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COMMONWEALTH OF PENNSYLVANIA.

DEPARTMENT OF AGRICULTURE.

BULLETIN NO. 63.

A COURSE IN NATURE STUDY FOR
USE IN THE PUBLIC SCHOOLS.

By *LOUISE MILLER.*



PUBLISHED BY DIRECTION OF THE SECRETARY.

1900.



WM. STANLEY RAY,
STATE PRINTER OF PENNSYLVANIA.
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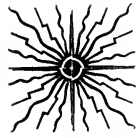
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PREFACE.

Harrisburg, Pa., June 25, 1900.

The following Bulletin, giving a course in Nature Study for the public schools, is one of the most important and valuable of all of those which the Department has hitherto published. The course was outlined and prepared by Miss Louise Miller, who for several years had charge of Nature Study work in the schools of Detroit, Mich., and will commend itself to natural history teachers as being not only scientifically accurate and exceedingly suggestive, but as also outlining in a systematic way, a branch and method of education peculiarly adapted to country schools. The study of nature, by observing the things themselves, is the new and rational method of instruction and constitutes what now is known by the modern name, "Nature Study."

This bulletin is intended as a guide to teachers, indicating the subjects adapted to each grade of scholars, and giving the order in which the subject ought to be pursued. An inspection of the work proposed by this course will show how much there is in the vicinity of every country school to interest and instruct in the numerous natural objects, in regard to which the mass of our population have but little knowledge, and which, if properly presented, may be, at least partially understood, by the smallest pupil.

The bulletin is also informal notice to teachers in Pennsylvania that in the near future, such instruction as it outlines, will be required in every country school. Those, therefore, who wish to follow this profession will do well to acquaint themselves with the method here presented, and begin preparation for the work to be performed, so that when their examiners come to question them as to natural objects, whose uses and characteristics they are expected to understand and explain to others, they may be ready to answer intelligently, and satisfactorily perform the duties required.

This is no new fad in education, but is older than the Commonwealth itself. William Penn, near the close of his life, in a work entitled "Reflections and Maxims," suggested substantially the method now proposed to be pursued in the education of our youth. His words are so closely in accord with advanced modern thought in education along nature study lines, that I present them here in full in the hope that the most conservative may be influenced to accept

this teaching, and adopt the new education, which promises so much for the development of country children and country life.

He says:

“The world is certainly a great and stately volume of natural things and may be, not improperly, styled the hieroglyphics of a letter; but, alas, how very few leaves of it do we seriously turn over! This ought to be the subject of the education of our youth; who, at twenty, when they should be fit for business know little or nothing of it. We are in pain to make them scholars but not men; to talk rather than to know, which is true canting. The first thing obvious to children is what is sensible; and that we make no part of their rudiments. We press their memory too soon, and puzzle, strain and load them with words and rules to know Grammar and Rhetoric, and a strange tongue or two, that it is ten to one may never be useful to them; leaving their natural genius to mechanical, physical or natural knowledge, uncultivated and neglected; which would be of exceeding use and pleasure to them through the whole course of their lives.

“To be sure, languages are not to be despised or neglected; but things are still to be preferred. Children had rather be making tools and instruments of play, shaping, drawing, framing, building, etc., than getting some rules of propriety of speech by heart; and these also would follow with more judgment, and less trouble and time.

“It were happy if we studied nature more in natural things; and acted according to nature; whose rules are few, plain and most reasonable. Let us begin, therefore, where she begins, go her pace, and close always where she ends, and we cannot miss of being good naturalists. The creation would not be longer a riddle to us. The heavens, earth and waters, with their respective, various and numerous inhabitants, their productions, natures, seasons, sympathies and antipathies, their use, benefit and pleasure, would be better understood by us; and an eternal wisdom, power, majesty, and goodness, very conspicuous to us, through these sensible and passing forms; the world wearing the mark of its Maker whose stamp is everywhere visible, and the characters very legible to the children of wisdom. And it would go a great way to caution and direct people in their use of the world, that they were better studied and known in the creation of it. For how could men find the confidence to abuse it, while they should see the great Creator stare them in the face, in all and every part thereof? Their ignorance makes them insensible; and to that insensibility may be ascribed their hard usage of several parts of this noble creation; that has the stamp and voice of a Deity everywhere, and in everything, to the observing.

“It is a pity, therefore, that books have not been composed for youth, by some curious and careful naturalists, and also mechanics. in the Latin tongue, to be used in schools, that they might learn

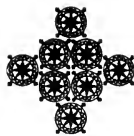
things with words; things obvious and familiar to them, and which would make the tongue easier to be obtained by them.

“Many able gardeners and husbandmen are ignorant of the reason of their calling; as most artificers are of the reason of their own rules that govern their excellent workmanship. But a naturalist and mechanic of this sort is master of the reason of both; and might be of practice too, if his industry kept pace with his speculations, which were very commendable, and without which he cannot be said to be a complete naturalist or mechanic.

“Finally, if a man be the index or epitome of the world, as philosophers tell us, we have only to read ourselves well, to be learned in it. But because there is nothing we less regard than the characters of the Power that made us, which are so clearly written upon us, and the world he has given us, and can best tell us what we are and should be, we are even strangers to our own genius; the glass in which we should see that true, instructing and agreeable variety, which is to be observed in nature, to the admiration of that wisdom and the adoration of that Power which made us all.”

Had these suggestions been adopted at the time they were offered, the education of to-day would have been far in advance of its present state, and the country schools in Pennsylvania would be turning out classes of enthusiastic scholars, informed and interested in the wonderful phenomena of the natural world in which they have been placed, and which they are endowed with power, to study, use and enjoy.

JOHN HAMILTON,
Secretary of Agriculture.



LETTER OF TRANSMITTAL.

To Prof. John Hamilton, Secretary of Agriculture:

Dear Sir: I have the honor to present herewith the Bulletin upon a course in "Nature Study," which, several months ago, you requested me to prepare.

My hope is, that it may prove useful, in directing the attention of school directors and teachers, to the importance and practicability of the study of nature in our public schools.

Nature Study should mean Nature loving. Its object should be to open the minds and hearts of the children to a greater interest, keener appreciation, deeper reverence for the beauties and wonders of creation. The inquiring minds should be quickened.

Most of the work outlined has been accomplished by children in the grades indicated. As conditions differ, each teacher should select from the outline material which can be used to best advantage, and arouse the greatest interest. It is neither expected nor desired that all the work herein outlined shall be accomplished, but that it shall prove largely suggestive.

It is hoped all will grasp fundamental principles and teach only that which is vital. Too much time is spent upon non-essentials, and the great unity in nature overlooked. Nothing should be taught in isolation, but the close relation between organic and inorganic should be emphasized. Plants should be studied as the great animating principle, forming a connecting link between dead mineral matter and the highly organized animal life.

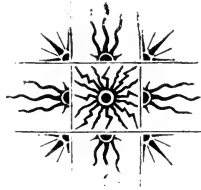
Teachers should constantly encourage pupils to collect material, to construct apparatus, to observe all natural phenomena, and then gradually lead them to discover relations. All knowledge is largely a matter of relations. The ethical value also should always be prominently brought out.

Pupils should be led to realize their place in nature, and to feel that they are but higher expressions of the same energy which produced a drop of dew, or a world.

Very respectfully,

LOUISE MILLER.

Ithaca, N. Y., June 25, 1900.





A COURSE IN NATURE STUDY FOR USE IN THE PUBLIC SCHOOLS.

FIRST GRADE.

SEPTEMBER.

PLANTS.

Compare growth of twigs on different trees—maple, horse-chestnut, poplar, spruce.

Relation of insects to leaves—used as nests, for food, for depositories for eggs, not disturbed.

Fruits.—Classification as to color and taste; reason for color and taste.

ANIMALS.

Migration of birds. Study cat and dog. Compare coats as to texture, color, distribution, warmth and protection.

ELEMENTARY GEOGRAPHY.

Construct a magnetic needle to determine directions.

Daily record of day, date, frost or dew, direction of wind, clouds or fogs, rain, temperature.

Locate places in the horizon where the sun rises and sets. Position of sun at noon; morning and evening star.

MINERALS.

Make collections of pebbles. Classify as to color, form, smoothness, weight, etc. Examine coarse and fine sand. Relate to smoothness of pebbles, and effects of water.

NOTE.—In the study of trees, observations should be confined to a few throughout the year. The shape, bark, wood, leaves, blossoms, fruit cocoons, should be studied and comparisons made. The life infesting the tree should be noted, and, if possible, reasons assigned.

Place list of different kinds of birds observed by pupils during summer in a conspicuous place on the board, also list of those observed during first weeks of school. Relate migration of birds to Weather Record, noting effect of temperature upon insect life, growth, bud scars and leaf scars. Relate structure and migration to food getting; robin and earthworm; woodpecker and grub; quail and seeds.

Construct magnetic needle by magnetizing end of a needle with opposite poles of a magnet, inserting through center of small cork, and suspending by silk thread.

Suspend a prism in a window where the sun may strike it, forming a spectrum.

Compare color of flowers, leaves, fruits, pebbles with spectrum, noting prevailing color.

Much attention should be given to sense-training. Children should be led to detect form and texture by touch alone, perfume by smell, sound by hearing, flavors by tasting, weight by the muscular sense, different fruits, leaves, flowers, minerals, birds, insects by sight.

OCTOBER.

PLANTS.

Buds for next year's growth; color of bark, growth of wood; hardness of bark and wood.

Leaves.—Effect of frost, color of falling leaves, leaf-scars. Seeds.—Distribution by wind, bursting pods. Protective coloration of seeds.

ANIMALS.

Disappearance of birds, insects and animals. Relate covering to disappearance. Compare movements of cat and dog with birds, insects and other animals.

ELEMENTARY GEOGRAPHY.

Compare frost, dew, winds, clouds, fogs, rain and temperature with September.

Change in rising and setting sun; position of sun at noon. Change of length of day and night.

MINERALS.

Classify as to physical properties sandstone and limestone. Compare sand and clay. Relate to disappearance of frogs, turtles, snakes, etc.

NOTE.—Children should be led to see that destiny of trees does not depend alone upon the production of its seeds, but that much of its energy is devoted to growth. Compare number of buds formed by different trees and relate to its development. Relate falling leaves to disappearance of sap into roots, structure of leaves to distribution, etc.

Fruits whose germs are destroyed when eaten, are usually of a dull color when ready for distribution—nuts; those whose germs are not so destroyed, assume a brilliant color; luscious taste and fragrant odor—cherries, peaches, grapes.

Relate frost to disappearance of birds and insects, winds to distribution of seeds, change of position of sun to change in temperature and its effects upon life. In primary grades pupils should be forming geographical concepts and they can do so most effectually by coming in contact with things.

NOVEMBER.

PLANTS.

Preparation of twigs for winter—thickened bark, scales on buds, etc.

ANIMALS.

Preparation of animal life for winter. Compare covering of cat, dog and sheep in their preparation for winter. Use of wool for clothing.

ELEMENTARY GEOGRAPHY.

Prevailing winds cold or warm, wet or dry. Clouds higher or lower than in September and October. Examine frost crystals.

Compare rising, setting and position of sun at noon with September. Rising of new, full and waning moon.

MINERALS.

Examine granite and marble. Compare size of crystals. When are snow crystals large?

NOTE.—Compare preparation of twigs, thickening of bark, number and character of scales on bud, varnish and protection of leaves inside of bud. Relate change in temperature to preparation of animals for winter. Relate change of position of sun to change of temperature.

DECEMBER.

PLANTS.

Effect of frost upon plant life; protection and use. Any germination.

ANIMALS.

Compare dog, cat, sheep, horse and cow as to movements, means of getting food, means of protection, use to man.

ELEMENTARY GEOGRAPHY.

Examine snow-flakes. Frost and snow protection to life.

Compare rising, setting and position of sun at noon with September.

MINERALS.

Compare structure of granite, marble, limestone, and sandstone.

NOTE.—Relate length of day to frost and its effects. Spruce trees should be studied in relation to Christmas. Difference between evergreen and deciduous trees, leaves and needles, fruit and cones, bark, wood, etc. Relate structure of animals to environment. Compare manner of putting down the feet, length and structure of limbs, cushions, claws, hoofs, etc. Relate to manner of getting food. Relate snow flakes and frost, dew and rain, to change in temperature. Note effect of frost upon soils. Relate to plants and seeds and hibernating animals.

JANUARY.

PLANTS

Effect of warm days upon plants. Enemies of buds—birds and frost; protection of buds. Sap in trees.

ANIMALS.

Compare food of January and June. Compare teeth of dog and cat, sheep, cow and horse with human teeth and relate to kinds of food.

ELEMENTARY GEOGRAPHY.

Compare number of rainy or snowy days with December. Increase of day; rising and setting sun. Compare with November.

MINERALS.

Compare physical characteristics of granite, marble, sandstone, limestone and slate.

NOTE.—Of what advantage or disadvantage, are warm days in January to plants? When and why are buds used by birds as food? Examine twigs of maple, horse-chestnut, and spruce. Note buds destroyed by birds, wind, or killed by frost. Compare hibernating and non-hibernating animals as to covering, structure, manner of getting food, etc.—turtle, cat, dog or bird. Place hibernating animals in a box of moist earth and permit pupils to observe them disappear.

FEBRUARY.

PLANTS.

Determine location of frozen buds on twigs; number found, kind, number killed and number alive.

ANIMALS.

Manner in which dog, cat, sheep, horse and cow take their food. Compare prehensile organs with man's.

ELEMENTARY GEOGRAPHY.

Increased or decreased temperature since December. Compare January and February. Prevailing wind—cold or warm.

Compare length of day and night with previous months. Note sunrise and sunset.

MINERALS.

Compare different kinds of coal in color, weight, softness, hardness, etc.

NOTE.—Observe the amount of work done by different trees in preparation for winter. Relate to effectiveness. The horse-chestnut has a few well protected buds prepared; others many, but not so well protected. Moral lesson.

Function of leaves, assimilation of food.

Compare this year's growth of horse-chestnut, maple, and spruce as to number, size, shape, texture, etc. Reason.

Compare perfection of jaws of animals with length of jaw.

MARCH.

PLANTS.

Study tree—environment, beauty, form, leaves, blossoms, etc.

ANIMALS.

Begin Natural History Calendar—observation, day, date; by whom, remarks. Watch for the first appearance of birds.

ELEMENTARY GEOGRAPHY.

Change in cloudiness, rainfall. Compare with September and December.

Compare length of day and night.

MINERALS.

Compare granite, limestone, marble, sandstone and coal, as to color, texture, weight, tenacity.

NOTE.—Effect of location of a tree near house, other trees, in open space. Observe trunk and branching of maple, horse-chestnut and spruce. Note beauty, grace, symmetry, form. Press specimens of leaves from different kinds of maple trees, also preserve fruit of trees.

APRIL.

PLANTS.

Germination of seeds—bean, pea, corn, wheat.

ANIMALS.

Appearance of moths and butterflies. Change in covering of cat, dog, sheep. Compare eyes. Imitate sounds made by cat, dog and sheep.

ELEMENTARY GEOGRAPHY.

Observation of temperature, direction of wind, number of foggy and clear days. Compare with other months.

Relate lengthening day to change in movement of sun; to shadow at noon. Compare with previous months.

MINERALS.

Examine sand, gravel, loam and clay. Value of earth in relation to plant life.

NOTE.—Examine dry and soaked peas, beans, corn, and wheat. Note coats, scars and opening near the scar.

In all work in plant life, as in every other study, thought should first be acquired, and then expression.

Collect larvae during the fall, permit pupils to see and note date of spinning cocoons, and appearance of insects.

Animals and plants should be studied in life cycles.

Relate movement of sun to temperature and its effect upon life.

Encourage pupils to plant seeds at home and care for the plants.

MAY.

PLANTS.

Flowers; buds, color, perfume, honey; pollen distributed by insects, wind; leaves—blade, parallel and netted veined.

ANIMALS.

Observe habits of common birds, location and kinds of nests, protective coloration of feathers.

ELEMENTARY GEOGRAPHY.

Compare clear, cloudy and rainy days with April.

Continued observation of sun and shadow; relate to temperature and life.

MINERALS.

Study of soils.

NOTE.—In teaching flowers, technicalities should be avoided. Emphasize color, form, marking, perfume, honey. Influences which produced the flower—earth, air, rain, sun, insects, birds.

Relate soils to food for plants.

JUNE.

PLANTS.

Continued study of flowers and leaves. Parts of flowers—calyx, sepals, corolla, petals, stamens, carpel. Plants as wholes.

ANIMALS.

Birds—hatching of young, care of young, food. Compare young of cats, dogs, birds, butterflies, in covering, ability to help themselves, food, movements, etc.

ELEMENTARY GEOGRAPHY.

Thunderstorms, hailstones. Destructive effects of each. Compare length of day and night.

NOTE.—Children can readily distinguish parts of fruit blossoms. The dandelion should be studied as a whole.

The sparrow, robin, woodpecker and criole are best adapted to this grade.

SECOND GRADE.

SEPTEMBER.

PLANTS.

Compare growth of twigs of different trees, of different years. Oak, elm, pine.

Relation of insects to leaves as food, as nests, as depositories for eggs. Prevailing color in same leaves. Plants storing food.

ANIMALS.

Migration of birds. Compare coats of squirrel and rabbit as to texture, color, distribution, warmth, protection. Habits of grasshoppers. Observe caterpillars spin cocoons. Prepare an ants' nest. See fifth grade.

MINERALS.

Visit a stream; forces acting upon pebbles; formation of marbles.

ELEMENTARY GEOGRAPHY.

Daily record of day, date, frost or dew, direction of wind, clouds or fogs, rainfall, temperature. Moon's phases, rising and setting sun.

Locate places in the horizon where the sun rises and sets.

NOTE.—Weather Records should be kept from year to year and differences in growth of different years should be referred to variations in atmospheric conditions.

Observations of life infesting trees continued.

Record of migration of birds same as Grade I.

Study squirrel and rabbit as to shape of body, head, ears, mouth, legs and paws.

Oak, pine, turnips, parsnips store food for animals.

Remove an ant hill to a glass fruit jar and cover with brown paper. Food—sugar. By removing the paper, halls, galleries, and habits may be observed.

Place larvae of insects in an empty chalk-box containing leaves on which they feed. Slide piece of glass in the top that the feeding and spinning cocoons may be observed. Record dates.

OCTOBER.

PLANTS.

Preparation of twigs for winter; disappearance of sap, drying leaves; falling leaves, scars; location and arrangements of buds; structure of seed for distribution—wings, pappus, hooks. Color of seeds.

ANIMALS.

Habits of squirrel, of rabbit, as to storing food—how, where, kind and quantity.

MINERALS.

Formation of pebbles. Compare as to transparent, translucent and opaque.

ELEMENTARY GEOGRAPHY.

Effect of prevailing wind upon clear, cloudy, wet and dry weather. Direction of heaviest rains. Compare with September.

Compare October and September as to rising and setting sun, length of day and night.

Constant position of North Star, revolution of Great Bear around it; pointers in Great Bear.

NOTE.—The wind distributed seeds are supplied with wings and pappus, usually found on tall trees accessible to wind. Seeds supplied with hooks grow on low bushes so they can attach themselves to passing animals. Before seeds are ripe they are enclosed in green pods or shucks, color of leaves of plants. When ripe, they are brown like earth upon which they fall. Compare leaf scars of horse-chestnut and butternut.

In studying squirrel and rabbit, secure a live specimen if possible. Pupils enjoy the action, and the results are more effective. Nothing engenders a love for animals as care of them. Collect nuts for food of squirrels. Observe manner of eating, manner of opening shell. Do you find shells in the woods which have been opened by squirrels?

Place fragments of rock in bottle of water and shake frequently. Place pebbles of different sizes in bottle and shake frequently. Which wears away more quickly?

NOVEMBER.

PLANTS.

Dormant condition of plant life: annuals—those producing many seeds; biennials—those storing nourishment; perennials—those producing buds and seeds.

ANIMALS.

Squirrel and rabbit—manner of eating. Food of squirrel stored by itself; food of rabbit stored by plants.

MINERALS.

Collect and classify metals and minerals—very soft, soft, hard and very hard.

ELEMENTARY GEOGRAPHY.

Frost or dew more common? Effect of wind, and clear or cloudy night upon formation of frost or dew.

Compare course of sun with September and October. Effect upon length of day and night; temperature.

NOTE.—Relate effect of shortening of days upon temperature and plant life.

Compare milkweed, turnip and tree. Destiny of annuals depends entirely upon production of seed. Count seeds in pods of one milkweed plant. Trace life history of biennial—appearance of root and stem of first year; root, stem, leaves, flowers, fruit of second year. Count seeds. Show relation between number of seeds prepared and number of buds formed by perennials.

Relate minerals and metals to material stored away in the ground for man's use.

DECEMBER.

PLANTS.

Effect of frost upon twigs, buds, and seeds.

ANIMALS.

Compare development of limbs in quadrupeds and bipeds; position of body in each; use of upper limbs. Compare squirrel and rabbit with cat and dog.

MINERALS.

Effect of thawing and freezing upon roots of plants. Power of granite, limestone, sandstone, coal, sand, clay, iron ore, copper ore to absorb and retain moisture.

ELEMENTARY GEOGRAPHY.

Increased or decreased cloudiness, rainfall; wind more or less variable; wind preceding rain or accompanying clearing weather.

Relation of line showing apparent paths of sun since September. Winter solstice.

NOTE.—Pupils should have definite ideas as to rising and setting of sun, its position at noon in December. From personal observation difference between animal and plant life of June and December carefully noted.

Development of most parts of animal organism is for the purpose of securing food. Erect position of body is proportioned to development of fore-legs as prehensile organs.

The work on minerals is for the purpose of showing the value of each for building purposes. Weigh in air, immerse in water and weigh again while wet. Difference in weight shows absorptive power. Effect of frost—cracking rock.

JANUARY.

PLANTS.

Dormant condition of plants.

ANIMALS.

Winter condition of animal life. Compare teeth of rabbit and squirrel with dog and cat. Compare teeth and food of each with man.

MINERALS.

Recognize different kinds of iron ore by color, hardness, crystals, weight. Relate to steel and sharp cutting instruments and tools.

ELEMENTARY GEOGRAPHY.

Month of greatest change in temperature. Compare prevailing winds with previous months. Effect of temperature upon rainfall.

Note sun at noon; apparent movement, effect upon day and night.

NOTE.—Effect of frost upon germination. Snow a warm covering. A poor conductor of heat, excludes cold and prevents radiation of heat. Relate prevailing winds to frost and snow.

