment
D. Types of spectra (define wavelength; Doppler effect)
   1. Continuous
   2. Bright-line (emission)
   3. Dark-line (absorption)
   4. Compare spectra of several earth elements (bright-line) with stellar spectra (dark-line) and match lines
   5. Compare spectra of objects moving away from earth and toward earth with standard; relate to "red-shift" and "blue-shift"
   6. Relate Doppler effect in light to sound
E. Speculations as to implications of "red-shift" of most of observed galaxies, quasars, etc.
   1. Expanding universe?
   2. Oscillating universe?
   3. Steady-state?
F. Conclusion, questions, comments

III. Student Objectives:
During and following the program of instruction, students will be able to perform the following tasks:
A. Explain and diagram any 2 of the 3 light-speed determining experiments (Roemer, Fizeau, Michelson)
B. Define wavelength and Doppler effect
C. Identify continuous, bright-line and dark-line spectra
D. Given a spectrum of a moving celestial object, state whether object is approaching or receding
E. Give an example of Doppler effect in sound
F. State at least one piece of evidence for: expanding, oscillating and steady-state universe

GRADE 10 - Biology

I. Visit 1: "Introduction to the Planetarium & Orientation"

A. Definition of astronomy versus astrology
B. Direction orientation - cardinal points
C. Sky at N. Pole
D. Latitude by altitude of Polaris; azimuth
E. Geocentric earth to locate equator, poles and recall how latitude is measured
F. Relate "E" to celestial equator and poles and measuring astronomical latitude (declination)
G. Geocentric earth to recall longitude measurement
H. Relate "G" to celestial longitude (right ascension)
I. Measure several earth locations in latitude and longitude
J. Measure several celestial objects in declination and right ascension

I. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Student will be able to recognize and identify the Cardinal Points N, E, S, W.
B. Student can locate the Big and Little Dipper at the North Pole and at our latitude - 40° N.
C. Student will be able to explain that the height of Polaris above the horizon in degrees is equal to an observer's latitude in N. Hemisphere.
D. Students will be able to orally distinguish between star brightness and colors.
E. Students will be able to locate and identify the following additional constellations: Orion and Cassiopeia
F. Students will be able to explain the difference between terms inferior and superior planets.
G. Students can recognize and name earth's equator and poles
H. Students will be able to identify a full moon, new moon and quarter phase moon.
I. Students will successfully locate the cardinal points N, E, W, & S.

II. Visit 2: "Exo-Biology -- Life in the Universe"

A. Sunset and moonrise
B. Conditions for life as we know on planet earth
C. "Visit" other 8 planets and evaluate conditions for life as we know it with particular emphasis on findings on Mars.
D. Spectroscopic analyses of light from other stars, nebulae, etc. and evidence of life-related elements, radicals, and compounds.
E. Evidence for other kinds of life or non-existence of same.

II. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:
A. List necessary conditions for life as we know it on earth
B. Briefly evaluate conditions for life, as we know it, on each of the other 8 planets
C. Cite findings of life-related chemicals and substance in outer space from spectroscopic analyses of light from stars, nebulae, etc.
D. Comment as to the possibilities of other forms of life elsewhere, or the possibilities of non-existence of it.

GRADE 11 - Chemistry

I. Visit 1: "Introduction to the Planetarium and Orientation"
A. Definition of astronomy versus astrology
B. Direction orientation - cardinal points
C. Sky at N. Pole
D. Latitude by altitude of Polaris; azimuth
E. Geocentric earth to locate equator, poles and recall how latitude is measured
F. Relate "E" to celestial equator and poles and measuring astronomical latitude (declination)
G. Geocentric earth to recall longitude measurement
H. Relate "G" to celestial longitude (right ascension)
I. Measure several earth locations in latitude and longitude
J. Measure several celestial objects in declination and right ascension

I. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Student will be able to recognize and identify the Cardinal Points N, E, S, W.
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D. Students will be able to orally distinguish between star brightness and colors.
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F. Students will be able to explain the difference between terms inferior and superior planets.
G. Students can recognize and name earth's equator and poles
H. Students will be able to identify a full moon, new moon and quarter
I. Students will successfully locate the cardinal points N, E, S, & W.

