SCIENCE

FOR IOWA SCHOOLS

JUNIOR HIGH

STATE OF IOWA
DEPARTMENT OF
PUBLIC INSTRUCTION

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1966

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FOREWORD

It is obvious that America has changed from an agrarian to a scientific-technological society; from a predominately rural to a predominately metropolitan way of life. Iowa has been and is continuing to be a leader in this changing society.

In order to maintain our position, we are placing great demands upon our educational system. Obsolescence is one of our greatest enemies. The student who is taught with antiquated materials by outdated methods will be excluded from the intellectual life of these dynamic times.

A science curriculum designed with versatility, flexibility, and challenge must be made available to our schools. This publication is designed to meet these goals.

The Iowa State Department of Public Instruction encourages science teachers to adapt this course of study to their local science programs. The format provides liberal "write-in" space to allow up-dating by the individual instructor. Approximately one-third of this handbook can, therefore, be written by the teacher who uses it.

We have confidence in the resourcefulness of the science teachers of Iowa. For that reason, we believe that *Science for Iowa Schools, Junior High* will make a substantial contribution to our educational program in the years immediately ahead.

PAUL F. JOHNSTON
State Superintendent of Public Instruction

COURSE OF STUDY RATIONALE

Every science program needs periodic evaluation and revision if it is to be kept up-to-date. The junior high school science program, long a neglected stepchild, is no exception.

In addition to the fact that the junior high program needs improvement because it has long been neglected, there are other reasons why great changes need to be made. Greatly expanded elementary science programs and the rapidly changing senior high school science curriculum have made it mandatory that something be done at the junior high school level.

The volume of tested new scientific information which becomes available each year is almost beyond comprehension. Our scientific knowledge has increased to such an extent that it is impossible to study all the basic concepts during the kindergarten through grade 12 years, or even in the college years. This situation, combined with the generally accepted realization that younger children are capable of understanding science, has caused a great change in philosophy and content of the junior high school course of study. Thus, because of the lack of junior high school science programs, or because of programs incompletely planned, revision was needed even before the present pressures developed.

This science program has been planned with the following criteria in mind:

1. The program should be teacher-directed rather than teacher-dominated.
2. The average student should not be forgotten; therefore, this program is planned for the greatest number.
3. Concept development should follow and be the result of investigation and experimentation.

Thus, this junior high school science program has been designed to take advantage of the many new sources of information as well as the richer science background of the student.

We can no longer afford to train today's students with yesterday's methods for life tomorrow. Each teacher must be aware of the many ways in which he can keep up to date by attending local workshops, inservice courses, National Science Foundation and U. S. Office of Education sponsored programs, and other meetings specially planned for junior high school personnel. There are also several experimental science programs for the junior high school, which will be helpful to those responsible for the planning at this level.[1] These programs may not be completely adaptable to every junior high school, but they will be invaluable as a means of keeping the teacher informed of what others are doing and as a source of enrichment ideas.

In an effort to upgrade junior high school science in Iowa and avoid duplication of the elementary science program, the junior high school course of study as presented here is planned to accomplish two objects:

1. To serve as a capstone for the elementary school science program (grades kindergarten through six) without duplication.
2. To provide the necessary background for the science courses available to the student in senior high school.

The above can be accomplished by providing a greater variety of opportunity and content than has been outlined in the Iowa program for the elementary schools.[2]

The new science curriculum for Iowa has been developed by a committee[3] whose background and experience is varied enough so that all educational levels are represented. The actual production of these curriculum materials was by outstanding experienced classroom teachers, who worked with content specialists.

This curriculum has been planned to provide continuity, kindergarten through grade 12. It emphasizes development of content by experimentation and studying in depth as much as possible. It includes enrichment provisions and provides opportunity for students to become involved directly in science.

It emphasizes the way the scientist works (the "process") rather than the facts-for-facts-sake (the "product") approach of the past. It includes application of concepts taught to develop understanding of environment, methods of inquiry, and ways to find and verify knowledge.

Much leeway has been allowed in this junior high school science program by not grade-placing each topic. This should help keep the program flexible.

The handbook is meant to provide resource materials and aids for schools that are developing their own science programs. It is not designed as a prescribed course of study.

The Science Area Committee recommends (1) that each school include the content outlined here in its junior high school science program and (2) that this material be covered completely by the end of the ninth grade. The order of the content should be determined by each school.

If these suggestions are followed, this handbook can be used effectively to give junior high students an adequate background for senior high school science courses.

T. R. Porter
Chairman, Science Area Committee

[1]Frederick L. Ferris, Jr. "The Princeton Junior High School Project," *Journal of Research in Science Teaching*, I (1963), p. 281.

Junior High School Science Project, *Time, Space, and Matter: Investigating the Physical World*, Progress Report II (Princeton, N. J.: November 1963).

[2]*Science for Iowa Schools, Grades K-3* (Des Moines: State of Iowa, Department of Public Instruction, 1964) and *Science for Iowa Schools, Grades 4-6* (in preparation)

[3]Ibid, p. iv.

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6. Theory
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2.

C. Suggested Activities

1. Compare astronomy and astrology.
2. Look at horoscopes in papers. What is predicted for your birthday?

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Science and Superstition* U of I, U-2371. ISU, NS-839. 11 minutes.
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8. Single surface mirror
9. Light year
10. Concave
11. Convex

B. Concepts and Understandings

1. The telescope was invented by accident.
2. Each type of telescopic system has distinct advantages and disadvantages.
3. Many discoveries in the sky are made with cameras attached to telescopes.
4. It is thought that the composition of our sun and the stars is very much the same.
5. Observatories and planetariums are special laboratories where astronomers work.

C. Suggested Activities

1. Find what 7 x 50, 10 x 50, 6 x 35 in binoculars mean. Why do some guns have telescopic sights? (Note: In 7x50, the *7* means magnification and the *50* is the diameter of the objective lens in millimeters.
2. Inspect several binoculars. Find the meaning of "power."
3. Report on telescopes.
4. Report on Roger Bacon.
5. Demonstrate refraction in water and glass.
6. Construct a model of a reflector telescope using concave shaving mirror, flat mirror, and microscope eyepiece.
7. Make a report on the radio-telescope. Make a model of it.
8. Construct a pin-hole camera. (For directions, see Brinckerhoff and others, *The Physical World,* page 268.)
9. Point any camera at the North Star and expose for 10 minutes, 30 minutes, and 3 hours.
10. Point any camera straight up (zenith) and expose all night.
11. Use a prism to break up light into bands of color.
12. Construct a simple spectroscope with plastic grating.
13. Report on Hale, Mt. Wilson, and Mt. Palomar.
14. Build a model observatory.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Refractor type and reflector type telescopes for class inspections.
2. *Exploring the Night Sky.* U of I, U-4424. 11 minutes.
3. *Exploring the Universe.* U of I, NS-499. 11 minutes.
4. Spitz Junior Planetarium.
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F. Teacher Notes

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A. Vocabulary

1. Photosphere
2. Chromosphere
3. Prominences
4. Corona
5. Eclipse
6. Sunspots
7. Apogee
8. Perigee
9. Light year

B. Concepts and Understandings

1. The solar system is composed of the following:
   a. Central sun
   b. Nine planets, and their moons, if any
   c. Comets
   d. Asteroids, planetoids, and meteors
2. No one knows for certain how the solar system originated. Many theories and hypotheses have been advanced.
3. The sun is more than 100 times larger than the earth. The sun is our nearest star.
4. The parts of the sun include:
   a. Photosphere—the brilliant visible part in which sunspots occur
   b. Chromosphere—the red sub-surface from which prominences leap
   c. Corona—the strange halo or ring around the sun, which is visible only during a total eclipse
   d. Sunspots—violent storms in the photosphere
5. The earth is 93,000,000 miles on the average from the sun. Light takes eight minutes to travel from the sun to the earth.
6. The sun makes all living things possible.
7. The sun is the source of all our power.
8. Atomic energy theories can explain the operation of the sun.
9. The following are types of atomic reactions:
   a. Atomic fission.
   b. Atomic fusion.

C. Suggested Activities

1. Review elementary concepts of astronomy.
2. Use a well-constructed pre-test to motivate those who have prior knowledge in astronomy.
3. Assign reports in the following areas for advanced students:
   a. Dust hypothesis
   b. Gaseous tidal theory
   c. Nebular hypothesis
   d. Planetesimal hypothesis
4. Use field glasses, binoculars, rifle scopes, and spotting scopes as aids in viewing the night sky.
5. Let a ping pong ball represent the earth. Draw a circle for the sun on scale of one inch equal to 8,000 miles. Use this same scale to construct the other eight planets.
6. Make bulletin board displays which

show the parts of the sun.

7. Determine whether or not sunspots affect the earth.
8. Have pupils determine how long it would take to go by jet at 1,000 miles per hour to the sun. To go by car at 100 miles per hour.
9. Discuss the speed of light.
10. Place a young plant seedling in total darkness with all essentials except light. Compare to a like seedling left in the light after five days.
11. Place a *radiometer* in sunlight. Discuss possible reasons for the movement.
12. Report on light meters, solar batteries, and "electric eye" cameras.
13. Learn what splitting (fission) of atoms and fusion of atoms mean.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Our Solar Family.* U of I, U-460. 11 minutes.
2. *Solar System.* U of I, U-358. 11 minutes.
3. *Our Sun.* 60 minutes. Color. Bell Telephone Company. (Call your local Bell Telephone office.)
4. Radiometers
5. Light meters
6. Solar batteries
7. Photo-electric cells.
8. "Electric eye" camera
9. *Atomic Energy.* U of I, U-2322. ISU, NS-2256. 11 minutes.
10. *The Solar System.* U of I, U-4585. 11 minutes.
11. *The Moon.* U of I, U-4585. 11 minutes.
12. Filmstrip: *Our Neighbor, the Moon.* U of I.
13. *The Moon and How It Affects Us.* U of I, U-4966. 11 minutes.
14. Bulletin boards, flannel boards, flashlight.
15. *Rockets, How They Work.* U of I, U-4928. 16 minutes.
16. Film lists for the latest on this subject.
17. Volcanic lava furnace cinders of badly eroded granite.
18. Flannel board to show the behavior of comets.

F. Teacher Notes

This topic about the sun and its energy cycle may be postponed until a formal study of energy is undertaken.

IV. THE NINE KNOWN PLANETS

A. Vocabulary

1. Rotate
2. Revolve
3. Reflect
4. Light year
5. Magnitude
6. Mercury
7. Venus
8. Earth
9. Mars
10. Jupiter
11. Saturn
12. Uranus
13. Neptune
14. Pluto

B. Concepts and Understandings

1. The earth and eight other planets revolve around the sun.
2. Planets shine by reflected light from our sun.
3. Mercury is the planet closest to the sun.
4. Venus is the second from the sun and is our morning or evening star.
5. The earth is our home in space.
6. Mars is the red planet, known to the ancients as the god of war. It is the fourth from the sun. Sometimes Mars is called our sister planet.
7. Mercury, Venus, Earth, and Mars are called the terrestrial planets. They may also be called the minor planets.
8. Jupiter is the giant of the planets and fifth from the sun.
9. Saturn is the sixth planet from the sun and the only planet with "rings."
10. Uranus is the seventh planet from the sun.
11. Neptune is the eighth from the sun.
12. Pluto is the most distant of the known planets.

C. Suggested Activities

1. Construct all planets to the scale of one inch equal to 8,000 miles.
2. Use a flashlight and a ping pong ball in a darkened room to show reflection.
3. The school's longest hall makes a dramatic place to show distance in the solar system. Place the sun at one end and Pluto at the other. Get assistance from the mathematics department for scale distances. This is an excellent project for advanced students.
4. Calculate the length of time to:
   a. Go by jet at 1,000 miles per hour to the various planets.
   b. Go by car at 100 miles per hour.
5. Make reports on the various planets.
6. Discuss the possibility of life on each planet.
7. Find the density of Saturn. What is the density of water?
8. Report how Neptune was discovered.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *How Many Stars?* ISU, NS-836. 22 minutes. A Moody Institute film.
2. *Exploring the Universe.* U of I, U-1073. ISU, NS-499. 11 minutes.
3. *Exploring the Night Sky.* U of I, U-4424. ISU, NS-2337. 11 minutes.
4. *The Stars and Constellations.* U of I, UK-3936. 30 minutes.
5. The Spitz Junior Planetarium (will do a fair job for the constellations.)

F. Teacher Notes

V. OTHER MEMBERS OF OUR SOLAR SYSTEM

A. Vocabulary

1. Satellites
2. Apogee
3. Perigee
4. Lunar craters
5. Tides
   a. Spring
   b. Neap
6. Full moon
7. New moon
8. Eclipse
9. Partial
10. Total
11. Umbra
12. Penumbra
13. "Little" planets
14. Asteroids
15. Planetoids
16. Meteors
17. Meteorites
18. Atmosphere
19. Periodic
20. Stony metallic
21. Comets
22. "Head"
23. "Tail"
24. Circular
25. Elliptical
26. Orbit

B. Concepts and Understandings

1. The blocking of light by the earth or moon will cause an eclipse.
2. The vast area between Mars and Jupiter contains many thousands of asteroids and planetoids.
3. Nearly all meteors burn up in our atmosphere before they have a chance to become meteorites.
4. Comets are flimsy bodies with elliptical orbits moving around the sun.
5. Comets have altered the course of history at times.
6. Most comets are not visible to the *naked* eye.
7. A collision with any comet would cause a brilliant meteor shower.
8. It is believed that a collision with a comet would not harm life on the earth.
9. Halley's Comet is our most famous periodic comet and should be back in 1985 or 1986.

C. Suggested Activities

1. Use a bulletin board to show partial and total eclipse.
2. Discuss the placing in orbit of man-made instruments.
3. Make a list of satellites now in orbit.
4. Discuss what can be gained by this program.
5. Explore theories as to the origin of these.

6. Report on periodic meteor showers.
7. Report on stony and metallic meteorites.
8. Examine a piece of known meteorite.
9. Construct elliptical and circular orbits.
10. Show how the tail behaves as a comet approaches the sun; also what happens when the comet goes away from the sun.
11. Use models of the sun, earth, Jupiter, and Pluto. Construct the orbit of Halley's Comet.
12. Determine where Halley's Comet is now.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

VI. BEYOND OUR SOLAR SYSTEM

A. Vocabulary

1. Astronomical units
2. Light year
3. Radio-telescope
4. Magnitude
5. Constellations
6. Circumpolar
7. The Milky Way
8. Binaries
9. Dwarfs
10. Nebulae
    a. Light
    b. Dark
11. Variables
    Cepheids
12. Nova
13. Supernova
14. Clusters
15. Island Universe

B. Concepts and Understandings

1. A new yardstick must be used for distance in astronomy.
2. The brightest star may not be the nearest star.
3. Constellations are groups of bright stars which seem to form a pattern in the sky.
4. The Milky Way is the "edge" of our galaxy.

5. Space is so vast that man's mind cannot comprehend all of it. Man and his earth occupy only a very small fraction of it.

C. Suggested Activities

1. Make a list of 10 nearest stars.
2. Find a list of the 10 *brightest* stars.
3. Identify the circumpolar constellations. Learn the location and names of a few winter and summer constellations.
4. Report on Andromeda.
5. See page 218 in *Science, A Search for Evidence,* Book 7. Make single or "team" reports. (A team means two or more students working in the same area.)
6. Visit a planetarium.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

1. Some interesting questions concerning our universe. Notes for testing:
   a. What is included in our universe?
   b. Is there a limit to our universe?
   c. What is space?
   d. Can we see to the "edge" of our universe?
   e. Why will our "space travel" always be limited?
   f. Can there be life on other worlds?

ATOMS AND MOLECULES

I. GENERAL PROPERTIES OF MATTER

A. Vocabulary

1. Mass
2. Weight
3. Inertia
4. Impenetrability
5. Momentum
6. Density
7. Specific gravity

B. Concepts and Understandings

1. Weight is good evidence of the mass involved in a measured volume of any substance, particularly when the substances are solids or liquids and the buoyancy of the atmosphere does not greatly affect the attraction of the earth.
2. Other good evidences of mass are resistance to change of motion, the sting of a baseball, slipping on curves, collisions on the highway, movement of objects by the wind, and the washing action of water waves.
3. The conservation of momentum is one of the most fundamental concepts concerning mass. $M_1V_1 + M_2V_2 = M_1V_3 + M_2V_4$ where V_1 and V_2 are velocities before collision, and V_3 and V_4 are the velocities after collision, whether the objects are elastic or not.
4. Density and specific gravity are to be treated here only as properties in the qualitative sense. They will be treated quantitatively in Unit IV.

C. Suggested Activities

1. Perform the inertia demonstrations suggested in a good physics book.
2. Flick a small card from under a coin. Pull a sheet of writing paper from under a book. Suspend a heavy weight of approximately five pounds with a string attached above and below. Pull slowly to break the bottom string.
3. Put a one-kilogram weight on a small board and accelerate slowly. Arrange to stop the board suddenly and watch the weight continue forward.
4. Demonstrate conservation of momentum apparatus. (Use commercial apparatus or make your own by using a V-trough and several balls or marbles of equal weight. Roll first one, then two, then three against the bunch and note that one, then two, then three leave.)

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

Molecular Theory of Matter. U of I, N-S-2406. 10 minutes. Sound.

F. Teacher Notes

II. STATES OF MATTER

A. Vocabulary

1. Solids
2. Liquids
3. Gases

B. Concepts and Understandings

1. The general physical properties that distinguish the three states of matter are:
   solid—definite shape and volume
   liquid—volume but no definite shape
   gas—no definite shape or volume
2. The following understandings should be considered:
   What causes changes of state?
   What happens when something melts or evaporates?
   What happens when it condenses or freezes?

C. Suggested Activities

1. Take two small beakers, one with ice water and one with water and cracked ice. Heat with thermometers in each. Demonstrate qualitatively that energy is absorbed as the ice melts without change of temperature in one case and with rise of temperature in the other.
2. Prepare students for the molecular theory.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

III. THE MOLECULAR THEORY

A. Vocabulary

1. Molecular motion
2. Brownian movement
3. Diffusion
4. Osmotic pressure
5. Gas pressure
6. Solutions

B. Concepts and Understandings

1. This is a good opportunity to teach the relationship of hypothesis, theory, and supporting experiments. Explain present theory as to the nature of motion of molecules in solids, liquids, and gases. Gold and silver diffuse. Gases are absorbed into solids (hydrogen and aluminum). Odors spread rapidly because of diffusion of gases. Since individual molecules cannot be seen, matter must be made of very small particles. Solids dissolve into liquids and divide into particles too small to be seen.
2. Explain pressure of gases in terms of the bombardment of very small particles moving very rapidly. Osmotic pressure gives evidence that large molecules move more slowly than small ones.
3. Develop the ideas of physical properties only, rate of motion, and perfect elasticity. Defer any questions on the chemical nature of matter to the unit on "Chemical Behavior."

C. Suggested Activities

1. Demonstrate "Brownian Movement" if apparatus is available. Another piece of apparatus—very effective and not expensive—is a microscopic piece, Stoekles "Molecular Vibration Tube" (#1724 by W. M. Welch). Mercury heated to near boiling evaporates, and the molecules leave with momentum sufficient to carry colored glass pieces upward so that all of the class may see.
2. Show rates of diffusion by filling rubber balloons with hydrogen, helium, city gas, air, and carbon dioxide. Leave until the next class and note the amount of deflation. Take a glass tube approximately one inch in diameter and three feet long. Soak pieces of cotton in HCl and in NH_4OH. Insert in the ends simultaneously. After a few moments note the ring of white NH_4C farthest from the end diffusing lighter gas.
3. Place a partially filled balloon in a bell jar and evacuate. Have the pupils explain why the balloon expands.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *How Big Are Atoms?* U of I, U-4327. 30 minutes. Sound.
2. *The Atom,* U of I, S-879, S-552.

F. Teacher Notes

IV. KINDS OF SUBSTANCES

A. Vocabulary

1. Elements
2. Atoms
3. Molecules
4. Compounds
5. Mixtures
   a. Two or more elements
   b. Two or more compounds
   c. Elements plus compounds
   d. No definite formula
   e. No exact proportions

B. Concepts and Understandings

1. Use a single chemical process to explain the difference between elements and compounds. For example, separate water into hydrogen and oxygen by electrolysis. The latter cannot be further subdivided by chemical processes. List the common and familiar elements. Describe the system of chemical symbols used.
2. Describe molecules from the chemical point of view. Compounds do not have the properties of the elements that compose them.
3. Show that all different combinations of elements have different properties even when involving the same elements; e.g., H_2O and H_2O_2, the carbohydrates, the hydrocarbons, and the alcohols.
4. Explain that most of the familiar objects and substances we know are composed of mixtures—foods, clothing, building materials, paints, soil, plants, and living things. If the proportions can vary—strong coffee or weak coffee—they are mixtures. Pupils will find the ingredients whose proportions cannot vary. Separation by physical means will give the opportunity for many interesting experiments.

C. Suggested Activities

1. Get together several elements, such as powdered zinc, copper, iron, and sulfur. Also get zinc sulfide, copper sulfide, and iron sulfide. Note the differences in properties of the elements when compared with the compounds as to color, texture, and magnetic properties. Separate water into hydrogen and oxygen by electrolysis. Plate red copper from the blue ion by chemical deposition or electroplating.
2. Stir concentrated sulfuric acid with sugar in a beaker. Allow the black porous carbon to form on the stirring rod for removal and inspection.
3. Separate alcohol from water or a colored solid from water by distillation.
4. Have the pupils suggest separation problems and how to solve them—sugar from sand, iron filings from sand, gases from other gases by gas masks, and gold from foreign matter by panning.
5. Use a flannel board. Demonstrate relative size, space, and shape by cutouts.

b. Protons
c. Neutrons
2. Arrangement
a. Orbits
b. Nucleus
c. Binding forces
d. Atomic numbers
e. Atomic weight units
f. Isotopes

D. Teacher and Pupil References

B. Concepts and Understandings

1. Build up two-dimensional pictures to represent the atoms. Use simple circular orbits for the electrons and simple clusters of protons and neutrons for the nuclei. Arrange special reports on the present theory concerning some of the variations from the simple picture. Do the first 20 elements show the regularity of adding more protons and electrons? Adding a few more atoms will demonstrate some irregularities. State the charge and relative masses of the building blocks. Note that the electrons' attraction to the nucleus can be explained by electrical theory. The binding forces in the nucleus are still being explored.
2. Note that the chemical properties of atoms are due to protons and electrons in the atom and these are the bases of chemical classification.
3. Note the gradual progressive change in the proton-neutron ratio—that variations occur for a given element (isotopes) and other variations are not permissible, leading to radioactivity, the next topic.
4. Explain that the weight of the atom is approximately the weight of the protons and neutrons that form the nucleus. Actually, there is some loss in mass as small atoms combine to form larger atoms. Otherwise the atomic weight assigned to an element is explained by the isotopes that compose it and their relative abundance.

E. Audiovisual Aids, Equipment, and Supplies

1. *Atomic Radiation.* U of I, U-3682. ISU, NS-3436. 11 minutes. Sound.
2. *Nuclear Energy.* U of I, S-835.