Pupils should be led to see that animals use their claws for digging, and their teeth for cutting and tearing their food, but man has too many demands for his physical organism and is forced to construct tools for his use.

FEBRUARY.

PLANTS.

Winter condition of trees.

ANIMALS.

Compare structure of head, hand and teeth of different animals; effect of development of one upon the other. Compare jaw, teeth and hand of squirrel, rabbit and man.

MINERALS.

Recognize different kinds of copper ore by color, hardness, crystals and weight. Uses.

ELEMENTARY GEOGRAPHY.

Compare snowfall, rainfall and fogs with previous months.

Note lengthening day; morning or evening longer. Movement of sun on horizon.

NOTE.—Shape of tree, angle of branching, development of tree.

Compare head of cat or dog, sheep or cow, rabbit or squirrel, and human teeth.

Relation of lengthening of day to enlivening of bark and swelling of buds.

Use of copper for wires; value to man. Man's superiority over other animals in his use of tools.

MARCH.

PLANTS.

First awakening of plant life; select a tree for accurate and systematic study; difference between a tree and shrub.

ANIMALS.

Return of birds, appearance of insects. Natural History Calendar. Protective coloration of squirrel and rabbit.

MINERALS.

Study soils in relation to plant life; power of different kinds of soil to absorb and retain moisture.

ELEMENTARY GEOGRAPHY.

Highest and lowest temperature during the month; character and amount of cloudiness in March, December and September.

Compare number of rainy days, in autumn, winter and spring.

Vernal equinox; seasons of year since autumnal equinox; rising and setting sun; length of shadow at noon.

NOTE.—Observations should be recorded on Natural History Calendar. Foster an interest in Nature, and gradual unfolding of life.

Select a tree convenient for constant observation. Measure diameter, height of branching, etc. Secure transverse and longitudinal sections of wood of the same kind of tree. Note carefully color, hardness, softness, toughness of bark of different years' growth. Location and arrangement of buds. Study color, size, covering, protection, etc. Record first appearance of leaves, flowers and fruit. Study continued to end of year.

Nesting habits of birds; location of nests, material used. Birds of dull color have open nests,—brilliant colors concealed nests.

Relate color of squirrel to bark of tree, color of rabbit to ground and weeds. Why are black squirrels disappearing?

Study meadow-lark, owl, duck, snipe, tanager, duck; relation to color, structure to environment and manner of getting food.

APRIL.

PLANTS.

Observe germination of seeds, different parts of seed; ratio of leaf buds and flower buds.

ANIMALS.

Earthworm—food, manner of moving, value to mankind. Relate earthworm to preparation of soil for plants. Compare earthworm and squirrel and rabbit, as to appearance, senses, movements, manner of getting food.

MINERALS.

Power of different soils to absorb and retain heat. Relate to plant life.

ELEMENTARY GEOGRAPHY.

Wind that accompanies wet, dry, clear, cloudy or foggy weather. Difference between April and winter rains.

Compare course of sun with December, reason for shortening of shadow; relation of length of shadow to temperature.

NOTE.—Measure a gill of corn, wheat, beans and peas; soak twenty-four hours. Measure. Which absorb water? Let each pupil examine a dry and soaked seed. Plant seed in different kinds of soil—clay, sand and loam. Place in light, shade, and dark to detect influence of light upon plant. Record time of planting, first appearance above ground, dropping of exhausted cotyledons.

Seed.	Bean.	Pea.	Corn.	Wheat.
Planted.	April.			
Depth.	1 inch.			
Above ground.	April.			
Cotyledons.	Above.	Below.	Below.	Below.
Leaves.	Netted.	Netted.	Parallel.	Parallel.
Leaves.	Compound.	Compound.	Simple.	Simple.
Position.	Alternate.	Alternate.	Alternate.	Alternate.
Margins.	Entire.	Entire.	Entire.	Entire.
Shapes.				

To compare gradual development of plant, pull up, press, and mount specimens on alternate days, showing development of different parts from seed to seed. Development may also be observed by being placed in bottles of alcohol. Carefully date each specimen. Plant acorns in yard.

Fill a large sponge with flaxseed and place in a shallow dish filled with water. Keep moist.

Mark off a yard square and observe the work of earthworms. Each morning, carefully collect castings and measure. Some idea of amount of work being done in renewing and fertilizing soil. Study structure, food, habits, senses; adaptation of structure to environment. Pupils should be led to see that each plant and animal is adapted to perform its function in the economy of nature.

Relate April showers to increasing temperature—greater heat, greater evaporation, consequently greater condensation.

MAY.

PLANTS.

Reason for early appearance of wild flowers; food; protection and color of spring flowers; advantage of color; unfolding of buds. Venation.

ANIMALS.

Study snails—land and water snails; difference in structure, shells, food, etc. Compare with earthworm, as to senses, manner of moving, muscular action, food protections. Compare snail shells with other shells.

MINERALS.

Examine soils carefully. Origin of soil—decayed vegetation and disintegration of rock. Relate qualities of soil to vegetation.

ELEMENTARY GEOGRAPHY.

Number of frosts or dews; compare with November; temperature of nights; direction of prevailing wind. Relation of wind to rainfall.

Lengthening of days; changing course of sun and effects upon all life.

NOTE.—Compare roots of spring beauty, crow-foot, water-cress, Indian-turnip, tulip, crocus. Relate food stored by plants in roots to nourishment provided by cotyledons. Rapid growth due to food already assimilated.* Color to attract insects and effect fertilization of flower. Relate lengthening days and increasing temperature to appearance of wild flowers and abundance of pond life. Relate falling leaves to formation of vegetable mould. Effect of rain upon surface of ground to disintegration of rocks.

Note difference in growth of plants grown in sand and loam. Reason. Make a collection of spring flowers.

JUNE.

PLANTS.

Continue study of flowers. Arrangement of leaves on twigs; simple and compound, netted and parallel veined.

ANIMALS.

Insects; compare ants, spiders, flies and beetles; likenesses and differences in habits. Usefulness.

MINERALS.

Compare soil used as homes by ants, and earthworms. Effect of each upon soil.

Elementary geography.

*Compare annual and perennial rootstalks.

NOTE.—Parts of leaves—petiole, blade, midrib, veins, veinlets, base, apex, margin. Distinguish between simple, palmately and pinnately compound. Press and mount specimens of all species of oak leaves. Make a collection of acorns.

Recognize linear, lanceolate, oblong, elliptical, and oval forms. Bases—heart-shaped and shield-shaped. Apex—acute and obtuse. Margins—entire, toothed, notched.

Function of veins—to carry sap; blade—to absorb moisture and carbon dioxide.

Flower: Calyx—sepals, corolla—petals, stamens—filament, anther and pollen; carpel—ovary, ovules, style, stigma.

Study syringa and pansy.

Parts of insects: head—eyes, antennae, mouth-parts. Compare life history of each—egg, larva, pupa, imago; community life of ants. Habits of spiders and beetles. Encourage habit of personal observation on part of pupils.

The study of the ant is suggested for this grade, being accessible and harmless. The habits, home making and community life can better be observed in a nest than in the ground; food getting and storing by watching them in the grass and on sidewalks. Study members of the household:—queen, workers, warriors, etc. Note care of young, intelligence, communication; battles, excursions for food, etc.

THIRD GRADE.

SEPTEMBER.

PLANTS.

Relate growth of twigs on north, south, east and west side of trees to symmetrical development of tree. Study pine—type of excurrent tree, fruit tree—type of deliquescent tree. Note color of leaves on different parts of tree. Relate coloration of seed to distribution by animals as food, by animals in covering, by wind.

ANIMALS.

Distinguish between vertebrated, molluscous, articulated and radiated animals. Food, homes, and means of protection. Use familiar examples of each—bird or fish, oyster or clam, insects, starfish, etc. Review and classify animals previously studied.

MINERALS.

Compare sandstone and limestone. Sedimentary rock. Classify rocks in your neighborhood.

ELEMENTARY GEOGRAPHY.

Evaporation; dew, frost, rain.

Daily record of day, date, direction of wind, clouds or fogs, rainfall, temperature, barometer, moon's phases, morning and evening stars.

Rotation and revolution of the earth; inclination of axis; day and night; change of seasons; Autumnal Equinox; Little Bear, Jupiter and Venus.

NOTE.—Emphasize geology in this grade, and do as much field work as possible. Take advantage of any natural features in the vicinity of the school house.

Forces at work: air, water, wind, frost; building coasts; crumbling cliff; deepening gulch; filling marsh.

Note erosion and sedimentation, in school yard and street. Always relate physical characteristics of minerals and soils to erosion and change in earth surface.

Relate lime in solution in water to life in water, and beds of limestone.

OCTOBER.

PLANTS.

Compare new and old growth of twigs as to color, hardness, softness, texture; seeds growing on twigs—wings, hard, round, shell; near ground—pappus, hooks and prickles.

ANIMALS.

Relate color of animals to their environment. Protection and attractive coloration. Frogs, toads, grasshoppers, quail, wild cat, polar bear, leopard, tiger, etc. Relate to food-getting.

MINERALS.

Stratified and unstratified rock; limestone, sandstone, slate, granite and marble.

ELEMENTARY GEOGRAPHY.

Condensation—formation of rain, snow, hail, frost, dew, clouds. History of a raindrop.

Different forms of clouds: Cirrus, Cumulus, Stratus, Nimbus. Elevation of each.

Time and place of rising of new, full and waning moon. Effect of day and night upon life.

Movements of Jupiter and Venus.

NOTE.—Powder gray sandstone, put into a jar of water, shake contents and allow to settle. Next day drop powdered red-sandstone and continue for several days. Result—stratified material. Drop sand, gravel, loam, clay into a jar of water. Shake and allow to settle. Result—stratified, assorted material. Dissolve lime in water and allow to settle.

NOVEMBER.

PLANTS.

Mode of distribution of seeds of animals, biennials, and perennials. Effect of frost upon twigs, scaly and naked buds.

Preparation of plants for winter.

ANIMALS.

Preparation of animals for winter—thickening of coat, preparation of homes and storing food. Relation of structure of animals to manner of getting food; land and water animals.

MINERALS.

Life history of a pebble—part of cliff or rock; acted upon by air, water and frost. Compare sandstone, granite and limestone pebbles—as to color, form, smoothness, hardness, etc.

ELEMENTARY GEOGRAPHY.

Compare rainfall with October and September. Forms of clouds most common—high or low. Relation of temperature to cloudiness and rain; relation of cloudiness to rainfall.

Compare variation of shadow of October, September, and November. When greatest? When least?

NOTE.—No work can be more conducive to the cultivation of the imagination than to trace the history of a pebble. Moral lesson: contact with different conditions in wearing off the rough edges. Difference in color and texture show different origin; bands and faults show varied experience in life history. Physical forces acting.

DECEMBER.

PLANTS.

Examination of horse-chestnut, maple and fruit trees. Compare growth, bark, scars, number of arrangement and covering of buds formed. Probable fate of buds.

ANIMALS.

Distinguish between vertebrated animals; mammals, birds, fishes, reptiles, amphibians.

MINERALS.

Action of acids upon sandstone, limestone, marble, granite, mica, quartz, coral, shell. Relate to formation of caves—chemical forces acting.

ELEMENTARY GEOGRAPHY.

Influence of storm upon barometer. Effect upon temperature.

Winter Solstice. Compare shadow of September 21 and December 21.

NOTE.—Place small piece of rock in test-tube and note effect of dilute sulphuric or hydrochloric acid upon it. Result. Note which one dissolves most readily. Beds of rock best adapted to formation of acids. Effect of water, holding acid in solution, upon lime rock. Why was it possible for Mammoth Cave to have been formed where it is? Why is the Blue Grass region so fertile?

Compare physical and chemical forces acting.

JANUARY.

PLANTS.

Dormant condition of plant life; death of all annuals; roots of biennials; stems or perennials.

ANIMALS.

Compare teeth, hoofs, and claws of rodents, carnivorous, herbivorous, and omnivorous animals; teeth—trown, fangs, enamel, incisors, canine, bicuspid, molars.

MINERALS.

Fossil animals, teeth, shells, plants, leaves, etc. Identify fossil animals and plants with living things. Conditions of fossilization. Change in earth conditions. Account for fossil ferns in coal.

ELEMENTARY GEOGRAPHY.

Variation of temperature before, during and after a storm; variation of barometer and thermometer.

Effect of sun's position on temperature. When do shadows correspond and differ most?

NOTE.—Relate fossil animals and plants to kind and quantity of life extant in remote ages. Compare similar life of the present day.

Pupils should be encouraged to make collections of fossil plants and animals and to look for them in limestone used for building purposes. At first it is sufficient to be able to distinguish them by sight.

FEBRUARY.

PLANTS.

Examine trees for frozen buds and twigs; roots and blades of grasses; trunks of trees for mosses.

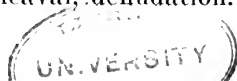
ANIMALS.

Begin study of birds; environment—earth, air, water. Relate structure to environment. Aerial birds—long, slender bodies, powerful wings; terrestrial birds—large bodies, strong feet, small wings; aquatic birds—boat-shaped bodies, short legs, webbed feet, or long legs, long neck, long bill; eagle, chicken, duck or crane.

MINERALS.

Continue study of fossil animals. Change of structure in earth's crust; erosion, sedimentation, upheaval, denudation.

Life history of a fossil fern.



ELEMENTARY GEOGRAPHY.

Compare temperature, barometer, rainfall, fogs, clouds, wind with previous months; with months whose days are about the same length.

When do shadows correspond and differ most.

NOTE.—Compare fossil ferns with ferns growing at present. Study a coal mine. Life history of a piece of coal.

MARCH.

PLANTS.

Begin close and comparative study of horse-chestnut, maple and fruit trees. Environments, shape, symmetry.

ANIMALS.

Continue study of birds. Manner of getting food, etc. Birds of prey, climbers, perchers, scratchers, waders, swimmers and divers.

MINERALS.

Recognize different kinds of iron ore and coal by color, weight, crystals and external appearance.

ELEMENTARY GEOGRAPHY.

Compare March with September. Note frost, or dew, wind, clouds, fogs, rainfall, temperature, barometer, sunrise and sunset.

Relative position of earth on September 21 and March 21.

NOTE.—In this grade children should get some general ideas of silvi-culture and forestry, and economic importance of trees and forest protection. Nuts as a food product.

APRIL.

PLANTS.

Germination of seeds; continue tree study.

ANIMALS.

Continue study of birds; parts of bird—head, body, wings and legs. Nesting habits of birds. Relate color to nesting habits.

MINERALS.

Reduction of iron. Compare pig iron, cast iron, wrought iron and steel. Uses of iron. Iron as a factor in civilization.

ELEMENTARY GEOGRAPHY.

Compare April showers with winter rains; temperature of nights and days. Explain differences of character and position of clouds in winter and spring.

Compare variation of shadow with November.

NOTE.—Germinate peach, apple, horse-chestnut, maple and pine seeds. Relate protection of the embryo to use of fruits for food.

Compare structure of birds' nests with the homes of other animals, and man. Visit a rolling mill if possible and learn the reduction of iron from observation.

MAY.

PLANTS.

Parts of flower—floral envelope and essential organs. Compare fruit, blossoms, maple and horse-chestnut.

ANIMALS.

Continue study of birds; hatching of young; care of young; manner of walking, of movement, of flight. Relate nesting habits, and food of birds to trees.

MINERALS.

Recognize different kinds of iron ore. Mining interests of Pennsylvania.

ELEMENTARY GEOGRAPHY.

Influence of April showers upon May flowers. Wind that accompanies highest and lowest temperatures.

Compare long twilights of summer with short twilights of winter.

NOTE.—Pupils should be led to see that the energy of the plant is directed toward maturing seeds; that each part of the plant has its own work to do; that color, form, texture, perfume, are modifications of effect cross-fertilization of the flowers.

JUNE.

PLANTS.

Continue study of flowers; plan of flowers. Distinguish between imperfect and incomplete flowers. Continue tree study. Leaves: simple and compound, parallel and netted veined.

ANIMALS.

Study bees in relation to fertilization of flowers. Continue study of birds. Feathers: shaft, vane, quill, barbs, barbules. Compare feathers on different parts of body. Relate to food getting. Eagle's wing, feathers of an owl, tail of a woodpecker, body of a duck, wings of an ostrich.

MINERALS.

Mining of coal. Drilling of oil wells. Importance of petroleum.

ELEMENTARY GEOGRAPHY.

Which month had largest number of clear days, rainy days; which coldest month; which warmest. Extremes of temperature.

Summer Solstice. Relative position of earth and sun June 21. Compare sunrise, sunset and sun at noon with September, December and March.

NOTE.—The study of bees is a very interesting subject. Their community life, habits, food, keen sense perception furnish a fine opportunity for investigation.

Pupils should be encouraged to imitate the calls of the birds, and note manner of communication.

Influence of iron and coal upon civilization.

FOURTH GRADE.

SEPTEMBER.

PLANTS.

Each pupil select tree for systematic study throughout the year. Protective coloration of leaves and fruit; development of flowers into fruit; form of fruit—fleshy, stone, dry.

Lower forms of plant life—algae, fungi, and lichens.

ANIMALS.

Swamp life. Observe larval stage of insects. Compare clam and oyster, as to food, habits, structure, movements, protection, nature of shell.

MINERALS.

Character of soil formed in swamps and marshes. Relate to peat bogs.

ELEMENTARY GEOGRAPHY.

Magnetic needle; compass; construction and use. Relate to iron and steel.

Dissolve, salt, alum, lime in water. Relate solution to erosion of rock, and lime in solution to shells and bones of animals.

Daily record of day, date, frost or dew, clouds or fogs, rainfall, temperature, barometer, sunrise, sunset, morning star, evening star, moon's phases, moonrise, moonset.

Measure slant of sun's rays on shadow stick. Autumnal Equinox, September 21; path of sun, Mars, Mercury.

NOTE.—Systematic study for trees following outline for tree study. Environment, shape, parts.

Observe fallen leaves exposed to the air, and those in streams or ponds.

Prepare a self-sustaining aquarium, showing the co-operation of animal and plant life.

In this grade pupils should get a glimpse of the evolution of plants and animals and their interdependence.

OCTOBER.

PLANTS.

Protection of unripe nuts; distribution of nuts and seeds; different appliances for distribution. Make collections of seeds in their pods. Storing of seeds by insects and animals.

ANIMALS.

Careful and systematic study of insects hibernating and non-hibernating. Habits of turtle and crayfish. Animals that store food and those that do not.

MINERALS.

Study coal. Collect carbon from burning candle, sugar, paper, wood, meat, wool and coal. Relate carbon to plants and animals.

ELEMENTARY GEOGRAPHY.

Influence of mountain ranges and large bodies of water upon rainfall and temperature.

Compare variation of shadow with September. Compare shortening of days in morning and evening. Change in position of constellations and stars.

NOTE.—Pupils should be led to regard the sun as a great benefactor—a great store-house of energy, supplying all our needs, clothing the world with beauty and majesty, and giving us power to respond to the influences of creation.

Coal should be regarded as energy stored up during ages. Distinguish between anthracite and bituminous coal, cannel, coke and charcoal. Formation of coal (Shaler's First Book in Geology). Relate to plants. Account for presence of carbon in sugar, paper, wool, meat, etc. Forces which produce different varieties of coal.

NOVEMBER.

PLANTS.

Select annual and biennial plants and trace life history; as—pea or morning-glory, turnip or carrot. Compare root, stem and leaves with aquatic plants. Storing of nourishment; preparation for winter.

ANIMALS.

Coverings of animals; change in coverings for different seasons. Value of skins, hair, wool, shell in commercial world.

MINERALS.

Continued study of coal. Formation of coke and charcoal; illuminating gas; other products. Relate to comfort and protection of man.

ELEMENTARY GEOGRAPHY.

Relation of barometer to change of weather. Compare fluctuations of barometer with September and October.

Relate change in animals and plants to position of sun.

NOTE.—The structure and covering of animals should be closely related to their environment and change of seasons. The economic relations of animal life should be emphasized. Call attention to man's dependence upon Nature for his necessities, comforts and luxuries.

DECEMBER.

PLANTS.

Dormant condition of plant life.

ANIMALS.

Animal movements. Compare horse, cow, dog, cat, sheep, squirrel, and man as to manner of walking. Compare hoofs, claws, paws, hands. Relate to homes, manner of getting food, intelligence.

MINERALS.

Distribution of carbon; compounds in all mineral, vegetable, and animal matter; obtained by chemical change. Relate carbon to plant life—food of animals; interchange of carbon between plants and animals.

ELEMENTARY GEOGRAPHY.

Compare variation of temperature before, during and after storm. Compare temperature, barometer, rainfall, fogs, clouds, wind with previous months. Trace snow line on signal service map.

Compare area covered by beam of light in September and December. Relate heat received in different latitudes to life.

NOTE.—Lead pupils to see stores of wealth deposited for man's convenience, comfort and progress. Civilization is man's power to overcome his environment.

JANUARY.

PLANTS.

Effect of frost upon plant life.

ANIMALS.

Food of animals that do not migrate or hibernate.

MINERALS.

Study quartz crystals; form, size, color, hardness, texture, varieties.

ELEMENTARY GEOGRAPHY.

Compare snow line with December; when farthest north; farthest south; range of latitude covered; influence of Great Lakes.

Compare marks on shadow stick with previous months; effect upon temperature.

NOTE.—Relate effect of frost upon plants, scarcity of food of animals, the southern limit of snow line, the length of shadow to movement of sun.

Examine snow crystals. Note form, size, and law of crystallization.

Saturate solution of salt, alum, chalk, soda, blue vitriol, copperas, bichromate of potash. Note temperature of water in solution. Place solution in shallow dish or bottle with a string suspended in it. Evaporate rapidly; slowly. Relate solution to erosion of rocks; crystallization to crystalline rocks, quartz-crystals, geodes, etc.

FEBRUARY.

PLANTS.

Any awakening in plant life. Observe trees for mosses.

ANIMALS.

Any appearance of animal life.

MINERALS.

Distinguish different species of quartz. Relate hardness of granite to quartz. Association of quartz with other minerals.

ELEMENTARY GEOGRAPHY.

Compare snow line and zero isotherm with January. Influence of wind upon course of storm.

Compare angle of sun's rays at New Orleans and Detroit. Compare relative amount of heat and light; effect upon life.

NOTE.—Relate effect of frost upon rocks to rapid disintegration. Effect of chemical and physical forces upon calcareous and silicious rock.