II. Visit 2: "Chemistry in the Universe"

A. Color changes on Mars as a function of hygroscopic chemicals -- observe Mars at different times via slides and relate to color changes of 3 chemicals listed in Visit 3 - this activity could precede or follow Visit 2.
B. Observing atmospheres of planets and determining composition (how done and results)
C. Elements in the sun and stars -- spectral studies; comparing spectral absorption lines with absorption lines of earth elements.
D. Chemical action versus nuclear reactions in stars

II. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Relate color changes on Mars to color changes of 3 hygroscopic chemicals in the laboratory
B. Explain why hygroscopic chemicals change color when heated and cooled
C. Explain how composition of atmospheres and luminous objects is determined
D. Identify elements and compounds found in and on celestial objects by observing their spectra
E. Explain and diagram briefly the difference between chemical burning (oxidation) and nuclear burning (fission and fusion)

III. Visit 3: "Experiment -- Hygroscopic Chemicals" (May be performed in science lab, adjacent to planetarium or in Senior High Chemistry lab. before or after Visit 2)
A. Weigh out 3 g. of CuSO₄, CoCl₂ and NiCl₂ separately
B. Place in separate test tubes and observe; record observations of color, texture, etc.
C. Heat each gently and record all observations while heating
D. Observe end result after 2-3 min. of heating and record
E. Let results stand overnight in the open or less preferable add 2 or 3 drops of water - why?
F. Draw conclusions and relate observations to color changes on Mars

III. Student Objectives
A. Weigh out 3 g. of CuSO₄, CoCl₂, and NiCl₂ separately
B. Place in separate test tubes and observe; record observations of color, texture, etc.
C. Heat each gently and record all observations while heating
D. Observe end result after 2-3 min. of heating and record
E. Let results stand overnight in the open or less preferable add 2 or 3 drops of water - why?
F. Draw conclusions and relate observations to color changes on Mars

GRADE 12 - Physics and/or Physical Science

I. Visit 1: "Introduction to the Planetarium & Orientation"
A. Definition of astronomy versus astrology
B. Direction orientation - cardinal points
C. Sky at N. Pole
D. Latitude by altitude of Polaris; azimuth
E. Geocentric earth to locate equator, poles and recall how latitude is measured
F. Relate "E" to celestial equator and poles and measuring astronomical latitude (declination)
G. Geocentric earth to recall longitude measurement
H. Relate "G" to celestial longitude (right ascension)
I. Measure several earth locations in latitude and longitude
J. Measure several celestial objects in declination and right ascension

I. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:
A. Student will be able to recognize and identify the Cardinal Points N, E, S, W.
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E. Students will be able to locate and identify the following additional constellations: Orion and Cassiopeia.
F. Students will be able to explain the difference between terms inferior and superior planets.
G. Students can recognize and name earth's equator and poles.
H. Students will be able to identify a full moon, new moon and quarter phase moon.
I. Students will successfully locate the cardinal points N, E, S & W.

II. Visit 2: "The Expanding Universe I" (May be conducted in planetarium or adjoining science lab. or Sr. High lab.)

A. Demonstration: with Bunsen burner heat a piece of wire and observe colors from dull red thru orange, yellow and white.
B. Types of spectra: continuous, bright-line, dark-line (absorption); observe with spectrosopes and relate to types of objects which produce these types of spectra.

II. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Record color change order as piece of wire is heated in Bunsen burner flame.
B. Relate observations to practical situation in the shop, kitchen,
C. From review: List the 3 types of spectra.
D. Explain how each spectrum type is produced.

III. Visit 3: "The Expanding Universe II"

A. Evidence for the expanding universe
B. The Doppler Effect -- most objects exhibit the red-shift, few objects exhibit the blue-shift.
C. Relate the Doppler Effect in light to Doppler Effect in sound.
D. Why the red-shift of most objects does not mean earth is in the center of universe -- popcorn example and balloon example
E. The "Big-Bay" -- How long expansion? Then what?
F. Oscillating Universe
G. Relate to quasars
H. The steady-state universe versus the expanding universe and oscillating universe.

III. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Cite available evidence for expanding universe.
B. Explain how this evidence has been obtained and its reliability.
C. Cite evidence in refutation of the expanding universe idea.
D. List 2 single experiments to document evidence in "C".
E. Relate "Big-Bang" to expanding universe, oscillating universe, and steady state universe.

The following is a list of auxiliary planetarium programs applicable at various subject levels. Teachers are encouraged to evaluate the planetarium as a teaching tool at all subject levels and if applicable, contact the planetarium director to make arrangements for a program related to the teaching experience. All grade levels are invited and encouraged to participate in planetarium experience.
ENGLISH - related

I. "Sight and Sound Experience" - consisting of a 15-18 minute unnarrated program during which time students will observe a rapid sequence of events on the planetarium sky accompanied by music and sound effects. The total program is un-titled and open-ended as to interpretation of meaning and conclusion. It is suggested this might be followed by a 20-25 writing experience the goals and objectives of which could be set by the individual instructor.

I. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Observe a 15-18 minute unnarrated, open-ended program consisting of music, sound effects and sights in the planetarium sky.
B. Compose a titled composition interpreting what has been experienced during the presentation.

II. "Poetry in Motion"; "Astronomy in Literature" - in various levels below would consist of poetry or literature reading in the planetarium accompanied by machine application where appropriate.