C. Suggested Activities

F. Teacher Notes

V. THE STRUCTURE OF ATOMS

A. Vocabulary

1. Particles
a. Electrons

VI. RADIOACTIVITY

A. Vocabulary

1. Natural radioactivity
2. Alpha particles
3. Beta particles
4. Gamma rays
5. Penetrating power
6. Half-life
7. Ionization
8. Fluorescence
9. Physiological effects.
10. Scintillation counters
11. Electroscopes
12. Dosimeters
13. Geiger counters
14. Radioactive transmutations
15. Nuclear equations
16. Fusion
    a. Solar energy
    b. Hydrogen bomb
17. Fission
    a. Fissionable materials
    b. Neutron capture
    c. Slow neutrons
18. Critical mass
19. Chain reaction
20. A-bomb
21. Atomic power plants
    a. Controlled chain reactions
    b. Atomic pile
    c. Moderator
    d. Control rods
    e. Enriched fuel
22. Shielding
23. By-products
24. Particle accelerators
    a. Cyclotrons
    b. Betatrons
    c. Synchrotons
    d. Linear accelerators
       Van de Graff generator
    e. Cosmotron
    f. Bevatron
25. Radioisotopes
26. Tracers
27. Biological effects of radioactivity

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Atomic Energy*. U of I, U-2322. ISU, NS-2256. 11 minutes. Sound.
2. *Atomic Power*. U of I, U-2403. ISU, NS-2266. 32 minutes. Sound.

F. Teacher Notes

28. RBE factor
29. Ionizing effects
30. Roentgen
31. Lethal dose—650 r.
    Death generally in second week
32. Medium lethal dose—400 r.
    50-50 chance of death (probably fourth week)
33. Sublethal dose—100-250 r.
    Probably on road to recovery by fourth week

B. Concepts and Understandings

1. The nature of radioactivity is partially explained in the history of Becquerel's discovery. Explain precisely the nature of alpha and beta particles and of gamma rays. Compare their penetrating power. A chart will help. See under "Activities." Explain "half-life" and why the terminology must be used. A relatively short half-life (1,690 years) explains the great activity of radium. A long half-life explains the greater abundance of residual natural radioactive elements and isotopes.
2. Beta radiation may be associated with television fluorescence effects; ionization of body tissue with physiological effects. Explain fluorescence and ionization effects in other contexts.
3. Ionization power is generally the inverse of penetrating power.
4. The energies of radioactivity have their source in the conversion of mass to energy. Radioactivity is detected by electroscopes, Geiger counters, scintillation counters, and dosimeters.
5. The emission of either alpha or beta particles results in changing one element into another.
6. Fusion is the source of the great energy of the sun and probably of all the stars. (It should be pointed out that many products of fusion are not radioactive.)
7. The mass of four hydrogen atoms is more than the mass of one helium atom. Mass is converted into energy according to the equation: $E = MC^2$, where, for example, E is in foot pounds, M is in 32-pound units (slugs), and C is the velocity of light in seconds (186,000 x 5,280).
8. The hydrogen bomb is an example of fusion with the "A" bomb developing the necessary high temperature and pressure. Tell briefly of the current attempts at controlled fusion reactions and how the high pressures and temperatures are attained.
9. When a nucleus absorbs a particle, the resulting nucleus is generally unstable. When the absorbed particle is a neutron and when the nucleus is either $92U_{235}$ or $94PU_{239}$, the nucleus breaks into two nearly equal parts. These nuclei absorb neutrons best when the neutron is moving relatively slowly. In addition to the two new nuclei (both probably unstable because of an improper ratio of protons to neutrons) a few neutrons are emitted, which in turn may cause other atoms to break up. The sum of the masses of the parts of a broken nucleus is not equal to the mass of the atom before being split. The difference in mass is converted into great amounts of energy.
10. When enough fissionable material is brought together, the rate of fissioning may accelerate, and a chain reaction results. When this is done with suddenness and not controlled, an enormous explosion results.
11. Atomic power plants are fueled with natural uranium enriched with U-235. Fuel is piled up until fission is rapid enough to heat. Neutron capture is speeded and heating increased by slowing down fast neutrons with moderators (lightweight elements which do not fission or capture neutrons well).
12. Reaction is slowed down by control rods inserted to absorb neutrons and prevent fission. (The control rods, themselves, do not fission.)
13. Nuclear reactors produce best, which can be converted into wanted power.
14. Fission produces much radiation in the form of stray neutrons, alpha

and beta particles, and gamma rays. Heavy metals and concrete make the best shielding materials.

15. Power is obtained by converting mass to energy according to the equation $E = MC^2$.
16. Energy is taken from the reactor by a fluid and passed on to a second fluid. The first fluid must be such that, although it may become radioactive, it cannot pass that radioactivity to the second fluid.
17. Particle accelerators are designed to speed up the very small particles such as electrons, protons, deuterons, and alpha particles. The accelerators have names which sometimes refer to their function, sometimes to their design, sometimes to their power. They use changing electrostatic or magnetic fields to push or pull the particles at the proper time interval and accelerate them to velocities closely approximating the velocity of light. The particles become heavier and constitute the bullets for bombarding the nuclei of atoms. Atoms which absorb the "bullets" or are broken up by them become radioactive. Radioactive atoms have been made of all the known elements. These radioactive atoms can be introduced in chemical processes which need the element involved; e.g. the bones need phosphorous, the thyroid needs iodine, and leafy plants need nitrogen. Processes may be understood by tracing the radioactive atoms.
18. Different parts of the body are more susceptible to radiation damage than others.
19. Generally growing young people are more susceptible to radiation damage than older people because their bodies are assimilating the elements whose radioactive isotopes cause the most damage. Alpha, beta, and gamma rays do not cause equal damage. Radiation which may not do much damage from without (as dust on the body or clothing) may be especially dangerous when ingested. Ionization in the body causes transmutation of the elements, interferes with cell functions, and overloads waste disposal.
20. The roentgen is the quantity of X- or gamma radiation that will produce one electrostatic unit of charge in one cubic centimeter of air at S. T.P. This is equivalent to 2.083×10^9 ion pairs.

C. Suggested Activities

1. With a cloud chamber, show the ionization effects of radioactivity.
2. Repeat the Becquerel discovery in some form with photography materials.
3. Demonstrate the penetrating power of radioactive particles with a Geiger counter and sheets of metal for variable depth of shielding.
4. Have the pupils predict the amount of beta radiation coming through the television tube and glass shield and affecting the viewer.
5. Compare the energy of natural radioactive particles with the energy of electrons in the television tube.
6. With a cathode ray tube, show the fluorescence of beta particles and how they are deflected by magnetic electrostatic fields.
7. Summarize with a table.
8. Build a model of an atomic pile. Have the pupils devise automatic means of entering the control rods if excessive heat should develop.
9. Have the pupils build a model chain reaction. The mousetrap type is most effective. A simple one can be built by stacking overlapping rows of dominoes.
10. Make a model chain reaction with matches, "treeing out" two or more butts on each head. Cutting the stem short speeds the process.
11. Use a static machine of moderate power and of any type to puncture paper and cardboard when held between the terminals. This is not atom smashing, but it does illustrate the striking power of the fast moving particles.

12. Produce X-rays in the laboratory. A very good induction coil in conjunction with an inexpensive cold cathode X-ray tube will produce X-rays sufficient to fog or film photographic papers.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Atom Smashers.* U of I, U-4122.
2. *Atomic Research:* Areas of Development. U of I, U-3764. 14 minutes. Sound.
3. *Atom and Agriculture.* ISU, NS-342. 12 minutes. Sound.
4. *The Atom and Medicine.* U of I, U-3456. ISU, NS-3369. 12 minutes. Sound.
5. *The Atom and Industry.* U of I, U-3449. ISU, U-4123. ISU, NS-347. 11 minutes. Sound.
6. *Atomic Energy Can Be a Blessing.* ISU, NS-3419. 21 minutes. Sound.
7. *Atom and Biological Science.* U of I, U-3693. ISU, NS-346. 11 minutes. Sound.
8. *Atomic Alert.* U of I, U-3184. 19 minutes. Sound.
9. *Atomic Alert—School, Home, Street.* ISU, U-3184. 15 minutes.
10. *Fallout (When and How to Protect Yourself.)* U of I, U-5047. 14 minutes. Sound. Color.

F. Teacher Notes

ELECTRICITY AND MAGNETISM

I. STATIC ELECTRICITY

A. Vocabulary

1. Static
2. Current
3. Electricity
4. Atom
5. Hydrogen
6. Helium
7. Lithium
8. Electron
9. Negative
10. Proton
11. Positive
12. Neutron
13. Neutral
14. Friction
15. Pith ball
16. Like
17. Unlike
18. Attract
19. Repel
20. Lightning
21. Discharge
22. Lightning rod
23. Grounded
24. Induction coil

B. Concepts and Understandings

1. We recognize electricity as being of two kinds: (1) static or non-moving and (2) current electricity or moving.
2. The theory of electricity is that a source of electrical energy is found when any substance is broken down into its smallest particles, the atoms.
3. The atom contains electrons, or negatively charged particles; protons, which are positively charged particles; and neutrons that are neutral, or have no charge at all.
4. Static electricity can be produced by friction.
5. There are two kinds of static electricity charges: positive and negative.
6. Like charges repel, and unlike charges attract.
7. Lightning is a discharge of static electricity within a cloud, between clouds, or between a cloud and an object on earth.
8. When discharge occurs between cloud and earth, we say the object has been "struck by lightning."
9. Lightning rods are used to protect buildings from lightning.
10. A lightning rod is a sharp-pointed metal rod placed on a high point of a building and connected to the ground by a wire cable.

C. Suggested Activities

1. Read from references given about the two kinds of electricity for general information. Find the reference that gives historical developments of our knowledge about these two kinds of electricity.
2. Use representative drawings of hydrogen, helium, or lithium atoms in the study of the structure of the atom.
3. Define and illustrate: atom, electron, proton, and neutron.
4. Have pupils make large-sized drawings for use in the classroom.
5. Draw a comb through your hair several times and then pick up small pieces of paper with the comb. (Damp or oily hair may not produce a static charge.) There is no known use of static electricity.
6. Rub a hard rubber rod with fur or wool and suspend it on string which can revolve. Rub another hard rubber rod and bring it near the suspended rod. Observe what happens. Do the same with two glass rods rubbed on a silk cloth.
7. Bring a charged glass rod near a suspended hard rubber rod that has been charged. Note what happens. Do the same with two pith balls suspended on a thread.
8. Read about the dangers of static electricity in industries that produce dust particles in the manufacture of certain products.
9. Read the story of Benjamin Franklin and his kite experiment. Don't try to do the experiment. Why? (It is dangerous!)

F. Teacher Notes

1. Chart for classroom use illustrating structure of atoms of several different substances.

D. Teacher and Pupil References

II. MAGNETISM

A. Vocabulary

1. Magnet
2. Iron
3. Steel
4. Cobalt
5. Nickel
6. Alnico
7. Non-magnetic
8. Iron filings.
9. Law of magnetic poles
10. Repel
11. Attract
12. Field of force
13. Lines of force
14. Horseshoe magnet
15. Dipping needle
16. Direct current
17. Permanent
18. Geographic pole
19. North magnetic pole
20. South magnetic pole
21. Electro-magnets

E. Audiovisual Aids, Equipment, and Supplies

1. *Atomic Energy.* U of I, U-2322. 11 minutes.
2. *Static Electricity.* U of I, U-4521. 11 minutes.
3. Two hard rubber rods
4. Two glass rods
5. Piece of wool or fur
6. Piece of silk cloth
7. Pith balls

B. Concepts and Understandings

1. Metals such as iron and steel that attract other materials are called magnets.
2. In addition to iron and steel that are magnetic metals, we find that nickel and cobalt are also magnetic substances.
3. Magnetic attraction is greatest near the ends of a magnet. The ends are called poles.
4. Like poles of magnets repel and unlike poles attract.

5. The area of magnetic lines around a magnet is called the field of force.
6. A magnet may be bar-shaped, U-shaped, or in the shape of a horseshoe.
7. Substances are composed of molecules. Each molecule has north and south pole magnetism. When north or south poles are aligned, substances are said to be magnetized.
8. Three ways to develop magnetism in a magnetic substance are:
   a. By stroking on another magnet.
   b. By wrapping a coil of insulated wire around material to be magnetized and then sending direct current through the coil.
   c. By tapping a rod as it is pointed toward the earth at the angle at which a dipping needle will point.
9. When a magnetic substance retains its magnetism, it is called a permanent magnet.
10. Materials that become magnetic by a natural process in the earth rather than being man-made are called lodestones.
11. The earth is like a large permanent magnet because it has a magnetic north pole and a magnetic south pole. These poles are not the same as the geographic poles.
12. A magnetic compass needle is a permanent magnet mounted to swing freely. It is a north-seeking magnet.
13. A magnetic compass can be used to determine directions.

C. Suggested Activities

1. Make a collection of magnets of various shapes and sizes. Discuss uses of each.
2. Get some pieces of nickel and cobalt metals to test their magnetism.
3. Collect small articles and pieces of many different substances. Make a check list to indicate those things that are magnetic and those that are non-magnetic.
4. Sprinkle iron filings evenly over a magnet. Lift the magnet and note that the most filings cling to the ends of the magnet.
5. Suspend a bar magnet to swing freely. Bring the pole of another magnet to an end of the suspended magnet. Note what happens. Try this with other magnets. Does your experiment prove the law of magnetic poles?
6. Place a thin cardboard over a magnet. Sprinkle iron filings evenly over cardboard. Tap edges gently and note pattern filings make. Do the same with magnets of different shapes and end arrangements.
7. Make interesting permanent designs by using blueprint paper instead of cardboard. Look up directions for the processing of blueprint paper.
8. Use an overhead projector to demonstrate a magnetic field.
9. Use a magnetic board to show that balanced pieces can be aligned by passing a magnet over them.
10. Magnetize a knitting needle and test for north and south pole magnetism. Carefully file the needle at the center, break it, and then test the two pieces for magnetic poles. Do this by bringing the ends of each of the pieces near the poles of a magnetic needle that is swinging freely.
11. Obtain three 10 to 12-inch lengths of ¼-inch steel rod. Check these pieces to note that they are not magnetized. Stroke one end of piece number one across the end of a permanent magnet several times. Test it for magnetic poles.
12. Wrap a coil of insulated wire around piece number two. Send direct current electricity from several dry cells through the coil for a few minutes. Test it for magnetic poles.
13. Using piece number three, hold it at the same angle toward the earth as made by a dipping needle and tap it gently several times. Test this piece for magnetic poles. These processes, when done correctly, should produce three permanent magnets.
14. Obtain a piece of magnetite known as a lodestone. Check it with the magnetic compass for magnetic poles.

15. Use a magnetic compass and note that when allowed to swing freely it assumes a north-south direction. This action is due to magnetism of the earth.

9. Bar magnets (4)
10. U-shaped magnets (2)
11. Horseshoe magnets (2)
12. Nickel metal
13. Cobalt metal
14. Collection of non-magnetic materials.
15. Iron filings
16. Ring stand
17. Magnet saddle
18. Magnetic board
19. Knitting needles
20. Triangular file
21. Magnetic compass
22. Steel rods, ¼ in. x 10 in. (3)
23. Bell wire, insulated
24. Dry cells
25. Lodestone

F. Teacher Notes

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Induction coil
2. Dry cells
3. Metal plate
4. Connecting wire switch
5. Copper wire for frame of miniature house.
6. *Magnetism.* U of I, U-3675. ISU, NS-3567. 18 minutes.
7. *Magnetism.* U of I, U-3842. 11 minutes.
8. *Magnets.* U of I, U-2277. ISU, NS-2480. 13 minutes.

III. CURRENT ELECTRICITY

A. Vocabulary

1. Circuits
2. Series
3. Parallel
4. Electric meter
5. Volt
6. Ampere
7. Ohm
8. Watt
9. Kilowatt
10. Tungsten
11. Fluorescent

12. Conductor
13. Resistance
14. Motor
15. Telephone
16. Telegraph
17. Radio
18. Television
19. Voltaic cell
20. Dry cell
21. Storage battery
22. Magnetic field
23. Generator
24. Dynamo
25. Magneto
26. Alternating
27. Direct
28. Current

B. Concepts and Understandings

1. Electricity may flow in circuits with resistance arranged in series and parallel.
2. The amount of electricity we use can be measured by a meter.
3. The amount of current actually used depends upon the voltage or pressure, the amperage or rate of flow, and the resistance of the circuit or ohms.
4. Electric power is measured in watts. A larger unit is the kilowatt (1,000 watts).
5. Electricity is used to produce light, heat, and power.
6. A filament of tungsten inside an electric light bulb will glow brightly when electricity flows through it.
7. Fluorescent tubes produce a soft light more like daylight.
8. When electric current is forced through a conductor of great resistance the electrical energy is changed to heat.
9. Motion can be produced by using electricity in an electric motor, which in turn can operate other machines.
10. Electric power is necessary for several communication devices.
11. Current electricity is a flow of electrons through a conductor. It can be produced by chemical cells such as the voltaic cell, the dry cell, and the storage battery.
12. The storage battery stores chemical energy which can be changed into electrical energy.
13. Mechanical production of an electric current may be done by moving a coil of wire across a magnetic field. This is the principle of the generator, dynamo, and magneto.
14. Current produced by machines may be alternating (AC) or direct (DC).
15. To transmit or distribute electricity, a path must be provided along which the electrons can flow.
16. A conductor is a substance along which electrons flow easily. Metals such as copper, silver, and aluminum are good conductors.
17. Conductors usually are covered with a material called insulation that prevents short circuits and protects people from shock.
18. Some controlling devices in electric circuits are fuses, switches, and circuit-breakers. Transformers are necessary to move high voltage electricity long distances.

C. Suggested Activities

1. Arrange materials to actually produce series and parallel circuits.
2. Use a series-parallel lamp board to show series and parallel circuits.
3. Obtain a meter from an electric company for study of dial readings.
4. Ask the electric company for a "rate schedule." Use it to construct problems representing payment of monthly electric bills.
5. Make a list of things that use light from electricity.
6. Study the structure of a light bulb to understand how it works.
7. Make a list of things that use electricity for heat energy.
8. Use a heat coil to study structure in producing heat energy.
9. Make a list of things that use electric motors.
10. Study a St. Louis model to learn how a motor works.
11. Construct a "paper clip" motor.
12. Explain the use of electricity in telephone, telegraph, radio and television as forms of communication.

13. Explain how chemicals are used to produce flow of electrons.
14. Make drawings of cells and label parts.
15. Take a "dead cell" apart to study its structure.
16. Arrange simple materials to produce an electric current.
17. Obtain the generator from a "junked" automobile engine or a magneto from a "hand crank" telephone for study of mechanical production of current electricity.
18. Study diagrams of a generator to learn differences in production of AC-DC current.
19. By using a galvanometer, test to determine if AC or DC current is produced with a generator or magneto.
20. Make a diagram showing the route of electricity flowing from the power plant to your home.
21. Explain the structure and working of a transformer.
22. Arrange an electric circuit to show use of the switch, circuit-breaker, and fuse.
23. Make a list of safety rules concerning the handling of electricity.
24. CAUTION: *Do not* have students hold hands in a circle while cranking a hand telephone generator. Statistics show that students with specific heart malfunctions have died from this type of class experiment.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Measurement of Electricity.* U of I, U-2708. 11 minutes.
2. *Series and Parallel Circuits.* U of I, U-1618. 11 minutes.
3. *Light and Power.* U of I, U-2494. 22 minutes.
4. *Radio and Television.* U of I, U-767. 11 minutes.
5. Equipment
   a. Ammeter
   b. Voltmeter
   c. Galvanometer
   d. Electric meter
   e. Light bulb
   f. Heater coil
   g. Electric motor (St. Louis)
   h. Charts of radio and television circuits
   i. Transformer
   j. Series-parallel lamp board
   k. Dry cell
   l. Voltaic cell
   m. Storage bell
   n. Insulated doorbell wire
   o. Bar magnets
   p. Generator (AC-DC)
   q. Magneto
   r. Fuse
   s. Switch
   t. Circuit breaker
6. *Primary Cell.* U of I, U-1617. ISU, NS-1826. 11 minutes.

7. *Electricity All About Us.* U of I, U-4953. 11 minutes.
8. *Introduction to Electricity.* U of I, U-2560. 11 minutes.
9. *Principle of Generator.* U of I, U-3428. 11 minutes.
10. *Elements of Electrical Circuits.* U of I, U-1593. 12 minutes.
11. *Electricity: How to Make a Circuit.* U of I, U-5215. ISU, NS-1389. 11 minutes.

F. Teacher Notes

GEOLOGY

I. THE EARTH'S BEGINNING

A. Vocabulary

1. Planetismal
2. Theory
3. Solar
4. Star
5. Molten
6. Core
7. Solid
8. Rock
9. Granite
10. Crust
11. Volcanic action
12. Basalt
13. Depression
14. Dense
15. Continent
16. Compression
17. Gas
18. Condense
19. Water vapor
20. Carbon dioxide
21. Convection currents
22. Acid
23. Strata
24. Isostasy

B. Concepts and Understandings

1. There are several theories concerning formation of the earth. Most theories agree that the earth originated as a result of some inter-action among stars:
   a. Whirling Cloud Theory
   b. Double Star Theory
   c. Planetismal Theory
   d. Kuiper Theory
2. The birth of the earth was followed by a long cooling off period.
   a. During the molten state, denser substances sank to form the inner core.
   b. Lighter materials cooled and formed floating islands of solid rock.
   c. Islands of granite came to rest on denser basalt rock; as these depressed, continents were formed.
   d. Outer layers prevented the core from cooling.
3. Gases that did not cool enough to condense, remain today as the earth's atmosphere.
   a. Water vapor and carbon dioxide were liberated from earth's interior.
   b. Convection currents formed clouds from which rains of acid fell.
   c. Rains turned into vapor as they fell on hot strata.
   d. Water collected in low areas forming lakes and seas.
   e. Sun warmed the planet, winds began to blow, and clouds disappeared.
4. Land and sea were formed as water flowed into depressed areas, forcing lighter land areas to rise.
   a. The weight of basalt rock formed depressions into which water flowed.
   b. As the amount of water increased, depressions became deeper. Continents became higher; now believed to be afloat upon a molten sea of rock.