Read Ruskin's "Ethics of the Dust" in connection with the study of crystals.

MARCH.

PLANTS.

Watch first awakening of the tree following outline for "Tree Study."

ANIMALS.

Note first appearance of insects. Note beauty of color, delicacy of marking. Compare fully developed insect with larva; what likenesses and differences—food, manner of feeding, locomotion.

Pond life—spawn of frogs and toads; development of tadpoles into frogs. Crayfish; turtles; snails.

MINERALS.

Water. Place a drop of salt, hydrant, lime, rain, filtered or distilled water on a clean piece of glass, and evaporate. Explain result. Relate to animal life in water, and beds of lime-stone.

ELEMENTARY GEOGRAPHY.

Compare lowest and highest temperature of March with September and December. Compare most northern and southern isotherm of September and March.

Vernal Equinox. Angle of sun's rays with horizon; relate to latitude. Relation of latitude to climate.

NOTE.—Relate lime, shell life and coral in ocean to beds of limestone. Encourage pupils to make collections of land and sea shells; note beauty of texture, color, form, markings, spines, etc.

APRIL.

PLANTS.

Continue tree study. Examine lichens, fungi, for spores. Note color, texture, form, growth of lower forms of plants.

ANIMALS.

Study dragon fly. Compare life history with that of a moth.

MINERALS.

Effect of rain upon soil. Transporting power of a stream of rapid and slow velocity. Effect of stream carrying sediment and one which does not. Relation of hardness of minerals to erosion.

ELEMENTARY GEOGRAPHY.

What isotherm passes through Detroit. Compare this with October. Compare temperature and rainfall with October.

Compare force of sunbeam in Detroit with December.

NOTE.—Pupils should observe forces acting about them, and should be led to see the great sculpturing of the face of Nature produced by same forces acting on a greater scale. Relate hardness of rock to resistance to erosion.

MAY.**PLANTS.**

Compare flowering and flowerless plants; flowers and spore cases.

ANIMALS.

Study May fly—egg deposited in water; long larval period, nymph, adult. Compare parts with other insects.

MINERALS.

Pupils should be encouraged to make field excursions, to collect and classify minerals studied during the year; to verify by observation facts learned about erosion and sedimentation.

ELEMENTARY GEOGRAPHY.

Variation of sun's rays indicated by shadow stick: changing angle of sun's rays (indicated by shadow on stick changing) to horizon; effect upon temperature and life.

NOTE.—In early spring pupils should be encouraged to go to the woods and fields and enjoy the beauty of Nature in its entirety. Discourage any careless plucking and destroying of flowers, birds, insects, or life of any kind.

JUNE.**PLANTS.**

Continue study of flowers and plants. Follow outline.

ANIMALS.

Reptiles: Compare snakes and turtles—scales, shells, manner of locomotion, kinds of food, manner of taking food, manner of laying and hatching eggs.

MINERALS.

Co-operation of mineral, plant and animal world.

ELEMENTARY GEOGRAPHY.

Compare isotherm of this month with last. The same isotherm in plains, mountains near coast lines; compare variations of isotherms in north and south. Reasons. Regions of lowest and highest temperature.

NOTE.—If the work is carefully presented in the first three grades, by the end of the fourth grade pupils should have a good, general idea of the mineral, plant and animal worlds. No attempt should be made at any scientific classifications, except that which comes from the personal experience of the pupils. Lead the pupils to see, enjoy, love and reflect upon the beauties and wonders of creation.

FIFTH GRADE.

SEPTEMBER.

PLANTS.

Make collection of fruits—fleshy, stone, dry. Compare color, texture of covering; color, texture, and marking of pit; parts of flower developed into fruit.

Fermentation: Place bottles of grape, apple, peach juice where cool, warm, light and dark. Note effect and conditions most favorable to it. During fermentation place a lighted taper in jar; effect upon flame. What might force the cork out?

ANIMALS.

Make breeding cage, collect larvae on tomato, cabbage, milkweed, caraway, maple, oak, chestnut. Supply appropriate food; watch changes.

MINERALS.

1. Pebbles. Make collections; distinguish—
 - (a) River, ocean; life history of each.
 - (b) Glacial; life history of each.
 - (c) Conglomerates; life history of each.
 - (d) Breccia; life history of each.

NOTE.—Children should now be able to do some independent work, and supplement the work of the school by making their own collections. An effort should be made to form and properly label and catalogue a collection.

A collection of leaves pressed and mounted will serve to identify related trees and plants. Seeds of different fruits may be preserved in bottles or jars and neatly labelled.

During the year they should learn the life histories of the most common insects—their form, color, marking, movements, food, habits, homes. As the eggs and skins are difficult to preserve, they can be painted or drawn and the cocoons chrysalids, and adult insects preserved. A few clear related ideas based upon individual observation are of more value than much haphazard information.

Observe formation of pebbles in a stream bed; compare with those in gravel pits; what does a gravel pit suggest? Do you find pebbles of different color, hardness, composition? Compare them with the rock in your neighborhood. What results from the formation of pebbles?

OCTOBER.

PLANTS.

Agents for distribution of seeds.

1. Wind.

- (a) Winged—pine; pappus—dandelion, thistle, milkweed.
- (b) Entire plant scattered—as Russian thistle, tumble weeds.

2. Animals.

- (a) Covering—"stick tights," sand bur, clot-bur, burdocks, pitchforks, beggar's ticks.
- (b) Feet—on hoofs of horses, cows; feet of birds.
- (c) Food—fruit eaten, digested, seeds discarded; cherries, blackberries, raspberries, strawberries, cedar by birds; oats, maize, and grasses by herbivorous animals; apples, peaches, pears, by man.

3. Water.

- (a) Streams—seeds that will float, nuts in the husk.
- (b) Ocean currents—cocoanuts.

4. Mechanical means.

- (a) Bursting pods—peas, beans, violet, bloodroot, crane's bill.
- (b) Rolling—nuts.

ANIMALS.

1. Galls.

- (a) Willow cones—at end of willow twigs along streams. Remove gray velvety scales, and find larvae in the center.
- (b) Oak galls—observe position of leaf on stem, size, structure; cut open to find larvae. Compare galls produced by a single larva with compound galls containing many cells.
- (c) Mossy rose galls. Compare structure with oak gall.
- (d) Conical galls on witch hazel. Find opening.
- (e) Poplar galls. Compare those at base of leaf and those on end of a twig.
- (f) Golden rod galls. Compare with oak galls as to location on plant.

What causes local enlargement of plant?

MINERALS.

Observe mineral deposit in your neighborhood. Is it limestone, sandstone, granite, marble? What are the physical characteristics? From your study of pebbles, can you give a reason for the structure of

any of the rock? Do you find any layers in the rock—are they horizontal, vertical, or tilted? Have the rocks changed any during the last six months? If they are wearing away, what agents are active?

NOTE.—In studying distribution of seeds the results of observation should be tabulated. Count number of seeds in each pod or husk and number produced by each plant.

Plant.	Number of Seeds.	Means of Distribution.
Annuals: Corn Beans. Biennials: Carrot. Turnip. Perennials: Apple. Grape.	200 on cob, 2 cobs, 400. 10 in pod, 20 pods, 200.	Animals. Bursting pods.

Relate cultivation to production of seed. Children should very early get the idea of the great interdependencies of the animal, vegetable, and mineral worlds; the great amount of plant food which is locked up in the rocks, the agents which are at work unlocking this plant food and making it available. They should see in the rocks great store houses of energy which must be liberated, and become familiar with the organic and inorganic agents at work.

NOVEMBER.

PLANTS.

Life histories of plants.

Work of a plant—taking food and reproducing its kind.

Vegetative parts of plant—root, stem, leaves; reproductive parts—flower and fruit.

1. Annuals.

Those which usually mature seed during a year, as corn, beans, peas, phlox, morning-glories, etc.

2. Biennials.

Those that store nourishment in some part of plant first year to be utilized in developing seed second year.

Nourishment in root—turnip, parsnip, beet, radish; stem—potato, cabbage, celery; leaves—cabbage, cauliflower, century-plant.

3. Perennials.

Those that bear fruit year after year.

ANIMALS.

Collect and compare cocoons, chrysalids, and nests of insects, noting form, size, texture, material.

Pupa stages of *Cecropia*, *Polyphemus*, *Promethra*, *Sphinx* moth, *Luna* moth, bag-worms, leaf rollers, various wasps nests.

Compare cocoons in breeding cages with those found in the woods and fields.

MINERALS.

1. Soils.

- (a) Examine sands, gravel, loam, clay.
- (b) Power of each to absorb and retain moisture.
- (c) Power of each to absorb and retain heat.
- (d) Relation of soil to plant and animal life.
- (e) Relation of physical properties to fertile and desert regions.

NOTE.—Tabulate number of seeds produced by annuals, biennials, and perennials. Relate number of seeds to effort of plant to perpetuate its kind. Compare seeds of annuals with those of perennials as to color, form, texture, abundance and means for distribution. Compare food values of annuals, biennials, and perennials, and the part of the plant utilized.

To gain some idea of the various constituents of plants, weigh a turnip, potato, some seeds, or fruit; dry thoroughly and weigh again; burn the dried vegetable matter and weigh the ash, and tabulate results.

	Weight.	Water Evaporated.	Carbon Consumed.	Ash or Mineral.
	oz.	oz.	oz.	oz.
Turnip.				
Potato.				
Apple.				

The life in an aquarium or breeding cage is abnormal and the main object of having them in the school room is to interest the children and stimulate observation and investigation. The specimens secured by the effort of the individual child are of the greatest value to him. The teacher should suggest and direct.

Make collections of different soils, as sand, gravel, loam, and clay, and intermediate stages as sandy loam, sandy clay, etc. Distinguish physical characteristics—color, texture, composition, weight, etc.

Test temperature under ordinary conditions; subject all to the same degree of heat; test again, does the mercury indicate an equal increase in temperature? Subject all to the same degree of cold; test again. Have all given up an equal degree of heat?

Power of each to absorb and retain moisture. Tie a circular piece of cheese cloth over the top of a tumbler in such a way as to form a

bag in the tumbler. Arrange four in the same way. Put a gill of sand, gravel, loam and clay respectively in each of the bags. Pour a gill of water through the soil in each glass, being careful to have all pass through the soil and not the cloth. After six hours compare the amount of water in the glasses. Which soil retained the most water?

Soil.	Water in Soil.	Soil in Water.	Temperature.
No. 1. Sand. No. 2. Gravel. No. 3. Loam. No. 4. Clay.			

Effect of freezing upon soil; upon water in a bottle. Frozen water pipes.

Relate experiments to rainfall and its effect upon soil; to formation of flood plains; to material carried in suspension by streams; formation of springs; effect of heat and moisture of soils to plants and animals.

Remove bags containing soils and expose them to different conditions of air—a dark, cool place, sun light and wind. Which soil yields its moisture most readily, and under what conditions. Relate this to exposure of fields to atmospheric conditions.

Germinate seeds under different conditions of soil, moisture and atmospheric conditions.

DECEMBER.

PLANTS.

Dormant condition of plant life. Compare the buds on different trees; can you distinguish the leaf and flower buds; the live and frozen buds? Which buds have the most effective covering? Open a few to note internal conditions. Which is most destructive to twigs and buds, continued cold or a variable temperature, very dry or very wet soil? What effect has the heaving of the soil on the roots of plants?

ANIMALS.

Compare life conditions in an aquarium with condition in cocoons and nests collected. What changes, if any, are taking place in each? What insects have you observed that develop without metamorphosis; incomplete metamorphosis; complete metamorphosis.

MINERALS.

1. Origin of soils.

- (a) Materials—disintegrated rock and decayed organic matter.
- (b) Agencies at work—water, air, frosts and glaciers, low orders of plants, earth worms, high orders of plants, chemical action.

What agents have you observed that are active during the winter?

NOTE.—The too common opinion is that plants should be studied only in spring, summer, and autumn. The winter condition is the most trying, and should have its attention. The individuality of the trees and shrubs is more apparent, the characteristic branching, color and texture of bark, arrangement and protection of buds. Observe the "winter rosettes" in the grass.

There is such a ruthless destruction of the young evergreen forests for Christmas that an effort should be made to have trees planted in their places.

In no place in the realm of nature is the using over and over again of the same material more apparent than in the relation of plant life to soil. The plants absorb the mineral matter through the roots and the carbon dioxide through the leaves. When the different parts of the plants have performed their functions they fall to decay—the carbon uniting with the oxygen of the air and passing into the atmosphere as a gas and the mineral matter reverting to the soil; the plants form a connecting link between the mineral and animal worlds and both finally return to the mineral world.

To show that plants act chemically upon rocks, germinate a few seeds in a clam shell or on a piece of marble; remove the soil and observe tracing on shell or marble. Fold a piece of blue litmus paper around the roots of beans and corn germinated between blotting paper. The color will turn to pink showing the acid reaction, proving that the roots are giving out an acid. Dissolve a piece of egg shell, coral, clam shell, marble and limestone in strong vinegar or hydrochloric acid. Try clay sandstone and granite; which yields to the acid? What kind of rock would plants affect most? Have you observed any instances when the growth of roots has split the rocks? The roots of plants make the soil more porous and allow water containing acids in solution to have access to underlying rocks, causing them to disintegrate. Note the variety of mosses and lichens on granite boulders and exposed surfaces of rock. What is their effect? What relation do you see between the water, air and frost and disintegration of rock?

JANUARY.

PLANTS.

Effect of frost upon plants. Select a number of twigs from fruit and forest trees and count number of buds formed, dormant, frozen.

What proportion are in good condition? Which trees suffer most, those on north or south side of a house; of a street; northern slope of a hill or southern slope? Would you plant fruit trees on a hillside, facing a lake, near the base, top, or on the slope? Why? Distinguish between air, drainage and water drainage in their relation to plants.

ANIMALS.

Economic relation of insects. Make a study of the silk industry. Compare food, habits, cocoons with the silk spinners of your own neighborhood.

MINERALS.

Agents at work on surface.

1. Air. Destructive action of moist air; of changes of temperature; of wind. Constructive action.
2. Water.
 - (a) Rain.
 - Its chemical action, producing weathering. Soil.
 - Its mechanical action, removing and renewing soil.
 - (b) Rivers and streams.
 - History of river from source to mouth. Its destructive and constructive effect. Bars.
 - (c) Ice.
 - Destructive effects of frost, frozen rivers and lakes.
3. Life.
 - Plants and animals are destructive and constructive agents. Soil, peat, mosses, coral reefs and limestone.

NOTE.—A few fundamental ideas about absorption and radiation of heat and its relation to currents of air will give children a knowledge of the best life conditions of plants.

Material for the study of the silk worm can be secured from silk manufacturers, and sometimes from the Smithsonian Institute, at Washington.

The study of the soil producers might be classed as geographical nature study. Geography is no longer the study of flat, brightly colored maps with a few black lines for rivers and various sized dots for cities and towns. The universe is a wonderful laboratory in which great physical and chemical and biological forces are at work. Children should be led to realize and appreciate the constantly changing relationship between earth, air, water and life.

FEBRUARY.

PLANTS.

Effect of warm days upon plants. Which trees expand most quickly? Which buds swell first? Watch for dandelion blossoms.

ANIMALS.

Winter condition of insects. Examine trees for egg masses of tent caterpillar and forest tentless caterpillar, bark of trees for cocoons of codling moth. What birds are seen feeding on eggs and larvae in the trees? Imagine the hiding places of insects, and life conditions.

MINERALS.

Kinds of rock.

Examine different kinds of rock in your neighborhood. Is it sandstone, limestone, marble, slate, shale, or granite? Compare texture, hardness, cleavage. Which yields to erosive agents most rapidly? What is the nature of the soil derived from the different kinds of rock? Do you find evidences of life in any of the rocks?

NOTE.—A few warm days may be sufficient to arouse activity in plants, and children should be on the alert for first evidences. A Venessa butterfly which has been hibernating in the bark of a tree may be lured from its hiding place. When we think of the myriads of insects that swarm during the summer, it is interesting to contemplate their abiding places during the winter. After vegetation has been killed is a good time to study the rock structure; long fringes of icicles on the breast of a ledge of rock speak plainly of the frost giants at work there; masses of rocks dislodged will disclose a tracery of rootlets; the talus formation at the base of the cliffs show the wreckage, much of which will be carried away by the spring freshets.

MARCH.

PLANTS.

Cut twigs from different trees and bring into the school room for daily observation. Compare color and texture of bark; length of a year's growth; position and size of buds; leaf and flower buds. In fruit twigs can you detect fruit spurs? Relation of fruit spurs to growth of twigs. Compare covering and protection of buds. Observe the way leaves and blossoms are folded in buds.

ANIMALS.

First appearance of insects; have they hibernated or emerged from cocoons or nests?

Make an insect calendar for school, or encourage each child to keep his own calendar.

Common Name.	Scientific Name.	Date of Appearance.	Laying Eggs	Deposition of Eggs.

Hatching of Eggs.	Larval Period.	Pupa Stage.	Adult.	Stage of Winter Condition.	Remarks.

MINERALS.

Erosive work of rivers.

1. Rain.

- (a) Supplies water to surface and underground streams.
- (b) Carries acids in solution.
- (c) Carves soft rock.
- (d) Wears harder rock.
- (e) Carries sediment to streams.

2. Underground Streams.

- (a) Dissolve mineral matter.
- (b) Form caves in calcareous rock.
- (c) Furnish river with mineral matter in solution.

3. Rivers.

- (a) Slowly dissolve rock in stream bed.
- (b) Wears stream bed.
- (c) Meanders and broadens its valley.
- (d) Carries and wears detritus supplied to it.
- (e) Assorts and deposits material in bed.
- (f) Forms waterfalls, gorges, canons and broad valleys.

NOTE.—It is important that the buds should open in the house, because later in the spring so many things claim attention that they are apt to be neglected. It is not so important that children should gain a great many facts as that they should have the right attitude toward nature. It is not best for them to be told a great many things; they should see a great many things for themselves.

The life histories of insects, appearance and disappearance, is of the greatest importance to persons who are to live on the farm. Their habits are exceedingly interesting in themselves and a knowledge of their habits is of great value in combatting them. Children should be encouraged to keep the calendar year after year. They easily acquire scientific names, and it is well for them to begin the work correctly, although not necessary for an appreciation of insects.

There are very few schools that have not access to a stream. Pennsylvania has such noble rivers, children should be encouraged to read the chapter in the history of the State that these streams are writing.

APRIL.

PLANTS.

Germination of seeds.

I. Seedage.

1. Requisites for germination.

- (a) Moisture.
- (b) Free oxygen.
- (c) Definite temperature.
- (d) Influence of light. ✓

2. Experiments.

(a) Moisture most important factor.

- (1) Place a gill of each of several kinds of seeds, as corn, beans, peas, wheat, in a glass. Pour over each a gill of water. Observe absorption of water at end of twenty-four hours.
- (2) Plant some of each kind of seeds in dry, moist and wet soils. Observe germination according to amount of moisture.

(b) Free oxygen.

- (1) Plant seeds under favorable conditions as regards moisture, in jars. Cover one with glass to exclude air, and leave the others exposed to atmosphere. Note effect.

(c) Definite temperature.

- (1) Expose germinating seeds to cold, cool, warm, and hot temperatures. Observe most congenial conditions.

(d) Influence of light.

- (1) Submit germinating seed to light, shade, and darkness. Observe best conditions for germinating.

II. Testing Seeds.

Soak a given number of seeds, as 100, or if preferred, all that one plant produced, as a pea vine, morning-glory vine. Note successful and unsuccessful efforts at perpetuation of species.

III. Sowing of seed.

Teach children to apply the principles gained from the above in practical experience. Encourage formation of gardens.

IV. Uses of Plants.

- (a) Which are used for food of man? Of horse? Of cow? Of sheep? Of swine? Of fowls?
- (b) Which are valued for their seeds? Their fruits? Their leaves? Their stalks? Their roots?
- (c) Which are planted in hills or drills and tilled? Which sown broadcast or in close drills and not tilled?

- (d) Study effect of shallow and deep planting on different seeds.
- (e) Observe the usual time of planting and of harvesting different crops.

ANIMALS.

Study moths and butterflies. If cocoons are kept in a warm place the moths and butterflies usually come out some time in April. Keep in a conspicuous place. Note the opening, size and shape. Note condition of wings and body at time of egress. Note time from first appearance until wings are entirely expanded. Note number, color and form of eggs. Learn different parts of body. Compare with larva.

MINERALS.

Study capillarity of soils in relation to germination of seeds and gardening. Preparation—blotting paper in a drop of ink; lump of sugar in tea; piece of crayon in ink; wicks in candles; lamp wicks; explain. Put glass tubing of large and small bore in colored water. Note difference in height of water in tubes. Fill a pan with sand. Fill four argand lamp chimneys respectively with sand, gravel, loam, and clay. Stand them in the pan of sand with large end down. Pour water over the sand in the pan. In which chimney does water rise most rapidly? What becomes of it? Compare this experiment with experiments with soils for November. Fill a chimney with compact soil nearly to the top. Add some dry loose sand. Do you notice any difference in the action of the water? Relate these experiments to tillage of the soil.

When soil moisture, or the water table is too low to be useful to plants, capillarity may be established by rolling loose soil and making it more compact, thus bringing the water to a place where it is available. To prevent its evaporation, the soil should be ploughed or harrowed, forming an earth mulch, thus destroying capillarity.

Why should we try to conserve the winter rains and snows? What effect would rolling have upon soil? How could you prevent the moisture from being lost by evaporation? Walk over finely ploughed ground. What makes the foot print so apparent in a short time? What is meant by earth mulch and what is its value?

NOTE.—There is such a difference in the vitality of seed and so much poor material put in the market it is well to know how to test seed, to determine the per cent. that will grow; before planting, seed must have proper life conditions in order to develop in the most vigorous manner.

MAY.

PLANTS.

I. Leaves.

1. Form.

- (a) Simple—parallel and netted veined; lily, geranium.
- (b) Compound—palmately and pinnately; horse-chestnut and walnut.

2. Arrangement—opposite and alternate.

3. Adaptation.

- (a) Light—turning edges or upper surface to sun.
- (b) Heat—folding to prevent radiation; development of hairs.
- (c) Moisture—surface for absorbing, as thistle; shedding, as mullein.
- (d) Rain—shedding from plant axis, as horse-chestnut, to be absorbed by tips of roots; shedding toward plant axis—violet, mullein, burdock, plantain, turnip. Upper surface of leaves channelled, leaves folded in cups, petiole grooved, leading to tap root.