Copies of a through d are available from planetarium director. (Elementary)

**Elementary:**
- a. "Modoc Indian Legend"
- b. "Why the Sun & Moon Live in the Sky" - an Efik Ibibio legend from Nigeria
- c. "Indian Legend"
- d. "Ibo Legend"
- e. Books: *Time and Mr. Bass, Wonderful Flight to the Mushroom Planet*, *Mr. Base's Planetoid, Stowaway to the Mushroom Planet*, *The Little Prince* (p.16)

**Secondary:**
- a. Shakespeare - *Julius Caesar* (Ii, II i, IIV, IV iii)
- b. Shakespeare - *Romeo and Juliet* (I iv, II iv, III iv)
- c. Chaucer - *Troilus and Criseyde*
- d. Canterbury Takes - (Part of Prologue, and Physician)
- e. Milton - *Paradise Lost* (selected passages)
- f. Coleridge - *Rime of the Ancient Mariner*
- g. Drummond - *A Cypress Grove*
- h. Books: *Voyage of the Nina II*, - Robert Marx
  *Tinkerbelle* - Robert Manry
  *Aku Aku* - Thor Heyerdahl
  *Good Friday 1613* - Donne
  *Kon-Tiki* - Thor Heyerdahl
  *The Watershed* - Arthur Koestler
  *Koduku* - Kenichi Horie
- i. Other Poems: "Moonlight" - Shakespeare
  "Freedom of the Moon" - Frost
  "When I Heard the Learn'd Astronomy" - Whitman
  "To the Evening Star" - Blake
  "Comfort of the Stars" - R. Burton
  "Old Astronomer to His Pupil" - William

II. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Explain how an astronomical subject has been used to develop at least two poems or one story (from teacher hand-out sheets).
B. Look up the names of at least 4 additional poems or 2 stories and tell what topic in astronomy is built into it.
C. Read and report on 2 poems or 1 short story which is developed around some astronomical subject.

III. "The Star of Bethlehem" - suggested as enrichment or for a follow-up critical writing experience on 8th grade English.

III. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Observe the Christmas Story told astronomically.
B. Write a composition including: validity of arguments presented as to possible explanations of the "Christmas Star"; which one seems most documented, and least documented; what other possibilities exist which might serve as explanations?

HISTORY - related (Secondary)

I. "History of Astronomy I -- The pre-Copernican Period"

a. Theories of the universe of Plato & Eudoxus
b. Theories of the universe of Aristarchus & Heraclides
c. Theories of the universe of Appollonius & Hipparchus
d. Theories of the universe of Claudius Ptolemy

I. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. List the contributions to astronomy of Plato and Eudoxus
B. List the contributions to astronomy of Aristarchus and Heraclides
C. List the contributions to astronomy of Appollonius and Hipparchus
D. List the contributions to astronomy of Claudius Ptolemy
E. Evaluate the time when each lived and explain whether the times influenced the man, or the man the times.

II. "History of Astronomy II - The Copernican Revolution and Later"

a. Copernicus' heliocentric revolution
b. Observations of Tycho Brahe
c. The Laws of Johannes Kepler
d. Newton introduces gravitational theory
e. Einstein, Hoyle and the modern day

II. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. List the contributions to astronomy of Nicholaus Copernicus
B. List the contributions to astronomy of Tycho Brahe
C. List the contributions to astronomy of Johannes Kepler
D. List the contributions to astronomy of Isaac Newton
E. List the contributions to astronomy of Einstein and Hoyle
F. Evaluate the time when each lived and explain whether the times influenced the man, or the man the times.

GEOGRAPHY - related:

I. "Surveying the Earth"
a. The earth's poles and equator
b. Latitude, longitude and the time zones
c. The tropics (Cancer and Capricorn)
d. Arctic and Antarctic circles

I. **Student Objectives:**
During and following the program of instruction, students will be able to perform the following tasks on a globe or in planetarium using geocentric earth:

A. Locate earth's 2 poles and equator and define each
B. Define latitude, longitude and time zone
C. Locate the Tropics of Cancer and Capricorn on a globe as in planetarium using geocentric earth
D. Locate the Arctic and Antarctic Circles using globe or planetarium

II. "Seasons and Climate on the Surface of the Earth"

a. Sun in relation to the Tropics
b. Sun in relation to the equator
c. Indirect rays versus direct rays of the sun
d. Specific heat capacities of land and water
e. Prevailing winds in relation to water and land masses
f. Ocean currents in relation to land masses

II. **Student Objectives:**
During and following this program of instructions, students will be able to perform the following tasks:

A. Explain the relationship of the sun to the 2 tropics and the equator
B. Diagram the difference between direct and indirect rays of the sun
C. Explain the different heating effect of direct and indirect rays of the sun
D. Explain why land heats and cools quickly and water slowly and how this affects ocean breezes and winds
E. Sketch 4 globes of the earth and properly place on direct and indirect rays of the sun for each of the 4 seasons.