C. Suggested Activities

1. Have students make reports on various theories of the earth's origin.
2. Demonstrate isostasy.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Face of the Earth.* U of I, U-3681. ISU, NS-3530. 11 minutes. Color. Sound.
2. *In the Beginning.* Modern Talking Pictures. ISU, NS-1133. Sound. Color.
3. *How We Think Our Earth Came To Be.* Jam Handy. U of I, S-290.
4. *Our Earth is Changing,* Jam Handy. U of I, S-291.
5. Blocks of wood
6. Glass tank
7. Set of weights

F. Teacher Notes

II. THE EARTH'S HISTORY

A. Vocabulary

1. Bedrock
2. Chemical change
3. Deformation
4. Earth's crust
5. Era
6. Fossil
7. Geologic eras
8. Prehistoric
9. Strata
10. Stratified
11. Topography
12. Deposition
13. Erosion
14. Radioactive
15. Radiocarbon
16. Residual
17. Sediment
18. Upheaval
19. Cast
20. Impression
21. Mold
22. Paleontology
23. Index fossils
24. Conifer
25. Glacial drift
26. Mantle rock
27. Petrified
28. Spillway

B. Concepts and Understandings

1. The history of earth is written in fossil records of life, in relative positions of rock strata, in radioactive decay of minerals, and in chemical changes in rock materials. This history is divided into four eras.
   a. Pre-cambrian
   b. Paleozoic
   c. Mesozoic
   d. Cenozoic
2. There are several methods of measuring geological time.
   a. Old methods
      (1) Rate of deposition
      (2) Rate of erosion
      (3) Salt in the ocean
   b. New methods
      (1) Radioactive uranium-lead
      (2) Radioactive rubidium-strontium
      (3) Carbon 14

3. Fossils dated from where they are found reveal portions of the story of life's past changes.
   a. Index fossils
   b. Original remains
   c. Replaced remains
   d. Molds and casts
   e. Impressions
4. Climate has changed many times during the Earth's history. During the last million years, there have been four cold periods during which glaciers covered the northern one-third of the United States. These glaciers had important effects on topography.
   a. Laurentian upland, thin soil, forests, conifers
   b. Lakes in Northern Minnesota and Western Ontario
   c. Waterfalls and rapids.
   d. Glacial drift-rich soil
   e. The Great Lakes
   f. Glacial spillways—transportation
   g. Abundance of sand and gravel
   h. Boulders interfering with cultivation

C. Suggested Activities

1. Show by use of a fossil collection what the climatic conditions were at a given time.
2. Make a rock column showing, in proper sequence, the rock formations that outcrop in your area.
3. Build a diorama of an ancient sea bottom.
4. Put a mixture of sand and clay into a tall vessel of water. Stir it and let stand. Record different times required for deposition of each sort of sediment.
5. Write reports on various theories proposed to determine geological time. What are the limitations?
6. Collect and prepare a fossil collection. UNESCO, 700 Science Experiments For Everyone: Doubleday, 1958, Chapter 5.
7. Locate as many fossils as possible for each of the listed types.
8. Show how fossils are formed, using leaves, twigs, shells, and plaster of paris.
9. Draw on a map of the United States the southern boundary of the glaciated area.
10. Collect rocks showing glacial markings.
11. Discuss how snow is turned into glacial ice and what makes glaciers move.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Plaster of paris
2. Modeling clay
3. Vaseline
4. Maps of U. S.
5. Wall map showing glacial areas
6. Fossils

7. *Rivers of Ice.* U of I, U-4392. 19 minutes. Color. Sound.
8. *Geological Work of Ice.* U of I, U-728. ISU, NS-2072. 11 minutes. Color. Sound.
9. *Continental Glaciers.* U of I, U-4270. 20 minutes. Color. Sound.
10. *Prehistoric Times.* U of I, U-3588. 11 minutes. Sound.
11. *The Story of the Earth We Find in the Rocks.* U of I, S-293.
12. "Geologic Time Scale," page 26 of *Teaching Guide for Earth and Space Science.*
13. Schaffel, Simon. "A Volcano Model," *Journal of Geological Education,* Volume II, Number 2, Fall, 1954.
14. *Mountain Building.* U of I, U-344. ISU, NS, 3534. 11 minutes. Sound.
15. *Earthquakes and Volcanos.* U of I, U-4616. ISU, NS-3573. 13 minutes.
16. *Work of Running Water.* U of I, U-1585. 11 minutes. Sound.
17. *Work of Rivers.* U of I, U-340. ISU, NS-615. 11 minutes. Sound.

F. Teacher Notes

III. THE CHANGING EARTH

A. Vocabulary

1. Bacteria
2. Carbonation
3. Hydration
4. Oxidation
5. Solution
6. Wind
7. Delta
8. Sand dune
9. Avalanche
10. Diastrophism
11. Eruption
12. Fault
13. Flood plain
14. Fracture
15. Fragment
16. Geyser
17. Glacial scratches
18. Mechanical
19. Seismograph
20. Tremor
21. Volcano

B. Concepts and Understandings

1. The surface of the earth is under constant attack by weathering and erosion which tend to wear down mountains, fill up basins, and deposit material in oceans.
2. Weathering is a process by which rocks at the surface of the earth are broken up mechanically and changed chemically.
   a. Chemical weathering is breaking down of materials and rocks by chemical change.
      (1) Oxidation
      (2) Hydration
      (3) Carbonation
      (4) Solution
   b. Mechanical weathering involves breaking of rocks into smaller fragments without chemical change.
      (1) Wind
      (2) Ice
      (3) Water
      (4) Heating and cooling
      (5) Plants and animals
3. Erosion includes those forces that not only break rocks into fragments but also carry the rock fragments from one place to another.
   a. Running water
   b. Wind
   c. Glaciers
4. Earthquakes and volcanoes furnish evidence that forces are operating

today which tend to deform earth's crust. Mountain systems, folds, and fractures in rock strata show that such forces have worked in the past.

a. Volcanoes are mountains formed by ejection of molten rock or ash. Geysers and hot springs are related to volcanic activity.
b. Earthquakes are tremors of the earth's surface; they may be barely discernible vibrations or violent shocks causing extensive damage.

C. Suggested Activities

1. Show how limestone is eaten away by acids.
2. Place a small piece of limestone in vinegar (or diluted HCl) and note results. Try assorted sizes and note time of change. Relate surface area to time.
3. Show presence of acids in soil by using litmus paper or pH test paper.
4. Show effects of temperature change on rocks by heating them in a burner flame. (Watch for flying pieces.) After heating, plunge in ice water.
5. Leave an iron nail outdoors for a period of time to show oxidation. (Clean protective coating from nail before doing this.)
6. Find rocks that show signs of weathering. What types of weathering are illustrated?
7. Use a sandbox and a stream of water to show the result of changing stream velocity.
8. Point out the evidences of erosion and weathering on the school grounds and building.
9. Show location of volcanic areas on a map of the world.
10. Make a model volcano.
11. Draw a diagram comparing a geyser to a coffee percolator.
12. Build papier-mache models of local topography. Give explanations for the various topographic types.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Trays of identified rocks and minerals
2. Periodic table
3. Hardness scale
4. Streak plates
5. Rock hammers
6. Hydrochloric acid
7. Copper sulfate
8. Black light (ultra violet)
9. Geiger counter
10. Alum
11. Hand lenses
12. Dilute HCl or vinegar
13. *Crystals.* Bell Telephone Company. 25 minutes.
14. *Minerals and Rocks.* U of I, U-4679. 18 minutes.
15. *How Rocks Are Formed.* U of I, S-292.

16. Map of world
17. Lead
18. Sinker mold
19. Charcoal
20. Lead oxide
21. Asbestos sheet
22. Uranium ore
23. Flower pots
24. Seeds
25. Capillary tubes
26. Soil samples of clay, sand and loam
27. Ring stands
28. Chimneys
29. Cheesecloth
30. Litmus paper
31. pH tester
32. *Lead from Mine to Metal.* U of I, M-3405. 33 minutes.
33. *Story of Coal.* U of I, U-4160. 29 minutes.
34. *Pacific Halibut Fishing.* U of I, U-4130. 16 minutes. ISU, NS-1282.
35. *Water for the Community.* U of I, U-4976. 11 minutes.
36. *How Man Uses Soil,* E. B.
37. *How Man Conserves Soil,* E. B.
38. *Oil from the Earth to You,* American Petroleum Institute.
39. *Drilling for Oil,* Standard Oil of New Jersey.

F. Teacher Notes

IV. THE EARTH'S CRUST

A. Vocabulary

1. Compound
2. Element
3. Cleavage
4. Crystal
5. Fluorescence
6. Fracture
7. Hardness
8. Impervious
9. Luster
10. Minerals
11. Aggregate
12. Chert
13. Clastic
14. Conglomerate
15. Extrusive
16. Gneiss
17. Granite
18. Gypsum
19. Igneous
20. Intrusive
21. Limestone
22. Magma
23. Marble
24. Metamorphic
25. Organic
26. Sedimentary
27. Slate
28. Quartz

B. Concepts and Understandings

1. There are three elements that make up over 80 per cent of the earth's crust. They are oxygen, silicon, and aluminum. Most of the crust is made up of compounds of these elements.
2. Minerals are materials in the crust that have definite chemical composition formed by natural processes.
   a. Chemical properties
      (1) Acid reaction
      (2) Taste
      (3) Radioactivity
   b. Physical properties
      (1) Crystal form
      (2) Cleavage
      (3) Fracture
      (4) Hardness
      (5) Color streak
      (6) Luster
      (7) Fluorescence

3. Rocks are aggregate minerals.
   a. Igneous (fire-formed)
      (1) Magma-original rock
      (2) Intrusive and extrusive
      (3) Color and chemical composition
   b. Sedimentary (in layers)
      (1) Clastic: conglomerate, sandstone and shale
      (2) Chemical: Limestone, gysum and chert
      (3) Organic: Coal
   c. Metamorphic (changed by heat and pressure)
      (1) Shale-slate
      (2) Granite-gneiss
      (3) Limestone-marble
      (4) Sandstone-quartzite

C. Suggested Activities

1. List several common minerals with their chemical composition.
2. Collect rocks and minerals.
3. Organize, label, and catalog the rock collections.
4. Cut wooden or plaster models of the crystal forms.
5. Discuss and demonstrate Moh's hardness scale. What is its value?
6. Grow crystals from solutions of copper sulfate or alum.
7. List different kinds of rocks in school and other buildings. Why are these types used for building materials?
8. Study rock and rock crystals, using a hand lens, streak plate, hardness scale, ultra-violet light, and Geiger counter.
9. Make a collection of rocks and minerals of economic importance.
10. Visit a rock quarry.
11. Demonstrate rock cutting and polishing. Contact a local "rock club" for aid and materials.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

V. THE EARTH'S WEALTH

A. Vocabulary

1. Anthracite
2. Bituminous
3. Petroleum
4. Metal
5. Ore
6. Minerals
7. Non-metal
8. Acid soil
9. Alkali soil
10. Artesian soil
11. Conservation
12. Contouring
13. Clay
14. Crop rotation
15. Cultivation
16. Decay
17. Fertilizer
18. Ground water
19. Humus
20. Lignite
21. Mulch
22. Nitrogen fixing
23. Non-renewable
24. Renewable
25. Reforestation
26. Strip cropping
27. Sub-soil
28. Terracing
29. Transported soil
30. Water table

B. Concepts and Understandings

1. All metals, as well as many important non-metals, are obtained from minerals in rocks.
2. The earth's crust is a major source of many fuels.
   a. Coal
   b. Petroleum
   c. Natural gas
   d. Rocket and missile fuels
3. All useful metals come from the earth's crust.
   a. Iron
   b. Gold, silver
   c. Tin, lead, zinc
   d. Uranium
4. Many useful non-metals besides fuels come from the earth's crust.
   a. Graphite
   b. Sulfur
   c. Gypsum
   d. Clays
5. Many valuable resources come from the ocean.
   a. Seafood
   b. Chemicals
      (1) Salt
      (2) Water
      (3) Magnesium
      (4) Bromine
      (5) Iodine
      (6) Gold
6. The supply of natural resources in the future depends on wise use and development of them.
   a. Non-renewable resources
      (1) Metals
      (2) Non-metals
      (3) Coal and oil
   b. Renewable resources
      (1) Forests
      (2) Soil
      (3) Water
      (4) Wildlife

C. Suggested Activities

1. Make reports on chemical products from coal and oil.
2. On a map of the world, locate vital mineral deposits not found in the U. S.
3. Make a study of precious stones. List common names and mineral names.
4. Use melted lead and sinker mold to show how metals can be shaped.
5. Show how lead may be extracted from its ore.
6. Collect different kinds of clays. Report on their uses.
7. Make reports on the uses of gypsum and graphite.
8. Show reaction of a Geiger counter to uranium ore. Discuss uranium mining and prospecting. What does the Geiger counter detect?
9. Collect soils in your area. Test pH, grain size.
10. Fill flower pots with samples collected and grow and test seeds.
11. With two potted plants, show the effects of poor drainage.
12. Observe and report on erosion in unprotected areas.
13. Make a diagram of the water cycle.

14. Demonstrate capillarity using capillary tubes.
15. Visit a watershed area. Arrange for this visit through your county soil conservation officer.
16. Explain the water table.
17. Demonstrate the ability of different kinds of soil to hold water. How is the water table affected by this?

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

HUMAN PHYSIOLOGY

I. THE CIRCULATORY SYSTEM

A. Vocabulary

1. Auricles
2. Ventricles
3. Pericardium
4. Organ
5. Corpuscle
6. Plasma
7. Lymph
8. Platelet
9. Vena cava
10. Aorta
11. Pulmonary vein
12. Pulmonary artery
13. Arteries
14. Veins
15. Capillaries
16. Heart beat
17. Pulse
18. Occlusion
19. Bone marrow
20. Spleen
21. Blood clot
22. Anemia
23. Transfusion
24. Blood type
25. Rh factor
26. Hemoglobin
27. White count
28. Oxygen
29. Carbon dioxide

B. Concepts and Understandings

1. Man is a highly complex organism.
2. Organ systems are groups of interworking organs.
3. The circulatory system transports blood through the body.
   a. The heart is a four-chambered pump which keeps blood in circulation by muscular contraction.
   b. Blood is a fluid tissue composed of plasma, red and white corpuscles, and platelets.
   c. Arteries, veins, and capillaries are tubular muscle structures which transport blood.
4. The heart beats an average of 70 times per minute, 38 million times per year. The female heart beats five to 10 times more than the male per minute. The heart pumps 4 to 5 thousand gallons or about 20 tons of blood per day. Diseases include: cardiovascular, coronary narrowing, coronary occlusion, rheumatic fever, bacterial endocarditis, myocarditis, pericarditis.
5. The average person has from 25 to 30 trillion red cells. The red coloring is due to the iron-containing pigment, hemoglobin. Red cells live three to four months and are manufactured in the spleen and bone marrow. White cells fight disease. There is approximately one white cell to every 600 red cells. Platelets are fewer than red cells and live three to four days. Blood types are 45 per cent type O, 42 per cent A, 10 per cent B, and 3 per cent AB.
6. Arteries, veins, and capillaries if laid end to end would reach a distance of 100,000 miles.

C. Suggested Activities

1. Dissect a preserved animal and locate all parts of circulatory system.
2. Examine a human blood smear under a microscope. (Teacher demonstration.)
3. Examine flow of blood through a goldfish's tail. Directions: Soak cotton in H_2O and wrap this around fish's gills. Place tail fins under microscopic slide to observe and diagram observation.
4. Obtain an untrimmed beef or veal heart from a locker plant or meat market. Dissect carefully to locate chambers, valves, veins, and arteries.
5. Obtain an artery and vein from a meat market and note differences. Pull and stretch each.
6. Check your pulse by placing index finger on inside of wrist and pressing slightly. Count and record after eating, holding your breath, resting, and exercising. Explain.
7. Using your mathematics background, compute flow of human blood from the heart for one hour, one day, one week, one month, one year, and average life of 70 years.
8. Examine bone marrow by breaking open various kinds of animal bones. Examine cells under a hand lens.

11. *Digestion of Foods.* U of I, U-463. 11 minutes. Filmstrip accompanies this for 25 cents.
12. *Alimentary Tract.* U of I, U-522. ISU, NS-715. 11 minutes.
13. *Fundamentals of Diet.* U of I, U-1603. ISU, NS-1832. 11 minutes.
14. Preserved frog
15. Microscope slides
16. Dissecting pan
17. Microscope
18. Test tubes
19. Soda
20. Iodine
21. Benedict's solution
22. Bunsen burner
23. Sugar
24. Incubator
25. Beaker (500 ml.)
26. Hand lens

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Heart, Lungs and Circulation.* U of I, U-5264. ISU, NS-694. 11 minutes.
2. *Open Heart Operation.* U of I, U-5050. 27 minutes.
3. *Hemo the Magnificent.* Bell Telephone Company. Distributed by local Bell offices. ISU.
4. Microscope
5. Stereoscope
6. Dissecting kit
7. Goldfish
8. Human manikin model
9. Wall charts on human body
10. Hand lens

F. Teacher Notes

II. THE DIGESTIVE SYSTEM

A. Vocabulary

1. Salivary glands
2. Saliva
3. Esophagus
4. Small intestine
5. Large intestine
6. Enzyme
7. Stomach
8. Chemical action

9. Secrete
10. Peristalsis
11. Gastric juice
12. Gastric gland
13. Mechanical action
14. Pylorus valve
15. Chyme
16. Indigestion
17. Gallstones
18. Hepatitis
19. Ulcer
20. Cancer of stomach
21. Food poisoning
22. Appendicitis
23. Constipation
24. Diarrhea
25. Anus
26. Feces
27. Hydrochloric acid
28. Carbohydrate

B. Concepts and Understandings

1. The digestive system chemically changes foodstuffs into materials which can be dissolved in water.
2. The alimentary canal is a muscular tube running from mouth to anal opening, including mouth, esophagus, stomach, small intestine, and large intestine.
3. Glands of secretion in mouth, esophagus, stomach, and small and large intestines secrete chemicals that aid in digestion of foods.
4. The stomach mixes all swallowed food with gastric juices by peristalsis (motion of alimentary muscles).
5. Small intestines complete mixing action when bile, pancreatic juices, and intestinal enzymes are added.
6. The large intestine absorbs all water left over in rough, undigested foods known as feces, which are eliminated through the anus.
7. Digested foods become part of the body only when absorbed into the blood through villi in the small intestines which are well supplied with capillaries.
8. Digested proteins and carbohydrates go into the blood stream to be used by body cells or are stored in the liver. Fats are absorbed by lacteals, which empty into a vein near the left shoulder.

C. Suggested Activities

1. Make a complete list of all gastric juices and enzymes which aid digestion.
2. Dissect a preserved frog and locate various parts of digestive tract.
3. Examine digestive organs obtained from meat market. (Use microscope, stereoscope, or hand lens.)
4. Conduct digestion experiments. A suggested source of these experiments is *A Sourcebook for the Biological Sciences* published by Harcourt, Brace, and World.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Human Body—Skeleton.* U of I, U-3747. 11 minutes.
2. Microscope
3. Stereoscope
4. Dissecting kit
5. X-ray pictures
6. Chicken leg
7. Human skeleton
8. Plastic manikin
9. Dilute hydrochloric acid
10. Beaker (200 ml.)
11. Bunsen burner
12. Saw
13. Chicken (for skeleton)
14. Hand lens
15. *Posture and Exercise.* U of I, U-990. ISU, NS-1088. 11 minutes.

F. Teacher Notes

III. THE SKELETAL SYSTEM

A. Vocabulary

1. Skeleton
2. Skull
3. Vertebra
4. Marrow
5. Calcium
6. Phosphorus
7. Calcium phosphate
8. Cartilage
9. Joint
10. Ligaments
11. Hinge joint
12. Ball and socket joint
13. Gliding joint
14. Pivot joint
15. Immovable joint
16. Simple fracture
17. Compound fracture
18. Green-stick fracture
19. Sprain
20. Dislocation
21. Rickets
22. Osteomyelitis

B. Concepts and Understandings

1. The skeletal system forms the framework and shape of the human body.
2. The skeleton is composed of bones to which the rest of the body is attached.
3. Bones (skull and ribs) provide protection for internal organs. Long bones (arms and legs) are used for locomotion of the body.
4. The vertebral or spinal column protects the spinal cord and connects all upper and lower extremities.
5. Bones are made up of bone cells which take calcium and phosphorous from blood and combine them into hard calcium phosphate material.
6. Bones are protected in the spine by "jolt-absorbing" cartilage, which also composes nose and ear tissues.
7. Joints are places where bones join. They are held together by tissue called ligaments.
8. Joints are named according to directions in which they move: i.e., hinge, ball and socket, pivot, gliding, partially movable, and immovable.
9. Common bone injuries include fractures and bruises.

C. Suggested Activities

1. Cut an animal bone in half and identify the various layers.
2. Examine animal bone marrow under a hand lens.
3. Burn a chicken leg bone in fire and see what happens. Explain. Compare with an uncooked bone which has been soaked overnight in diluted HCl.

4. Examine ligaments of the ankle in a chicken. Pull these and see how strong they are. Examine under hand lens.
5. Using a human skeleton, identify bones as to names. How many are there?
6. Try wiring a chicken skeleton together after cooking off all meat.
7. Obtain and examine X-ray pictures of human bones from your family doctor.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Preserved frog
2. Dissecting kit
3. Dissecting pan
4. Microscope
5. Stereoscope
6. Chicken leg
7. Dry cell
8. Copper wire hook-up
9. Ring stand
10. String
11. Gram weight set
12. Stop-watch
13. Hand lens
14. *Heart, Lungs and Circulation.* U of I, U-5264. 11 minutes.
15. *Exercise and Health.* U of I, U-2710. 11 minutes.
16. *Healthy Lungs.* U of I, U-3328. ISU, NS-3434. 11 minutes.

F. Teacher Notes

IV. THE MUSCULAR SYSTEM

A. Vocabulary

1. Muscle
2. Voluntary
3. Skeletal
4. Striated muscle
5. Organ
6. Involuntary
7. Smooth muscle
8. Cardiac muscle
9. Tissue
10. Tendon
11. Cell
12. Impulse
13. Contract
14. Strain

15. Muscle tear
16. Bruise
17. Charley horse
18. Cramp
19. Rupture
20. Hernia
21. Bursitis
22. Life processes
23. Flex
24. Relax
25. Fatigue

B. Concepts and Understandings

1. The muscular system produces movement.
2. Voluntary or skeletal muscles, known as striated muscles, work in pairs to support and move the skeleton.
3. Involuntary muscles, known as smooth muscles, are those which make up organs. They are controlled by the subconscious brain.
4. The heart or cardiac muscle works automatically to circulate blood.
5. Tendons are tissues which connect muscles to bones.
6. All muscles are composed of tiny muscle cells tied in bundles which are controlled by electrical impulses from the brain.
7. Muscles act by pulling or contracting.
8. Muscle injuries include strains, tears, bruises, ruptures, and hernias.

C. Suggested Activities

1. Dissect a preserved frog or chicken and probe for different types of muscle tissue. Examine these under a hand lens.
2. Bring a chicken leg from home and locate muscles, tendons, and ligaments.
3. Show prepared slides of different types of cells from ligaments, muscles, and tendons.
4. Drop untrimmed lungs into a bucket of H_2O and have the students explain why they float.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Learning About Your Nose.* U of I, U-4365. ISU, NS-2365. 11 minutes.
2. Frog
3. Dissecting pan
4. Dissecting kit
5. Microscope
6. Stereoscope
7. Glass slides
8. Cover slips
9. Hand lens
10. *Healthy Lungs.* U of I, U-3328. ISU, NS-3434. 11 minutes.
11. *Human Skin,* U of I, U-2405. 11 minutes.
12. *Work of the Kidneys.* U of I, U-895. ISU, NS-948. 11 minutes.

F. Teacher Notes

V. THE RESPIRATORY SYSTEM

A. Vocabulary

1. Lungs
2. Mouth
3. Nares
4. Nasal passage
5. Glottis
6. Epiglottis
7. Larynx
8. Pharynx
9. Trachea
10. Bronchial tube
11. Cilia
12. Alveoli
13. Inhale
14. Exhale
15. Diaphragm
16. Virus
17. Pneumonia
18. Tuberculosis
19. Pleurisy
20. Tracheitis
21. Bronchitis
22. Streptococcus
23. Laryngitis
24. Artificial respiration
25. Asphyxiation
26. Emphysema

B. Concepts and Understandings

1. The respiratory system is composed of mouth, nose, throat, and lungs through which gases pass during breathing.
2. Inhaled air passes down the throat to the larynx and trachea into bronchus tubes, which branch off in lungs.
3. Alveoli are small air sacs in lungs which contain many capillaries.
4. Oxygen and carbon dioxide are exchanged by diffusion. Oxygen is absorbed by hemoglobin in red cells.
5. Absorbed oxygen is used by body cells to burn or oxidize food with the heat energy released by chemical reaction and metabolism.
6. Diaphragm muscles contract against lungs and force air out.
7. Respiration is a process in which the body uses oxygen to change foodstuffs by chemical action into carbon dioxide gas, and water.
8. Diseases of the respiratory system include common cold, pneumonia, tuberculosis, pleurisy, tracheitis, bronchitis, streptococcus, laryngitis, whooping cough, lung cancer, and emphysema.