4. Modification.

- (a) Support, tendrils, entire leaf, as grape; part of leaf as sweet pea; petioles of leaves as clematis.
- (b) Food—pitchers of pitcher plants; viscous tentacles of drosera or sundew; trap of Venus-fly.
- (c) Reproduction.
 - (1) Evergreens—scales of cones and calkins.
 - (2) Flowers—calyx, corolla, stamens and pistils.
- (d) Storehouse for food—cabbage, house leek, century-plant.

ANIMALS.

Social Communities of Ants.

- (a) Colony—males, females, or queens and workers. Males and females winged and workers wingless.
- (b) Eggs very small, not easily seen.
- (c) Larvae white and legless.
- (d) Pupae—some enclosed in oblong, egg-shaped cocoons; others naked. Look out for nests; in decayed stumps covered with moss, under stones, in sand, and in the woods. Contrast life conditions. Observe black ants on trees and shrubs. What is their association with aphids or plant lice.

Construct an ant nest for observation.

MINERALS.

Of what value are ants to soil? In what kind of soil do they work most?

Make careful observation of the work of earth worms. On what kind of soil do you find castings most abundant; relation to porosity and capillarity of soil; to rainfall and evaporation. Estimate the number of earthworms in an acre of good soil.

NOTE.—Mark off a square yard in sandy soil, on a grassy plot, and under trees. Remove all the earth worm castings. Collect castings every twenty-four hours.

	A.M.	Clear or Cloudy.	Temperature.	Bar.	Sand.	Grass.	Trees.	Single Casting.
			Degrees.		Gr.	Gr.	Gr.	Gr.
May,...	8.00	Cloudy.	50	29.7	7.15	42.5	43.75	4
May,...	8.00	Clear.	70	29.7	4.7	21.7	107.2	3

By computing the amount of soil brought to surface in twenty-four hours and comparing the area of a square yard with an acre, some idea can be gained of the amount of work being done by these humble but effective agents. Read Charles Darwin's work on earth worms.

JUNE.

PLANTS.

1. Flowers.

(a) Form—regular and irregular; texture; color; markings of flower in relation to insects. Maturing of pistils and stamens.

(b) Pollen.

(1) Distribution—by wind and insects.

(2) Protection.

Against rain; nodding—fuschia, columbine; method of closing during rain or cloudy weather—poppy; irregularity of flowers—iris, sweet pea.

Against animals; hairs on leaves, flowers on throat of flower—mullein, thistle, violet; latex—milk in stem and leaves, hardens in air, stalk smooth, epidermis delicate, feet of insects puncture epidermis, are caught and stick—milkweed; isolation—teasel, pond of water in cup formed by leaf; shape of flower—sunflower, sweet peas, snap-dragon, milkweed, orchids, yucca, salvia, catnip.

ANIMALS.

Study bees, wasps, butterflies and moths in connection with fertilization of flowers.

- (a) Bees—honey bee, leaf cutter bee, solitary bee, bumble-bee.
Community—males or drones, females or queens and workers.
- (b) Wasps—solitary wasps, social wasps, and digger wasps.

MINERALS.

“Fill a flower pit with soft, dark earth and mold from the border of the wood and carry it to the student of entomology, and see if he can name one half of the living forms of this little kingdom of life; or hand it to the botanist, well trained in the lower orders of plants, and see how many of the living forms which these few handfuls of dirt contain he can classify. Present this miniature farm to the chemist and the physicist and let him puzzle over it. Call in the farmer, and ask him what plants will thrive best in it; or keep the soil warm and moist for a time and have the gardener say of the tiny plants that open as if by magic, which are good and which are bad. Mark well what all these experts have said and call in an orchidist to tell you how to change dead, lifeless, despised earth into fruit; ask the physiologist to explain how sodden earth is transformed into nerve and brain.”—(Taken from “The Fertility of the Land,” by Prof. I. P. Roberts, Cornell University.)

NOTE.—The perpetuation of the species depends upon the vitality of the seed. Continued self-fertilization produces weak seed; cross fertilization is a toning up process and is effected by the structure of flowers and aid of insects. Close study will reveal the secrets.

If possible have a bee hive in the school room for observation. It can be arranged with glass sides, so that the bees will not have access to the room. Nests of bumble-bees will be found in deserted nests of field mice. Observe rose leaves for work of leaf cutter bee. Can you find the nests? Collect nests of solitary and social wasps. Inspect dead branches of sumach and other pithy plants for nests of bees, wasps, and digger wasps.

Read “Bees, Ants, and Wasps,” by Sir John Lubbock.

INSECTS.

There is no problem so difficult for the farmer to solve as the economic relation of insects. It is well, therefore, for the children to become acquainted with the life histories of insects that they may have an intelligent interest in and a keen appreciation of those which are injurious and those which are beneficial. There is much valuable literature on the subject. The best results are secured by studying the creatures themselves in their native haunts, and live speci-

mens in the school room. An equipment for collecting is simple and can be made by an ingenious teacher or pupil.

Collecting Net:

The ring should be of iron or brass wire, ten to twelve inches in diameter, fastened to a wooden handle about three feet long. The bag can be made of cheese cloth or unbleached muslin.

The Killing Bottle:

Take a wide-mouthed bottle holding four or six ounces, or for large moths, a Mason self sealing fruit jar. Put into the bottle a cubic inch of cyanide of potassium and cover with water. Add enough plaster of Paris to entirely soak up the water. Keep the bottle open until entirely dry, and then keep securely corked.

Directions for mounting and preserving insects can be found in "Insect Life," by John Henry Comstock, a book which is full of suggestion for the work.

The most valuable study can be made by keeping insects in breeding cages. These can be simply made by tying mosquito netting or Swiss muslin over the top of a box, or by putting a lamp chimney or broken fruit jar on the top of a flower pot filled with soil. The soil should be moist and the food material of the larvae renewed every day. Larvae in different stages of development should be secured to compare markings of different moults.

The movements, manner of eating, amount of food consumed, moulting, varied markings of different stages, protective and attractive coloration, means of defense—as spines, bristles, secreted liquid—the sluggish condition before transformation, will be of continued interest day by day.

Larvae of different insects should be collected and carefully observed. A record should be kept of the different species, as to time of collecting, of going into pupa stage, and of changing into the adult. The larvae on the tomato plant, cabbage, milkweed, wild carrot, horse-chestnut, maple, oak, will supply valuable material. The larval, pupa and adult stages should be associated so that one would recall the others. It is well, but not necessary, for the children to be familiar with the scientific names; they should know the scientific facts and their interest will lead to deeper study.

There is so much that is interesting in pond life that an aquarium is a valuable addition to the school room. Suitable jars or fish globes or battery jars can be secured at moderate prices, but a fruit jar can be used. The plant and animal life in the water will demonstrate the interdependence of one upon the other. If the aquarium is properly stocked the equilibrium will be preserved; the plants will keep the water pure.

The Aquarium:

PLANTS.

Water cress, duck weed, frog spittle, slime wort, bladder wort, water weed.

ANIMALS.

Water scavenger beetle, back swimmer, water scorpions, water bugs, mosquito larvae, water boatmen, nymphs of dragon and damselflies, nymph of May flies, caddice larvae.

ANTS.

An ant's nest in a school room is a source of much interest and delight. An artificial nest can be cheaply and easily constructed. Partially fill a tin or galvanized iron pan 12x15x2½ inches with water. Above the water, support a pane of glass 10x10 inches on small blocks of wood. Remove an ant's nest from the ground or a decayed stump and put it on the glass, spreading it so that when a second pane is placed on top the space between the panes will be one-quarter of an inch. Cover the glass with a piece of cardboard to exclude the light, removing only during observation. Keep the soil moist, and supply food—crumbs or sugar. In addition to the nest, a park can be made in a dish containing moss, decayed earth, and material the ants have been accustomed to in the woods. Connect the park and nest. The community life seen through glass is of great interest.

PLACE OF INSECTS IN ANIMAL KINGDOM.

INVERTEBRATES.

1. Branch.

(a) Arthropoda.

2. Class.

(a) Crustaceans—crayfish, sow bugs.

(b) Arachnida—spiders, scorpions, grand-daddy-long-legs, mites, and ticks.

(c) Myriopoda—centipeds, millipeds.

(d) Hexapoda—insects.

PARTS OF AN INSECT.

1. Head.

(a) Antennae—"feelers."

(b) Compound eyes.

(c) Simple eyes or ocelli.

(d) Mouth parts.

- (1) Labrum—upper lip.
- (2) Mandibles—jaws.
- (3) Maxillae, and maxillary palpi.
- (4) Labium and labial palpi.

2. Thorax.

(a) Prothorax.

- (1) First pair of legs.

(b) Mesothorax.

- (1) Second pair of legs.
- (1) First pair of wings.

(c) Metathorax.

- (1) Third pair of legs.
- (2) Second pair of wings.
- Wing—veins and cells.

Legs—coxa, trochanter, femur, tibia, tarsus, and claws.

3. Abdomen.

- (a) Ears (in locust).
- (b) Spiracles—breathing holes.
- (c) Ovipositors—for depositing eggs.

METAMORPHOSIS OF INSECTS.

1. Developtment with Metamorphosis.

- (a) Stages—egg, immature insect, adult.
- (b) Examples—Thysanura.

2. Incomplete Metamorphosis.

- (a) Stages—egg, nymph (several stages), adult and imago.
- (b) Examples—locust, cricket, dragon fly, damsel fly, May fly.

3. Complete Metamorphosis.

- (a) Stages—egg, larva, pupa, imago.
- (b) Examples—moths, butterflies, bees, ants, beetles, flies.

ECONOMIC RELATIONS OF INSECTS.

1. Effects.

\$400,000,000.00 of the agricultural products of the United States are annually destroyed by insects. The Codling-moth exacts a yearly tax of \$3,000,000.00 in one State.

Many insects are injurious and many are very beneficial.

2. Warfare against Insects.

- (a) Is the insect injurious?
- (b) How does the insect feed?
 - (1) Mouth parts formed for sucking.
 - (2) Mouth parts formed for biting.
- (c) How can it best be attacked and when?
- (d) Are mechanical or chemical means most effective?

3. Some Mechanical Methods.

- (a) Hand-picking—tomato worm, pear tree borer.
- (b) Collecting and destroying eggs—tent caterpillar and forest tentless caterpillar.

4. Insecticides.

- (a) Biting insects—Paris green or Bordeaux mixture for potato beetle and codling moth.
- (b) Sucking insects—kerosene emulsion.

5. Spraying.

- (a) Apparatus for spraying.
- (b) How to spray.
- (c) When to spray.

The time will depend upon the vulnerable stage or period of the pest.

Children should learn the principle and working of the lifting and force pump.

INJURIOUS INSECTS.

1. Apple Pests—nearly 400 insect pests.

- (a) Roots—wooly aphid.
- (b) Trunk—round-headed and flat-headed borer.
- (c) Leaves.
 - (1) Spring and Fall canker worm. Observe trunk at night.
 - (2) Apple tent caterpillar. Collect eggs and destroy.
 - (3) Forest tentless caterpillar. Jar off and kill.
 - (4) White-marked tassock moth.
 - (5) Red-humped apple worm.

(d) Fruit.

- (1) Codling moth.

Eggs laid on surface of apple or adjacent leaves. Caterpillars emerge in about a week, enter fruit and calyx.

Larval stage inside apple; emerge through a hole in the side of the apple; crawl into crevice of bark or elsewhere.

Pupa stage, a week or two. Moths emerge for a second brood. Change to pupa may not take place until spring.

Spray with Bordeaux mixture.

- (a) Before the blossom opens.
- (b) After the blossoms fall.
- (c) A week later.

2. Plum Pests.

(a) Fruit.

Plum curculio. Observe the insect lay the egg in fruit. Jar tree and destroy affected fruit.

3. Peach Pests.

(a) Trunk and roots.

Peach tree borer. Dig out borers before July 15, and destroy.

4. Cherry Pests.

(a) Fruit.

Cherry fruit fly. Lays eggs through skin of reddening cherry; maggot feeds on pulp near it. Maggot leaves fruit; goes to ground, transforms to parent fly in spring.

5. Grape Pests.

(a) Leaves and buds.

Grape vine flea beetle. Small blue beetle attacking swelling buds. Destroys crop.

6. Currant Pests.

(a) Stems.

Two borers, adult of one a beetle, of the other a moth. Cut out and destroy infested stalk.

(b) Leaves.

Imported currant worm. Green worm, larva of saw-fly. Eggs layed along veins in under side of leaves.

7. Raspberry and Blackberry Pests.

(a) Canes.

Raspberry cane borer. Cut and burn wilted tip of cane.

(b) Leaves.

Raspberry saw-fly. Eggs on leaves in spring; larva—thickly spined green worm. Pupa stage in ground.

8. Potato Pests.

(a) Leaves.

Colorado potato beetle. Hibernates in ground. Five hundred to 1,000 eggs. Grows full grown in two or three weeks. Pupate in ground. Grubs and beetles feed upon leaves.

9. Totmato Pests.

(a) Leaves.

Tomato larva. Larva green or brown in color. Pupa stage in ground. The adult, the Sphinx moth.

Often attacked by Ichneumon fly, which deposits eggs under skin. Larvae feed upon caterpillar. On emerging they spin white cocoons.

10. Cabbage and Cauliflower Pests.

(a) Leaves.

Eggs on leaves. Caterpillar full grown in two weeks. Butterflies emerge from chrysalis in ten days. One of the best species to observe the life history, it is completed in so short a time.

SOME OF NATURE'S INSECTICIDES.

1. Wind.—Removes from trees.
2. Temperature.—Insects can endure extremes but not variation.
3. Rain.—Destroys plant lice.
4. Fires.—Destroy insects in all stages, especially those infesting decayed wood.
5. Birds.—Prey on the egg, larval, pupa, and adult stages of insects.
6. Predaceous Insects.—Prey on other species, in air, as dragon-fly; in water as scavenger beetle.
7. Ichneumon Flies.—Deposit eggs in larva of insects; in mines of the engraver beetle. Remove bark and compare engravings of different species.
8. Mantis.—Habits of mantis or praying insect.
9. Spiders.—Traps for catching insects—funnel web, orb web.
10. Frogs and Toads.—Structure of mouth for catching insects.
11. Lady-bug.—Destroys San Jose Scale and aphis, very beneficial and should be protected.

OUTLINE FOR TREE STUDY.

ALL GRADES.

Cause each pupil or class to select an individual tree for systematic and consecutive study throughout the year. If a maple is chosen, careful observations should be made and recorded in writing, painting, and drawing; different species as to shape, symmetrical development, bark, wood, leaves, flowers, fruit, etc. Skillful effort on part of teacher may foster love for trees that shall be life-long.

I. Environment.

- (a) Open fields—symmetrical development.
- (b) In a forest—tall, slender, etc.
- (c) Near another tree or house—development irregular.

II. Shape.

- (a) Excurrent—development of terminal buds.
- (b) Deliquescent—development of lateral buds.

III. Symmetry.

IV. Parts of Tree.

(a) Roots.

- (1) Tap-root—long root deep in ground, as nut trees, hickories.
- (2) Multiple roots—many large roots extending outward from trunk, as in maple, elm, horse-chestnut, poplar.
- (3) Primary roots—growing from root-end of embryo, as in apple, peach, cherry.
- (4) Secondary roots—growing from slips or stems, as in willow.

(b) Stems and Branches.

- (1) Tree—plant of woody structure branching some distance above ground.
- (2) Shrub—plant of woody structure branching directly above ground.
- (3) Exogenous stems—separable bark, wood in annual layers, as maple, oak, etc.
- (4) Endogenous stems—no separable bark. Woody substance in threads within pithy material; as palmetto, cornstalk, etc.

(c) Bark.

- (1) Birch—bark peels in thin horizontal layers.
- (2) Ash—bark opens in many irregular netted cracks near each other.
- (3) Chestnut—bark opens in longitudinal cracks quite distant from each other.

(d) Wood.

- (1) Heart-wood—dead, dark, central wood.
- (2) Sap-wood—carries sap in growing season.
- (3) Medullary rays—silver grain.
- (4) Annual layers—minute tubes or cells. Large in early growing season; small in late growing season.
- (5) Age of tree generally told by annual layers.

(e) Branches.

- (1) Opposite leaves, generally opposite branches.
- (2) Alternate leaves, always alternate branches.
- (3) Erect, horizontal and drooping Lombardy poplar, pine and weeping willow.

(f) Buds.

I. As to Position.

- (1) Terminal—at end of twig.
- (2) Lateral—along sides of twig.
 - (a) Axillary, in the leaf axil.
 - (b) Accessory, buds clustered around axillary buds.
 - (c) Adventitious, buds produced irregularly.

Nodes—points on stem at which buds are produced.

Internodes—spaces between nodes.

II. As to Activity.

- (1) Active—those that develop.
- (2) Dormant—those that form but do not develop.

III. As to Covering.

- (1) Scaly—covered with dry, tough, bark-like layers.
- (2) Naked—without scaly covering.
- (3) Hidden—those buried under or in bark.

IV. As to Arrangement.

- (1) Opposite—two at same node and opposite.
- (2) Whorled—three or more arranged around the same node.
- (3) Alternate—in ranks around stem not being opposite or whorled.

(g) Leaves—lungs of plants.

- (1) Arrangement—alternate — poplar; opposite—maple; clustered—pines; scattered—spruce.

- (2) Parts—blade—thin expanded portion; petiole—leaf stalk; stipules—pair of small blades at base of petiole.
- (3) Veining—parallel, netted; midrib—central line; ribs—second in size; veins—third in size; veinlets—minute lines.
- (4) Kinds of leaves—simple—one blade, compound—more than one blade, palmately compound—blades from one point, pinnately compound—blades arranged alongside.

V. Forms of leaves—broadcast in the middle—orbicular, oval, elliptical, oblong, linear, needle-shaped; broadest near base—deltoid, ovate, cordate or heart-shaped, lanceolate, awl-shaped, scale-shaped; broadest near apex—obovate, obcordate, oblanceolate, cuneate or wedge-shaped.

- (1) Bases of leaves—cordate or heart-shaped, auriculate. Abrupt, tapering, peltate or shield-shaped, reniform or kidney-shaped, halberd-shaped, oblique.
- (2) Apexes of leaves—truncate, retuse, emarginate, obcordate, obtuse, acute, acuminate, bristle-pointed, spiny-pointed, mucronate.
- (3) Margins—entire, repand, sinuate, dentate, serrate, crenate, lobed, notched, cleft, parted, divided, pinnatifid.

VI. Nature of Leaves.

- (1) Surface—pubescent, glabrous, canescent, scabrous.
- (2) Texture—succulent, punctate, membranous, thick, thin.

OUTLINE FOR TREE DESCRIPTION.

Tree as a whole: size, general form, trunk, branching, twigs, character of bark, color of bark on trunk, branches, and fine spray.

Leaves: parts, arrangement, kinds, size, thickness, form, edges, veining, color, surface, duration.

Buds: position, size, form, covering, number, color.

Sap and juice.

Flowers: size, shape, color, parts, odor, position, time of blooming, duration.

Fruit: size, kind, form, color when young and when ripe, time of ripening, substance, seeds, duration, usefulness.

Wood (often necessarily omitted): hardness, weight, color, grain, markings, durability.

Remarks: the peculiarities not brought out by the above outline.

FOUR FORMS OF TREE DESCRIPTION.

- I. A bare skeleton written by aid of topical outline from observation of single tree and its parts.
- II. A connected description conveying as many facts given in outline as can well be brought into good English sentences. This a description of a single tree.
- III. A connected readable description of a certain kind of tree, made up from observation of many trees of same species to be found in neighborhood.
- IV. Fourth description, including information to be obtained from outside sources in regard to origin, geographical distribution, hardness, character of wood, habits, durability, etc.

NOTE.—The outline for study of a tree is for entire year. Tree should be selected at opening of school year. Monthly drawings and written descriptions by each child regarding its condition at that time. Papers should be of uniform size, properly dated, so that by June the record for a year will be complete. Specimens of autumn leaves, showing depredations of insects, pressed and mounted. Collection of seed made. Specimens of twigs from north, east, south and west sides mounted and compared. Carefully prepared transverse and longitudinal sections of wood. Specimens of newly developed leaves pressed and mounted, showing exposition of leaf area to sun. Specimens of flowers mounted and preserved. Written description should relate growth of tree to atmospheric conditions, soil, etc., and should contain everything that influences its growth.

DRAWINGS.

September—Leaves showing depredation of insects, insects' nests, cocoons, birds' nests and birds found in tree.

October—Groups of fruit—transverse and longitudinal sections, seed.

November—Twig showing buds and scars.

December—Tree as a whole showing shape of top, cone, sphere, hemisphere, oval, ellipse.

January—Transverse section of wood.

February—Longitudinal section of wood.

March—Drawing of twig.

April—Transverse and longitudinal section of bud.

May and June—Weekly drawings showing development, enlarged bud, arrangement of scales, opening buds, flower and parts of flower.

TREES FOR DIFFERENT GRADES.

First. Horst-chestnut, maple and spruce.

Second. Oak, hickory and pine.

Third. Fruit trees—apple, cherry, plum; fir.

Fourth. Willow, sycamore, poplar, hemlock.

Fifth. Comparison of trees commercially: as to food, building material, fuel, machinery, railroads, ships, telegraph and telephone poles, arts and sciences.

Sixth. Distribution of trees as to latitude and altitude. Comparison of foreign and domestic woods.

Seventh. Effect of ruthless destruction of trees. Famous trees in history.

Eighth. Literature of trees.

The horse-chestnut is chosen for the First grade because the parts are large and conspicuous, and can be easily discovered by the unskilled hand and untrained eyes of little children; the maple for its beauty, abundance, graceful form of fruit, and brilliant coloring of its leaves in the fall; the spruce, that comparisons may be made between evergreen and deciduous trees, and because of its relation to Christmas.

The oak, hickory and pine may be studied as supplying food for the squirrel. The leaves and acorns of as many different oaks, as possible, should be collected and form, size, color, texture of leaves, cups and acorns compared. One class found thirteen varieties in one locality.

Make a collection of pine cones and twigs and distinguish between white, yellow, red, Scotch, and pitch pine, by length, form, arrangement of needles and nature of cones. Make collections of nuts that have been used as food and notice where they have been opened, and compare hardness of shells.

The fruit trees are studied in the third grade in connection with birds and insects and birds showing interdependence of animal and plant-life, in the distribution of pollen and seeds in return for honey and fruit. Also in connection with the study of amber and gums in which insects have been imprisoned showing difference between extinct and extant species.