**MATHEMATICS** - related: (Secondary)

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During and following this program of instruction, students will be able to perform the following tasks:

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F. Students will be able to explain the difference between terms inferior and superior planets.
G. Students can recognize and name earth's equator and poles
H. Students will be able to identify a full moon, new moon and quarter phase moon.
I. Students will successfully locate the cardinal points N, E, S, & W.

II. Visit II - "Calculating time from the celestial clock"

A. Review carefully: locations of big dipper and little Dipper
B. Review carefully: Pointer stars and their relationship to Polaris
C. Demonstrate with diurnal motion changing position of Pointer Stars in relation to Polaris and read "Big Dipper Time"
D. Begin developing the time formula: $53-2(m+c) = S$ where $M =$ month no., $S =$ standard time and $C =$ time on the Pointer Stars "clock" (demonstrate)
E. Do one or two sample problems
F. Have students develop why the minus (-) in the formula; why the 2 in the formula; why the constant 53.
G. Develop the formula further: $53-2(C+9) = ST$ where $ST =$ sidereal time.
H. Develop the formula further: $53-2(C+M)-GT = RA$ where $GT =$ Greenwich time and $RA =$ the local hours of right ascension.

II. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Locate Big Dipper, Little Dipper, "Pointer Stars" and Polaris
B. Explain relationship of "Pointer Stars" to Polaris
C. Read "Big Dipper Time" and acquire month number
D. Do sample time problems using formula: $53-2(M+C) = S$ where $M =$ month no., $S =$ standard time, and $C =$ time on the "Pointer Stars Clock"
E. Have students develop why the minus (-) in the formula; why the 2 in the formula; and why the constant 53.
F. Further develop the formula: $53-2(C+9) = ST$ where $ST =$ sidereal time.
G. Complete formula development: $53-2(C+M)-GT = RA$ where $GT =$ Greenwich time and $RA =$ the local hours of right ascension.

III. Visit III - "Geometry of Latitude by the Pole Star"

A. Review our latitude (40°) and observe altitude of Polaris (40°)
B. Repeat for 2 or 3 other stations (same result - altitude of Polaris = latitude
C. Locate zenith, equator, pole, horizon
D. Review degrees in complementary and supplementary angles
E. Develop the diagram and relationship below:
The angular distance from the equator, $E$, to the zenith, $Z$, (along the meridian) is the complement of the distance from $Z$ to the pole, $P$, since their sum is $90^\circ$. The distance from the north point, $N$, on the horizon, to $P$ is the complement of the distance from $P$ to $Z$. Since complements of the same angle are equal, $N-P$, the altitude of the pole star is equal to $Z-E$, the latitude of the observer.

III. Student Objectives:
During and following this program of instruction, students will be able to perform the following tasks:

A. Recite our home latitude; read altitude of Polaris
B. Repeat for 2 other known latitudes
C. Define zenith, celestial equator, celestial poles, horizon, meridian
D. Recite definitions of complementary and supplementary angles
E. Construct, explain and develop relationships among all parts of developed diagram according to geometrical rules for complementary angles:

![Diagram](image)

The angular distance from the equator, $E$, to the zenith, $Z$, (along the meridian), is the complement of the distance from $Z$ to the Pole, $P$, since their sum is $90^\circ$. The distance from the north point, $N$, on the horizon, to $P$ is the complement of the distance from $P$ to $Z$. Since complements of the same angle are equal, $N-P$, the altitude of the pole, is equal to $Z-E$, the latitude of the observer.

Sources, Materials and References

Spitz A-4 Planetarium Projector with accessories. Prepared slides from major observations of the world and personal observations of Mr. Sultner.

Prepared transparencies by Milliken

Introduction to Astronomy by McLaughlin
Principles of Astronomy by Wyatt
Astronomy Made Simple by Degani
New Handbook of the Heavens by Bernhard, Bennett, Rice
Field Guide to Stars and Planets by Menzel
Stars by Zim & Baker
Modern Astronomy by Birney
Our Sun by Menzel
Earth, Moon and Planets by Whipple
Picture History of Astronomy by Moore
Astronomy by Menzel
Early Theories of the Universe by Coleman
Astronomy: Fundamentals and Frontiers by Jastrow and Thompson
Dear Friends and Colleagues,

Please permit this short personal note. We hope you are pleased by this new planetarium lesson handbook, compiled by G. Henry Sultner, and that the many ideas presented will be helpful in the preparation of your own future school programs. Such publications are possible only if all planetarians are united toward the goal of ready intercommunications for a free exchange of knowledge and ideas. ISPE was formed for this very purpose. It needs your support through membership now if it is to succeed in its long range goals and still early growing pains.

If you are not a member, please, let us hear from you!!

With sincere best wishes,

Frank C. Jettner