C. Suggested Activities

1. Dissect an animal's lungs and probe for all parts of the respiratory system. Cut out and insert a small glass straw into the bronchial tubes and gently blow. Note what happens. Examine under miscroscope, stereoscope and hand lens. Diagram.
2. Obtain the windpipe of a chicken and note how it stretches and resists crushing.
3. Collect pictures of various organs of the system and of diseases that affect the system.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Dissecting kit
2. Preserved frog
3. Microscope
4. Slides
5. Cover slips
6. Stereoscope
7. Hand lens
8. Pork, beef, or lamb kidney
9. *How the Ear Functions.* U of I, U-2011. 11 minutes.
10. *The Spinal Column.* U of I, U-4436. ISU, NS-524. 11 minutes.
11. *Learning About Our Bodies.* U of I, U-3473. 11 minutes.
12. *How You See It.* U of I, U-1039. 11 minutes.
13. *The Human Nervous System.* U of I, U-4944. ISU, NS-1265. 14 minutes.
14. *Human Brain.* U of I, U-3987. ISU, NS-3753. 11 minutes.
15. *Human Throat.* U of I, U-2406. 11 minutes.
16. Vision test chart
17. Animal brain
18. Dissecting pan
19. Frog
20. Cow eye

F. Teacher Notes

VI. THE EXCRETORY SYSTEM

A. Vocabulary

1. Kidney
2. Skin
3. Lung
4. Intestine
5. Nitrogen waste
6. Proteins
7. Bladder
8. Liquid waste
9. Salt
10. Urea
11. Sweat glands
12. Alveoli
13. Feces
14. Anus
15. Uremic poisoning
16. Nephritis
17. Kidney stones
18. Acne
19. Tuberculosis
20. Ulcers
21. Diabetes

B. Concepts and Understandings

1. The excretory system functions to eliminate the various waste products through kidneys, skin, lungs, and intestines.
2. Kidneys are responsible for elimination of nitrogen waste from oxidized proteins carried in the blood stream. Liquid waste is stored in the bladder.

3. The skin eliminates salt, urea, and water through sweat glands.
4. Lungs eliminate carbon dioxide and water vapor given off by the blood stream in alveoli.
5. The large intestine eliminates undigested foods, known as feces, through the anus.
6. Diseases of the excretory system include:
   a. Uremic poisoning
   b. Nephritis
   c. Kidney stones

C. Suggested Activities

1. Diagram pictures of kidney, lungs, and intestine and label parts which aid in eliminating body wastes.
2. Look up information on artificial kidney and kidney operations.
3. Dissect an animal and locate various parts of the excretory system. Examine under microscope and diagram.
4. Examine human skin under a hand lens.
5. Dissect and study a fresh animal kidney, such as an untrimmed beef, lamb, or pork kidney obtained from a meat market or locker plant.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Control Your Emotions.* U of I, U-3114. ISU, NS-3312.
2. *Mental Illness.* U of I, Part I, U-4169. 11 minutes. Part II, U-4170. 11 minutes.
3. *Snap Out of It.* U of I, U-3372. 11 minutes.
4. *Understanding Your Emotions.* U of I, U-3115. 11 minutes.
5. *Endocrine Glands.* U of I, U-1021. ISU, NS-1983. 11 minutes.

F. Teacher Notes

VII. THE NERVOUS SYSTEM

A. Vocabulary

1. Nerve
2. Spinal cord

3. Sense organ
4. Stimulus
5. Brain
6. Ganglia
7. Neurons
8. Reflex action
9. Medulla
10. Cerebrum
11. Cerebellum
12. Sensory nerves
13. Motor nerves
14. Mid brain
15. I.Q.
16. Convolutions
17. Gray matter
18. White matter
19. Retina
20. Farsightedness
21. Nearsightedness
22. Ear drum
23. Semi-circular canals
24. Taste buds
25. Olfactory nerve
26. Cerebral hemorrhage
27. Brain tumors
28. Polio
29. Stroke
30. Meningitis
31. Rabies
32. Hydrophobia
33. Concussion
34. Skull fracture
35. Cerebral palsy
36. Epilepsy
37. Multiple sclerosis
38. Shingles
39. Response
40. Balance mechanism

B. Concepts and Understandings

1. The nervous system consists of the brain, spinal cord, and sense organs which control body behavior.
2. The spinal system is the center of nerve action. It connects nerve cells of sensory organs to the brain. Nerve cells which carry impulses to the spinal cord are known as sensory nerves. Nerves which carry impulses away from the spinal cord are motor nerves; they stimulate muscles into action.
3. The brain is composed of:
   a. Cerebellum for balance and muscle coordination.
   b. Cerebrum for control.
   c. Medulla to control all automatic reflexes.
   d. Mid brain to connect cerebrum to spinal cord.
4. Sense organs are sight, hearing, smell, taste, and touch.
5. Diseases of the nervous system include meningitis, rabies, hydrophobia, cerebral palsy, epilepsy, multiple sclerosis, shingles.

C. Suggested Activities

1. Obtain an animal brain from a meat market and dissect it. Locate the various parts. Examine cells under a microscope or hand lens.
2. Conduct a vision test in class and see how students rate.
3. Wearing a blindfold, try to identify 10 objects by smell.
4. Make drawings of eyes for nearsightedness, farsightedness, and normal vision and show corrective lenses.
5. Dissect a cow's eye; examine the parts under a microscope.
6. Dissect a frog brain. Locate the various parts. Examine under microscope.
7. Compare the eyes of various animals by structure.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Your Health: Disease and Its Control.* U of 1, U-3756. 11 minutes.
2. *Bacteria: Friend and Foe.* U of I, U-3808. ISU, NS-3610. 11 minutes.
3. *I Never Catch a Cold.* U of I, U-2196. 11 minutes.
4. *Health Heroes: The Battle Against Disease.* U of I, U-5249. 11 minutes.
5. 10 petri dishes
6. Test tubes
7. Test tube rack
8. Water
9. Milk
10. Agar jelly
11. Iodine
12. Alcohol
13. 2 thermometers
14. *Body Care and Grooming.* U of I, U-2524. ISU, NS-1220. 17 minutes.
15. *Care of the Skin.* U of I, U-2944. ISU, NS-483. 11 minutes.
16. *How to Be Well Groomed.* U of I, U-2694. 11 minutes.
17. *Your Health: Disease and Its Control. U of I,* U-3756. 11 minutes.
18. *The Mosquito.* U of I, U-3756. ISU, NS-2969. 11 minutes.
19. *Silent War: Colombia's Fight Against Yellow Fever.* U of I, U-1529. 11 minutes.

F. Teacher Notes

VIII. THE ENDOCRINE SYSTEM

A. Vocabulary

1. Endocrine
2. Regulator
3. Ductless
4. Hormone
5. Vital activities
6. Metabolism
7. Pituitary gland
8. Adrenal gland
9. Thyroid gland
10. Parathyroid gland
11. Pancreas gland
12. Insulin

B. Concepts and Understandings

1. The endocrine system produces powerful chemical regulators of body.
2. Ductless glands secrete chemical hormones directly into the blood stream.
3. Hormones control growth, maturing, and many other vital activities.
4. The pituitary gland at the base of brain is known as the "Master Gland."
5. Adrenal glands at the top of the kidney control unusual muscular strength.
6. The thyroid gland in the neck controls body temperature.
7. Parathyroids in the neck control bone growth.
8. The pancreas gland, found near the stomach and small intestine, controls use of body sugar.

9. Male and female sex hormones control secondary sex characteristics.

C. Suggested Activities

1. Report on insulin.
2. Collect pictures showing endocrine abnormalities such as midgets and giants.
3. Make a chart of the various glands and the hormones secreted.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *The Story of Doctor Jenner.* U of I, U-901. 11 minutes.
2. Petri dishes
3. Test tubes
4. Beakers
5. Ammonia
6. Alum
7. Halazone pill
8. Hand lens
9. Agar
10. *Attitudes and Health,* U of I, U-2745, 11 minutes.
11. *Care of the Skin.* U of I, U-2944. ISU, NS-483. 11 minutes.

IX. CAUSES OF HUMAN DISEASE

A. Vocabulary

1. Microbe
2. Germ
3. Infection
4. Bacteria
5. Pathogenic
6. Bacterium
7. Fusion
8. Bacillus
9. Spirillus
10. Coccus
11. Fungus
12. Protozoa
13. Virus
14. Filterable virus
15. Spores
16. Infection
17. Airborne
18. Droplets
19. Glycol spray
20. Water-borne
21. Contaminated
22. Impure water
23. Polluted
24. Chemical treatment

B. Concepts and Understandings

1. Diseases may be caused by microscopic organisms which invade the body and cause infection.

2. Bacteria are tiny plants which make up the most abundant form of life. Not all bacteria are harmful. Those which cause disease are called pathogens.
   a. Bacteria range in size from 1/1000 to 1/50,000 of an inch.
   b. There are about 1,300 species of bacteria.
   c. Bacteria reproduce by fission or splitting.
   d. Bacteria are placed in three major classifications:
      (1) Bacilli or rod shaped.
      (2) Spirilla or spiral shaped.
      (3) Cocci are spherical shaped.
3. Fungi often are small organisms but larger than bacteria. Most are beneficial.
4. Protozoa are one-celled animals, which can cause disease.
5. Viruses are extremely small organisms which reproduce in living cells.
6. Infectious organisms are spread by various means.
7. Airborne or droplet infection results when bacteria or virus ride droplets of sprays from respiratory tract.
8. Water-borne infection results from drinking impure water.

C. Suggested Activities

1. Place antibiotic discs in a culture of bacteria and note the effects.
2. Collect pictures of different types of bacteria, viruses, and other organisms.
3. Make a chart of types and causes of diseases.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Your Health: Disease and Its Control.* U of I, U-2756. 11 minutes.
2. *Health Heroes.* U of I, U-3469. 11 minutes.
3. *Understanding Vitamins.* U of I, U-3467. ISU, NS-728.
4. *Fundamentals of Diet.* U of I, U-1603. ISU, NS-1832. 11 minutes.
5. Soil
6. Test tubes
7. Microscope
8. Glass slides (microscope)
9. Cover glasses
10. Petri dishes
11. Agar
12. *Health in Our Community.* U of I, U-5056. ISU, NS-3854.
13. *Improving America's Health,* U of I, U-5240.
14. *Exercise and Health.* U of I, U-2710.
15. *Your Health at School.* U of I, U-3757.
16. *Your Health at Home.* U of I, 3758.

F. Teacher Notes

X. HOW DISEASES ARE SPREAD

A. Vocabulary

1. Food infection
2. Organism
3. Germ
4. Digestive tract
5. Pasteurization
6. Sterilization
7. Wound infection
8. First aid
9. Insect-borne
10. Inject
11. Carrier of disease
12. Sewage
13. Direct contact
14. Indirect contact

B. Concepts and Understandings

1. Food infections are the result of eating foods contaminated with organisms which cause sickness in the digestive tract.
2. Wound infections are caused by bacteria and viruses which enter the body by injuries to skin.
3. Insect-borne diseases are transmitted by insects that bite and inject germs directly into the blood or are carriers of disease that transfer organisms externally.
4. Contact diseases are transferred by direct contact with carriers of disease or by indirect contact with people who harbor the germs.

C. Suggested Activities

1. Make cultures of bacteria on sterile agar plates.
2. Make a list of good habits in stopping airborne infection.
3. Examine some contaminated water from a pond, using your microscope or hand lens.
4. Bring in some food which has been left open for several days. Examine it under a microscope or hand lens.
5. Demonstrate how milk is pasteurized.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Alcohol and Tobacco.* U of I, U-3740. 11 minutes.
2. *Alcoholism.* U of I, U-3285. ISU, NS-3357. 22 minutes.
3. *Drug Addiction.* U of I, U-3262. ISU, NS-3283. 22 minutes.
4. *No Smoking.* U of I, U-3282. 10 minutes.
5. *The Story of a Drug Addict.* U of I, U-3265. 19 minutes.
6. *What About Drinking?* U of I, U-4097. 11 minutes.
7. *Tobacco and the Human Body.* U of I, U-4670. ISU, NS-3675. 15 minutes.

XI. DEFENSE MECHANISMS

A. Vocabulary

1. Mechanism
2. Mucous membrane
3. Mucus
4. Fever area
5. Blood serum
6. Antibodies
7. Immunity
8. Natural immunity
9. Vaccination
10. Acquired immunity
11. Innoculation
12. Antitoxin
13. Toxin
14. Vaccine
15. Serum
16. Toxoid
17. Vitamins
18. Hormones
19. Wonder drugs

B. Concepts and Understandings

1. The first defense mechanism of the body is composed of the skin, mucous membranes, and gastric juices.
2. The second defense mechanism is composed of the tissue cells.
3. The third line of defense is composed of the blood serum chemicals known as antibodies.
4. Natural immunity is the ability of the body from birth to develop antibodies which fight disease. This immunity does not result from vaccination.
5. Acquired immunity develops during life as a result of vaccination, inoculation, or by having certain diseases and recovering from them.
6. Vaccines, which contain antitoxins, are given by vaccination.
7. Serum is fluid taken from another animal or person who has had a disease and developed antibodies. When injected into healthy humans, it gives immediate passive immunity.
8. Toxoids are weakened toxins injected into blood streams to stimulate production of antitoxins.
9. Antibiotics are "wonder" drugs commonly obtained from molds.
10. Vitamins are the chemicals found in foods. They are necessary for keeping the body healthy.

C. Suggested Activities

1. Report on the life history of Doctor Jenner and Louis Pasteur.
2. Make a chart of various types of vaccines and how they were developed.
3. Write to a drug manufacturer and ask about new miracle drugs on the market.
4. Examine different types of microbes and draw diagrams of them.
5. Examine soil. Plan how you could learn whether or not it contains bacteria.
6. Report on a proper immunization program.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *First Aid on the Spot.* U of I, U-3991. 11 minutes.
2. *First Aid on the Spot,* (3rd edition). U of I, U-3391. ISU, NS-3851. 10 minutes.
3. *First Aid: Fundamentals.* U of I, U-3746. 11 minutes.
4. *First Aid.* U of I, U-976. 11 minutes.
5. *Help Wanted.* U of I, I-1528. ISU, NS-5481. 33 minutes.
6. Pictures of germs
7. Sterile gauze
8. Dressings
9. Bandage rolls
10. Cravat bandage
11. Band aids
12. Antiseptics
13. First aid kits
14. Twine

F. Teacher Notes

XII. PUBLIC HEALTH

A. Vocabulary

1. Health
2. Public health
3. Physical health
4. City health department
5. County health department
6. State department of health
7. Agency
8. Surgeon general
9. National health
10. World-wide health
11. Health education

B. Concepts and Understandings

1. Public health deals with prevention of disease, prolonging life, and extending mental and physical well being.
2. County and city health departments work in the immediate community.
3. The State Department of Health cooperates with local agencies.
4. Public Health Service, directed by the surgeon general, controls national health activities.
5. The World Health Organization (UN agency) controls world-wide disease prevention.
6. Health education teaches importance of disease prevention.

C. Suggested Activities

1. Obtain a list of duties a local health agency carries out in a community.
2. Obtain a list of duties carried out by the State Department of Health.
3. Learn how sanitation is controlled in your city and state.
4. Check on the teaching of health education in your schools.
5. Learn the functions of the Federal Food and Drug Administration.
6. Write the National Health Council, 1790 Broadway, New York 10019, for information concerning additional activities.

XIII. DEPRESSANTS AND STIMULANTS

A. Vocabulary

1. Stimulant
2. Depressant
3. Narcotic
4. Nervous system
5. Morphine
6. Codeine
7. Heroin
8. Opium
9. Habit
10. Craving
11. Synthetic
12. Drug
13. Painkiller
14. Opiates
15. Addict
16. Alcohol
17. Novocaine
18. Marijuana
19. Sedative
20. Barbiturate
21. Coal tar
22. Bromide
23. Nicotine
24. Tobacco
25. Caffeine
26. Theophyline
27. Theobromine

B. Concepts and Understandings

1. Narcotics are depressant drugs which slow down the nervous system, causing a craving or "habit" if used continually. If a drug is used often and then withheld, the addict becomes "sick."
   a. The opium family is a group of products made from opium plant. It includes codeine, morphine, heroin, and opium.
   b. Synthetic drugs made by chemists and used by dentists and doctors as painkillers also act like narcotics if used too often.
   c. The alcohol family includes products used in beverages. Alcohol damages the nervous system, the

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

digestive tract, and the circulatory system.

d. Cocaine, which comes from the cacao plant, is the most dangerous drug.
e. Novocaine is a synthetic drug used by dentists to deaden pain.
f. Marijuana is obtained from leaves of the marijuana plant, which grows wild in the United States. It is made into cigarettes.

2. Sedatives are synthetics used by doctors for quieting the nervous system and promoting sleep.
   a. Barbiturates are synthetic drugs made from coal tars. They cause death if taken in large doses.
   b. Bromides are synthetics used in headache remedies.
3. Stimulants are drugs which increase heart rate and nerve reaction.
   a. Tobaccos contain nicotine and coal tars.
   b. Coffee contains caffeine.
   c. Tea contains theophylline.
   d. Cocoa contains theobromine.

C. Suggested Activities

1. Make a report on the Harrison Act of 1914.
2. Collect news items on harmful effects of drugs.
3. Have class discussion on the harmful effects of drugs.
4. Discuss the use of alcohol by adults and teenagers.
5. Read stories of addicts and discover how they lived and recovered.
6. Learn how drugs are smuggled into the United States.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

XIV. FIRST AID

A. Vocabulary

1. First aid
2. Medical help
3. Victim
4. Severe bleeding
5. Poisonous

6. Fractures
7. Unconsciousness
8. Dislocation
9. Burn
10. Patient
11. Punctured wound
12. Infection
13. Dressings
14. Sterile gauze
15. Bandage
16. Triangular bandage
17. Cravat bandage
18. Roller bandage
19. Bleeding spot
20. Shock
21. Stimulant
22. Spirits of ammonia
23. Tourniquet
24. Powder burns
25. Splinter
26. Tetanus
27. Lockjaw
28. Animal bite
29. Rabies
30. Hydrophobia
31. Snake bites
32. Venom
33. Infected
34. Pus
35. Lungs
36. Respiration
37. Prone-pressure method
38. Prone-arm-life method
39. Mouth-to-mouth method
40. Artificial respiration
41. Rescue
42. Technique
43. Electric shock
44. Poison gas
45. Gas mask
46. Poisons
47. Baking soda
48. Vomit
49. Patient
50. Victim
51. Acid poisoning
52. Lye poisoning
53. Fracture
    a. Compound
    b. Simple
54. Splint
55. Sprain
56. Dislocation
57. Displaced
58. Joint
59. Stretcher

B. Concepts and Understandings

1. First aid is immediate aid given to people who are ill or injured.
2. First aid requires that the victim be kept lying down and quiet until injuries are known.
3. The victim should be checked first for severe bleeding, breathing failure, and possible poisoning; then for wounds, unconsciousness, fractures, dislocations, and burns. Wounds are called injuries when the skin is cut or punctured and infection sets in.
4. Immediate medical help should be summoned. Doctors should be told where the patient is, the nature of his illness, and the first aid given so far.
5. The patient should be kept warm, comfortable, and quiet.
6. Proper dressing of sterile gauze and bandaging is very important to stop infection.
7. Bleeding can be halted in most cases by applying pressure directly on the bleeding spot.
8. Keep an injured person quiet, treat for shock, and do not give stimulants or spirits of ammonia.
9. Apply a tourniquet to stop bleeding in the limbs and apply a dressing over the wound.
10. Wounds that do not bleed freely (powder burns and splinter injuries) sometimes cause tetanus (lockjaw).
11. Animal bites sometimes cause rabies (hydrophobia) and result in death if proper treatment is not given.
12. Snakes are seldom poisonous.
13. Infected wounds become red and tender and develop pus.
14. In case of eye injuries the best procedure is to send the patient to a doctor. If liquids are splashed into eyes, have patient wash eyes with water.
15. Concerning the breathing system and application of artificial respiration:

a. Breathing is necessary to facilitate exchange of oxygen and carbon dioxide in lungs.
b. The prone-pressure method is seldom used.
c. Prone-arm-lift method is the most common method.
d. Mouth-to-mouth method is the easiest and safest way to apply respiration.

16. Do not try the swimming rescue of drowning person until all other techniques have been tried.
17. Electric shock rescues are very difficult when water conditions are present.
18. Poison gas rescues should not be attempted without a gas mask.
19. In treating for poisons, remember that
    a. Sometimes foods eaten in too large quantities are poisonous.
    b. If help is not immediately available, give patient water to drink. If baking soda is at hand, give two teaspoonsful in a glass of water.
    c. Try to make the victim vomit by giving him large quantities of water and soda; or try tickling the back of the throat. After he vomits, give him warm water and put him to bed.
    d. For acid poisoning, give baking soda followed by milk.
    e. For lye poisoning, have the patient drink water containing lemon juice or vinegar followed by milk.
20. Body frame type of fractures
    a. Fractures are broken or cracked bones of the body.
    b. Fractures are of two kinds, simple and compound.
    c. Fractures are made immobile by splinting broken bones.
21. Treatment for dislocations and sprains
    a. Sprains and dislocations are very painful injuries.
    b. Sprains occur where a great amount of pressure is applied to bones around joints, but where bones are not displaced.
    c. Sprains should be treated by applying wet cloths and cold water as soon as possible.
    d. Dislocations occur when bones are sprung out of place at the joint.
    e. Dislocations should be treated as broken bones.
22. Moving injured or sick people
    a. Always splint broken bones where the patient lies. Haste is usually unnecessary and often harmful.
    b. Stretcher-like supports are the best means for moving injured victims.
    c. In cases where injuries are not serious, the patient can be carried by his extremities.

C. Suggested Activities

1. Have class discussion on the meaning of first aid.
2. Collect data on how many people were killed accidentally each year in the last five years.
3. Make a list of various accidents that could happen and have class discussion on means of preventing them.
4. Learn how to make and apply triangular, cravat, and roller bandages.
5. Apply tourniquets for bleeding in limbs.
6. Try applying figure-eight bandages on the palm.
7. Apply finger pressure on various wounds on which tourniquets cannot be applied.
8. Apply an arm sling and tell when it would be used.
9. Learn how to apply cravat bandage on arms or legs.
10. Explain the parts of the respiratory system and how they function.
11. Make a list of safety organizations in your community.
12. Discuss how you can tell when a person is not breathing.
13. Explain the drowning process.
14. Obtain newspaper stories of how many people die due to accidents.
15. Have discussion on how best to prevent accidents in home, school, and community.