The willow and sycamore are trees which grow best near streams, and should be taken in connection with swamp vegetation. The poplar and willow show marked difference between drooping and erect branching. Compare protection of buds and development of catkins.

In the early years of a child's school life, most of the work should be devoted to instilling into his soul an interest and love for trees, but when he reaches the fifth grade he should begin to appreciate their utility; the factor they have been in civilization. Compare the characteristics of different woods and their value for certain purposes. Why should the wood of one tree be used for the mast and another for the keel of a vessel that will weather the fiercest gale, and of an-

other the body of a violin whose vibrations shall thrill the hearts of men.

Relate great forest belts to regions of constant rainfall. Compare growth of same trees under different conditions of climate.

Specimens of ebony, mahogany, bamboo, etc., should be compared with pine, oak, etc. Relate to house furnishing and furniture.

A love for trees should be engendered and a sentiment against the great destruction of forests aroused. When possible have trees planted, and others cared for by destroying harmful insect life infesting trees.

Some experiments can be made showing something of the physiology of plants. Some very valuable suggestions may be found in "Botany," for June, in "Nature Study," by W. S. Jackman.

Outline from "Trees of North America," by Apgar. Read "Under the Trees," by Hamilton R. Mabie.

As forest products rank next to agricultural products, children should be led to have a proper appreciation of the care and development of forests and their relation to soil and climate.

1. Formation of Forests.

1. Choice of Species.

2. Reclamation of Soil.

(a) Irrigation.

(b) Drainage.

(c) Fixation of soil.

(1) Mountain sides.

(2) Treatment of gullies.

(3) Eroded land.

(d) Fixation of shifting sand.

(e) Treatment of indurated and heavy soils.

3. Formation of Forests by

(a) Direct sowing.

(b) Cuttings.

(c) Planting.

4. Formation of Nurseries.

(a) Select good seed.

(b) Mother tree of good condition and age.

(c) Germinating beds in good condition.

(d) Young seedlings, just enough light.

(e) Shade-enduring and light-demanding seedlings.

5. Natural Regeneration of Forests.

(a) Mother trees.

(b) Shelter woods.

(c) Adjoining woods.

(d) Coppice.

II. Influence of Forests upon Water Flow.

1. Rainfall.

- (a) Deposition on foliage, trunks, underbrush, litter and forest floor.
- (b) Reduction of progress of erosion, washing of soil.
- (c) Prevention of formation of shifting sand and sand dunes.

2. Drainage.

- (a) Surface drainage changed to subsoil drainage.
- (b) Porous soil absorbs rainfall.
- (c) Time element in "run off" prolonged.
- (d) Force and rapidity of surface waters reduced.

3. Snow.

- (a) Distribution of snow masses more even.
- (b) Melting of snow under forest cover prolonged.
- (c) Spring floods reduced.

4. Floods.

- (a) Large floods dependent upon cosmic causes and uncontrollable terrestrial causes.
- (b) Large floods modified by
 - (1) Topography of land.
 - (2) Character of the soil.
 - (3) River systems.
 - (4) Forest cover.

5. Modifying Influence of Forests.

- (a) Prolongs time of "run off."
- (b) Reduces water stages.
- (c) Reduces extremes of drought and flood.
- (d) Reduces extremes in low and high temperature.

6. Condition of Forest Floor.

- (a) More important in influence upon soil conditions and water flow than trees.
- (b) Forest fires destroy litter.

7. Regulation of Water Supply.

- (a) Relation of water supply to agriculture.
- (b) Relation of forests to conservation of water.

8. Sanitary Influences.

- (a) Reduction in extremes of temperature.
- (b) Reduction of severity of winds.
- (c) Comparative freedom from microbes.
- (d) Injurious lack of rapid evaporation on poorly drained soil.
Southern swamps.

9. Relation of Agriculture to Forestry.

III. Enemies of Forests.

1. Man.

- (a) Destructive lumbering.
- (b) Excessive taxation on forest land.
- (c) Devastated lands revert to State.

2. Animals.

- (a) Grazing.
 - (1) Destruction of young trees.
 - (2) Fires—burning soil cover improves grass.
 - (2) Fires extend area of pasturage.
- (b) Trampling.
 - (1) Compacting of soil.
 - (2) Destruction of young trees.
 - (3) Destruction of forest floor.
 - (4) Interference with water flow.
 - (5) Formation of flood.
 - (6) Denudation of mountain sides.

3. Insects.

4. Fungi.

5. Wind.

6. Snow.

7. Fire.

(a) Causes.

- (1) Negligence—hunters.
- (2) Lightning.
- (3) Malice.
- (4) Berry pickers and herders.

(b) Effects.

- (1) Destruction of certain species; weak perish first.
- (2) Destruction of species after species.
- (3) Change in physical condition of surface of earth.
- (4) Plains and prairies largely due to fire.
- (5) Destruction of organisms at work in soil—earth worms, bacteria, moulds, insects.
- (6) Equilibrium in nature destroyed.

IV. Some Important Forest Trees.

White pine,	Red juniper,
Sugar pine,	Arbor vitae,
Cuban pine,	Big-tree,
Balsam fir,	Swamp white oak,
Noble fir,	Beech,
Hemlock,	Black walnut,
Tamarack,	Pecan,

Tulip tree,
Sugar maple,
White elm,
Basswood,
Cottonwood,
Long leaf pine,
Short leaf pine,
Black spruce,
White spruce,
Douglas spruce,
Ball cypress,
Western larch,

White cedar,
Redwood,
White oak,
Bur oak,
Chestnut,
Shag bark hickory,
Locust,
White ash,
Red maple,
River birch,
Sycamore,
White willow.

OUTLINE FOR DETERMINATION OF MINERALS.

I. Scale of Hardness.

1. Talc and Gypsum. Very soft. Can be scratched with finger nail, or very easily with a knife.
2. Calcite and Fluorite. Soft. Cannot be scratched with finger nail, but easily scratched with knife.
3. Apatite and Orthoclase. Hard. Not easily scratched with knife; scratches glass.
4. Quartz and Topaz. Very hard. Cannot be scratched with knife; scratches glass. Topaz scratches quartz.
5. Corundum and Diamond. Corundum scratched by diamond and itself; diamond not scratched by any other mineral.

II. Specific Gravity.

1. Weight in air.
2. Weight in water.
3. Specific Gravity—weight in air; loss of weight in water.

III. Form.

1. External. Surface—grape like. Porous—mineral incrustations formed from solutions. Stalactitic—hanging from under surface of rock, cone-shaped. Stalagmitic—formed on floors of caverns from dripping water. Stratified—deposited in layers.
2. Internal. Granular, coarse or fine—small crystals. Compact—crystals invisible to unaided eye.

IV. Tenacity.

1. Brittle—breaks easily.
2. Malleable—flattens into thin sheets under hammer.
3. Sectile—may be cut into thin slices.
4. Flexible—retains its form when bent.
5. Elastic—comes back in its original form when bent.

V. Lustre.

1. Metallic, as in Metals.
2. Non-metallic—vitreous, as in glass. Pearly, as in pearl. Resinous, as in sulphur, sphalerite, resins. Pitchy, as in cannel coal. Silky or satiny, as in satin spar. Greasy, or waxy, as in serpentine. Dull, as in chalk.

- VI. Streak.—Color obtained by rubbing mineral over surface of a piece of ground glass or file.

VII. Diaphaneity.

1. **Transparent, semi-transparent.**
2. **Translucent, sub-translucent.**
3. **Opaque.**

VIII. Acid Tests. Use H. Cl. (hydrochloric acid) or dilute H^2SO^4 (sulphuric acid), or both. Use a little of the mineral in a test tube.

1. **Insoluble.**
2. **Soluble.** With effervescence, with or without heat. Without effervescence, with or without heat.

IX. Flame Tests. Use a fine splinter of the mineral, or thin edge in the flame of an alcohol lamp or bunsen burner. Note color imparted to flame.

1. **Fusible—melts.**
2. **Infusible—does not melt.**
3. **Decrepitates.** Breaks into small pieces with crackling sound.
4. **Intumesces.** Swells up without fusion.

Taken from "Nature Study," by W. S. Jackman.

GERMINATION OF SEEDS.

I. Function of Life to Reproduce Itself.

II. Environment and Activity of a Plant Directed Toward Producing Seed.

A SEED.

I. Outer parts: hilum or scar-point of attachment; micropyle—opening near hilum. Seed-coats; outer—testa; inner—tegmen.

II. Inner parts: cotyledons—thickened leaves in which nourishment is stored. (a) Dicotyledons—two. (b) Monocotyledons—one.

Plumule—small terminal bud; caulicle or radicle—small stem within seed-coats.

Embryo—plantlet.

Seed,	I. Dicotyledon.	II. Monocotyledon.
Venation,	Netted.	Parallel.
Wood,	Ringed.	Fibrous.
Flower,	Fives.	Threes.

I.
Bean.
Pea.

II.
Corn.
Wheat.

III. Plant Seeds under Different Conditions.

- (1) Light, shade, dark.
- (2) Sand, clay, gravel, loam.
- (3) Dry, moist, damp.
- (4) Hot, warm, cold.

IV. Development of Plantlet.

- (1) Bursting of seed-coats.
- (2) Plumule into stem.
- (3) Radicle into root.
- (4) Cotyledons that are leaf-like.
- (5) Cotyledons not leaf-like.
- (6) Those that grow above ground.
- (7) Those that do not grow above ground.

NOTE.—Record accurately the date of planting, first appearance of plant, first leaves, second leaves, etc. Press and mount plants showing development during two or three days.

SIXTH GRADE.

PLANTS.

Earth, air, and water play such an important part in the development of plants it is well for the children to have some simple experiments which will show how some of the work is done.

OSMOSIS.

1. Experiments.

- (a) Place some thin slices of red beet, carrot and turnip in a vessel of fresh water, in a 5 per cent. salt solution, and in strong sugar solution. Examine after a few hours. Remove slices from salt solution and sugar solution, wash, and place in fresh water. Compare results.
- (b) Treat bean and corn seedlings in the same way; leaves of geranium and coleus, allowing petioles to project above liquid.
- (c) Compare stewed prunes and raisins and dried fruit with uncooked.
- (d) Soak cucumbers in strong salt water; in fresh water.
- (e) Tie tightly a piece of bladder membrane over the large end of an argand lamp chimney. Place a strong solution of sugar—two parts sugar and one part water—in the chimney, allowing it to extend partway up the chimney. Immerse in water in a wide-mouthed vessel, having both solutions on the same level. Support chimney by means of corks. Note change in level of liquids. What is the direction of greatest flow?
- (f) Use same apparatus. Change liquids. Color fresh water in chimney. What is the direction of greatest flow?

2. Absorption of Liquid Nutrient.

Roots are composed of cells. Cell sap more dense than soil moisture; flow of soil moisture through protoplasmic lining of cell wall; cell sap diluted; cell sap of next cell dense, diluted sap flows toward denser sap and so on until large ducts are reached.

Plant peas, beans, corn or buckwheat in soil, distilled water, and undistilled water. The water cultures can be set up by tying a thin piece of cotton over the top of a glass jar and germinating the seed on it. Note the time they grow equally well and give reason, and any difference afterwards.

Germinate a few seeds between blotting paper, and apply blue litmus paper. Acid property of root hairs sets free chemical compounds of potash, phosphoric acid, etc., which are deposited in the soil and not soluble in water. Germinate seeds in shells.

3. Wilting of Plants.

- (a) Remove leaves from a geranium or coleus; place some in open air and others under a glass. Examine in a few hours. Put a branch in a jar of water with top exposed to air, and one with top covered. Note any difference in twenty-four hours.
- (b) What enables tender, succulent shoots to stand erect?
 - (1) Remove successively strips from the petiole of a rhubarb leaf six inches long. Note the effect. Replace the strips. What do you notice?
 - (2) Cut a transverse section half an inch in length from a willow shoot an inch in diameter. Remove the bark. Try to replace it.

4. Root Pressure.

Observe sap exuding from pruned branches and vines in spring.

Root pressure in nettle sufficient to hold a column of water fifteen feet; in vine, sufficient to support a column of water 6.5 feet; in birch, sufficient to support a column of water 84.7 feet.

Experiment to demonstrate root pressure.—A plant in the open may be used or a plant grown in a pot. Cut the stem two inches from soil. Connect a long glass tube of small bore and the cut stem in the soil with a short piece of rubber tubing. Moisten end of stem. Support the glass tubing. Observe the water rising in the tube. Does it rise continuously or rise and fall?

TRANSPIRATION OF MOISTURE.

1. Experiments.

- (a) Place a handful of fresh, green, succulent leaves with dry surfaces under a glass jar and place in light or sunlight. Set up another jar in exactly the same way but containing no leaves. In six hours compare results.
- (b) Cover the surface of the soil of an actively growing plant, in a pot, with a sheet of rubber cloth, to prevent evaporation. Cover with a bell jar and place in the sunlight.
- (c) Take a young oak, maple, or peach tree. Cut a slit from the circumference to a small hole in the center of a circular piece of cardboard. Slip the stem of the plant through slit to the small hole. Seal the opening around the stem and the opening to edge of cardboard. Place the cardboard over

a wide mouthed jar, allowing the roots to extend into water. Cover part of plant above the circle with a jar and seal. Compare amount of water given off with leaf area. Estimate amount of water given off by a tree, a forest, a field of corn or wheat.

- (d) Immerse geranium, coleus, some seedlings in hot water. Another set in cold water. Spread out in a dry room. Make repeated comparisons during the day. Results.

PATH OF LIQUIDS IN PLANTS.

1. Experiments.

- (a) Insert the cut ends of a leafy shoot in colored water—nasturtium, "touch-me-not," caladium, corn, horse-chestnut. Note appearance of leaves. Make a cross section and longitudinal section of the stem. Try different plants. In how many are the colored areas in a circle? In how many are they scattered irregularly? Associate arrangement of fibre, vascular bundles, with structure of seed monocotyledons and dicotyledons.

RESPIRATION OF PLANTS.

- (a) Put some peas soaked from twelve to twenty-four hours in a pint fruit jar. Keep in a warm place securely sealed for twenty-four hours. Remove cover and quickly pour into jar some lime water and seal again. Note precipitation of calcium carbonate.
- (b) Burn a splinter or sandle in a jar, forming carbon di-oxide. Pour in lime water. Note precipitation of calcium carbonate.
- (c) Through a tube, blow your breath into some lime water. Note precipitation of calcium carbonate.
- Compare respiration of plants and animals.

CARBON FOOD OF PLANTS.

- (a) Test corn starch with iodine to get the well known reaction for starch; cut a potato and scrape the cut surface into a pulp; beans; corn.
- (b) Test leaves that have grown in light; in dark; seedlings. First remove chlorophyll by boiling in alcohol.

- (c) Cover the upper and under surface of a part of a leaf with a piece of cork and place in sunlight. Next day remove cork and test leaves for starch.
- (d) Give a reason why the upper surface of leaves is always turned to the light. Note shape and arrangement of leaves with relation to sunlight.

GROWTH OF PLANTS.

1. Growth of Roots.

(a) Germination.

Soak peas, beans, corn, squash, pumpkin, etc., for twelve hours; place between folds of paper or cloth; keep moist and warm.

(b) Pumpkin.

When radicle or first root is a quarter of an inch in length; beginning with the tip, mark off sections one-sixteenth of an inch in length. Keep moist and warm. Determine the growing part of root.

2. Growth of Stem.

Embryo develops into root, stems and leaves. Nodes are enlargements at the juncture of the leaves with the stem; internodes, spaces on stem between successive nodes.

- (a) Use a bean or corn seedling. Mark off several internodes into sections one-sixteenth of an inch apart. Note region of greatest elongation. Compare growth of root and stem.

IRRITABILITY.

1. Influence of Earth on Direction of Growth.

- (a) Pin germinating peas, beans, or squash seeds marked off as above, on a large cork in such a position that one may be horizontal, one in a normal position, one in inverted position. Keep moist and warm. What changes do you observe? What is the region of greatest activity.
- (b) Remove tip of roots of other seedlings and place on corks as above. Contrast the two experiments.
- (c) Turn pot containing germinating seedlings over on the side. Note effect.

2. Influence of Light.

- (a) Plant seeds in dark, shade and light.
- (b) Subject seedlings to one sided illumination.
- (c) Put growing seedlings in a dark chamber with small opening.

3. "Sleep of Plants."

- (a) Folding of leaves—clover, oxalis, lupine, acacia. Note manner of folding.
- (b) Seedlings—cotyledons fold up and leaves down.
- (c) Upper surface of leaves avoids zenith at night to prevent radiation of heat.

4. Movement, Result of External Stimuli.

- (a) Twining stem of dodder.
- (b) Tendrils of grape, flowering cucumber, sweet pea.
- (c) Leaves of sensitive plant, Venus fly-trap, drosera.

BIRDS.

I. Relation of Birds to Man.

1. Scientific—Type of Animal Kingdom.

2. Economic--Service Rendered.

- (a) Checking increase of insects.
- (b) Devouring small rodents.
- (c) Destroying seeds of harmful plants.
- (d) Acting as scavengers.

3. Aesthetic—Appreciation of Birds.

- (a) Beauty of form and plumage.
- (b) Grace of motion.
- (c) Power of song.
- (d) Habits of life.

II. Outline for Identification.

1. Size—Compare with Sparrow or Robin.

2. Color.

- (a) Attractive—oriole, cardinal, tanager.
- (b) Protective—song sparrow, quail, creeper.

3. Markings.

- (a) Top of head—kinglet, chickadee.
- (b) Back—oriole, bobolink.
- (c) Breast—kingfisher, plover.
- (d) Wings—golden-winged woodpecker, night hawk.
- (e) Tail—meadow lark, king bird, cedar bird.

4. Shape.

(a) Body.

- (1) Long and slender; short and thick.
- (2) Relation of shape to habitat—earth, air and water.

(b) Bill.

- (1) Short and stout; long and slender; long and heavy; slender and delicate; hooked; curved; crossed.

- (2) Relate shape of bill to food and manner of getting it.
- (c) **Wing.**
- (1) Short and round; long and slender.
- (2) Relate shape of wings to flight, food, and development of feet.
- (d) **Tail.**
- (1) Square; notched; fan-shaped; graduated; pointed for bracing; long and forked for steering; short and tipped with spines for bracing.
- (2) Relate shape of tail to food getting.
- (e) **Feet.**
- (1) Weak; strong; webbed.
- (2) Compare feet and legs of divers, swimmers, waders, scratchers, climbers, perchers and birds of prey.
- (f) **Movements.**
- (1) Hopping, walking, creeping, climbing, flying, wading, diving, swimming.
- (g) **Flight.**
- (1) Rapid—direct, abrupt and zigzag; smooth and circling.
- (2) Slow—flapping; sailing and soaring; flapping and sailing alternately; oblique flight; undulatory flight.
- (3) Relate flight to food getting.

III. Parts of a Bird.

1. Head.

- | | |
|------------------------------|------------------------------|
| (a) Culmen. | (k) Circum auricular region. |
| (b) Upper mandibles. | (l) Ear coverts. |
| (c) Lower mandibles. | (m) Cheek. |
| (d) Forehead. | (n) Side of Neck. |
| (e) Crown. | (o) Jugulum. |
| (f) Occiput. | (p) Throat. |
| (g) Nape. | (q) Chin. |
| (h) Eyes. | (r) Submaxillary line. |
| (i) Circum orbicular region. | (s) Gape. |
| (j) Ear. | |

2. Body.

- | | |
|---------------------------|-------------------------|
| (a) Back. | (f) Tail feathers. |
| (b) Interscapular region. | (g) Lower tail coverts. |
| (c) Scapulars. | (h) Abdomen. |
| (d) Rump. | (i) Breast. |
| (e) Upper tail coverts. | (j) Sides. |

3. Wings.

- | | |
|-------------------------|---------------------------|
| (a) Primary feathers. | (d) Greater wing coverts. |
| (b) Secondary feathers. | (e) Middle wing coverts. |
| (c) Tertiary feathers. | (f) Lesser wing coverts. |

4. Legs.

- | | |
|-------------------|-----------------|
| (a) Tibia. | (e) Middle toe. |
| (b) Tarsus. | (f) Outer toe. |
| (c) Carpel joint. | (g) Inner toe. |
| (d) Hind toe. | |

IV. Bird Music.

1. Songs.

- (a) Character of song.
- (b) Call notes; alarm calls.
- (c) Manner and time of singing.

2. Sexual Differences in Song.

- (a) Compare notes of male and female.
- (b) Relate color to song.

V. Color of Birds.

1. Variation of Color.

- (a) With age—robin, bobolink.
- (b) With seasons—tanager, snow-bunting.
- (c) During moulting and wearing off of feathers.

2. Color in Relation to Haunts and Habits.

- (a) Protective—against enemies—quail, sparrow.
- (b) Deceptive—to prey—owl, hawk.
- (c) Attractive—in harmony with leaves and flowers—oriole, humming bird, warbler.

3. Sexual Differences.

- (a) Tanager, bobolink, peacock, pheasant.

Read "The Law Which Underlies Protective Coloration," in "The Auk," New York City, Vol. XIII, p. 124.

4. Relation of Color to Nesting Habits.

- (a) Location.
 - (1) Ground—meadow lark, song sparrow.
 - (2) Trunks of trees—woodpeckers; holes—bluebird.
 - (3) Branches—robin, cat bird.
 - (4) Pendant from branch—oriole.
 - (5) Banks—bank swallow, kingfisher.

5. Form of Nest.

- (a) Open nests—thrushes.
- (b) Pocket shaped—oriole.
- (c) Basket shaped—vireo.
- (d) Dome shaped—oven bird.
- (e) Wall pocket shaped—chimney swift.

6. Relation of Color to Song.

- (a) Dull color—generally beautiful song—song sparrow, thrushes, vireo.
- (b) Brilliant colors—usually unpleasant notes—peacock, woodpecker, humming bird.

VI. Food.

1. Kinds of Food.

- (a) Weed seeds, fruit.
- (b) Animal—eggs, larvae, pupae, insects; birds; fish; mice and rats.

2. Manner of Obtaining Food.

- (a) On the wing.
- (b) With call of warning.
- (c) In wait for prey.
- (d) On prey without warning.

VII. Insect-Eating Birds.

1. Potato Beetle.

Rose-breasted grossbeak, cuckoo, quail, hairy woodpecker.

2. Tent Caterpillar.

Crow, chickadee, oriole, red-eyed vireo, yellow-billed cuckoo.

3. Cutworms.

Robin, crow, cat bird, house wren, meadow lark, cow bird.

4. Ants.

Catbird, thrasher, house wren, woodpecker.

5. Scale Insects.

Woodpeckers, cedar bird, bush-tit.

6. May Beetle.

Hermit thrush, robin, meadow lark, brown thrasher, blue-bird, cat bird, blue jay.

7. Weevils.

Crow, crow blackbird, red-winged blackbird, Baltimore oriole, cat bird, cow bird, scarlet tanager.

8. Chinch Bug.

Brown thrasher, meadow lark, cat bird, red-eyed vireo, robin, bob white.

9. Wire Worm.

Red-winged blackbird, crow blackbird, crow, woodpecker, brown thrasher, cat bird, scarlet tanager, oriole cow bird.

10. Crane Flies.

Robin, cat bird, wood thrush, crow, crow blackbird, red-winged blackbird.

11. Cotton Worms.

Bluebird, blue jay, red-winged blackbird, thrushes, prairie chicken, quail, kilden, bobolink, cardinal.

12. Gypsy Moth.

Yellow-billed cuckoo, black-billed cuckoo, hairy woodpecker, downy woodpecker, king bird, great-crested fly-catcher, Phoebe, wood pewee, blue jay.

13. Grasshoppers and Crickets.

Mocking bird, thrasher, bluebird, wren, shore lark, goldfinch, song sparrow, junco, rose-breasted grosbeak, cardinal, bobolink, cow bird, blue jay.

14. Army Worm.

King bird, Phoebe, bobolink, cow bird, Baltimore oriole, robin.

VIII. Nesting Habits of Birds.

1. Location of Nests.

- (a) Land birds.
- (b) Water birds.
- (c) Aerial birds.

2. Structure.

- (a) Form, size, material.
- (b) Time and method of construction.

3. Eggs.

- (a) Number, color, markings.
- (b) Time of incubation.

4. Care of Young.

- (a) Feeding.
- (b) Teaching to fly.

IX. Migration.

1. Migrative and Breeding Records.

- (a) Name of bird and order.
- (b) Common name.
- (c) Summer residents.
 - (1) Date of spring arrival.
 - (2) Date of fall departure.
- (d) Winter residents.
 - (1) Date of fall arrival.
 - (2) Date of spring departure.

2. Breeding Records.

- (a) Date of laying of eggs.
- (b) Number of eggs.
- (c) Time of incubation.
- (d) Number of young hatched; reared.

3. Occurrence.

- (a) Abundant.
- (b) Common or rare.
- (c) Number at different seasons.

4. Locality.

- (a) Where observed.
- (b) Character of immediate vicinity.
 - (1) Gardens and orchards—oriole.
 - (2) Lanes and highways—song sparrow.
 - (3) Open meadows—meadow lark.
 - (4) Thickets of undergrowth—thrush.
 - (5) Dense woods—hermit thrush.
 - (6) Rivers and lakes—kingfisher, snipe.
 - (7) Marshes—marsh wren, bittern.

X. Classification.

- 1. Orders and Families Based Upon.
 - (a) Skeletal.
 - (b) Muscular.
 - (c) Visceral.
- 2. Genera—External Characteristics.
 - (a) Bill, feet, wings and tail.
- 3. Species and Sub-Species.
 - (a) Color and size.

XI. Key to Orders.

WATER BIRDS.

A. Divers.

- Order I. Pygopodes.
Grebe, loon, auk.
- Order II. Longipennes—long-winged.
Gull, tern.
- Order III. Tubinares.
Albatross, petrel.
- Order IV. Steganopodes.
Gannet, cormorant, pelican.

B. Swimmers.

- Order V. Anseres—swimmers.
Duck, goose, swan.

C. Waders.

- Order VI. Odontoglossae.
Flamingo.
- Order VII. Herodiones.
Heron, stork, ibis.
- Order VIII. Aludicolae.
Crane, rail.

SHORE BIRDS.

- Order IX. Limicolae.
Phalarope, snipe, plover.

LAND BIRDS.

- Order X. Gallinae—scratchers.
Turkey, grouse, quail.
- Order XI. Columbæ.
Pigeon, dove.
- Order XII. Raptores—birds of prey.
Vulture, hawk, owl.
- Order XIII. Psittaci.
Parrot, paraquet.
- Order XIV. Cocyges.
Cuckoo, kingfisher.
- Order XV. Pici.
Woodpecker.
- Order XVI. Machrochires.
Goat sucker, swift, humming bird.
- Order XVII. Passeres—perches.
Flycatcher, bluebird, blue jay, oriole, sparrow,
finch, swallow, vireo, warbler, wren, thrush.

The work on birds has been outlined very much in detail, simple enough to be of use to the most casual observer, and comprehensive enough to be of value to pupils who wish to go more deeply into the subject. It should ever be borne in mind that the chief aim of this work is to stimulate the effort and enthusiasm of the individual pupil. Very effective work can be accomplished by having each pupil select a pair of birds, and make them the object of his especial attention, comparing them with other birds of the same species and order. An interest in one bird is a stepping stone to a knowledge of many birds.

Encourage children to make boxes and nesting places for birds; to supply them with food during any stress of weather; to attempt to tame wild birds; to photograph birds from life. Discourage all egg collecting and desire for a collection of stuffed birds. Make the living, moving, singing bird the object of supreme interest.

Classification taken from "Handbook of Birds of Eastern North America," by Frank M. Chapman.

MINERALS.

After making observations of the rock structure and its relation to animals, plants and soil, it is important to become acquainted with some of the most common their characteristics, composition and weathering.

e of the
nt for
ls. Minerals

A mineral may be defined as a homogeneous solid, of definite chemical composition, occurring in nature, but not of apparent organic origin.

I. Minerals.

1. Mixtures.

Granite, quartz, mica and feldspar.

2. Compounds.

Quartz—silicon and oxygen.

3. Elements.

Oxygen, gold, mercury.

An element is a substance which cannot be reduced into other elements; silver, gold.

4. Important Elements in Earth's Crust.

(a) Gaseous.

Oxygen, hydrogen, nitrogen, chlorine.

(b) Liquid.

Mercury.

(c) Solid.

Silicon, aluminum, iron, calcium, magnesium, potassium, sodium, carbon, phosphorus, sulphur.

5. Important Minerals in Earth's Crust.

(a) Quartz.

Flint; hornstone; white, brown, yellow or black pebbles, uniform in color; sand; amethyst; false topaz; smoky quartz; cairngorm stones; agate, cornelian.

(b) Silicates—rocks containing silica.

Feldspar, mica, hornblend, augite or pyroxene, garnet, serpentine, chlorite, tourmaline, olivine.

(c) Carbonates—compounds of carbonic acid.

Calcite—calcium carbonate; magnesium limestone or dolomite.

(d) Sulphates—compounds of sulphuric acid.

Gypsum—sulphate of lime; barite—barium sulphate; copperas or green vitriol—iron sulphate.

(e) Ores—metal bearing minerals.

Iron pyrites; chalcopyrites or copper pyrites; magnetite or magnetic iron ore; hematite or specular iron ore; limonite—brownish yellow iron ore; siderite or spathic iron ore; chalcopyrites, or yellow copper ore; galenite, or lead ore; malachite—green copper carbonate; azurite—blue copper carbonate.

II. Kinds of Rock.

1. Calcareous.

Limestone; magnesium limestone; chalk; marble.

2. Silicious.

Sandstone—dull, gray, brown, brownish-red and red.

3. Conglomerates.

Mass of smooth, rounded fragments, cemented in a matrix; limestone, shell, quartz-pebble, granite-pebble, and volcanic conglomerates.

4. Shale.

Shale—consolidated fine sand, mud or clay; color, gray, yellowish, brown or black. Black most common, due to organic remains of animals and plants.

5. Argillaceous Sandstone.

Consolidated clayey beds of sandstone, which usually break into thin slabs, flagstones for sidewalks.

6. Slate.

Structure fine and firmer than shale. Splits easily and evenly. Used for roofing.

7. Granite.

Composition—quartz, feldspar, mica, mixed promiscuously together. Quartz, grayish or smoky in color, no cleavage; feldspar—white or flesh-red, good cleavage, sparkling faces in sun; mica—white, brownish or black, perfect cleavage; quartz and feldspar hard—mica soft.

8. Gneiss.

Same constituents as granite, but arranged in planes; owing to cleavage of mica, rock splits into layers.

9. Mica Schist.

Constituents same as granite and gneiss—mica and quartz most abundant; divides into thin layers. No dividing line between granite, gneiss and mica schist.

10. Syenite.

Granite-like rock, mica replaced by hornblend; little or no quartz.

11. Trap, Basalt, Lavas or Volcanic Rocks.

Igneous rocks, cooled from fusion.

III. Structure of Rocks.

1. Stratified Rock—layers piled one upon another.

- (a) Sandstone.
- (b) Limestone.
- (c) Shale.
- (d) Slate.



2. Unstratified Rock—made up of layers.

(a) Granite.

(b) Trap.

IV. Making of Rock.

1. Igneous Rocks—formed by fusion.

(a) Holocrystalline—coarse grained; granite.

(b) Cryptocrystalline—fine grained; obsidian.

2. Sedimentary Rock.

(a) Deposition from solution.

(1) Stalactites and stalagmites in caves.

(2) Calcareous sponges.

(b) Mechanical action of water.

(1) Fragmentation—parts of older rocks.

(2) Shales, slates, sandstone and conglomerates.

(c) Organic remains

(1) Limestone—corals, shells, crinoids, and foraminifera.

(2) Siliceous deposits—plants—diatoms; animals—radiolarians, sponges.

(d) Making of peat beds.

(1) Deposition of leaves, stems, and remains of plants.

(2) Growth and death of sphagnum moss.

(e) Remains of animals.

(1) Heat caused by streams.

(2) Abrasion of stream bed and banks.

(3) Transportation of material in suspension and solution.

(4) Deposition of detritus. Depends upon volume and velocity of stream.

(f) Work of heat.

(1) Expansion and contraction from change of temperature.

(2) Formation of rock by fusion.

(g) Cementing of rocks by

(1) Carbonate of lime; limestone, clay and sandstone.

(2) Iron; sandstone.

(3) Silica; sandstone.

(h) Metamorphosis.

(1) Change in texture—limestone to marble.

(2) Rearrangement of material—granite to gneiss.

PHYSICS.

WATER.

(a) Properties—liquid, clear, colorless, transparent, tasteless, odorless, cannot be compressed into smaller space, presses in all directions equally.

(b) Relation—to animals, plants, soil, and medium for transportation.

1. Pressure of Liquids.

(a) Presses downward and sideways.

With a nail make a row of holes near the bottom of a baking powder can; fill with water. Compare streams issuing from holes. Make a row of small holes and row of larger holes down the side of a similar can; fill with water. Compare streams from three sets of holes.

(b) Pressure upward and in every direction.

(1) Press glass down in a vessel of water.

(2) Partly fill a jar with water; float a circular piece of cardboard on the surface of the water. Place the large end of an argand lamp chimney on the card and press down. What supports the card? Carefully pour water into the chimney. Compare the height of the water in chimney and jar when the card floats away.

(c) Buoyancy of liquids.

(1) Buoyancy of water.

(a) Corks in water; buoys; life boats, preservers.

(2) Buoyancy of salt water.

(a) Learning to swim in fresh and salt water;

(b) Put an egg in a jar of water; it stays in. Why? Through a tube or funnel pour strong brine to the bottom of the jar. What makes the egg change position? Stir the water. What makes the egg to rise to the top?

(3) Buoyancy of mercury, salt and fresh water.

(4) Specific gravity.

(a) Floating vessels and icebergs.

(b) Oil on water; cream on milk.

2. Water as a Solvent.

(a) Action on salt, sugar, alum, soda, etc.

(b) Uses of water dependent upon solvent power.

(1) Formation of caves and springs.

(2) Assimilation of minerals by plants.

(3) Lime in solution in ocean and rivers used by coral and shell animals.

3. Water as Vapor.

(a) Evaporation. Effect of heat upon evaporation; heat at different times of day; seasons; zones.

(b) Condensation. Fog, mist, clouds, rain, steam. Relations. Effect of cold upon vapor. Condensation in different latitudes and altitudes.

- (c) **Snow and ice.** Compare snow, ice and water. Meaning of frozen. Compare, snow, ice and hail. Uses of snow and ice. Relations.

Snow a warm covering for plant and animal life, poor conductor of heat, prevents radiation of heat. Ice a protection to fish in rivers and lakes.

ATMOSPHERIC PRESSURE.

1. Air Presses Equally in all Directions.

- (a) Fill a glass with water. Press a blotter down on the top of it; invert the glass; turn in all directions. What causes the blotter to remain?
- (b) Cut a circle from a soft piece of leather; draw a cord through a hole in the center, making it air tight; wet the leather; press it on a slate or smooth stone, forcing all the air out. Suspend slate by the string. What prevents it from falling?
- (c) Boil an egg hard. Remove the shell. Heat a bottle whose opening is almost the size of the egg. Put the egg in the opening and put in a cool place. What forces the egg into the bottle?
- (d) Weigh a corked test tube filled with air. Remove the cork and heat the test tube. Recork while hot and weigh. What caused the difference in weight?
- (e) Fill a glass tube closed at one end with water and place open end under the surface of a vessel of water. What supports the column of water?

2. Variation of Pressure.

- (a) Altitude.
- (b) Latitude.
- (c) Amount of vapor contained. Consult barometer.

3. Pumps.

Relation of pressure of atmosphere to lifting pump. Construction, action and uses of lifting pump. Windmills.

Relation of pressure, compressibility and elasticity of atmosphere to force pump. Uses of force pump.

4. Siphon.

Formation of siphon, action, uses. Conducting water, emptying casks, etc., flow of springs.

HEAT.

Expansion and Contraction.

- (a) Gases—air—wind.

(b) Liquids—water—evaporation—condensation.

(c) Solids—rock—disintegration of rock.

1. Gases.

Experiments.

- (1) Half fill a bladder with air, tie securely, and place in front of the fire. It begins to swell, almost at once, and is soon quite full. Heat expands gases.
- (2) Half fill a rubber balloon with air and tie securely. Place in water and heat gradually. The balloon enlarges. Plunge it into cold water. It becomes smaller. Why? Cold contracts gases.
- (3) Blow thistle down or milkweed pappus over a hot stove or register. They rise. Why? The air is heated, expands, and is forced up by cold currents.
- (4) Observe the direction of sparks, smoke and cinders of a bonfire; the disturbance of the leaves around the fire. Account for the result. The air is heated, expands, thus carrying sparks, smoke and cinders. The cold air coming from all sides to replace the heated air, forms currents carrying the scattered leaves toward the fire.

Relate these experiments to absorption and radiation of heat by earth's surface and production of winds.

2. Liquids.

- (1) Fit a glass tubing through a cork. Fill a test tube with colored water. Press in the cork, causing the water to stand in the tube just above the cork. Heat the water. It rises in the tube. Why? Heat expands liquids. Cool the tube. The water falls. Cold causes liquids to contract. Water is the exception. It contracts until it reaches freezing point and then expands. Put a bottle filled with water in a cold place where the water will freeze. What causes the bottle to burst? What causes the rocks to crack in winter? Observe ledges of rocks; do you see any effects of freezing? Observe the upheaval of soil in damp places in winter. What effect does freezing have upon wet, clay soil? What effect does this freezing have upon the disintegration of rock? Relate this disintegration to liberation of plant food in the rock.
- (2) Put one-half pint of water into vessels 4x4x4 inches, 4x8x2 inches, 4x2x8 inches, 4x4x2 inches. Expose to great heat, cold, wind, for twenty-four hours and measure the water in each vessel. Relate the amount of evaporation in the deep and shallow vessels to deep and shallow bodies of water. Relate the amount evaporated in places of different temperatures to places of different altitudes and latitudes.

Boil a gill of water until all passes off as vapor. Put a

gill of water in a plate, a cup, a bottle. Record the length of time taken for the water to evaporate from each vessel. Relate time to amount of heat and surface exposed.

Hold a cold glass in steam. What causes the water to form into drops. Blow your breath on a cold window pane. Breathe deeply in cold air. What causes fogs, clouds, dew, and frost? Relate evaporation and condensation to rain-fall.

- (3) Put a thermometer into cold water. The mercury descends in the tube. Heat the water. The mercury ascends in the tube. Why? Heat expands liquids.

3. Solids.

- (1) Fit a marble into a steel or iron ring. Heat the ring. The marble falls through. Why? Heat causes solids to expand. Cool the ring; the marble cannot fall through. Why? Cold causes solids to contract.
- (2) Take a bar of iron which exactly fits into a hole. Heat the bar; it will no longer pass through. Why?

4. Questions.

- (1) Why does boiling water raise the tea-kettle lid?
- (2) Why does a hot lamp chimney break when a drop of cold water falls upon it?
- (3) Why is the tire of a wheel fitted while it is hot? Why is cold water then poured upon it?
- (4) In laying rails for a railroad why are the ends not fastened together.
- (5) Why do chestnuts burst open with a loud report when they are roasted?
- (6) Why does a punching ball become soft in the cold air when it was firm in a warm room?
- (7) Would the tires of a bicycle be firmer on a cold day or a warm day?

SEVENTH GRADE.

The great majority of pupils never reach the high schools, colleges, or universities. They should be given some idea of the relation of minerals, plants and animals in time and space. Type specimens of animals and plants should be studied to show the natural order of development. These should be compared, as far as possible, with fossil species in the rocks. It will be shown that the higher types have evolved from the lower, and that development or evolution can be traced vertically in the rocks, and horizontally in existing species.

The relation between the animal, vegetable and mineral worlds should be emphasized. Much of the work in this grade is organizing and relating work done in lower grade.

The following lessons are suggested hoping that an interest may be aroused in minerals, and a desire to read the wonderful story graven in rocks during past ages. It is sincerely hoped that a collection of specimens will be secured for every school. No neighborhood will supply all varieties. An exchange may be effected between different parts of the State. The bulletin of the American Bureau of Geography, published at the State Normal School, Winona, Minn., has a bureau for the exchange of geographical supplies. The most useful material is that which is secured by the individual pupil, during visits to quarries, bluffs, mines, in his vicinity. Each geographical situation has its own history and interest. Are the rocks igneous or sedimentary; stratified or not; horizontal, tilted or folded; result of mechanical, chemical, or organic agencies. Collect fossil plants, animals and minerals. Observe effects of a heavy rain storm—gullied hillsides and roads; flood plain, water falls, precipices, cataracts. All the conditions of a great river drainage system may be found in one of these miniature areas. As all continents are made up of adjoining drainage areas, the same land and water forms exist everywhere, modified by altitude, latitude and local conditions.

The economic side of the study of minerals is important, but the vital thing is that the children shall approach the work with a proper spirit, and an appreciation of the forces necessary to produce a crystal, record the life history of a fern in a piece of coal, or deposit a stratum of rock 40,000 feet in thickness.

Collections of minerals can be secured from Ward's Natural Science Establishment, 18-28 College avenue, Rochester, N. Y.

Edwin E. Howell, 612 Seventeenth st., N. W., Washington, D. C.

A. E. Foote, 1317 Arch st., Philadelphia, Pa.

Nature includes all created things. Nature study is not only the study of all created things but also all the changes which they undergo.

Natural law is the order in which things have been observed to happen; it is immutable; there are no exceptions. The relation of cause and effect is the fundamental law of nature. By comparing the geological forces at work at the present time, with geological effects of the past, causes can be ascribed.

The generally accepted Nebular theory should be given, as a foundation for the work.

I. Nebular Mass.

1. Gaseous State—hot, highly expanded.
2. Composition—elements, in gaseous state.

(a) Elements—about seventy in number.

- (1) Gaseous—hydrogen, nitrogen, chlorine, oxygen.
- (2) Non-metallic—sulphur and phosphorus.
- (3) Metallic—iron, lead, tin, mercury, copper, gold, silver and zinc.

Compounds and Mixtures.	Elements.
Water,	Oxygen and hydrogen.
Air,	Oxygen, nitrogen.
Carbon dioxide,	Carbon and oxygen.
Protoplasm,	Oxygen, hydrogen, nitrogen, carbon and others.

As oxygen, hydrogen, nitrogen and carbon are so widely distributed, at this point children should have some experimental work to become familiar with the properties of these elements.

3. Elements.

(a) Oxygen.

- (1) Sources: air, water, animals, crust of earth.
- (2) Preparation: potassium, chlorate and manganese dioxide.
- (3) Properties: odorless, colorless, tasteless, does not burn, vigorous supporter of combustion.
- (4) Experiments: burn in oxygen, splinter; watch spring; sulphur; phosphorus; zinc.
- (5) Distribution: destructive agent of air; purifies blood in human system; plants; minerals.

(b) Nitrogen.

- (1) Sources: atmosphere, ammonia, animal matter, mushrooms.
- (2) Preparation: burning phosphorus in air.
- (3) Properties: colorless, odorless, tasteless, does not burn, does not support life, inert.
- (4) Distribution: air, soil, plants and animals.

(c) Hydrogen.

- (1) Source: water.
- (2) Preparation: sulphuric acid and zinc; hydrochloric acid and zinc; decomposition of water by electricity.
- (3) Properties: colorless, odorless, transparent, lightest of all bodies, will burn, does not support combustion.
- (4) Distribution: water, animals and plants.

(d) Carbon.

- (1) Sources: carbon dioxide in atmosphere, plants, animals, coal, mineral carbonates.
- (2) Preparation: an element in nature—diamond, graphite.
- (3) Properties: diamond—colorless to black, transparent, hardest substance known, refracts light.
Graphite—black, soft, crumbly.

3. Cooling of Nebular Mass.

- (a) Contraction due to radiation of heat.
- (b) Revolution result of contraction.
- (c) Centrifugal force due to revolution.

4. Forces Acting in Nebular Mass.

- (a) Cohesive.
- (b) Gravitative.
- (c) Centrifugal.

Give simple experiments which will illustrate

- (a) Cohesion of gases, liquids and solids.
- (b) Law of gravitation; give illustrations.
- (c) Centrifugal force.

II. Formation of Planets.

Sub-central mass.

Planets.	Satellites.
Neptune,	One.
Uranus,	Four.
Saturn,	Eight; rings.
Jupiter,	Five.
Asteroids,	About 300.
Mars,	
Earth,	One.
Venus,	
Mercury,	

III. The Earth.

1. Cooling.

- (a) States of matter: gaseous, liquid, solid due to temperature.
- (b) Effect of heat upon gases, liquids and solids.
- (c) Effect of cold upon gases, liquids, solids.