16. Make a list of items which should be placed in a first aid kit and tell why they should be there.
17. Explain how various types of poisoning should be treated.
18. Discuss how vinegar helps in lye poisoning.
19. List ways to cause vomiting.
20. How can you tell whether or not a bone is broken?
21. Show how to apply splints for arm and leg fractures.
22. Make drawings of kinds of fractures.
23. Draw diagrams illustrating injuries due to breaks, dislocations, and sprains.
24. Explain the effect of cold on a joint that is injured.
25. Practice ways of placing people on stretchers.
26. Practice ways of making stretchers from blankets and doors.
27. Practice carrying victims on stretchers and removing them.
28. Practice three-man carry, eight-man carry, four-hand seat carry, and pack-strap carry.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Eyes and Their Care.* U of I, U-873. ISU, NS-1087. 11 minutes.
2. *Eyes: Their Structure and Care.* U of I, U-4450.
3. Tourniquet
4. Blanket
5. Triangular bandage
6. Figure-eight bandage
7. Sterile gauze
8. Dressings
9. Antiseptics
10. Snake-bite kit
11. Eye wash bottle
12. *Rescue Breathing.* U of I, U-4978. ISU. 22 minutes.
13. *Artificial Respiration.* U of I, U-3378. 6 minutes.
14. Gas masks
15. Splints
16. Blankets
17. Pillow
18. Stretcher
19. Wooden poles

F. Teacher Notes

LIVING THINGS

I. PLANT TYPES

A. Vocabulary

1. Gymnosperms
2. Angiosperms
3. Spermatophytes
4. Monocotyledon
5. Dicotyledon
6. Cotyledon
7. Primary root
8. Secondary root
9. Root hair
10. Stomata
11. Chloroplasts
12. Chlorophyll
13. Vein network
14. Cell layers
15. Transpiration
16. Sepals
17. Petals
18. Stamens
19. Anthers
20. Pistil
21. Stigma
22. Style
23. Ovary
24. Ovules

B. Concepts and Understandings

1. Spermatophytes are the seed plants.
   a. Gymnosperms produce naked seeds not enclosed in a fruit.
   b. Angiosperms are all flowering plants which produce fruits that enclose the seeds.
2. Monocotyledon is a single-seed leaf.
3. Dicotyledon is a two-seed leaf.
4. Cotyledon is a special type of leaf which develops in the seed.
5. Roots anchor plants to the soil, absorb water and minerals, and store food. They include:
   a. Primary roots
   b. Secondary roots
   c. Root hairs (outgrowths from both primary and secondary roots)
6. Stems produce leaves, connect roots to leaves, and store food.
7. Leaves manufacture food, exchange gases during respiration, and give off vapor during transpiration.
8. Flowers are the specialized reproductive organs. Parts of a flower are:
   a. sepals
   b. petals
   c. stamens and anthers
   d. pistil and stigma
   e. style
   f. ovary
   g. ovules

C. Suggested Activities

1. Make a collection of various kinds of seeds and classify them according to gymnosperms or angiosperms.
2. Plant different types of seeds like peas, corn, and beans and classify as to cotyledons.
3. Cut a fresh carrot down the middle and observe the various parts of the roots. Observe the root hairs on the outside covering. Perform germination tests to find the percentage of viability. 2, 3, 5,—triphenyl tetragobium chloride may be used to reduce the time of test.
4. Cut a stem in half from a common house plant, and observe the parts under a hand lens.
5. Examine an Elodea leaf (a simple water plant in most aquariums) under a microscope. Observe the following plant structures and discuss their function: chloroplasts, chlorophyll, stomata, veins (xylem and phloem).

D. Teacher and Pupil References (See Bibliography)

E. Audiovisual Aids, Equipment, and Supplies

1. *Plant Growth.* U of I, U-619. ISU, NS-969. 11 minutes.
2. *Growth of Flowers.* U of I, U-2191. 11 minutes.
3. *Growth of Seeds.* U of I, U-4678. ISU, NS-3996. 13 minutes.
4. *Leaves.* U of I, U-878. ISU, NS-2317. 11 minutes.
5. *Roots of Plants.* U of I, U-303. ISU, NS-610. 11 minutes.
6. *Trees: How We Identify Them.* U of I, U-4889. 11 minutes.
7. Seeds (peas, corn, beans)
8. Carrots
9. Radishes
10. Hand lens
11. Elodea leaf
12. Microscope
13. Potted plants (flowering)

II. THE CELL

A. Vocabulary

B. Concepts and Understandings

1. Protoplasm is the living substance of a cell which:
   a. Is irritable and responds to factors in the environment.
   b. Has the power to move and contract.
   c. Takes food materials and changes them into cell structure.
   d. Selects the food to be used and absorbs it.
   e. Takes in oxygen and oxidizes food into heat energy for motion.
   f. Gives off waste.
   g. Reproduces itself.
2. Chloroplasts are the green bodies inside leaf cells which contain chlorophyll.
3. Chlorophyll is a substance which, by chemical reaction, takes carbon dioxide gas and water and makes glucose sugar.
4. Cell wall is the outside covering of the cell which encloses the protoplasm.
5. Nucleus is a spherical mass in the protoplasm.

C. Suggested Activities

1. Place green plant near a window and observe how the leaves tend to lean in different positions. Also observe the flowers and what they do. Can you explain this movement?
2. Cover a plant leaf with a piece of dark paper for several days. Test what happens.
3. Examine prepared slides of cells and see what different parts of a cell you can identify.
4. Extract chlorophyll by boiling in alcohol. (CAUTION: Use water bath procedure). Stain leaves with tincture of iodine to show starch is present. Hint: Use a variegated leaf to illustrate starch differences.

F. Teacher Notes

III. PLANT REQUIREMENTS

A. Vocabulary

B. Concepts and Understandings

1. There are over 250,000 different species of plants. Sizes range from tiny bacteria to giant sequoia trees, 300 feet tall and 36 feet thick. Plants need food, water, minerals, and oxygen. Green plants need carbon dioxide and water.
2. Not all plants need sunlight, but it is essential for green plants to manufacture food. In the presence of light, the chlorophyll in chloroplast converts carbon dioxide and water into sugar and then into starch, giving off oxygen.
3. During respiration, oxygen enters leaf and combines with foods during oxidation.

C. Suggested Activities

1. Collect specimens of various kinds of plant life.
2. Plant diferent kinds of seeds in soil, sand and water, and blotting paper soaked in water. Notice which seems to grow best. Try to analyze your results.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *The Cell: Structural Unit of Life.* U of I, U-2709. ISU, NS-4015. 11 minutes.
2. *Behavior in Plants and Animals.* U of I, U-4743. 11 minutes.
3. Green plant (any)
4. Dark paper
5. Scotch tape
6. Prepared slides (all parts of plant)
7. Microprojector

3. Place some small house plants in different places in your classroom. Observe how plants with lesser amounts of sunlight grow. Explain why?

F. Teacher Notes

IV. PLANT PROCESSES

A. Vocabulary

B. Concepts and Understandings

1. Plant respiration is a destructive process which goes on day and night in all cells. By it:
   a. Foods are oxidized.
   b. Energy is released.
   c. Carbon dioxide is given off.
   d. Oxygen is taken in.
   e. Carbon dioxide and water are produced.
2. Oxidation breaks down sugar, forms water and carbon dioxide as waste products, and releases energy stored in sugar molecules. Much of the plant's food is dissolved in water and transported to cells in this form. (Sugar + oxygen = water + carbon dioxide + energy.)
3. Photosynthesis is a constructive process which goes on only in daylight

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Potting soil
2. Sand
3. Different kinds of soils
4. Blotting paper
5. Elodea plant
6. Rubber plant
7. Potting soil containers
8. *Plant Growth.* U of I, U-619. ISU, NS-969. 11 minutes.
9. *Plant Traps.* U of I, U-339. ISU, NS-2007.

and takes place with chlorophyll. By it:

a. Foods are accumulated.
b. Energy from sun is stored in glucose.
c. Oxygen is given off.
d. Complex foods are formed.

4. Transpiration is the process through which plants expel excess water through the stomata as water vapor.
5. Digestion is the process through which insoluable materials are changed for use by plants. This chemical change is due to enzymes; e.g. diastose, which changes starches to sugar, and lipose, which digests fats.
6. Assimilation is the constructive process whereby cells change digested foods into more protoplasm.

C. Suggested Activities

1. Cover a house plant with a bell jar or cellophane bag and place in the light. Note what happens. Explain this process.
2. Attach the stem of a rubber plant, leaf, or similar large leaf, to an air pump with a piece of rubber tubing. Place the leaf under water and operate the pump. Observe the air forced out through the openings on the underside of the leaf.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

V. BASIC FOODS PRODUCED BY PLANTS

A. Vocabulary

B. Concepts and Understandings

1. *Glucose* is plant sugar produced by combining carbon dioxide and water

during photosynthesis.

2. *Starch* is excess sugar stored in stems and roots.
3. *Plant cellulose* is made from glucose. It is the woody-like structure in cell walls. It is not digestible in man.
4. *Protein synthesis* is the process by which glucose is chemically combined with mineral salts taken from soil which contains phosphorus, sulfur and nitrogen. It forms protein. It does not require sunlight and chlorophyll for this process. Proteins are necessary for new cells, tissues, and plant growth.
5. *Fat synthesis* is the process by which starches are chemically changed into fats and oils and stored in seeds, nuts, or other foods for future energy requirements.
6. *Vitamins* of the same type as those used by human beings are also needed for healthy growth of plants.

C. Suggested Activities

1. Test different food substances for starch with the iodine method.
2. Examine some celery stalks and note long thread-like tissues. Also cut a cornstalk in half and examine it for these cellulose threads.
3. Examine the roots of a clover plant with a hand lens to observe the small nodules, or lumps, which contain bacteria. They remove nitrogen from the air and make it available to other plants.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Bell jar
2. Cellophane bags
3. *Characteristics of Plants and Animals.* U of I, NS-463. 10 minutes. Color.
4. *Simple Plants: Algae and Fungi.* U of I, NS-4004. 14 minutes.
5. *The Gift of Green.* U of I, NS-2513. 15 minutes. Color.

F. Teacher Notes

VI. PLANT PRODUCTS

A. Vocabulary

B. Concepts and Understandings

1. Crops
   a. Forage crops such as grasses, alfalfa, and clovers used for feeding livestock.
   b. Cereal grains such as wheat, oats, corn, and rice used as foods for human beings and animals
2. Vegetables, fruits, and nuts
   a. Those used by human beings as food: tomatoes, corn, peas, beans, etc.
   b. Fruits like apples, oranges, pears, and peaches, used by human beings and raised abundantly for food all over the world.
   c. Nuts such as hazel nuts, hickory nuts, walnuts, and pecans used as delicacy-type foods
   d. Tung nuts from the tung tree in the Orient used in making printers ink
3. Wood
   a. Lumber used to build homes, furniture, etc.
   b. Wood pulp used to make paper
4. Plant fibers
   a. Cotton and linens used to make cloth
   b. Hemp fibers used in making ropes and threads
   c. Jute plant fibers used in carpeting, cord, and burlap
   d. Kapok used in mattresses, pillows, and upholstered furniture
   e. Cellulose and plant fibers used to make celluoid, toys, dishes, aprons, stockings, tires, etc.
5. Plant saps and oil
   a. Latex from rubber trees used in making rubber
   b. Cottonseed oil, coconut oil, soybean oils, peanut oils, and olive oils used in cosmetics, candies, soaps, salad oils, and cattle feeds
   c. Turpentine oil from pine trees; and resins, a by-product used in making varnishes
   d. Linseed oil from flax plants used in making oilcloth, linoleum, patent leather, paints, and inks
6. Plastics and adhesives
7. Alcohols
   a. Wood alcohol (a deadly poison) obtained from plants by distilling wood chips
   b. Grain alcohol obtained from plants
   (Alcohols are used in anti-freeze, cosmetics, drugs, explosives, and preservatives and are utilized in the production of over 800 different products)
8. Sugar
   From sugar cane plants or sugar beets and wood pulp
9. Drugs
   a. Quinine to fight malaria fever
   b. Ergot to check human bleeding, obtained from fungus which grows on rye
   c. Narcotic drugs used to depress pain, from opium poppy
   d. Cocaine to deaden pain, from the coca plant
   e. Strychnine for heart trouble, from an oriental tree (safe only in small doses)

C. Suggested Activities

1. Collect different types of grasses and label them. Notice the different type structures of each grass. Collect specimens of different types of cereal grains, and paste in a notebook. Examine the different type structures of these and explain as to leaf size and stem length. Which ones are domesticated or non-domesticated?
2. Bring samples of different types of fruits and vegetables. Rank them according to the importance of each in your diet.
3. Bring in different kinds of wood.

4. Collect samples of different types of nuts and explain their uses.
5. Write various lumber companies and ask for literature on lumber. Make a list of things in your school, home, and town that require wood.
6. Collect samples of various types of cloth made from plant fibers. How expensive are they, and how well do they wear?
7. Obtain samples of various household articles that contain oils from various plants. What oil seems most valuable? Make a report on this oil and how it is manufactured.
8. Write to paint manufacturers and obtain literature on how paints are made. Report on these processes.
9. Obtain materials on the tung tree and learn where it grows and what its other uses are today.
10. Collect sample items of various types of plastic and how they are made.
11. Make a report on the manufacturing of wood and grain alcohols and their uses.
12. Tell how sugar cane and sugar beets are made into sugar.
13. Explain how various drugs are manufactured from plants, and list their uses today.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Chopped nuts
2. Clover plant
3. Celery stalks
4. Cornstalks
5. Carbonated water
6. Beakers
7. Straws
8. Dissecting kit
9. *Learning About Leaves,* U. of I, NS-3272. 11 minutes.
10. *Plastics.* U of I, U-2094. 22 minutes.
11. *Forestry and Forest Industries.* U of I, U-2242, 11 minutes.
12. *Cotton,* U of I, U-2160. ISU, NS-2323. 11 minutes.
13. *Homespun.* U of I, U-3448. ISU, NS-3337. 22 minutes.
14. *King Cotton.* U of I, U-1038. 22 minutes.
15. *Blades of Green,* U of I, NS-3545. 15 minutes. Color.
16. *The Changing Forest.* U of I, NS-3060. 10 minutes. Color.
17. *Forestry and Forest Industries.* U of I, NS-2269. 9 minutes.
18. *The Forest Produces.* U of I, NS-2948. 10 minutes. Color.
19. Notebooks
20. Bulletin board
21. Grasses
22. Fruits
23. Vegetables
24. Nuts

F. Teacher Notes

VII. PROBLEMS OF LIFE

A. Vocabulary

B. Concepts and Understandings

1. Nutrition

   All living things, both plant and animal, must obtain food or manufacture their own to give them energy needed to grow, work, and live.

2. Protection

   All living things must distinguish between harmful and beneficial factors in their environment. They must protect themselves.

3. Reproduction

   All living things must die; thus, they must produce young to take their place.

C. Suggested Activities

1. Make a report on how animals and plants protect themselves.
2. Collect photographs of the means of protection used by various organisms.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *How Green Plants Make and Use Food.* U of I, U-4752. 11 minutes.
2. *How Living Things Change.* U of I, U-4764. 11 minutes.
3. *Behavior in Plants and Animals.* U of I, U-4743. 11 minutes.

F. Teacher Notes

VIII. LIFE PROCESSES

A. Vocabulary

B. Concepts and Understandings (Definitions)

1. Ingestion is the process of taking in foods which must provide for fuel, growth and repair, and reproduction. Green plants manufacture their own food, whereas animals must depend on green plants for their food.
2. Digestion is the chemical process of breaking down raw materials into soluble form which can be used by the cell protoplasm.
3. Absorption is the process of taking (diffusing) food into the cells.
4. Circulation is the process whereby soluble food (in solution) is transported by a fluid to all cells in the organism. It also removes waste products from cells.
5. Assimilation is the changing of digested foods into new living protoplasm.
6. Respiration is the exchange of gases between the cells and the environment through the cell membrane by the process of diffusion.
7. Excretion is the process by which cellular wastes are eliminated by an organism.
8. Locomotion is movement of animals from place to place. (Plant leaves can only grow toward light; roots grow toward water.)
9. Secretion is the process by which certain cells give off substances necessary for life processes.
10. Reproduction is the process of organisms to produce their own kinds.
11. Sensitivity or irritability is the ability of living things to be aware of and to react to certain stimuli or changes in their environment.

C. Suggested Activities

1. Make a report on how you regulate your nutrition program.
2. Compute, by calories, a week's food consumption.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Life in a Drop of Water.* U of I, U-2368. 11 minutes.
2. *Life in a Pond.* U of I, U-3129. 11 minutes.
3. *Marine Life.* U of I, U-3633. ISU, NS-195. 11 minutes.
4. *Microscopic Life: The World of the Invisible.* U of I, U-4820. ISU, NS-49. 14 minutes.
5. *Simple Plants: Algae and Fungi.* U of I, U-4736. ISU, NS-4004. 13½ minutes.
6. *Animal Life.* U of I, U-1024. 11 minutes.
7. *Animals at Work in Nature.* U of I, U-4419. 10 minutes.
8. *Animals with Backbones.* U of I, U-4760. 11 minutes.

F. Teacher Notes

IX. CLASSIFICATION OF LIVING THINGS

A. Vocabulary

B. Concepts and Understandings

1. Taxonomy is the science of naming and classifying things.
2. Living things are commonly classed as either *plant* or *animal.*
3. The binomial system is the "two name" system which describes organisms: the *genus,* always written with a capital letter, and the *species.* (Example: Homo sapiens.)
4. All living things are divided into *kingdoms,* each subdivision of which has common characteristics.
5. Kingdoms are subdivided into *phyla.*
6. Phyla are divided into *classes.*
7. Classes are divided into *orders.*
8. Orders are divided into *families.*
9. Families are divided into *genera.*
10. Genera are divided into *species.*
11. Species is usually the final classification utilized. It may, however, be divided into *varieties* or *races.*
12. Variety or race refers to an individual plant or animal which differs slightly from others.
13. Classification of the plant kingdom is as follows:
    a. *Thallophyta*—no roots, stems, leaves or flowers. Examples are algae, molds, and bacteria mushrooms.
    b. *Bryophyta*—simple stems and leaves, no roots, or flowers. Examples are mosses and liverworts.
    c. *Tracheophyta*—vascular plants
        (1) *Pteridophyta*—true roots, stems and leaves but no flowers. Examples are ferns, horsetails, club mosses.
        (2) *Spermatophyta* — seed-bearing plants with roots, stems and leaves. Examples are trees, beans, grains, grasses.
14. Classification of the animal kingdom is as follows:
    a. *Protozoa*—one-celled animals. Examples are amoeba and paramecium.
    b. *Porifera*—simple many-celled animals. Examples are sponges.
    c. *Coelenterata*—animals with body tissues and cavity. Examples are hydra and jelly fish.

d. *Worms* (nemathelminthes, platyhelminthes, annelida) — animals with long, slender bodies. Some are segmented. Examples: earthworm, tape-worm, pin-worm.
e. *Echinodermata* — spiny-skinned animals. Examples: starfish, sea urchin.
f. *Molluska* — soft-bodied animals, usually with shells. Examples: snail, clam.
g. *Arthropoda*—Animals with jointed legs, and segmented bodies. Examples: insects, spiders, crabs.
h. *Chordata*—animals with internal skeletons and usually with backbones. Examples: fish, frog, bird, reptile, man.

C. Suggested Activities

1. Make a complete classification chart of various kinds of animals found in your community.
2. Chart a classification of yourself.
3. Report on the history of Linnaeus and his binomial system.
4. Make a comparative summary of different classification systems. Discuss the reason for these different systems.
5. Make a bulletin board with specimens of various phyla of plants found in your vicinity.
6. Arrange the different types of plants into large, colored diagrams, and label the parts which distinguish these phyla.
7. Take a field trip and collect specimens for identification.
8. Invite some seed and plant experts in your community to discuss different types of plants they handle, and how they have improved production of these.
9. Make a bulletin board with specimens of various phyla of animals found in your vicinity.
10. Take a field trip and collect and identify the phyla of animals in your community.
11. Bring in various kinds of skeletons found in the community and identify them.
12. Construct a key for both plants and animals to be utilized on a field trip.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

X. REPRODUCTION

A. Vocabulary

1. Gamete
2. Sperm
3. Spore
4. Egg
5. Zygote
6. Fertilization
7. Mitosis
8. Meiosis
9. Sexuality
10. Haploid
11. Diploid

B. Concepts and Understandings

1. Reproduction is a self-perpetuative device.
2. The patterns of reproduction are as follows:
   a. Molecular reproduction
      (1) by accumulation; e.g. H_2O
      (2) by enzymatic synthesis; e.g. fat
      (3) by template-dependent synthesis; e.g. protein
      (4) by self-duplication; e.g. DNA
   b. Cellular reproduction
      (1) by binary fission
      (2) by multiple fission
      (3) by budding
   c. Organismic reproduction
      (1) by vegetative reproduction
      (2) by sporulation
      (3) by gametic reproduction

C. Suggested Activities

1. Make root cuttings from geranium plants.
2. Examine some commercially prepared slides on asexual reproduction.
3. Grow some algae in the classroom. Send for Turtox Service leaflet #6, "Growing Fresh Water Algae in the Laboratory." Try to examine algae under a "low power" microscope and see if you can diagram them.
4. Prepare a culture of yeast to observe "budding" under a microscope. Crumble baker's yeast in a five per cent sugar solution which has been allowed to stand overnight in a warm place.
5. Bring various types of bread molds and fruit molds and examine under a hand lens. Diagram these.
6. Develop pure cultures of the mold on an agar base.
7. Observe the development of frog eggs.
8. Diagram an egg cell and label the major parts.
9. Collect pictures of various kinds of cells and place on bulletin board.
10. In the spring, collect some frog eggs and watch them with hand lenses every day until they hatch.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Reproduction in Animals.* U of I, U-4756. 11 minutes.
2. Frog eggs
3. Chicken eggs
4. Incubator
5. Wire pens
6. Chick food
7. *Growth of Flowers.* U of I, U-2191. 11 minutes. Color.
8. *Growth of Seeds.* U of I, U-4678. ISU, NS-3996. 13 minutes.
9. *Reproduction in Plants.* U of I, U-4735. 13½ minutes.
10. Lily plant
11. Soil
12. Sand
13. Germinating box
14. *Adaptations of Plants.* U of I, U-4726. 13½ minutes.
15. *How Living Things Change.* U of I, U-4764. 11 minutes.

F. Teacher Notes

XI. REPRODUCTION BY TWO PARENT PLANTS

A. Vocabulary

B. Concepts and Understandings

1. Stamens are the male sex structures of a flower.
2. Pollen grains are formed at the ends of the stamens which produce the male gametes.
3. The pistil is the female structure of the plant.
4. The ovary is the swollen structure at the base of the pistil. Mature eggs are produced here.
5. The style is the tube leading upward from the ovary.
6. The stigma is the tip of the style.
7. Pollination is the transfer of pollen grain from the stamen to the stigma by insects, air, or water.
8. Plants are self-pollinated if the pollen goes from the stamens to the stigma of the same plant.
9. Plants are cross-pollinated if the pollen goes from the stamens of one plant to the stigma of another plant.

C. Suggested Activities

1. Bring in flowering plants and identify each part.
2. Dissect a flower and draw diagrams of each part.
3. Collect different types of flowers and compare the parts of each. Are they all the same?
4. Develop activities to test the functions of the various plant parts.

XII. FUNDAMENTALS OF LIFE THEORIES

A. Vocabulary

B. Concepts and Understandings

1. Spontaneous generation—the theory that life sprang from various lifeless materials. (Snakes came from sticks, etc.)
2. Life concept—the theory that life comes only from life.
3. Like produces like—the concept that living organisms pass their characteristics on to their offspring.
4. Life span—the period of existence from origin to death. All living things pass through four stages of life: origin, growth, maturity, and death.
5. Life activity—the supplying of energy for continuation of life's activities.
6. Environment—all the factors (living and non-living) which make up surroundings.
7. Survival of the fittest—continued existence of the organism that fits into the whole environment best at a particular time.
8. Variation—the difference among numbers of a species.
9. Acquired characteristics — those characteristics not inherited.
10. Inherited characteristics — those characteristics which are heritable, and passed on to the next generation.
11. Mutations — new characteristics which have been inherited.
12. Selection—a process used in developing different types of organisms by "control" of parent types.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

13. Darwin's "Theory of Natural Selection"—the theory that living things pass on to their offspring characteristics which tend to extend the life span. Organisms are changed in the process, thus producing new species. Related subjects include
    a. Overproduction
    b. Struggle for existence
    c. Variation
    d. Survival of fittest
    e. Inheritance of variations
    f. Differential reproduction
14 Mendel's "Theory of Heredity"—the theory that something in the sex cells transmits their characteristics from parent to offspring.
15. Weismann's "Continuity of Germ Plasm"—the theory that germ cells carry inheritance traits.
16. de Vries "Mutation Theory"—the theory that variations of species are due to change mutations which best fit the organism for continued life.
17. "Chromosome Theory"—the theory that inheritance traits are passed by chromosomes in the nucleus of cells. Chromosomes contain genetics materials which are the determiners of characteristics.

C. Suggested Activities

1. Read how the "Spontaneous Generation" theories evolved. Discuss these theories with the class.
2. Make a chart of the life spans of various plants and animals.
3. Show how "survival of the fittest" applies to many species of organisms.
4. Study the eye colors of class members. Tabulate all colors represented and determine ratios of occurrence.
5. Learn what animals are in danger of becoming extinct. Find reasons why this may be true.
6. Visit a museum and see how variations of species have occurred.
7. Report on the various theories of life. How have these theories affected us today?