Experiments with heat outlined for Eighth Grade can be used here, and results used in connection with wind, ocean currents, evaporation and condensation, and disintegration of rock.

2. Formation of Earth's Crust.

- (a) Cooling and contraction.
- (b) Formation of igneous rock.
- (c) Formation of water. Hydrogen, oxygen.
 - (1) Condensation and evaporation.
 - (2) Formation of rain, lakes, rivers, ocean.
 - (3) Review oxygen and hydrogen.

3. Igneous Rocks.

- (a) Review lava—granite, contorted gneiss.
- (b) Compare crystalline structure of rocks.

To show that igneous rocks are due to the action of heat, form crystals of different substances. Make a saturated solution of alum, salt, sugar or copper sulphate; pour part of the solution into a saucer, and part over a woolen string suspended in a bottle. Allow the solution in the saucer to cool rapidly and that in the bottle to cool slowly. Observe form and size of crystals. Compare crystals of quartz, calcite, copper pyrites, iron pyrites, etc. Account for difference in size of crystals. Compare size and shape of snow crystals on cold and mild days.

IV. North America.

1. Archaean Rock.

- (a) Granite, gneiss, syenite, hornblendic, quartzite.
- (b) Deposits of iron ore.

2. Distribution of Archaean Rock.

- (a) North—northeastern Canada, Adirondacks and Lake Superior region.
- (b) East—north of New England to Georgia.
- (c) West—along ranges of mountains which later became Cordilleras.
- (d) Land areas surrounded by ocean.

V. Erosion.

1. Cause—Chemical and Mechanical Forces at work on exposed Igneous Rock.

2. Effect—Sedimentary Rock.

- (a) Origin of sedimentary rock—igneous rock.
- (b) Position—upon igneous rock.
- (c) Location—around igneous rock.

Review subject of erosion outlined for Sixth Grade.

VI. Appearance of Life.

1. Importance of Fossils.

- (a) Development of animal and plant kingdoms.
- (b) Distribution of animals and plants.
- (c) Climatic conditions.
- (d) Distribution of land and water.
- (e) Comparative age of strata.

2. Conditions for Forming Fossils.

- (a) Remains of plants and animals in water.
- (b) Exclusion of oxygen.
- (c) Deposition of fine sediment.

3. Forms of Fossils.

- (a) Cast or mold.
- (b) Original material.
- (c) Petrification.

4. Incomplete Life Record.

- (a) Few land animals and plants preserved.
- (b) Organisms exposed to oxidation decomposed rapidly.
- (c) Water animals with soft parts leave no trace.
- (d) Fossils destroyed by metamorphism or solution.

VII. Distribution of Land and Water.

1. Maps.

- (a) Duplicate maps of North America.
- (b) Indicate supposed areas of land and water during geological eras.

2. Hypothetical maps of North America.

- (a) Archaean era.
- (b) Carboniferous period.
- (c) Cretaceous period.
- (d) Tertiary period.
- (e) Glacial and Champlain periods.

These maps can be found in geological works by Shaler, Dana, Tarr. Children should compare in imagination the life conditions of different geological eras and periods with the present.

They should know that all geological time is divided into four great periods.

1. Archaean—possibly without life.

2. Paleozoic.

- | | | |
|---------------------|---|-------------|
| (a) Cambrian. | } | Trilobites. |
| (b) Lower Silurian. | | |
| (c) Upper Silurian. | } | Fishes. |
| (d) Devonian. | | |
| (e) Carboniferous. | | |

VIII. Classification of Animal Kingdom.

	Fossil Forms.	Modern.
1. Protozoans,	Rhizipods,	Amoeba.
2. Radiates,	Radiolarians,	Coral.
	Coral,	Crinoids.
	Crinoids,	Star fish, sea urchins.
3. Invertebrates,	Sea Urchins,	Clams.
	Brachiopods,	Nautilus.
	Ammonites,	Insects.
	Dragon Flies,	Sow bugs.
	Trilobites,	Crayfish, snail.
	Crustaceans,	
4. Vertebrates.		
a. Fishes,	Ganoid,	Shark.
	Perch,	Bass.
b. Amphibians,	Otozoum Moodii,	Frogs.
c. Reptiles,	Ichthyosaurus,	Alligator, snake.
d. Birds,	Archaeopteryx,	Robin.
e. Mammals,	Mastodon,	Elephant, dog, cat, horse, seal, whale.

By comparing fossil and modern forms, a progressive development will be observed.

The different species of ancient and modern life should be related to the work they have done and are doing in rock formation of the world. As mollusks to formation and marble; corals to building of islands.

IX. Classification of Plants.

	Fossil.	Modern.
1. Thallophytes,	Sea weeds,	Algae.
		Fungi.
2. Bryophytes,	Lichens,	Lichens.
	Land plants,	Mosses.
3. Pteridophytes,	Tree ferns,	Liverworts.
	Lepidodendrons,	Ferns.
	Cycads,	Lycopodium.
	Calamites,	Selaginella.
4. Spermatophytes,	Gingko,	Equisetum.
		Evergreen trees.
		Deciduous trees.

FORMATION OF COAL.

1. Conditions of Life.

1. Plants.

- (a) Extensive marshes.
- (b) Luxuriant growth of vegetation.
- (c) Gigantic ferns, club mosses, equisetum, cycads, lepidodendrons.
- (d) Climate tropical.
- (e) Atmosphere humid; laden with carbon dioxide.

2. Animals.

- (a) Crinoids, corals, brachiopods.
- (b) Worms, crustaceans, trilobites.

- (c) Spiders, scorpions, myriopods, land snails.
- (d) Dragon flies, cock roaches, crickets, beetles; no bees, no flowers.
- (e) Sharks, ganoids.
- (f) First terrestrial vertebrates—amphibians.

II. Subsequent Events.

1. Subsidence: Shallow Sea, Unstable.
2. Life Submerged.
3. Deposition of Sediment.
4. Generation of Heat.
5. Metamorphosis of Plants.

III. Stratification of Coal Measures.

1. Successive Layers of Clay and Coal.
2. Layers Vary in Thickness.

MINERAL OIL AND GAS.

I. Deposits.

1. Porous Rock—Trenton Limestone.
2. Reservoir Capped by Impervious Layer of Rock.

II. Origin.

1. Decomposition of Animal and Plant Life, Deposited in Seas and Lakes.
2. Slow Distillation Caused by Pressure and Heat.
3. Hydrocarbons Produced.
4. Hydrocarbons Exist as Gas or Oil.

GLACIAL PERIOD.

I. Glaciated Area of North America.

1. Canada, Greenland.

United States, from Atlantic Ocean west, north of Ohio and Missouri Rivers.

2. Kinds of Glaciers.

(a) Continental—Greenland.

(b) Valley—Western United States.

(1) Snow fields, accumulation of snow.

(2) Neve—granular ice.

(3) Ice stream—moving compact ice.

3. Moraines.

(a) Lateral—a moving talus.

(b) Medial—formed by union of two lateral moraines.

(c) Terminal—accumulation at front end.

(d) Ground—loose rock, material beneath the ice.

II. Work of Glacier.

1. Erosion.

- (a) Grinding of rocks carried and passed over, freeing boulder clay.
- (b) Polishing and striating rocks.
- (c) Wearing of surface contour by moving ice.

2. Transportation.

- (a) On top of ice.
- (b) Embedded in ice.
- (c) Under ice.

3. Deposition.

- (a) Unassorted and unstratified mass of clay and boulders.
- (b) Assorted and stratified sand and gravel left by glacial streams.
- (c) Irregular deposition forming lakes.

In connection with glaciers review evaporation, condensation and snow crystals.

Do you see any evidences of glaciers in your neighborhood—ground rock, scratched boulders, granitic boulders, moraines?

Compare glaciated areas of North America with non-glaciated.

Locate lake regions of North America. What effect did glaciers have on drainage systems, agricultural products of glaciated regions? What element in soil do grains require? What kind of rock supplies it?

Whether the world was made for man or not it was well made for that purpose. This work in geographical nature study is outlined for the purpose of having children see the relation between present and past geographical conditions; that present agricultural, commercial, and industrial progress is dependent upon the mineral deposits, drainage systems, soil and climatic conditions; that nothing is isolated—all nature is a unit.

As a rule very little attention is given to the lower forms of plant-life. They are so abundant and so beautiful they should be studied. The algae can be observed in the aquarium. If possible the threads should be examined with a compound microscope. Puff balls, toad stools, and mushrooms are of great interest and should be studied; some on account of their beauty of coloring, mushrooms because of their value for food. Remove the stem-like structure of a mushroom; put the cap on a piece of white paper, cover with a glass. After a few hours remove the glass and cap and notice the spore print. Lichens can be found on trees, rocks, old fences and on the ground all through the year. Note color, variety, form, fruiting cups. Relate to disintegration of rock and soil formation.

Different varieties of mosses and liverworts should be observed; structure is too difficult to attempt.

Ferns should be carefully studied—they are so abundant and so closely related to the coal period.

Plant.

Parts—roots, underground stem, leaves and sori.

Sori—groups of brown bodies on under side of leaf.

Note location—irregular distribution, regular.

SUN.

The sun is the great power for keeping the machinery of the universe in motion. It should be studied with great diligence. All light, heat, moisture, condition of animals and plants are dependent upon the relative positions of earth and sun. Weekly observations should be recorded.

Construct a "Shadow Stick." Fasten securely a piece of smooth board $4 \times 3 \times \frac{1}{2}$ inches to the end of one $12 \times 3 \times \frac{1}{2}$ inches, forming a right angle. Drive a post in the school yard. Make the top horizontal and on it make a north and south line which will coincide with the meridian of the place. Once a week, at noon, when the sun is on the meridian, place the shadow stick parallel with the line, with the upright piece toward the sun. Mark the shadow cast by a line on one edge of the 12 inch board and record the date. Shadow will increase in length from June 21 to December 21. As the shadow decreases from December 21 to June 21, mark records on the opposite edge. Compare records of March 21 and September 21.

Put a semi-circular piece of cardboard in an east window and one in a west window. Arrange an upright that will cast a shadow. Mark shadow at same time each morning and evening. What relation do the morning shadows, September 21 and March 21, have to the meridian line; the evening?

The length of shadow varies inversely with temperature and length of day. Arc through which the sun passes each day varies directly with length of day and temperature.

Compare force of morning, noon, and evening rays; of June and December rays. Compare climatic and life conditions of Arctic, temperate and tropical areas.

Children should now be able to make very accurate observations and to ascribe reasons for the phenomena observed.

A copy of the United States Weather Bureau should be daily studied. Observations should include:

Sky.

Color—dark, light, and grayish blue.

Twilight.

Cause and period in summer and winter; colors of morning and evening twilight; succession of tints and their cause.

Rainbow.

Situation at different times; tints.

Lunar Rainbows.

Tints.

Sundogs.

Halos.

Solar halo; lunar halo; color of sky within halo.

Precipitation of Vapor of the Air.

Origin of dew; most favorable conditions for formation. More abundant in country or town.

Hoar Frost.

Formation; crystalline structure; where most abundant.

Fog.

Cause; what time of day most common; occurrence on high or low land; near a body of water or land.

LIGHT.

Light plays so important a part in the economy of nature that the children should have some idea of its laws and influences.

1. Sources of Light.

Sun, stars, chemical and mechanical action, electricity, phosphorescence. Compare combustion without light and combustion accompanied with light.

Light by friction; light by percussion.

Indian's manner of making fire—by friction; striking a stone with a piece of steel. Spark in old flint lock guns.

Distinguish between transparent, translucent, and opaque bodies; self-luminous, non-luminous, and illuminated bodies.

Light travels in a straight line through one medium. Distinguish between reflected, refracted, and diffused light. Do we see most things with reflected or diffused light?

In connection with the study of light a sheep's eye or a pig's eye should be dissected, and the internal structure compared with that of the human eye. Carefully remove all flesh and fat. Observe color and texture of coats and optic nerve. With a sharp knife carefully cut through the sclerotic coat, and gently press the contents out on a piece of glass. The watery substance is the aqueous humor, the clear, transparent, firm humor the crystalline lens, and the white jelly-like substance the vitreous humor. The dark circular portion is the iris. Observe the two sets of muscles—radiating and circular.

The Human Eye.

(a) Protections.

Bony socket, cushion of fat, brows, lids, lashes, oil glands at base of lashes, tear gland, tear duct.

(b) Coats.

Sclerotic, choroid, cornea.

(c) Internal structure.

Aqueous humor, iris, crystalline lens, vitreous humor, retina, optic nerve.

Remove the crystalline lens and place it over printed paper. It magnifies the print. Relate this to the construction of lenses.

Uses of Lenses.

(a) Microscopes—simple and compound.

(b) Telescopes—refracting and reflecting.

(c) Cameras.

(d) Spectacles.

(e) Magic lanterns.

(f) Stereopticons.

Hang a prism in the window. Catch refracted light—the spectrum. Much time should be spent in training children to a fine appreciation of color in nature.

Observe clouds at sunrise and sunset; difference between color of summer and winter clouds. Rainbows, sundogs, halos and corona.

Significance of color in flowers, fruit, birds, insects, shells and animals. Contrast the coloring of the spring, summer, autumn, and winter landscapes.

Contrast color of seedlings grown in the dark, shade, and sunlight. Why do house plants turn the upper surfaces of their leaves to the light? Plants assimilate their food under the influence of sunlight. The form of leaves and arrangement on the stem are for the purpose of presenting the greatest leaf area to the light. Observe how the leaves have adapted themselves for this purpose. A field lesson with this point in view is of great profit. Compare plants of the same variety grown in the woods and in the open; leaves of plants that grow on the surface of water with those in the water; the trunks, branches and leaves of trees in dense forests with those in open fields. Compare light demanding trees with shade enduring trees.

Effect of light upon eyes of animals. Compare eyes of mole, cat, dog, owl, and horse.

SOUNDS IN NATURE.

So much of the nature study work is devoted to that which appeals to the child through the eye, that sounds in nature are apt to escape, and the phenomena of sound to be neglected.

Some sounds to be distinguished:

Songs, call notes, alarm calls of different birds.

Notes of different times of day and seasons.

Flapping and fluttering of birds' wings.

Music and musical instruments of insects.

Sound of flight of insects.

Step of a horse—trotter, pacer.

Sounds made by horse, cow, sheep, dog, cat.

Rustle of leaves made by snake, lizard, mouse or bird.

Sound made by wind in leaves of different trees, spring and autumn.

Contrast sounds made by pines, hemlocks, birches, oaks, chestnuts, poplars and Scotch firs; by fields of unripe and ripened corn, wheat, oats and barley.

Sound made by rain on leaves and grass.

Rippling of a stream, dashing of waves.

Detect any musical notes.

I. Classification of Sound.

1. Pleasant—tones—song sparrow's notes.
2. Unpleasant—noise—thunder.

II. Properties of Simple Tones.

1. Pitch—high, cricket's chirp.
2. Intensity—illustration.
3. Duration—illustration.

III. Transmission of Sound.

1. Gases—conductor of sound.

- (a) Are sounds clearer on a warm or cold day; summer or winter; colder countries or tropics; mountains or valleys; country or town?

2. Liquids; better conductors than gases.

- (a) Strike stones together under water; in air; where is sound more distinct; experience of divers.

3. Solids; better conductors than liquids.

- (a) Tap gently on a piece of wood; have another persons ten feet away; listen; tap again, and have the other person put his ear to the wood. In which case is the sound more distinct? Why do Indians put the ear to the ground to discover a footfall? Why is copper used more for telegraph and telephone wires than iron.

IV. Speaking Tubes.

1. Value and Use.
2. Ear Trumpets.
3. Gramophones.

V. Reflection of Sound.

1. Compare Reflection of Sound and Reflection of Light.
2. Echoes: cause.

VI. Velocity of Sound.

1. Light Travels Faster than Sound.

- (a) Lightning and thunder.
- (b) Steam and whistle.
- (c) Flash of a gun and report.
- (d) Falling tree and crash.

EIGHTH GRADE.

THE HOME.

In the A Eighth Grade, the grade below the high school, the children reach the period of sentimentality. The creative energy which has manifested itself in so many ways since the beginning, is now throbbing in their bodies as sex impulses, as natural, as pure, and as right as the beating of their young, vigorous hearts. This force is vital, it is life and should not be crushed, but directed in the proper channels, and avenues opened to them which will afford opportunities for self-expression.

In this grade the central thought is the home. The science work is that which will give them ideas of the best home making and home keeping.

Discuss the location, plans, material, ventilation, heating, lighting, sanitation, decoration, furnishing, books, music, food, dress, care of the house and landscape gardening. Each topic is elaborated and as much of the work is done experimentally as possible. The children should visit the water works, gas works, scientifically constructed buildings to see the lighting, heating and ventilating plants, and machinery for running the elevators; also, the Weather Bureau.

Each pupil can imagine he could build and furnish a house just as he desires. The wisdom of this might be questioned by some. The object is to give the children ideals of the best home possible. The work will certainly give them an impetus toward the best.

It will not be possible to go into the details of the work or describe experiments; it is only hoped that teachers may get suggestions which they can work out individually.

LOCATION.

1. Country.

Advantages.

- Pure air.
- Good food.
- Independent life.
- Contact with nature.
- Low taxes.

Disadvantages.

- Lack of social life.
- Poor communication.
- Bad roads.
- Poor schools.
- No postal service.

2. Suburbs.

Advantages.

Good air.
 Good schools.
 Good churches.
 Rapid transit.
 Good water supply.
 Fire protection.

Disadvantages.

Distance from business.
 Increased taxes.
 Distance from market.

3. City.

Advantages.

Library.
 Schools.
 Social life.
 Time saved.
 Rapid transit.

Disadvantages.

High taxes.
 Smoke.
 Danger from fire.
 Crowded conditions.
 Disease.

PLAN.

Number and arrangement of rooms arranged with reference to size of lot, exposure and proximity to other buildings.

Reception hall.	Music room.
Drawing room.	Nursery.
Living room.	Living room.
Library.	Closets.
Dining room.	Attic.
Kitchen.	Piazzas.
Bed rooms.	Conservatory.
Laundry.	Barn.

The children can make their own plans, or copy plans drawn by architects. This is optional. Original plans will show individuality, care and judgment. Good points and bad points in the drawings can be discussed, credit always being given for effort. Each child should keep a book containing the plans and elevations of his house, pictures of interiors—selected from magazines and art and architectural books. Selections give an opportunity for study into character, which is valuable. Selection of furniture is equally interesting—pictures of good sanitary plumbing, convenient equipment for laundry, best designs for cooking stoves, kitchen utensils, furniture for drawing, living and dining rooms, etc.

MATERIAL.

1. Stone.

(a) Kinds.

Granite.	Limestone.
Sandstone.	Marble.

- (b) Characteristics.
 Hardness—cutting.
 Texture—polish.
 Color—beauty.
 Durability—economy.
 Cost.
 Distribution—vertical and horizontal.
 Origin—igneous or aqueous.
 Quarrying—location.
2. Brick.
- | | |
|-------------------|---------------------|
| Manufacture. | Durability. |
| Material. | Brick laying. |
| Kinds and colors. | Advantage of brick. |
3. Wood.
- (a) Uses.
- | | |
|------------|--|
| Floors. | |
| Woodwork. | |
| Furniture. | |
- (b) Kinds.
- | | |
|--------|-----------|
| Oak. | Walnut. |
| Ash. | Cherry. |
| Maple. | Birch. |
| Ebony. | Mahogany. |
- (c) Characteristics.
- | | |
|-------------|-----------|
| Texture. | Markings. |
| Grain. | Color. |
| Durability. | Polish. |
- (d) Cutting.
- | | |
|---------------|----------------|
| Straight cut. | Quarter sawed. |
|---------------|----------------|

VENTILATION.

THE ATMOSPHERE.

1. Composition—mixture.
- (a) Nitrogen, four-fifths.
 (b) Oxygen, one-fifth.
 (c) Carbon dioxide, four-tén thousandths.
 (d) Water, variable.
2. Properties.
- | | |
|--------------|------------------------------------|
| Invisible. | Has weight. |
| Colorless. | Presses equally in all directions. |
| Transparent. | Compressible. |
| Odorless. | Elastic. |
3. Effects of Heat upon Air.
- (a) Heat expands air.

(b) Cold contracts air.

(c) Location of hot and cold air in room.

4. Experiments.

(1) Fit a glass tube with a rubber tubing on the end of it into a cork. Fit the cork in a test tube, making it air tight. Place the end of the rubber tubing in a glass of water. Heat the test tube. Why do the bubbles come up through the water?

Heat expands the air. Expanded air presses equally in all directions and finds the easiest egress through the tubes and water.

(2) Partially fill a small top rubber balloon or bladder with air. Securely tie the opening, making it air tight. Place in a vessel of cold water and heat slowly. When the air has become expanded remove and plunge into cold water.

Account for the result.

(3) Ascend a step ladder carrying a thermometer. Account for the difference in the reading of the thermometer.

5. Study of Flame.

(a) Dark zone—no combustion.

(b) Illuminated zone—partial combustion.

(c) Mantle—complete combustion.

6. Experiments.

(1) Place matches successively in the dark zone, illuminated zone, and mantle of a candle. Is there any difference in the time of igniting? Which zone is hottest?

(2) Place a match or splinter across a flame. Which zone burns the stick most? Which least?

(3) Press a sheet of white cardboard, held horizontally, upon the flame of a candle, almost down to the wick. Remove carefully. Which zone deposited the most soot? Which least? Why?

7. Experiments with Carbon Dioxide.

(1) Burn a candle or splinter in a jar of air forming carbon dioxide. Pour lime water into the jar of carbon dioxide and note change in appearance of limewater.

(2) Breathe through a glass tube into a jar of lime water. Note change in appearance of lime water. Compare results of the two experiments and account for phenomena.

(3) Place a glass containing lime water on the floor of the school room; on the window sill; near the top of the room; outside of the window exposed to the fresh air. Leave for twenty-four hours. Compare water in the different glasses and give reasons for the change, if there be any. Relate to previous experiments.

8. Respiration.

- (a) Organs connected with respiration.
Heart, arteries, capillaries and veins.
- (b) Organs used in respiration.
Pharynx, glottis, epiglottis, vocal chords, larynx, trachea,
bronchial tubes, air cells and blood vessels.
- (c) Chemistry of respiration.
Plants: inspiration carbon dioxide, expiration oxygen.
Animals: inspiration oxygen, expiration carbon dioxide.
Amount of work done by plants.
Amount of work done by animals.