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

XIII. EVOLUTION

A. Vocabulary

B. Concepts and Understandings

1. The changes that have been going on for millions of years continue in plants and animals.
2. Terms which are often encountered with reference to fossil formation or evolutionary developments include:
   a. Fossils—preserved remains or indications of animals and plants of an earlier geological age, most often found in rock.
   b. Sedimentation—layers of sedimentary rock, which preserve changes on the earth by forming hardened layers over specimens.
   c. Imprints—tracks left by organisms in sediment deposits.
   d. Tar pits—asphalt deposits in which animals may be trapped.
   e. Amber—a resin in which organisms are caught or trapped.
   f. Refrigeration—the process by which organisms trapped in glaciers and ice are frozen to prevent decay.
   g. Coal impressions—imprints of organisms formed during the process of coal deposition.
   h. Permineralization — replacement or molding of plant cells.
   i. Bogs—water deposits which contain large quantities of acid that prevented bacterial decay.
   j. Dried remains in caves—animals and plants that died in caves and were protected from decay.
   k. Embryology—the study of organisms from division of single cell zygote through the entire embryo stage.
   l. Vestigial organs—those which no longer serve a useful purpose.
   m. Geographical distribution — the effect on the habitat of plants and animals as determined by moves to environments where they can survive. All plants and animals disperse to regions where food is abundant and climate suitable.
   n. Effects of barriers—results of isolation by such natural barriers as oceans, seas, canyons, mountains, deserts, and glaciers.
   o. Comparative anatomy—the comparison of plant and animal organ structures.
   p. Classification—the grouping of living things according to structure and origin.
   q. Physiological similarities—indications of common ancestry and relationship as made evident by similarities in body chemicals.

C. Suggested Activities

1. Collect pictures and charts of the different ages of the earth and the life on it.
2. Report on various formations of fossils.
3. Conduct a class experiment on how fossils can be made.
4. Tell about various evidences of fossil formation.
5. Gather as many collector's items as possible and make a display table of the various types of fossils.
6. Discuss how various natural barriers have caused mutations and even extinction of some species.
7. List evidences we have to prove that animals have changed geographical locations.
8. Compare some animal skeletons you have found and list how many similarities you can detect.
9. Study what kinds of serum and medicines we have made from various kinds of animals that can be used on humans.

10. Investigate the types of domesticated plants and animals in your community.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

MATTER AND ENERGY

I. MATTER AND ENERGY, A GENERAL VIEW

A. Vocabulary

1. Forms of energy
   a. Heat
   b. Light
   c. Sound
   d. Electrical
   e. Mechanical
   f. Chemical
   g. Atomic
   h. Nuclear
   i. Radiant
2. Kinds of energy
   a. Potential
   b. Kinetic

B. Concepts and Understandings

1. Matter is anything that occupies space and has mass.
2. It exists in three states: solid, liquid, and gas. Many substances can be changed in state by raising or lowering temperature and controlling pressure.
3. All matter has general and special properties.
4. Matter alters chemical composition. It results in formation of one or more new substances.
5. A change in state or form is known as a physical change.
6. Energy is the ability of matter to move other matter or to affect the motion of other matter.
7. Matter and energy are neither created or destroyed; however, they can be changed from one to the other.
8. Transformation of energies is a change in form.
9. One source of energy is a chemical change.
10. A physical change is a nuclear change.
11. Energy comes from the sun.

C. Suggested Activities

1. Conduct a series of activities to find the properties of matter:
   a. Impenetrability and its effects
   b. Weight and mass compared
   c. Inertia
   d. Volume
   e. Malleability
   f. Ductility
   g. Hardness
2. Demonstrate physical change by tearing paper or breaking glass.
3. Explain why ashes are lighter than the original wood.
4. Explain why iron filings weigh more after they rust.
5. Show how the loss or gain of weight can be explained in regard to conservation of matter.
6. Take a field trip to the local power plant, garage, or telephone company and compare the various uses of energies.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Matter and Energy.* U of I, U-2372. 11 minutes.
2. *Laws of Conservation of Matter and Energy.* U of I, U-4977. 9 minutes.
3. Small graduated cylinder
3. Test tube to fit cylinder
5. Smooth wooden ball
6. Glass tumbler
7. Salt
8. Pyrex test tubes
9. Mercuric oxide
10. Sugar
11. Sawdust
12. Marble chips
13. Hydrochloric acid
14. Analytical balance

F. Teacher Notes

II. CHEMISTRY

A. Vocabulary

B. Concepts and Understandings

1. Chemistry is that branch of science which deals with the composition and change of matter and the energy involved in these changes.
2. Matter is composed of elements. The smallest unit of an element is the atom.
3. A compound consists of two or more elements chemically combined. The smallest unit of a compound is the molecule. Compounds may be broken down into their elements.
4. Symbols and formulas are used to identify elements and compounds. A chemical equation shows what takes place in a chemical reaction.
5. Every compound has definite composition and weight.
6. Combination, decomposition, single replacement, and double replacement represent the different heads of chemical change.
7. Oxygen is an important element involved in rusting and burning.
8. A solution is the uniform mixture of a dissolved substance (solute) and a dissolving substance (solvent).

9. Acids react with metals to release hydrogen. They have a sour taste and turn blue litmus paper red.
10. Bases are identified as the OH group in formulas. They have a bitter taste and turn red litmus paper blue.
11. A salt is formed when an acid solution reacts with a base.
12. Salt, sugar, diamonds and similar formations are known as crystals. They may occur when a saturated solution cools.
13. Electrolytes conduct electric current in water solution. Ions carry the charges.
14. Atomic energy is any change of atomic structure.
15. Atomic structures have as their basic atomic particles, electrons, protons, and neutrons.
16. An electron is a negative particle of electricity in motion around a nucleus.
17. A proton is a positive particle of electricity found in the nucleus.
18. A neutron is a neutral particle of electricity found in the nucleus of most atoms.
19. A nucleus is the central mass of an atom which contains the protons and neutrons.
20. Nuclear energy is the energy released when the nucleus is split.
21. Atomic particles are identified as *alpha, beta,* and *gamma.*
22. Isotopes are atoms having the same atomic numbers and chemical properties but different atomic weights.
23. The atomic number is the number of protons in the nucleus.
24. Atomic weight is the total weight of an atom. (Oxygen has a weight of 16.)
25. Altering atomic structure consists of:
    a. Fission, which is a breakdown of heavy atoms to form lighter elements. It is usually accompanied by release of radiation.
    b. Fusion, which is the combining of nuclei of the light elements to form a nucleus of heavier elements. It is usually accompanied by release of energy.
26. Radioactivity is that property of certain elements which causes them naturally to send forth radiant energy through breaking up of atoms. The term also refers to characteristics of substances made radioactive in an atomic pile.
27. Synonymous terms to keep in mind are tagged atoms, atomic bullets, radioactive elements and isotopes, and tracers.
28. A chain reaction is a self-sustaining atomic reaction.
29. Half-line is the rate of atomic disintegration of radioactive materials.
30. Atomic apparatus includes:
    a. Cyclotron—an atomic particle accelerator.
    b. Atomic pile—a means of controlling an atomic reaction. (Also called atomic reactor.)
31. Peacetime uses are those uses of atomic energy for the benefit of mankind.
32. Wartime uses are those uses of atomic energy for war purposes.

C. Suggested Activities

1. Make reports on early chemists, Lavoisier, Priestley, and others.
2. Show the structure of molecules by models.
3. Consult references and sourcebooks of the bibliography for numerous activities that may be utilized.
4. Report on pioneering scientists in atomic energy.
5. Determine whether or not there is a law that shows a relationship between matter and energy. Make a report on heavy water.
6. Report to the class on the various uses of atomic particles and their origins.
7. Collect pertinent information from local newspapers and magazine articles which use atomic terms.
8. Make a report on atomic accelerators.
9. Report on atomic reactors as a source of power.

10. Give group reports on the use of atomic energy in industry, medicine, agriculture, research and transportation.
11. Report on the atomic, cobalt, hydrogen, and neutron bombs.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Chemistry and a Changing World.* U of I, U-862. ISU, NS-656.
2. *Introduction to Chemistry.* U of I, U-2912.
3. *Molecular Theory of Matter.* U of I, U-298. ISU, NS-2406.
4. Ammonia
5. Cotton
6. 2-100 ml. graduates
7. Ethyl alcohol
8. Zinc powder
9. Powdered sulfur
10. Asbestos square
11. Lump sulfur
12. Deflagrating spoon
13. Litmus, red and blue
14. Charcoal
15. Red phosphorous
16. 100 cc beaker
17. Concentrated sulfuric acid
18. Lime (CaO)
19. Filter paper
20. Funnel
21. Glass tubing
22. Hydrochloric acid
23. Sodium hydroxide
24. Table salt
25. Sugar
26. Evaporating dish
27. Ring stand
28. Tripod
29. Wire gauze
30. Corn starch
31. Baking soda
32. Lead pellets
33. Magnesium ribbon
34. Iodine crystals
35. Sulfur crystals
36. Carbon disulfide
37. Copper sheet
38. Lead peroxide
39. Pyrex test tubes
40. Wood splints
41. Marble chips
42. Limewater
43. Potassium chlorate
44. Manganese dioxide
45. Water trough
46. Red or blue flower
47. Petals
48. Granular zinc
49. Silver nitrate
50. Sodium chloride solution
51. Ferric chloride solution
52. Lead acetate
53. Potassium iodide solution
54. Cream of tartar
55. Vinegar
56. Test tube clamps
57. Sodium thiosulfate
58. Geiger counter
59. Radioactive sources
60. Mousetraps

61. Corks
62. Cloud chamber
63. Hand lens
64. Radioactive dial watch
65. *Atomic Energy.* U of I, U-2322. ISU, NS-2256. 11 minutes.
66. *Atomic Power.* U of I, U-2403. ISU, NS-2266. 22 minutes.
67. *Atomic Radiation.* U of I, U-3682.
68. *Strange Story of the Cosmic Rays.* Bell Telephone Company.
69. *The Atom and Medicine.* U of I, U-3456. ISU, NS-3369. 12 minutes.
70. *Atomic Alert.* U of I, NS-3124. 15 minutes.
71. *A is for Atom.* U of I, NS-422. 15 minutes.
72. *Atom Smashers.* U of I, U-3683. 11 minutes.

F. Teacher Notes

MEASUREMENT

I. WEIGHTS AND MEASUREMENTS

A. Vocabulary

(Words used in table of weights and measures)

B. Concepts and Understandings

1. Weight units are used so that we can determine how heavy materials are: ounce, pound, ton, long ton.
2. We use length units as a measure of size: inch, foot, yard, rod, mile. Equivalents to 1 mile: 320 rods, 1,760 yards, 5,280 feet.
3. Liquid measure units teach us volume: gill, cup, pint, quart, gallon. Equivalent to 1 gallon: 4 quarts, 8 pints, 16 cups.
4. Units of weight can be used to determine that air has weight.

C. Suggested Activities

1. Explain to pupils the words that have the same or similar sound but different spelling or meaning as compared with the usage in weighing and measuring:
   a. Hour—(our-are)
   b. Pound—(verb usage)
   c. Yard—(playground area)
   d. Rod—(a staff)
   e. Second—(numbers system)
   f. Minute—(meaning small). This isn't pronounced the same.
   g. Week—(weak)
   h. Quire—(choir)
   i. Score—(as used in a game)
2. Develop problems or use science texts for problems and situations that make use of measurement situations.
3. Make actual measurements to better realize the measurement quantity.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Story of Our Number System.* U of I, U-4648. 10 minutes.
2. *Let's Measure: Inches, Feet, and Yards.* U of I, U-3610. 11 minutes.
3. *Story of Weights and Measures.* U of I, U-4044. 11 minutes.
4. *Weights and Measures.* U of I, U-3976. 11 minutes.
5. *The Calendar.* U of I, U-4024. 11 minutes.
6. *What Time Is It?* U of I, U-3346. 11 minutes.

F. Teacher Notes

II. THE ENGLISH SYSTEM OF WEIGHTS AND MEASUREMENTS

A. Vocabulary

(Words used in tables of weights and measures.)

B. Concepts and Understandings

1. We use dry measure for those materials not of a liquid nature: pint, quart, peck, bushel. Equivalent to 1 bushel: 4 pecks, 32 quarts, 64 pints.
2. Our daily living involves dividing time into units: second, minute, hour, day (solar day), week, month, year (leap year). Equivalent to 1 year: 365 days, 52 weeks, 12 months.
3. We use counting to determine with "how many" of a given item we are concerned: unit, dozen, gross. Equivalent to 1 gross: 12 dozen, 144 units.
4. Light varies in brightness: foot candle, candle power, light year.
5. Sound measurement helps determine comfort for our hearing decible.
6. The measure of electricity helps us know better ways to use it: volt, ampere, watt, ohm, kilowatt, kilowatt-hour.
7. Heat energy is important to body comfort: calorie, great calorie.

C. Suggested Activities

1. Use a photometer to learn about candlepower and foot candle.
2. Find how the term "light year" is determined.
3. Study instruments that indicate measurement units of electricity.
4. Make a record of meter readings such as indicated on the electric meter in the home.
5. Use a calorimeter to show how the unit calorie is determined in the quantity of food.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Measurement of Electricity.* U of I, U-2708. 11 minutes.
2.

F. Teacher Notes

III. OTHER UNITS OF MEASUREMENT

A. Vocabulary

(Use as vocabulary the names of the various unit divisions of the length, volume, and weight terms.)

B. Concepts and Understandings

1. Temperature depends upon the number of heat units: degree changes.
2. Electromagnetic waves are used in some forms of modern communication: light, cosmic, gamma, x-ray, ultraviolet, infra-red, hertzian or radio.
3. Length measurements in the metric system are built upon a uniform scale: millimeter, centimeter, decimeter, meter, decameter, hectometer, kilometer.
4. Volume of the metric system also follows a uniform scale: milliliter, centiliter, deciliter, liter, decaliter, hectoliter, kiloliter.

C. Suggested Activities

1. Study a thermometer and learn of temperature changes.
2. Study the different wave lengths described here, using the references given.
3. Develop problems that would use terms most commonly known such as millimeter, centimeter, meter, and kilometer.
4. In studying the metric system:
   a. Learn the prefix term of each unit.
   b. Learn the unit term of measurement; e.g. meter for linear measure, liter for volume, and gram for weight.
   c. Combine the prefix term with the unit term to produce units of length, volume, and weight measures.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Photometer
2. Standard candle
3. Ammeter-voltmeter
4. Electric meter (KWH)
5. Calorimeter
6. Thermometers
   a. Fahrenheit
   b. Centigrade
7. Wall chart of electromagnetic waves
8. Blocks of weights
   a. English
   b. Metric
9. Small rubber balloons
10. Set of dry measures

3. Check scale readings with the weights from the blocks of English and metric weights.

F. Teacher Notes

IV. MEASURE OF VOLUME

A. Vocabulary

B. Concepts and Understandings

1. The weight measurements also follow the same uniform pattern of the metric system: milligram, centigram, decigram, gram, decagram, hectogram, kilogram.
2. It is convenient to know some common equivalents: 1 centimeter equals 0.393 inches, 1 meter equals 39.37 inches, 1 gram equals 0.035 ounce, 1 liter equals 1.056 quarts.
3. Manipulation and use of the instruments of weights and measures is an important item of learning for use in the study of science.

C. Suggested Activities

1. Develop problems with the terms, milliliter and liter.
2. Develop problems with the terms, milligram, gram, and kilogram.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *The Metric System.* U of I, U-4874. ISU, NS-1179. 11 minutes.
2. Several meter sticks
3. Block of metric weights
4. Beakers of various graduates with metric measurements

F. Teacher Notes

V. INSTRUMENT MEASUREMENTS

A. Vocabulary

1. Instruments for weighing: spring balance, scale balance, blocks of weights, both English and metric
2. Instruments of length: foot ruler, yardstick, meter stick, 100 foot tape
3. Instruments of liquid measure: gill, cup, pint cup, quart cup, gallon jar, liter beaker, graduates and beakers of varying capacities
4. Instruments of dry measure: pint, quart, peck, bushel
5. Instruments of time: chart showing relationship of time units
6. Instruments of light measure: photometer, standard candle
7. Electricity measure: ammeter-voltmeter, electric meter (KWH)
8. Heat measure: calorimeter
9. Temperature change: thermometers, (Fahrenheit, Centigrade)
10. "Powers-of-ten" notation (used by scientists and mathematicians)

B. Concepts and Understandings

C. Suggested Activities

1. Use the balance to find the weight of varying quantities of a substance such as dry sand.
2. Determine size of the classroom, using units of the two systems of measuring.
3. Measure longer distances in school hallways or on the playground and athletic field.
4. Use instruments of liquid measure to determine whether or not bottles of liquids contain the stated amounts.
5. Perform activities similar to those suggested under the topic, "Other Units of Measure."
6. Determine the heat units of a slice of bread, using the calorimeter.
7. Use each of the two kinds of thermometers together in a beaker of water and compare their respective temperature readings.
8. Practice writing of planet distances in terms of exponential numbers.
9. Practice fundamental arithmetical processes, using exponential numbers.
10. Convert wave length numbers of electromagnetic waves into numbers represented by exponential numbers.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. 16 mm movies listed under the study of English and metric systems of weights and measures will provide information about the use of instruments listed.
2. Note: The items in "Concepts and Understandings" should be provided for study and use as indicated in "Suggested Activities."

F. Teacher Notes

VI. CONVERSION TABLES

A. Vocabulary

B. Concepts and Understandings

1. Conversion tables are available for the systems of weights and measures.
2. One system of weights and measures can be changed to the other system: 1 meter = 39.37 inches, 100 centimeters = 39.37 inches, 1 inch = $\frac{100}{39.37}$ centimeters or 2.54 centimeters.
3. Some *approximate* equivalents are important to know and convenient to use: 1 centimeter = 2/5 inch, 1 inch = 2 1/2 centimeters, 1 kilometer = 5/8 mile, 1 kilogram = 2 pounds, 1 liter = 1 quart.
4. Temperature readings of Fahrenheit can be changed to Centigrade readings, and Centigrade readings to Fahrenheit readings.

C. Suggested Activities

1. Study a combination meter stick and inch scale to find comparative relationships.
2. Measure objects in the classroom to determine comparative areas and volumes.
3. Study readings of a thermometer having scales of both Fahrenheit and Centigrade.
4. Make several different readings, then use the proper formula and convert the readings Fahrenheit to Centigrade and Centigrade to Fahrenheit.
5. To convert Fahrenheit to Centigrade, subtract 32 from the Fahrenheit reading and divide by 1.8.
6. To change Centigrade to Fahrenheit, multiply the Centigrade reading by 1.8, then add 32.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Slice of bread
2. Water
3. Centigrade thermometer
4. Fahrenheit thermometer
5. Meter stick
6. Yardstick
7. Ruler

F. Teacher Notes

MECHANICS

I. MACHINES AND TOOLS

A. Vocabulary

1. Force
2. Matter
3. Inertia
4. Momentum
5. Gravity
6. Catapult
7. Work
8. Effort
9. Matter
10. Mass
11. Distance
12. Vertical
13. Horizontal
14. Rate
15. Time
16. Power
17. Horsepower

B. Concepts and Understandings

1. Machines are devices (tools) which help man perform the work of the world.
2. Man has used some form of tools since the beginning of his existence.
3. Machines are used to perform work (in a scientific sense).
4. The measuring of work.
   a. The unit of work is the foot pound, which means the vertical lift of one pound one foot high.
   b. A simple expression of work is force times distance ($W = F \times D$).
   c. Work is accomplished when a force moves an object.
5. The rate of doing work.
   a. A fast worker may not be the "best" worker.
   b. The worker is hired who can do a careful piece of work in a minimum amount of time.
   c. Power is determined by the rate (speed) at which a machine can do a piece of work. $P = \frac{F \times D}{Time}$
   d. One horsepower is 33,000 foot pounds of work performed in one minute.
      (1) Formula: $HP = \frac{weight \times distance}{time \times 33{,}000}$
      weight in pounds
      distance in feet
      time in minutes
6. How machines help us do work.
   a. Increase the force we use
   b. Change the direction of a force
   c. Increase speed of operation
   d. Transfer forces—(chains, gears, belts)
7. Other factors for all machines.
   a. Mechanical advantage is resistance divided by effort.
   b. Efficiency is the ratio of work obtained from a machine divided by the work put into the machine.
   c. Friction may be helpful or harmful. It is the resistance of an object to moving.

C. Suggested Activities

1. List at least 50 machines or tools.
2. Show how a stick may have been used as a tool. Do the same with a rock.
3. Show how one may become exhausted from effort and yet do no work.
4. Show that dragging a log down hill is work.
5. Measure the work you do when you climb a stepladder. Figure the work involved in lifting a 10-pound object from the floor to a table top.
6. Write one word as fast as possible. Compare with doing it 10 times carefully.
7. Explain why some lawnmowers are called power mowers.
8. Report on the history of horsepower.
9. Report on a steam engine. Figure your own horsepower using stairs and a stop watch.
10. Explain why a large truck may have 200 HP while a car may have 300 HP.
11. Use a small motor (erector set) to show gears and belts.
12. Work several problems using the work formula as given in "Concepts and Understandings."
13. Show how efficiency can never be 100 per cent and is usually much less than 100 per cent.
14. Demonstrate the use of oil and grease. Use grease between two pieces of sandpaper. Get roller and ball bearings from garages for additional information.

F. Teacher Notes

1. Secure examples of actual tools. Determine the advantages and purposes of each.
2. Get bearings of all kinds from garages and supply stores.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Machines Do Work.* U of I, U-3023. 11 minutes.
2. *Force and Motion.* U of I, U-2857. 11 minutes.
3. *How We Get Our Power.* U of I, U-2952. 11 minutes.
4. *Energy and Its Transformation.* U of I, U-300. 11 minutes.
5. Use all available wall charts.
6. *Friction.* 20 minutes. (British Information Service). Rockefeller Plaza, New York City.

II. SIMPLE MACHINES

A. Vocabulary

B. Concepts and Understandings

1. These are factors for all simple machines:
   a. Effort is any force used to move an object.
   b. Effort distance is the distance the effort moves in any machine.
   c. Resistance is the weight of the object to be moved.
   d. Resistance distance is the distance the object is moved by effort.
2. Every tool or mechanical aid for man will have one or more simple machines as part of its components.
3. Six simple machines are:
   a. *Lever.* A lever is a rigid length of a certain substance (wood, metal, etc.). Every lever moves upon a

point or pivot called a fulcrum. Levers can be used in three ways to help man perform work.

(1) 1st class lever (effort-fulcrum-resistance) changes direction.
(2) 2nd class lever (effort-resistance-fulcrum) gains force.
(3) 3rd class lever (fulcrum, effort-resistance) gains speed. The law of levers (moments) is E x ED = R x RD
  (a) E = Effort
  (b) ED = Effort Distance
  (c) R = Resistance
  (d) RD = Resistance Distance

b. *Pulley.* Here are important facts about pulleys:
  (1) Single pulleys may be classed as either fixed or movable.
  (2) All terms about machines except fulcrum apply to pulleys.
  (3) A block and tackle consists of two or more fixed pulleys and two or more movable pulleys working in combination.

c. *Wheel-and-axle.* A wheel and axle is a modification of levers and pulleys. Apply first class lever concepts to the wheel and axle.

d. *Inclined plane.* To understand the inclined plane, visualize a mountain road complete with hairpin curves and switchbacks.

e. *Wedge.* A wedge is two inclined planes together.

f. *Screw.* Screws are modified inclined planes. They are characterized by:
  (1) Pitch
  (2) Slope
  (3) Radius
  (4) Circumference

4. Each of the six simple machines may be modified for special uses. Gears, chains, belts, roller bearings, and cams are all examples of modified machines.
5. All compound or complex machines are combinations of simple machines. A compound machine must have two or more simple machines working together as a unit.
6. Hydraulic machines (or systems) use liquids or gases to transmit the force to the resistance. Most grease racks use hydraulic lifts. (Figure the pressure per square inch.)
7. The future of machines involves the problem of automation in that it may be possible for machines to do all of man's work.
8. Perpetual motion machines are considered impossible. Many inventors worked on perpetual motion in the 18th century.