9. Necessity of Air.

- (a) Fatal results of poor air; no air.
Asphyxiation.
Drowning.
- (b) Necessity of ventilation in—
School room.
Churches.
Theaters.
Cars.
Sick rooms.
Hospitals.
Factories.
Mines.

HEATING.

1. Wood.

2. Coal.

- (a) Life history of trees and plants.
- (b) Food of plants.
Carbon dioxide.
Water.
Nitrogen salts.
- (c) Free oxidation of fallen trees and leaves.
- (d) Slow oxidation of fallen leaves covered with water.
- (e) Subsidence of carboniferous forests.
- (f) Deposition of soil.
- (g) Transformation of plant material into coal.
- (h) Upheaval of submerged area.
- (i) Mining of coal.
- (j) Use of coal as fuel.
- (k) Liberation of the sun's energy as heat.

3. Natural Gas.

- (a) Origin.
- (b) Source.

- (c) Pumping.
 - (d) Piping.
 - (e) Use.
 - (f) Advantages and disadvantages.
4. Systems of Heating.
- (a) Hot air.
 - (b) Hot water.
 - (c) Electricity.

LIGHTING.

1. Kinds of Lights.
- (a) Pine knots.
 - (b) Oil-fat lamps.
 - (c) Candles, tallow dips and molded.
 - (d) Coal oil lamps.
 - (e) Illuminating gas.
 - (f) Electricity.
2. Advantages and Disadvantages of Each.
- (a) Brilliancy.
 - (b) Steadiness.
 - (c) Economy.
 - (d) Effects upon ventilation and furniture.
3. Location of Lights.
- (a) Ceiling lights.
 - (b) Side lights.

SANITATION.

1. Study of Air.
- (a) Pressure.
 - (b) Compressibility.
 - (c) Elasticity.

Experiments.

- (1) Fill a glass with water; place a blotter securely over the top; turn the glass in every direction. Blotter does not fall from the glass because air presses equally in all directions.
- (2) Partially fill a bottle with water; fit a glass tube of small bore, drawn to a point, through a cork. Place the cork in the opening of the bottle making it air tight and extend the tube under the water. Blow through the tube and observe the bubbles rising through the water. As the water occupies the same space, the air must be compressed.
- (3) Apparatus same as in Ex. (2). After blowing through the tube remove the lips. Water comes from the glass tube in a fine stream. The air being elastic, when it is compressed tries to resume its normal density, presses in all directions,

finds the least resistance in the water and forces it up and out of the tube.

3. Pumps.

- (a) Lifting pumps.
- (b) Force pumps.

Glass models of pumps can be procured at small cost from any supply company, or can be easily constructed by the use of some argand lamp chimneys, corks, wire, and leather valves. The principle of the lifting and force pump is simple, every child can understand it. By observing the experiments on pressure, compressibility and elasticity of air, they will be able to construct pumps and understand their workings. The application is made in wind mills, spraying apparatus, etc.

4. Water Works.

- (a) Drinking.
- (b) Cooking.
- (c) Laundry.
- (d) Sanitary purposes of home.
- (e) Lawns.
- (f) Plants and animals.
- (g) Cleaning streets.
- (h) Sanitary purposes of city.
- (i) Fire protection.

5. Plumbing.

- (a) Sanitary plumbing.
- (b) Dangers of imperfect plumbing.
- (c) Diseases incident to imperfect plumbing.

FURNISHING.

1. Rugs.

- (a) Kind.
- (b) Quality.
- (c) Coloring.
- (d) Manufacture.

2. Furniture.

- (a) Polished wood.
- (b) Brass or iron beds.
- (c) Stuffed furniture—not hygienic.
- (d) Drapery.

Light—to admit sun.

Material that can be laundered.

3. Coloring of Walls.

- (a) Living and dining room—cheerful.
- (b) Library—quiet, restful color.
- (c) Bedrooms—personal choice.

ART.

1. Pictures.

- (a) Pictures appropriate for rooms.
- (b) Proper hanging of pictures.
- (c) Correct framing.

2. Statuary.

- (a) Casts.
- (b) Bas-reliefs.

BOOKS.

1. Standard Authors.

2. Selection of Books.

3. Binding.

- (a) Standard books.
- (b) Current literature.

MUSIC.

1. Instruments.

2. Kinds of Music.

3. Composers.

FOOD.

1. Health.

- (a) Food produces growth.
- (b) Exercise produces strength.

2. Kinds of Food.

- (a) Animal.
- (b) Vegetable.
- (c) Mixed diet.

3. Hygienic Cooking.

4. Proper Serving of Food.

5. Stimulants.

- (a) Coffee.
- (b) Tea.
- (c) Alcoholic beverages.
- (d) Evil effects of cigarettés.

DRESS.

1. Economy.

- (a) Best is cheapest.
- (b) Proper material.
- (c) Artistic coloring.
- (d) Hygienic dressing.

 SPRING WORK.

Landscape Gardening.

Suggestions for Planting.

- (a) Relate plants of a harmonious kind and color.
- (b) Plant beautiful flowers in beautiful groups.
- (c) Contrast methods of growth, and hues of blossom and leaf.
- (d) Make beds growing pictures.

Hints on rural school grounds, by L. H. Bailey. Bulletin
160, Cornell University.

Planting of shrubbery. Bulletin 121, Cornell University.

1. Trees.

- (a) Artistic planting.
- (b) Selection.

Maple,	Elm,
Oak,	Birch,
Ash,	Mountain ash,
Poplar,	Horse-chestnut,
Catalpa,	Evergreens.

2. Shrubs.

- (a) Artistic massing of shrubs.
- (b) Choice varieties.

Snowball,	Spirea,
Lilac,	Barberry,
Syringa,	Japonica,
Hydranga,	Flowering almond.
Roses,	

3. Vines.

- (a) Flowering vines.
- | | |
|-----------------|-------------------|
| Clematis, | Wisteria, |
| Honeysuckle, | Virginia creeper, |
| Moonvine, | Morning-glory, |
| Passion flower, | Sweet peas. |

4. Flowers.

Asters,	Petunia,
Ageratum,	Daisies,
Marygold,	Poppies,
Portulaca,	Larkspur,
Zinnias,	Balsam,
Pansies,	Eschlotzia,
Hollyhocks,	Sweet pea,
Bachelor's buttons,	Sunflower,
Candytuft,	Nasturtium,
Phlox,	Mignonette.

5. Bulbous Plants.

Crocus,	Tulip,
Narcissus,	Daffodil,
Hyacinth,	Chinese lily.

6. Propagation.

(a) Separation.

- (1) Secure a bulb, as tiger lily, Bermuda lily; remove the scales, planting those having bulbules in sand. Note the development of plant and the manner of multiplication. Secure mother bulbs from which young bulbs may be detached.
- (2) Cut a hyacinth bulb into quarters at the base, leaving the upper part intact. Plant in sand and observe the location of the growing bulbules.
- (3) Hollow the base of the hyacinth bulb, plant in sand, observe the development of bulbules.
- (4) Corm. Illustrate by gladiola. Plant in sand, remove from the ground occasionally and observe the development of new corms.

(b) Cuttings.

(1) Stem cuttings.

Many plants can be propagated by green wood cuttings.

- (a) Soft wood cuttings—geraniums, coleuses, carnations, fuchsias, marguerites, chrysanthemums, roses.

- (b) Ripened green wood cuttings—azaleas, oleanders and roses.

(2) Leaf cuttings.

Begonias and many thick, heavy leaves are propagated in this way.

- (a) Remove the petiole of leaf, and place in moss or sand in moist atmosphere. Small plants will start from the veins.

- (b) Cut the leaf in two pieces and place the cut margin in moist moss or sand in a moist atmosphere.
- (c) Cut the leaf into several fan-shaped pieces; put the strong rib into the moss or sand.

Various Kinds of Separation.

- (a) Tuber separation.
- (b) Root separation.
- (c) Stem separation.
- (d) Leaf separation.

CARE OF THE GARDEN.

1. Preparation of soil.
2. Layout out of beds.
3. Germinating seeds in boxes.
4. Transplanting seed-plants.
5. Care of plants.
6. Gathering harvest.

Pictures for walls of school room, by

Millet, Breton, Rosa Bonheur, Debat, Ponsan, Corot.

Inalterable Carbon Prints, published by

Mason Ad. Braunn & Co., of Paris, published by Braun, Clement & Co., Successors, Fine Art Publishers, 249 Fifth avenue, New York.

PICTURES SUGGESTED FOR USE IN SCHOOLS.

ADAM. 1801-1867.

499 Four Kittens.

500 The Cat Family.

JACQUE. 1813-1890.

505 The Sheepfold.

MILLET. 1814-1875.

508 Portrait from Life.

516 Shepherdess Knitting.

509 Angelus.

517 Sheep Shearing.

510 The Sower.

518 Water Carrier.

511 The Gleaners.

519 Woman Churning.

512 Going to Work.

520 Feeding the Hens.

513 Labor.

521 Feeding Her Birds.

514 Potato Planting.

522 The Wood Chopper.

DAUBIGNY. 1817-1878.

530 Landscape. Spring.

ROSA BONHEUR. 1822-1899.

- | | |
|--------------------------------|------------------------|
| 537 Portrait from Life. | 548 Changing Pasture. |
| 538 Horse Fair. | 553 On the Alert. |
| 539 Coming from the Fair. | 554 A Noble Charger. |
| 540 Ploughing. | 555 A Norman Sire. |
| 541 Lions at Home. | 556 A Humble Servant. |
| 542 An Old Monarch. | 557 Landais' Peasants. |
| 543 Morning in the High-lands. | |

AUGUSTE BONHEUR. 1824-1844.

- 561 Goats on the Mountain.

LAMBERT.

- 573 Study of Cats.

BRETON. 1827.

- | | |
|-----------------------|-----------------------------|
| 575 Song of the Lark. | 578 Recall of the Gleaners. |
| 576 Morning. | 579 End of Labor. |
| 577 The Gleaner. | 580 Blessing the Fields. |

LEROLLE.

- | | |
|----------------------|-------------------------------|
| 618 The Shepherdess. | 620 Arrival of the Shepherds. |
| 619 By the River. | |

DUPRE. 1851.

- | | |
|--------------------|---------------------|
| 601 The Haymakers. | 603 Escaped Cow. |
| 602 Milking Time. | 604 On the Prairie. |

LAUGEE.

- 615 In Autumn

DUTCH ART.

PAUL POTTER.

- | | |
|-------------|-------------------------|
| 738 Cattle. | 740 Head of Young Bull. |
| 739 Bull. | 741 The Prairie. |

MAUVE.

- 756 Sheep.

GERMAN ART.

MEYER VON BREMEN. 1813-1886.

792 The Pet Bird.

BRITISH ART.

SIR JOSHUA REYNOLDS. 1723-1792.

861 Angel Heads.

862 Age of Innocence.

863 Simplicity.

864 Penelope Boothby.

HERRING. 1795-1865.

886 Pharaoh's Horses.

887 The Village Blacksmith.

888 Three Members of a Temperance Society.

LANDSEER. 1802-1873.

891 The Connoisseurs.

892 Members of the Humane Society.

893 Saved.

894 My Dog.

895 Odin.

896 Dignity and Impudence.

897 Well-Bred Sitters.

898 King Charles Spaniels.

899 Sleeping Bloodhound.

900 Alexander and Diogenes.

901 "There's Life in the Old Dog Yet."

902 Highland Shepherd's Chief Mourner.

903 Piper and Nutcrackers.

904 The Sick Monkey.

905 The Prize Calf.

906 The Font.

907 A Highland Lassie with Fawns.

908 Shoeing the Horse.

909 Wild Cattle of Chillingham.

910 Red Deer of Chillingham.

911 A Deer Family.

912 King of the Forest.

913 Monarch of the Glen.

914 The Challenge.

915 The Combat: Night.

916 The Combat: Morning.

917 Stag at Bay.

918 The Sanctuary.

The Deer Pass.

BURNE-JONES. 1833-1898.

946 Spring.

947 Summer.

948 Autumn.

949 Winter.

953 First Day of Creation.

954 Second Day of Creation.

955 Third Day of Creation.

956 Fourth Day of Creation.

957 Fifth Day of Creation.

958 Sixth Day of Creation.

AMERICAN ART.

W. M. HUNT. 1790-1864.

- | | |
|-------------------|----------------------------------|
| 1002 Tiger. | 1004 Horses and Cart on a Beach. |
| 1003 June Clouds. | |

UNCLASSIFIED.

1093 St. Cecilia. Naujok.

FLEMISH ART.

VAN DYCK. 1599-1641.

- | | |
|----------------------------|------------------|
| 645 Portrait of Charles I. | Five Children. |
| 646 Children of Charles I. | 648 Baby Stuart. |
| 647 Children of Charles I. | |

ANCIENT SCULPTURE.

- | | |
|----------------------------------|--------------------------------------|
| 1160 Apollo. Head. | 1172 Venus de Milo. |
| 1161 Nike Loosening Her Sandals. | 1173 Victory of Samothrace. |
| 1163 Hermes. Bust. | 1174 Victory of Samothrace. Profile. |
| 1164 Athena. | |

ANIMALS.

- | | |
|--------------------|--------------------------|
| 1301 Camel. | 1308 Asiatic Lion. Head. |
| 1302 Elephant. | 1309 Rhinoceros. |
| 1303 Giraffe. | 1310 Royal Bengal Tiger. |
| 1304 Hippopotamus. | 1311 Shetland Pony. |
| 1305 Jaguar. | 1312 Tigers. |
| 1306 Leopard. | 1313 Zebra. |
| 1307 African Lion. | 1314 Zebu. |

HISTORICAL AND GEOGRAPHICAL.

- | | |
|-----------------------------------|-------------------|
| 1401 Yosemite; from Artist Point. | 1404 Pike's Peak. |
|-----------------------------------|-------------------|

EGYPT.

- | | |
|---------------------------------------|---|
| 1451 Colonnade in Great Hall. Abydos. | 1459 Karnak. Entrance to Temple of the Rameses. |
| 1455 Ghizeh. Sphinx and Pyramids. | |

ENGLAND.

1481 Houses of Parliament.
1482 St. Paul's Cathedral.

1485 Westminster Abbey.

FRANCE.

1537 Madeleine.
1545 Notre Dame.

1550 Pantheon.

GERMANY.

1601 Cologne Cathedral.

GREECE.

1611 Temple of Minerva.

1616 Parthenon.

NORWAY.

1644 Midnight Sun.

1649 North Cape.

SPAIN—GRENADA.

1850 Alhambra.

SWITZERLAND.

1883 Mont Blanc.

1884 Mer de Glace.

ITALY—FLORENCE.

1662 Baptistery.

MILAN.

1685 Cathedral.

PISA.

1718 Leaning Tower.

1720 Baptistery.

ROME.

1750 St. Peter's.

1763 Colosseum.

1758 Bridge and Castle of St.
Angelo, with St.
Peter's.

1766 Forum.

VENICE.

1802 St. Mark's.

1822 Eve. Statue.

1821. Adam. Statue.

These selections are from the Perry Pictures, price one cent each, and may be obtained from The Perry Pictures Co., Boston, Mass.

Also, pictures in colors—birds, animals, minerals, fruits—and pictures of forest trees—the tree, a section of the trunk, a spray of leaves, and a short description of the tree—may be obtained of the same firm.

STATUARY.

PARIS.

la Venus de Milo (ant.) Louvre.

ROME.

47a Jupiter (bust) Vatican.
55a Belvedere Mercury, Vatican.

RAPHAEL'S DAYS, Farnese Palace, Rome.

290b Diana (Monday).
291b Mars (Tuesday).
292b Mercury (Wednesday).
293b Jove (Thursday).
294b Venus (Friday).
295b Saturn (Saturday).
296b Apollo (Sunday).

RAPHAEL'S HOURS.

297b First Hour of the Day.
298b Second Hour of the Day.
299b Third Hour of the Day.
300b Fourth Hour of the Day.
301b Fifth Hour of the Day.
302b Sixth Hour of the Day.
303b First Hour of the Night.
304b Second Hour of the Night.
305b Third Hour of the Night.
306b Fourth Hour of the Night.
307b Fifth Hour of the Night.
308b Sixth Hour of the Night.

FRENCH SCHOOL.

COROT, JEAN BAPTISTE CAMILLE (1796-1875).

572b Landscape. Louvre, Paris.
573b Landscape, Morning. Louvre, Paris.
574b Landscape. Durand, Ruel Collection.
575b Orpheus and Euridice.
576b Diana at the Bath.
577b Landscape.
578b Landscape.

MILLET, JEAN FRANCOIS (1814-1875).

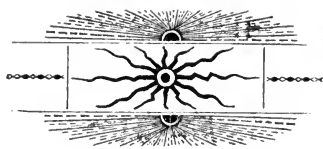
- 580b First Step.
- 581b Feeding the Nestlings.
- 582b The Gardener.
- 583b The First Step.
- 584b The Sower.
- 585b The Gleaners. Louvre, Paris.
- 596b The Spinner.
- 587b The Basket-maker (drawing).

These selections are from the catalogue of Francis Hendricks & Co., Art Publishers, Syracuse, N. Y.

APPARATUS.

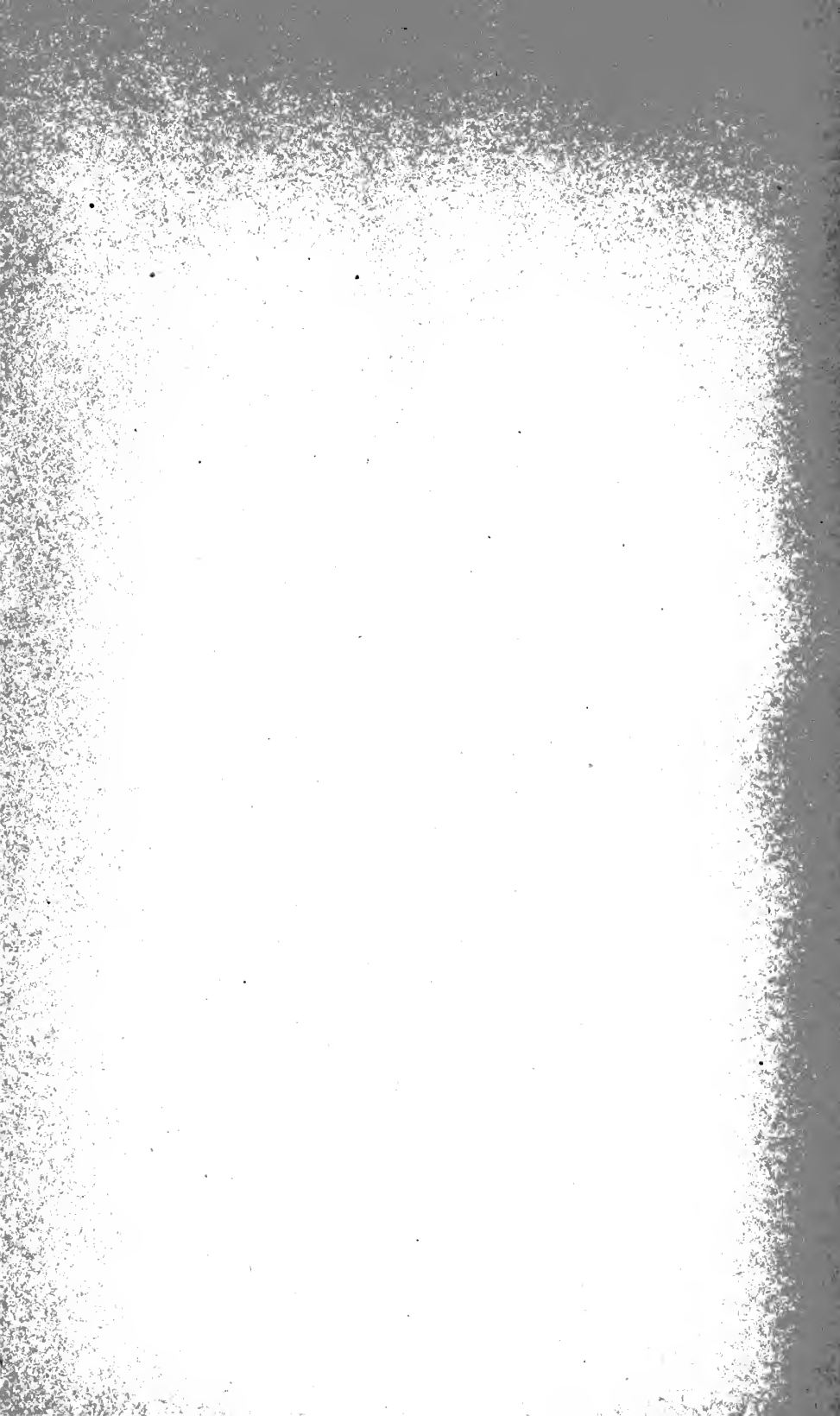
- | | |
|---|---------------------------------------|
| 1 beaker, 100 c. c. | 1 mortar and pestle, 85 mm. |
| 1 beaker, 200 c. c. | 1 porcelain crucible and cover. |
| 1 box matches. | 25 round filters. |
| 1 clay pipe. | 1 sand bath, flat. |
| 1 cork for cylinders. | 1 sand bath, hemispherical. |
| 3 cylinders. | 1 stick charcoal. |
| 1 deflagrating spoon and guard. | 6 test tubes, 5-inch. |
| 1 evaporating dish, No. 00. | 1 test tube holder. |
| 1 flask, 100 c. c. | 1 test tube rack. |
| 1 flask, 250 c. c. | 1 triangular file. |
| 1 funnel, 65 mm. | 1 tubulated retort. |
| 2 funnel tubes. | 1 U-tube, 4-inch. |
| 1 glass bottle. | 1 watch glass. |
| 3 glass plates. | 1 wire gauze, 4x4 inch. |
| $\frac{1}{2}$ length glass rod. | 1 galvanized iron pan, 15x18x3. |
| 2 lengths glass tubing. | Glass tubing of large and small bore. |
| $\frac{1}{2}$ dozen quart fruit jars. | 1 yard of rubber tubing. |
| $\frac{1}{2}$ dozen panes of window glass, 12x15. | 1 alcohol lamp. |
| $\frac{1}{2}$ dozen argand lamp chimneys. | Corks. |
| $\frac{1}{2}$ dozen tumblers. | Horse shoe and bar magnets. |
| 1 dozen test tubes. | Iron filings. |
| Hydrochloric acid. | Copper beaker. |
| Sulphuric acid. | Zinc. |
| Copper sulphate. | Thermometers. |
| $\frac{1}{2}$ length hard glass tubing. | |













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