C. Suggested Activities

1. Show how pulleys are also levers; how a wheel and axle can be a lever; how wedges and screws are modifications of the inclined plane.
2. Find as many simple machines as you can in a bicycle.
3. List several things that would make good levers. Use several lever-type car jacks as examples.
4. Set up all three classes of levers and show the advantages and disadvantages of each. Use meter sticks and weights to illustrate the classes of levers. (Spend more time on the 3rd class lever because it is radically different from the others in application.)
5. Use a bulletin board or flannel board to show different lever systems.
6. Work many problems using the lever formula.
7. Set up a single pulley and indicate whether it is fixed or movable.
8. Explain effort, effort distance, resistance, resistance distance.
9. Build and examine a small block and tackle. Apply all machine terms. Demonstrate the efficiency and mechanical advantages.
10. Build a small windlass. Determine E, ED, R, and RD.
11. Obtain a differential hoist and show how it works.
12. Investigate ramps, escalators, spiral stairs, cog railroads, ski lifts.

13. Show that an ax or hatchet is a wedge. Look at chisels, knives, chucks.
14. Examine drill bits, screw top lids, jack screws (house jacks), shop vises, boat and airplane propellers.
15. Get examples of machines listed in "Concepts and Understandings" and examine.
16. Indicate all the simple machines in a bicycle, vise, meat grinder, car jack, can opener, elevator, derrick, and many other items that each student can find.
17. Use a model force pump hooked to a water faucet to show a hydraulic system.
18. Watch a machine make a duplicate key.
19. Make a report on automation.
20. Debate the following:
    a. Can machines make machines?
    b. Why are labor unions concerned about automation?
21. Investigate how a radiometer runs.
22. Discuss these questions:
    Are artificial satellites perpetual motion machines?
    Why is perpetual motion impossible?

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Simple Machines: Levers.* U of I, U-4051.
2. Screw-drivers
3. Hammers
4. Nut-crackers
5. Bottle-openers
6. Tweezers
7. Ball bats
8. Fishing-poles
9. Oars
10. Wrenches
11. Pliers
12. Tongs
13. Shovels
14. *Simple Machines: Pulleys.* U of I, U-4052.
15. *Simple Machines: Wheel and Axle.* U of I, U-4050.
16. *Simple Machines: Inclined Planes.* U of I, U-4049. ISU, NS-891.
17. Egg-beaters
18. Mixers
19. Can-openers
20. Door-knobs
21. Lock-and-key
22. Steering-wheel
23. Manageable machines brought to class by students to illustrate modified and compound machines.
24. *Automation.* U of I, U-4150. 28 minutes. This is an especially good film for advanced students.

F. Teacher Notes

1. Get a chain hoist, wire stretcher, boat block and tackle.
2. Use household items such as egg-beater, mixer, can-opener, door-knob, lock-and-key, and steering-wheel for examples of wheel-and-axle.

METEOROLOGY

I. INTRODUCTION

A. Vocabulary

B. Concepts and Understandings

1. Awareness of weather as a phenomenon with many changes besides hot and cold, dry and wet.
2. Awareness of the fact that many sources are available from which weather information can be obtained; e.g. radio, television, and newspapers.
3. Definitions
   a. Weather—the condition of the atmosphere at the moment.
   b. Climate—the average weather conditions over a period of many years.
4. Effect of weather on
   a. How people live.
   b. Home construction.
   c. Industry in the community.
   (The way people live, the food they eat, the jobs available to them, the types of buildings they construct, and how they act all depend to a great extent on the type of weather in the local community.)

C. Suggested Activities

1. Discuss the local weather during a period of several months or a year.
2. Assign several students to bring to class the weather reports from at least three suggested sources.
3. Have a committee of two or three students survey the literature for definitions of weather.
4. Have a student committee of two or three students investigate one or all of the areas indicated.
5. Have members of the class interview different people to learn how the weather affects their work and how weather forecasts are valuable to them. After the evidence has been collected, put it together in a class report.
6. Have class members tell about experiences in a storm.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Collections of pictures from current magazines showing weather problems, conditions, storms, and storm damage.
2. *Life in the Central Valley of California.* U of I, U-2752. 11 minutes.
3. *Life in the Desert—North America.* U of I, U-4003. 11 minutes. Color.

F. Teacher Notes

A well-prepared pre-test to determine what the students already know about weather is suggested. It may be that some of the problems suggested could be omitted if the pre-test indicates a basic understanding.

II. THE OCEAN OF AIR

A. Vocabulary

1. Composition
2. Properties
3. Oxygen
4. Nitrogen
5. Carbon dioxide
6. Water vapor
7. Polluted air
8. Ultraviolet light
9. Compound
10. Density
11. Molecule
12. Mixture
13. Atmosphere
14. Troposphere
15. Stratosphere
16. Chemosphere
17. Ionosphere
18. Exosphere
19. Tropospause
20. Weather
21. Altitude

B. Concepts and Understandings

1. The nature of air
   a. The study of air involves an understanding of the molecular theory of matter.
   b. Air is a mixture of various gases.
   c. One of our great problems is keeping the air clean, for air contains many impurities.
2. The importance of air
   a. Without the atmosphere, the earth would be unbearably hot in the daytime and extremely cool at night.
   b. The oxygen in the air keeps us alive and supports living things on the earth.
   c. The atmosphere protects us from the hazard of meteors by causing most of them to burn up before reaching the surface of the earth.
   d. Air supplies us with elemental oxygen, nitrogen, and various rare gases such as argon and neon.
   e. Air protects us from cosmic and ultraviolet rays by preventing them from reaching the earth in dangerous quantities.
3. The structure of the air ocean
   a. The atmosphere is made up of various layers including troposphere, stratosphere, chemosphere, ionosphere, and the exosphere.
   b. Man lives at the bottom of an ocean of air.
   c. Half of the air in the atmosphere is in its lowest 3½ miles.
   d. The weather occurs in the troposphere.
   e. The air ocean extends at least 1,200 miles above the surface of the earth.

C. Suggested Activities

1. Make up fresh limewater, and fill a test tube about one-fourth full. Cause room air to bubble through for two or three minutes.
2. List and explain briefly how we can keep the air clean. Make special note of what your own community is doing.

3. Grow seedlings in each of two large jars by placing some beans in moistened cotton. After seedlings are well developed, cover one of the jars with a glass plate. Make sure the glass plate is sealed airtight.
4. List as many applications of the use of air pressure as time will permit.
5. Construct a chart showing a cross section of the atmosphere. Different colors for the various layers are suggested.
6. Describe some of the difficulties one might encounter in a rocket trip to a height of 700 miles.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Limewater
2. Test tubes
3. Soda straws
4. Bean seeds
5. Cotton
6. Glass jars
7. Glass plate
8. *Oxygen.* U of I, U-2366. 11 minutes.

F. Teacher Notes

III. THE SEASONS

A. Vocabulary

1. Revolution
2. Rotation
3. Season
4. Axis
5. Fall
6. Winter
7. Spring
8. Summer
9. Solstice
10. Equinox
11. Latitude

B. Concepts and Understandings

1. Why we have seasons
   a. The earth makes a complete revolution around the sun in a year.
   b. The earth's axis points in the same direction at all times of the year.
   c. The rotation of the earth plays a part.

2. Seasons in the northern hemisphere
   a. The fall and spring equinoxes occur respectively on or about September 23 and March 21.
   b. The winter solstice occurs on or about December 22.
   c. The summer solstice occurs on or about June 22.
   d. The seasons are most evident between latitudes 30 and 60 degrees north and south of the equator.
3. Seasons in the southern hemisphere
   The seasons in the southern hemisphere are in reverse order of those north of the equator.
4. The seasonal lag
   a. From the position of the sun, the months of May, June, and July should be our warmest months in the northern hemisphere. However, the months of June, July, and August actually are. The reason for this is that the earth absorbs more heat than it loses, reaching a maximum about July 20. After this more heat is lost than is gained, thus the earth begins to cool.
   b. As the shadows get longer, the amount of heat received from the sun is less.

C. Suggested Activities

1. Show how the tilt of the earth's axis causes the seasons (as the earth revolves) by setting up a model earth and a candle or small flashlight bulb for the sun.
2. Using a shadow stick, measure the length of the shadow at least once each week for several weeks. (Stick must be placed in same position each time and at the same time each day.)
3. Should there be a meteorologist or an astronomer in the community, have him visit the class and explain the seasons.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Tennis ball with a knitting needle through it for the axis. Candle or 15-watt electric light bulb.
2. World map and globe.
3. A bulletin board exhibit headed "How We React to Seasonal Weather." For example: clothing, air-conditioning systems, heating systems, insulation in houses.

F. Teacher Notes

IV. WEATHER ELEMENTS

A. Vocabulary

1. Fahrenheit
2. Celsius
3. Centigrade
4. Thermometer
5. Absolute zero
6. Temperature
7. Conduction (heat)
8. Absorb
9. Radiation
10. Convection currents
11. Expand
12. Contract
13. Element
14. Gravity
15. Barometer
16. Barograph
17. Aneroid barometer
18. Milibar
19. Circulation
20. Anticyclone
21. Cyclone
22. Prevailing winds
23. Air mass
24. Meteorology
25. Temperate zone
26. Torrid zone
27. Anemometer
28. Wind vane
29. Velocity (speed)
30. Beaufort scale
31. Knot
32. Radar
33. Theodolite
34. Foehn wind
35. Land breeze
36. Sea breeze
37. Monsoon
38. Jet stream

B. Concepts and Understandings

1. Air temperature—the degree of heat of a substance.
   a. Causes of fluctuation are
      (1) Latitude
      (2) Wind direction
      (3) Altitude
      (4) Large bodies of water
   b. Measurement
      (1) Thermometer scales used in measuring weather are Fahrenheit, Centigrade and Celsius.
      (2) Thermometer calibrations are based on two reference points or standards.
         (a) Freezing point of water*
         (b) Boiling point of water*
   c. Interesting Facts
      (1) All meteorological upper-air measurements are made in Celsius (Centigrade) degrees, but Fahrenheit degrees are used on the sea-level weather map.
      (2) Thermometers for special needs include:
         (a) Clinical thermometer
         (b) Cooking thermometer
         (c) Oven bimetallic thermometer
         (d) Meat thermometer
         (e) Maximum - minimum thermometer used by the weatherman (mercury-alcohol, constriction, and the bimetallic types)
      (3) The air is heated primarily by conduction from the earth to the air.
      (4) The earth receives its heat from the sun by radiation. Heat is absorbed.
      (5) The air is heated only slightly by radiant rays from the sun.
      (6) Heat and the atmosphere are the two greatest weather makers.
      (7) Heat is transmitted in three ways—by radiation, convection, and conduction.
      (8) The air expands when heated.

*Under standard conditions of air pressure which is 14.7 pounds per square inch.

(9) Hot air weighs less than cool air.

2. Air pressure—the weight of air on a unit area, which is generally taken as one square inch.
   a. Causes of fluctuation
      (1) Warm air is lighter than cold air.
      (2) Air with considerable moisture in it becomes lighter than an equal volume of dry air at the same temperature.
      (3) Unequal heating of air causes differences in the air pressure.
      (4) The higher you go into the atmosphere the thinner the air and the less the air pressure.
   b. Measurement by barometer
      (1) Torricelli in 1643 A.D. found that he could weigh the atmosphere by balancing the weight of a column of mercury in an evacuated tube with the weight of the atmosphere on an open dish of mercury into which the open end of the tube had been placed.
      (2) The decrease in the length of the mercury column amounts to roughly one inch of mercury for each 1,000 feet of vertical ascent within the lower few thousand feet of atmosphere.
      (3) Pressure measuring instruments are of two general types, the mercurial and the aneroid barometers.
      (4) Units of air pressure are usually in inches of mercury or in millibars. Normal air pressure in the units is 29.93 in. and 1013.2 mb.
      (5) The recording aneroid barometer is used to record air pressure. This type of barometer is called a barograph.
      (6) The dial barometer (aneroid) is often used since it can be hung on the wall or, if used in an airplane, can be calibrated to read in feet as an indication of the plane's altitude.
   c. Interesting facts
      (1) Normal air pressure is 14.7 pounds per square inch.
      (2) At high elevations, the weight of the column above the barometer becomes less and less, and the length of the mercury column required to effect a balance becomes shorter and shorter.
3. Wind—air in motion. Wind is essentially a circulation of air.
   a. Causes
      (1) Winds are due to changes in temperature and gravity.
      (2) The rotation of the earth only gives direction to winds.
   b. Measurement
      (1) The velocities of winds at the surface are measured by the anemometer.
      (2) The wind vane indicates the direction from which the wind is coming.
      (3) A pilot balloon is released and its movements determined by observing it with a special telescope called theodolite. In this way, the wind direction can be determined.
   c. Interesting facts
      (1) Wind movements over the earth's surface follow a definite pattern.
      (2) Winds blow from high-pressure areas.
      (3) Accurate information on wind direction and speed helps meteorologists to chart the positions of highs and lows.
      (4) By international agreement, all reports of wind speed are recorded in knots.
      (5) Radar is used to track balloons and learn about wind directions and velocity in the upper air. Radar wind soundings are called rawins.

(6) Downward movement of air causes contraction and heating.

(7) The jet stream of the upper air is a flow of westerly winds at middle latitude. These winds move at speeds of from 90 to 300 miles an hour or more. They can be 100 miles in width and several thousand feet thick. (Altitude of 20,000 to 40,000 feet.)

(8) The pattern of flow of the jet streams across the United States changes with the season, and often with each day.

(9) As the path of the jet stream varies so does the surface weather.

d. Definitions

(1) Prevailing winds — winds which blow almost always from one direction.

(2) Air current — the up-and-down motion of air.

(3) Cyclone—a large mass of air having a counter-clockwise whirl in the northern hemisphere, clockwise in the southern hemisphere. It is formed over large, heated land areas, and the air has a less than average density called a low.

(4) Anticyclone—a large mass of air having a clockwise whirl in the northern hemisphere and a counter-clockwise whirl in the southern hemisphere called a high.

(5) Buys Ballot Law—a law that states that in the northern hemisphere, with one's back to the wind, low pressure is to the left and high pressure is to the right.

(6) Foehn (pronounced like fern) winds — warm, dry winds that result from air flowing downslope.

(7) "Chinook" wind—a type of Foehn wind. This wind descends the eastern slopes of the Rocky Mountains into the plains area.

4. Air Moisture

a. Causes of fluctuation

(1) Warm air can absorb more moisture than cool air.

(2) Moisture gets into the air by
(a) Evaporation of water
(b) Transpiration (plants of all kinds)
(c) The wind capturing ocean spray

b. Measurement

(1) The relative humidity of the air is measured by
(a) Hygrometer (wet and dry bulb)
(b) Sling psychrometer
(c) Hair hygrometer

(2) For approximately every 20 degrees Fahrenheit increase in temperature, the capacity of a volume of air to hold water vapor is about doubled.

(3) The smaller the spread between temperature and dew point, the higher will be the relative humidity.

c. Interesting facts

(1) For good health 40 per cent to 50 per cent relative humidity is recommended.

(2) Scientists estimate that on a hot summer day 600 tons of water vapor enters the air from a single acre of grass.

(3) Condensation occurs when the air is cooled and thus contracts and squeezes out the water molecules. These water molecules may then collect on dust, salt, or charged particles that are found in the air.

(4) When the temperature of a layer of air is higher than its dew point, the air is termed "unsaturated."

(5) As a general rule, fog or low clouds should be considered likely when air temperature

is within four degrees of the dew point.

d. Definitions
   (1) Humidity—moisture in the air.
   (2) Relative humidity — the amount of moisture in the air at any one time relative to the amount which the air would hold if completely saturated at the same temperature.
   (3) Dew point—the temperature to which the air must be cooled at a constant pressure in order that it shall become completely saturated.

C. Suggested Activities

1. Check the laboratory thermometers for accuracy. If possible, make correction for air pressure. Check only the fixed points.
2. Have all students work several problems, suggested by the teacher, converting Fahrenheit degrees to Centigrade and likewise Centigrade to Fahrenheit. Of the two methods, choose the one you like and use it at all times. (Note: Both methods should be understood by all students.)
3. Ask a committee to survey and report on thermometers in use in the school. Bring as many to the class as possible and let pupils inspect them.
4. Have individuals or committees prepare drawings of the thermometers.
5. Record daily maximum-minimum temperatures for your town over a period of time. Use weather bureau reports to secure the facts. Possibly students may have at home a maximum-minimum thermometer. Comparisons could be made.
6. Place a lamp chimney over a burning candle. Make sure the chimney does not contact the table all the way around. Hold a smoldering taper or punk stick near the base.
7. Balance two similar varnish cans at the end of a stick which is supported at the middle. Heat one of the cans (lids off both) with a Bunsen burner.
8. Have student committees of two members each research the available literature and determine the effect of the four major air temperature regulators.
9. Demonstrate air pressure by using a hot water bag with hose adapter or the bladder from a basketball or water ball. Blow air into the bag with a student standing on top of a board which is, in turn, on top of the hot water bag.
10. Construct a siphon and determine how air pressure helps in its operation. Each student should make a diagram, label properly, and explain the science principles involved.
11. Fill a wide-mouth bottle half full of colored water and insert a one-hole rubber stopper. Insert one side of a glass U-tube to within one-eighth inch of the bottom of the bottle. Insert the other side of the U-tube to within one-eighth inch of the bottom of a second wide-mouth bottle, but do not use a stopper in the second bottle. Place the bottles under a bell jar, remove the air, and observe results. Explain.
12. Construct a student barometer using mercury.
13. Have students in each class throughout the day record the air pressures. A graph kept on the bulletin board or chalk board is suggested. If each student keeps a copy of the graph in his notebook, more interest will develop in this activity. All students should learn to read the two kinds of barometers and to convert from inches to millibars using appropriate tables. If tables are not available, make one.
14. Learn why water is not a suitable liquid to use in a barometer.
15. Compare air pressure and air moisture graphs for a period of 10 days. Use information given by radio or television. Better still, obtain the readings using lab instruments. Outside humidity readings must be used.

16. Release a hydrogen-filled balloon from a large area free from tall trees and observe the wind direction by its path. Do this three or four consecutive days. Compare with radio and television reports. It is best to do this at the same time each day. (Hydrogen gas can be prepared from zinc and diluted sulfuric acid. Extreme caution must be taken when generating this explosive gas.)
17. Place a sheet of typing paper on a piece of cardboard. Pin it to the cardboard at the center. As you rotate the paper to the left, draw a straight line from the pin toward a corner of the room.
18. Determine how Buys Ballot's law would be useful if one were caught in a hurricane, the center of which is unknown.
19. Demonstrate the anemometer and wind vane if they are available.
20. Obtain pictures of weather instruments for the bulletin board.
21. Have a student report on the special weather instrument called the station meteorograph or quadruple recorder.
22. Have students construct a theodolite and use it to determine upper winds.
23. Have committees report on famous Foehn winds and their characteristics.
24. Report on the monsoons of India.
25. Report on the relation of meteorology to the events on D-day in Europe during World War II.
26. Make a set of charts showing the jet stream in summer, fall, winter, and spring.
27. Dissolve 10 grams of cobalt chloride in 100 cc. of water. Soak small strips of cloth in the solution. Remove them and let them dry thoroughly. Mount the strips so that they land in the air. Notice the color change with changing humidity of the air.
28. Fill a metal beaker with ice water containing several ice cubes. Make sure the outside of the container is dry. Observe the formation of water drops on the outside surface. How does this show that moisture is in the air?
29. Have all students develop skill in using the relative humidity chart.
30. Construct homemade hygrometers (dry and wet bulb type and the hair hygrometer).
31. Demonstrate in the lab the various ways moisture gets into the air.
32. Soak a cotton cloth in water. Wring out as dry as possible. Cut the cloth into two pieces of equal size. Hang both on a line but several feet apart. On one adjust a fan so that the moving air strikes it. Let the other cloth hang in still air. Observe and explain the results after 10 minutes or so.
33. Erect a distillation apparatus and show the complete water cycle. Some copper sulfate crystals dissolved in the water to be evaporated will add interest to the experiment.
34. Determine the dew point of the classroom by placing crushed ice and water in a metal beaker. Use a Fahrenheit thermometer and gently stir the mixture. Note the temperature at which the first bit of moisture condensed on the outside of the beaker. This temperature is the dew point.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Thermometers: Centigrade and Fahrenheit. Also, clinical, household, maximum-minimum, metallic, and others if available.
2. *Heat—Its Nature and Transfer* (second edition). U of I, U-626. ISU, NS-989. 11 minutes.
3. Convection apparatus
4. Punk stick
5. Meter stick
6. Two varnish cans (1 gal. size)
7. *Climate and the World We Live In.* U of I, U-4728. 13½ minutes.
8. *Air All About Us.* U of I, U-5056. 11 minutes.
9. *Air All Around Us.* U of I, U-3026. ISU, NS-396. 11 minutes.
   (Note: The above two films present basic principles. The latter is more useful for better students. There is some duplication.)
10. *Air in Action.* U of I, U-2370. 11 minutes.
11. Hot water bag, rubber hose (5 ft.), board (12 in. x 12 in. x ¾ in.)
12. Rubber tube 10 feet long (for siphon)
13. Vacuum pump, bell jar, two wide mouth bottles (16 oz.)
14. One rubber stopper (one hole)
15. Glass U-tube, tubing as long as bell jar will accommodate
16. High vacuum grease
17. Bunsen burner with wing top
18. Barometer tube (34 in. long)
19. Mercury (2 lbs.)
20. Mercury dish (iron), or mortar dish
21. Medicine dropper (best to make your own so that the drawn end of the glass is quite small)
22. Beaker (2,000 ml.) to catch any mercury that may be spilled
    (NOTE: Mercury must be handled very carefully. Students should not be permitted to put their fingers in the liquid. Mercury is poisonous. Do not breathe the vapor that always exists above the surface of the liquid. If mercury is spilled on the classroom floor, it will slowly evaporate and thus contaminate the air in the room.)
23. Barometer (aneroid or mercury), hygrometer (dry-wet bulb or sling psychrometer)
24. Balloons (five that one may break, capable of being blown up to 10 to 12 inches in diameter), dilute sulfuric acid, zinc (mossy), flask (500 ml.), one-hole rubber stopper, glass tube (10 mm. or so in diameter). The pressure of the gas generated in the flask should be sufficent to inflate the balloon to desired diameter.
25. *Winds and Their Causes.* U of I, U-2684. 11 minutes.
26. Opaque projector to show diagrams of the wind belts of the world
27. Anemometer (working model)
28. Wind vane (working model)
29. *Unchained Goddess.* Bell Telephone. 1958. Free loan.
30. Pictures of radar stations that make weather observations
31. Relative humidity chart
32. *Water.* U of I, U-4264. ISU, NS-2654. 6 minutes.
33. Hygrometers (dry-wet bulb and sling psychrometer), hair-hygrometer if available, metal beaker, cotton cloth, fan, flask (500 ml.), condenser (water cooled), Fahrenheit thermometer, crushed ice.
34. *Nature's Plan.* U of I, U-3582. 17 minutes.
35. *Weather* (filmstrip), Harbrace

F. Teacher Notes

1. Some activities suggested in the 6th grade course of study may be reviewed or repeated.
2. The caution concerning mercury is more important to the teacher because vapor taken into the body cannot be removed and is thus cumulative.
3. It may be that the balloon will come back to earth and be found by someone. Why not attach a 4¢ postcard to the balloon with instructions for mailing it back to the class.

V. PRECIPITATION

A. Vocabulary

1. Precipitation
2. Physical change
3. Hail
4. Rainbow
5. Halo
6. Corona
7. Dew
8. Frost

B. Concepts and Understandings

1. Forms of precipitation
   a. Rain and snow
      The growth of a cloud droplet to a size large enough to fall out is the cause of rain and other forms of precipitation. This important growth process is called "coalescense."
      Very small particles in the air may act as nuclei upon which water vapor will crystallize to form snow.
      Precipitation is formed very nearly above the place where it falls.
   b. Sleet and hail
      If raindrops in falling pass through a layer of air sufficiently cold, they are frozen into bits of ice called sleet.
      Large pellets of ice called hail often fall. Hailstones are made of concentric layers of ice.
   c. Sheet ice or glaze
      When rain falls in winter time, it may freeze immediately upon touching the ground, trees, or other objects. This formation of ice is called sheet ice or glaze.
      Icing of aircraft occurs in flight through cumulus clouds.
2. Dew and frost
   Dew does not "fall out" of the air. It is formed right where we find it. When the air, in contact with grass, spider webs, and bushes, is cooled to the dew point, water droplets form.
   Frost is frozen water vapor. It is *not* frozen dew.
   Dew and frost do not form when the air is extremely dry.
   Most common frost forms near the ground and as high as roof tops.
3. Rain making
   Precipitation can be induced artificially by the action of dry ice or silver iodide crystals.
4. Measuring precipitation
   The tipping-bucket rain gauge actually measures the amount of rain by weighing it.
   Depth of snow is measured in an open area on the ground by means of a ruler.
   When snow is caught in a rain gauge, it is melted down and then measured. One inch of rain equals 10 inches of snow.
5. Related phenomena
   Rainbows are caused by the refraction and reflection of light in drops of water, forming a luminous arc.
   There are several sizes of halos, but the most common one is the halo of

22 degrees radius, surrounding the moon or sun. It is caused by ice crystals.

C. **Suggested Activities**

1. Experiment with a glass prism and sunlight to discover how rainbows are formed.
2. Observe a pitcher of ice water.
3. Observe the freezing coils of the home refrigerator or deep freeze for examples of frost formation.
4. Review the current literature on this relatively new idea.
5. Construct a simple rain gauge.

D. **Teacher and Pupil References**

E. **Audiovisual Aids, Equipment, and Supplies**

1. *Adventures of Junior Raindrop* (free), U. S. Forest Service or U. S. Department of Agriculture, Washington, D. C.
2. *Cloud Forms*, from U. S. Department of Commerce or Weather Bureau (10¢ each).
3. *ESB Weather Guide*. Electric Storage Battery Company, P. O. Box 8109, Philadelphia, Pennsylvania. Form 1-4, 1956. 12 pages each. Free. How to forecast weather from cloud formations shown in color photographs.
4. *Understanding Our Weather*. A chart published by the C. S. Hammond Company, New York. One copy free for the asking.
5. *The Weather*. U of I, U-993. I S U, NS-2313. 11 minutes.

F. **Teacher Notes**

VI. CLOUDS

A. **Vocabulary**

1. Clouds
2. Cumulus
3. Stratus
4. Cirrus
5. Nimbus
6. Cirrocumulus
7. Cirrostratus
8. Altocumulus
9. Altostratus
10. Stratocumulus

11. Nimbostratus
12. Cumulonimbus
13. Fog
14. Smog
15. Haze
16. Advection
17. Radiation fog
18. Noctilucent clouds
19. Auroras

B. Concepts and Understandings

1. Structure of clouds
   a. All clouds are composed of either minute drops of water or extremely small ice crystals.
   b. Clouds are classified according to how they are formed. Two basic kinds are:
      1. Cumulus formed by rising air currents.
      2. Stratus formed when a layer of air is cooled below the saturation point without vertical movement.
2. Cloud types
   a. There are 27 cloud types used by the weather bureau.
   b. Students should develop some skill and ability in identifying the clouds listed in the vocabulary.
   c. An understanding of clouds and cloud types is most valuable in weather forecasting.
3. Fog, smog, and haze
   a. Fog is a cloud that is clinging to the earth. When the warm air from the earth rises and cools, the moisture in the air condenses. If this occurs right at the surface, fog then forms.
   b. The best-known fogs are advection fogs. Advection is the transfer of heat through horizontal motion of the air.
   c. Ground fog is a good example of radiation-type fog. This fog usually forms shortly before sunrise.
   d. The mixture of fog and smoke is smog.
   e. Smog forms only in stagnant air. The air becomes stagnant when a great dome of high pressure settles down over a region. Winds in the high pressure area are light. The air in the high area sinks.
   f. The smoke control program in the larger cities is helping clean the air and thus prevent smog.
4. Clouds above the troposphere
   a. At an altitude of about 45 miles, thin type clouds composed of some kind of fine dust, or possibly water, are sometimes observed. These kinds of clouds are called noctilucent clouds. They may travel at terrific speeds of more than 340 miles per hour.
   b. At high latitudes (50 to 600 miles) auroras may result from cosmic rays hitting the ionized particles in the ionosphere. Auroras are not considered clouds.

C. Suggested Activities

1. Take pictures of cloud formations. If your camera is a kind to which you can attach a filter, buy a yellow (K-2) and a red filter. Take them along with you on a cloud hunt. Try each filter separately to to see which one works better. Take pictures of clouds of various types to enlarge and exhibit. Some may desire to try color film using a haze filter. The slides can be shown to the class.
2. Obtain from the U. S. Department of Commerce, Weather Bureau, a chart showing actual pictures of various cloud forms. Write the Superintendent of Documents, Washington, D. C., for current information concerning the chart.
3. Report on characteristics of the 10 cloud types listed using various reference books. Students with special interest may desire to know about all 27 of the types used by the Weather Bureau.
4. Display cloud pictures on the bulletin board. *Life* and *Look Magazines* are good sources.
5. Have reports on the danger of fog to to the driver of a car, the captain of a ship, or the pilot of an airplane.
6. Hold a lighted match at the mouth of an inverted gallon jug so smoke particles will enter the jug. Next blow

the breath into the jug several times to raise the relative humidity. This, together with the suspended smoke particles, creates ideal conditions for condensation. Now place the mouth of the jug against the lips, blow hard, and release the pressure suddenly. The sudden release of the pressure cools the air slightly and a thick fog forms. Blow into the jug again and the fog disappears. It reappears when the pressure is again released.

7. Try the same experiment without seeding the air in the jug with smoke particles.
8. Report on the smog problem in Los Angeles.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Gallon jug
2. Matches

F. Teacher Notes

There are several ways to produce a fog or cloud in a jug. One way is listed above. Students may find other ways.

VII. AIR MASSES OF NORTH AMERICA

A. Vocabulary

1. Source regions
   a. Polar Canadian (Continental) (Pc)
   b. Polar Pacific (Maritime) (Pp)
   c. Polar Atlantic (Maritime) (Pa)
   d. Tropical Continental (Tc)
   e. Tropical Gulf (Tg)
   f. Tropical Atlantic (Ta)
   g. Tropical Pacific (Tp)
2. Circulation
3. Horse latitude
4. Doldrum
5. Meteorology
6. Cold front
7. Warm front
8. Occluded front
9. Stationary front
10. Front

11. Occluded
12. Turbulence

B. Concepts and Understandings

1. Source regions
   a. Source regions are places where air moves slowly or almost stands still for days or even weeks at a time.
   b. Air that is changed in a source region is known as an air mass.
   c. Our weather is produced by huge masses of air that come from different source regions and travel in different ways across North America.
   d. When air masses meet a storm usually develops.
   e. The rising air over the equator results in low barometric pressure.
   f. The sinking air over the polar regions results in high barometric pressure.
2. How air masses change
   a. A warm air mass grows cold as it travels northeastward in the winter, but cold air that travels southeastward grows warmer and becomes humid.
   b. When the air mass is forced over the mountains, moisture is lost by condensation. As the air mass follows the downslope on the opposite side, it is warmed but still dry.
3. When air masses meet
   a. Warm air masses are deflected to the east and cold ones to the west.
   b. If the cold air mass is moving, we have a cold front.
   c. If the moving air mass is warm, we have a warm front.
   d. When a cold front approaches, towering cumulus or cumulonimbus clouds gather overhead. In the summertime, terrific turbulence, thunder, and lightning with showers would be quite typical.
   e. Warm front weather may take days to develop. The first sign of an approaching warm front is a feathery cirrus overhang, high in the air above. The clouds get heavier and lower. Then follows a steady rain which may continue for several hours or days. When the wind shifts to the southeast, the sky clears and the weather is hot and muggy. The warm front has arrived.
   f. The occluded front occurs when a cold front, closely following a warm front, finally overtakes the warm air mass off the ground. Occluded fronts may be either warm-front type occlusions or cold-front type occlusions.
   g. Stationary fronts are those which move little or not at all. Stationary fronts with rain may hang on for days. Of course, it could be hot or cold depending on the season of the year.

C. Suggested Activities

1. Locate on a map of North America, the seven source regions in which air masses form before traveling across the continent. Indicate the properties of each air mass after it has been formed.
2. Study U. S. weather maps for a two-week period and report on air mass movement. Sample maps may be obtained for a small charge from the U. S. Weather Bureau, Washington, D. C. Local newspapers also print an official weather map daily.
3. Record the movements of cold fronts and warm fronts on daily weather maps for a two-week period. Note particularly the direction of movement.
4. Show the types of weather associated with the various frontal systems by sequence weather reports.

VIII. STORMS

A. Vocabulary

1. Storm
2. Energy
3. "Eye"
4. Static electricity
5. Electron
6. Atom
7. Sound
8. Proton
9. Heat lightning
10. Thunderhead

B. Concepts and Understandings

1. General storms
   a. General storms occupy large areas of land or water.
   b. Cyclones occur over large land areas and may be 1,000 miles in diameter. They are great masses of air whirling in a counterclockwise direction.
   c. Hurricanes and typhoons
      (1) Hurricanes are born where the sea is warmest.
      (2) A hurricane averages 400 miles in diameter and often has winds of over 150 mph.
      (3) The southwestern part of the North Pacific has more hurricanes than any other place on earth. Next comes the South Indian Ocean, and third the West Indies.
      (4) Hurricanes are violent because of the tremendous energy released by the continuous condensation.
      (5) A typhoon is simply a hurricane by another name.
      (6) The round, clear "eye" or center of the storm may range in diameter from two or three miles to 75 miles. The lowest air pressure is found in the eye.
      (7) The United States Navy maintains hurricane flying teams on 24-hour alert to scout the storms.
2. Local storms
   a. Thunderstorms and lightning

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. *Air Masses and Fronts.* U of I, U-2918. 25 minutes. Color.
2. Chart: *Understanding Our Weather.* Copyright by C. S. Hammond and Company, New York.

F. Teacher Notes

(1) Thunderstorms occur when there is a great difference in the temperature between the air close to the earth and the air high above the earth.
(2) Lightning is a current of electricity surging through the air.
(3) The breaking up of big raindrops in a thunderstorm probably causes the electric charges to separate.
(4) In a single storm there may be several thousand flashes of lightning.
(5) Frontal thunderstorms are due to vertical displacement of warm, moist air by a cold air mass.

b. Tornadoes and waterspouts
(1) The whirling winds of a tornado may reach a velocity of over 500 mph. At the same time, there is an updraught in the center that lifts air at 100 or 200 miles per hour.
(2) A tornado at sea is called a "waterspout."
(3) The average path is about 1,000 feet wide and rarely more than 25 miles long.
(4) The proper conditions for tornado formation are found just ahead of severe cold fronts when the warm air in advance of the front is very moist.
(5) The tornado is the most violent of all storms. A most impressive sight is the funnel-like shape of the tornado itself. The funnel appears at the base of a cloud.

c. Blizzards

Blizzards are high, cold winds, filled with blinding masses of fine snow. They are common in the interior of North America.

C. Suggested Activities

1. Have a report to show the difference between cyclones and tornadoes.
2. Have a committee report on hurricanes and the "hurricane hunters" sponsored by the U. S. Navy and the U. S. Air Corps.
3. Collect information on a few of the most destructive hurricanes of the past.
4. Tell how hurricanes are named.
5. Look up in the Statistical Abstract of the U. S., the World Almanac, or other sources, the number of deaths caused by lightning in the U. S. A.
6. Read an account of Ben Franklin's experiment with the kite. (Remember do not perform this experiment yourself.)
7. Charge an electroscope or pith balls with positive and then negative electricity.
8. Charge an electrophorus with negative electricity and explain how the disk is charged positive.
9. Tell why lightning and thunderstorms are most common during the months of July, August, and September. A thunderstorm is a rare occurence in the northern part of the country during the winter months.
10. Construct a demonstration tornado.
11. Construct a box frame with glass for two sides and with the other sides painted black or lined with black velvet for contrast. Single strength glass is satisfactory. Make the top side of wood with a six inch hole cut to accommodate a chimney which should be the same diameter and four to five feet high. The box should be 15 inches on a side, with vertical slots about ¾ inch wide. (The glass thus must be cut about 14½ inches wide.) The box should be constructed so that it can be set in a metal pan 15¼x15¼ in. and one inch deep. Thus the box will have no bottom. Place about ¼ inch of water in a metal pan and set the entire apparatus on a hot plate, or support it and place a Bunsen burner under it. Heat slowly (make sure the chimney is in place) and as it is heating, project a light into one side. A funnel cloud will appear against a dark background at right angles to the

light beam. The view will be better if the lights in the classroom are turned off and the window curtains pulled.

8. Electrophorus metal disk (disk should have an insulated handle)
9. Hard rubber rod
10. Glass rod
11. Piece of silk
12. *Waco Disaster Study* (University of Texas). U of I, U-4146. 28 minutes.
13. *Tornado Safety Rules.* U. S. Department of Commerce, Weather Bureau. (Obtain several copies.)

F. Teacher Notes

D. Teacher and Pupil References

IX. THE UNITED STATES WEATHER BUREAU

A. Vocabulary

E. Audiovisual Aids, Equipment, and Supplies

1. Collect pictures from *Life, Look,* and other magazines showing the formation hurricanes and typhoons take.
2. *Static Electricity.* U of I, U-4521. 11 minutes.
3. *Story of a Storm.* U of I, U-3128. 11 minutes.
4. Electroscope
5. Pith balls
6. Ring stand
7. One-half cat fur or piece of wool

B. Concepts and Understandings

1. History of the development of meteorology as a science
   a. Francis Bacon (1561-1626) is believed to have made some contributions to adoption of the scientific method in meteorological circles.

b. Galileo Galilei (1564-1642) is believed to have first given Torricelli a clue as to the true nature of atmospheric pressure.
c. Robert Boyle (1627-1691) gave us the law on relationships of volume to pressure, which was the first step toward a study of the dynamics of the atmosphere.
d. Edmund Halley (1656-1742) endeavored to connect the distribution of the sun's heat over the earth's surface with the general circulation of the atmosphere.
e. Benjamin Franklin (1706-1790) is believed to have been the first American to recognize the general west-to-east movement of the weather in temperate regions of North America.
f. During the period from 1600 to 1850, there were many developments in meteorological instruments.
g. The United States Weather Bureau was established in 1890, with headquarters in Washington, D.C. There are now more than 1,000 observation stations throughout the country.

2. Services supplied by the U. S. Weather Bureau
   a. Making weather maps and forecasting the weather.
   b. Making special forecasts for aviators.
   c. Issuing warnings of storms, frost, and floods.
   d. Making special forecasts in connection with forest fires.
   e. Keeping records of the weather.
   f. Publishing crop reports.
   g. Studying the weather and publishing accounts of anything new that is discovered.
   h. Maintaining the Forest Fire-Weather Warning Service.
   i. Issuing daily bulletins and forecasts for business, commerce, industry, and the public.

C. Suggested Activities

The development of meteorology as a science makes a good extra credit report for an interested student or small committee of two or three. A special bulletin board could be used to advantage to show the development of meteorology.

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

F. Teacher Notes

X. PREDICTING THE WEATHER

A. Vocabulary

1. Superstition
2. True
3. False
4. Forecast
5. Isobar
6. Isotherm
7. Teletype
8. Wirephoto
9. Apogee
10. Inertial guidance
11. Orbit
12. Perigee
13. Satellite
14. Vacuum

B. Concepts and Understandings

1. Weather sayings (see end of this unit)
2. Observations made by the weather bureau
   a. The usual observations include
      (1) Cloud coverage and type of clouds
      (2) Air pressure
      (3) Air temperature and dew point
      (4) Air moisture
      (5) Wind speed and direction
      (6) Precipitation last three hours
      (7) Visibility
      (8) Pressure tendency
      (9) State of the weather
   b. Other observations made by some weather stations are
      (1) Aviation weather including ceiling, altimeter setting, notices to airmen (NOTAMS) concerning items such as radio facilities, field and runway conditions, upper wind reports (RAOB), which include humidity, pressure, and temperature
      (2) Sunshine recorders
   c. Methods and special instruments used to obtain weather data
      (1) The radiosonde
      (2) Sky Hook and Transosonde
      (3) Weather radar
      (4) Weather ships
      (5) Hurricane hunters
      (6) Robot weather stations
      (7) Rockets and satellites
3. Weather maps
   a. The United States daily weather map
      (1) Station model
      (2) 500-millibar constant pressure chart
      (3) Highest and lowest temperature map
      (4) Precipitation areas and amounts map
      (5) Millibars-to-inches conversion scales
      (6) Codes and map plotting
   b. Official maps are made eight times per day.
   c. The weather map is very useful because it gives much information in a short time.
   d. Practically all weather forecasts are made after studying various weather maps for surface and upper air conditions.
   e. At present, only about 10 per cent of the earth's atmosphere can be observed.
4. Weather stations in outer space
   a. Weather stations in outer space (300 to 500 miles above the earth and in orbit) would make it possible to observe and predict weather conditions around the world. Calculations could be made in minutes that now take hours or days.
   b. Two or three weather satellites could observe the weather around the entire earth every few hours.

C. Suggested Activities

1. Develop several sample code reports. Let students learn to plot, on a prepared map around a station circle, the weather data similar to that shown on the sample station model found on the map side. (If a map is not available, divide a sheet of typing paper into squares with the station circle at the center. This square should be at least two inches on a side.)
2. Work as a class, giving various students an opportunity to interpret the symbols and numbers around various station circles found on the U. S. Daily Weather Map. (This would require that all students have access to a map and that all maps be dated the same.)

D. Teacher and Pupil References

E. Audiovisual Aids, Equipment, and Supplies

1. Obtain from the Weather Bureau copies of the United States Daily Weather Map. All maps should have the same date. Order sufficient copies for each student. Cost is about two cents per copy.
2. Subscribe to the Daily Weather Map during the school year. Have a month's supply on hand before starting the weather unit.
3. Obtain two or three special maps of the United States equipped with plastic covering permitting the use of special erasable crayons. This type of map is useful in showing progress of fronts and special weather conditions in various parts of the country. (Map size about 40 in. x 30 in. is satisfactory.)
4. Use United States Daily Weather Maps, newspaper weather maps, and maps shown on television.

F. Teacher Notes

When requesting the maps, allow at least four weeks for delivery. Make sure you make it clear that all maps are to be duplicates with the explanation of the weather map on the back side.

XI. WEATHER SAYINGS AND SUPERSTITIONS

1. Dark clouds in the west,
   Stay indoors and rest.
2. When the sunset is clear,
   A cool night draws near.
3. When high clouds and low clouds do not march together,
   Prepare for a blow and a change in the weather.
4. When clouds move down and turn dark gray,
   A rainy spell is on the way.
5. A ring around the sun or moon,
   Brings rain or snow upon you soon.
6. When radio programs are peppered with static,
   There'll be lightning and thunder and weather aquatic.
7. When windows won't open and salt clogs the shaker,
   The weather will favor the umbrella-maker.
8. Smoke drifting lazily, close to the ground,
   Tells us that rain may be coming around.
9. Welcome the sound of crackling hair;
   It tells of weather clear and fair.
10. When teeth and bones and bunions ache,
    Expect the clouds to fill the lake.
11. Hark to the cricket, whose chattering sound
    Will tell you how hot is the air near the ground.
12. Flies and mosquitoes are biting and humming;
    The swallows fly low; a rainstorm is coming.
13. When marshy smells and flowery perfumes
    Invade the air, a rainstorm looms.
14. Red sky in the morning, sailor take warning.
    Red sky at night, sailor's delight.
15. When the wind veers too much to the east,
    'tis good for neither man nor beast.'
16. If the ground hog sees his shadow on February 2, there will be six weeks of bad weather.
17. When animals grow heavy coats, there will follow a cold winter.
18. Signs of Fair Weather
    The pressure is steady or rising;
    The wind is from the west, northwest, or a little south of west;
    There is a bright red sunset in a clear sky.
    The clouds are very high and do not grow;
    Cumulus clouds are white and decrease toward evening.
19. Signs of Approaching Rain
    The pressure is falling;
    Cirrus clouds develop and spread into cirrostratus;
    The clouds become lower and thicker;
    Cumulus clouds grow very high and dark (by 11 a.m.);
    The air is very hot and moist;
    A west wind changes to a south or east wind.
20. Signs of Clearing
    The clouds rise and scatter;
    The pressure rises and the temperature falls;
    The wind shifts to the west.
21. Dew on the grass in the morning is a good sign that there will be few clouds and no rain during the day.
22. Thunder in the early morning,
    Is a stormy weather warning.
23. If a ring around the moon,
    Rain is coming very soon.
24. Morning fog and drenching dew,
    A clear day is coming through.
25. South wind mild, and west wind fair;
    East wind storm, north wind chill air.
26. When cloudy days at sunset clear,
    Fair, cool weather's very near.
27. Evening red and morning gray,
    Sure sign of a lovely day.
28. Smoke rising upward in the air,
    Means the weather will be fair.
29. Mackerel scales and mare's tails,
    Warn great ships to carry small sails.
30. Animals with heavy fur in the fall indicate a cold winter to come.
31. When the crescent moon can hold water, it will be dry.
32. Fish bite best as the moon grows full.
33. Rainbow at morning, sailors take warning; rainbow at night, sailor's delight.
34. Flies and mosquitoes are biting and humming;
    The swallows fly low; a rainstorm is coming.
35. Some people, especially those with joint diseases, say that they can feel "rain in their bones."
36. Rain before seven, stop before eleven.
37. Birds perch more when a storm is coming on because low-pressure air is less dense and makes it harder to fly.
38. Gunners know that fowl tend to fly higher in good weather than in bad. Low air pressure affects their ears.

39. Lightning in the west or northwest usually is part of a storm that will reach you. Storms to south or east go past.
40. Dew on grass at night or in early morning is a sign of fair weather. It forms only when air is dry and skies are clear.
41. High clouds won't rain on you, no matter how threatening they look. It's lowering clouds that do the business.
42. Rising smoke foretells fair weather. Lowering pressure and unstable air, preceding a rain, drive smoke downward.
43. When the air is humid, rain is more likely at low than at high tide. Falling tide reduces atmospheric pressure.
44. High visibility over salt water means rain is on the way. Salty haze is dispelled by unstable air currents.
45. Leaves show backs before rain. They grow according to prevailing wind; a change of wind turns them over.
46. When distant sounds are loud and hollow, look for rain. Lowering cloud ceiling acts like a sounding board.
47. Smells are stronger before rain. Odors held captive by high atmospheric pressure escape when barometer drops.
48. Face the wind, and the storm will be on your right. In this hemisphere, winds circle low counterclockwise.

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