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EDITED BY

WILLIAM T. HARRIS, A. M., LL. D.

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INTERNATIONAL EDUCATION SERIES

SYSTEMATIC SCIENCE TEACHING

A MANUAL OF INDUCTIVE ELEMENTARY WORK FOR ALL INSTRUCTORS

BY

EDWARD GARDNIER HOWE

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EDITOR'S PREFACE.

A MANUAL of instruction in natural science for use in the elementary schools has long been in request; but attempts to supply this have hitherto failed, for one of two reasons. Either they were one-sided, giving too much prominence to some narrow field of science and apparently assuming that other fields had no claim on the attention of the pupil, or else they have given too little assistance to the teacher or the pupil, and have limited themselves to offering vague general directions as to matter and method. The teacher's manual should give much of the matter to be taught, and make definite references to other sources of information for much more material. Above all, it should illustrate methods of instruction; it should show the method of investigation adapted to each province of Nature. A dry list of topics, although arranged in the proper sequence, does not make a sufficient manual. It should give enough of the results of scientific research to set the teacher and pupil on the right track of inquiry. It should direct his investigation in a twofold direction: First, to authoritative books written by competent scientific men, and setting forth in a clear and succinct manner the results of the observations and experiments of scientific specialists in each field. Second, it should direct the teacher and pupil how to get access to the real objects in Nature, and how to verify for one's self the discoveries that have been made by the specialists. For this purpose the book must illustrate by a sufficient variety of experiments the method of discovery in each field of research. The school attempts to place the pupil on the point of advantage where he can profit by the results and by the methods of his predecessors. He must get not only the dead results, but also the living method—the method of observation and discovery.

The powers of observation are strengthened chiefly by learning to think about what one sees. It is often held that observation is cultivated only by using the senses. But sharpness of the senses is a different matter from the capacity for scientific observation. The latter is a matter of apperception, and not of mere perception. It is the act of recognizing, and not the act of mere seeing, that gives us scientific knowledge. The acute seeing of the hawk or the greyhound does not lead to science. The dim eyes of the aged Humboldt see a thousand circumstances in the object which escape the eyes of the bird and dog, because Humboldt's eyes are armed with the experience of the human race and with the methods discovered by a long line of scientific men. He brings with him their results and their methods, and a swift glance interprets the object even when dimly seen. From the details partially seen the observer knows the rest. Louis Agassiz or Theodore Gill could make a drawing of the entire fish from seeing only a scale; this has been done even when only the scale, and not the fish itself, had ever yet been seen by the one or the other. The geologist Lyell could read its history in a pebble. The archæologist Winckelmann could recognize a Juno, a Diana, or a Venus in classic sculpture if only the eye were uncovered and all the rest concealed. Such is the power of the reflective intellect, which discovers relations and interdependencies, to re-enforce the perception of the senses.

The first step above brute instinct begins when man looks beyond things as he perceives them with his eyes, ears, and hands, and commences to consider their possibilities. He then begins to add to his external seeing an internal seeing, and the world soon assumes a new aspect: each object appears to contain more than what is immediately visible and tangible; for there is a sphere of possibility environing it, a sort of halo about it in which shine other possibilities that essentially belong to the nature of the object perceived—namely, the past stages of development through which this object has become what it is, and the future stages through which it is destined to pass in its natural course of development. The sharp eyes of the lynx or of the eagle can not see this halo of possibilities; but the scientific man, endowed with this new faculty of inward sight, perceives, or rather apperceives it at once. He sees in each object its past and its future, and a great variety of uses and adaptations, transformations and combinations, in a long series stretching into the infinite behind each visible thing. The bodily eyes see the real objects, but not the infinite trails; these are invisible, except to the mind armed with science. The senses perceive what is now and here; the scientific mind makes a synthesis, and sees what is present in the perspective of all times and places.

What is called directive power on the part of man, his combining and organizing power, all rests on this power to see beyond the real things before the senses to the ideal possibilities invisible to the brute.

The more clearly man sees ideals the more perfectly he can construct for himself another set of conditions than those in which he finds himself.

Each object in the world exists now in one of its many possibilities; its reality of the past has changed, and its reality of to-day will give way to other forms of reality in the future. An acorn to-day was an oak blossom once, and before that a bud; it will be a sapling, and then an oak tree with a crop of acorns. But the senses can behold only one particular phase of this development —what happens to be then present. Science collects about each object all its phases of existence, for it is the systematized result of observation; it teaches the student to look at a thing as a whole, and see in it not only what is present but has been realized before and now outgrown, as well as what is now potential and will by and by come to be. Science unites facts into a system in such a manner that each fact throws light on the other facts, and thus all facts help to explain each. This is the definition of science.

From science comes the ability to conquer Nature and relieve mankind from mere drudgery for the sake of food, clothing, and shelter. For science lights the way to combinations of matter and force—to inventions whereby the energy in nature may be made to produce the supply of the human wants of food, clothing, and shelter.

The civilization in which we live is well described as scientific. It is the application of science to the invention and use of labor-saving machines that increases the productive power of the laborer. There is less and less place left for the mere drudge, who is all hands and no brain. Machinery can do his work so cheaply that his wages must grow more and more inadequate for his support. But for the educated laborer, armed with science and able to direct machinery, there is ever-increasing productive power and a continually increasing share in the productions of industry.

Science leads to invention, and invention leads to the demand for a scientifically educated class of laborers. Education emancipates the laborer from the deadening effects of repetition and habit, the monotony of mere mechanical toil, and opens to him a vista of new inventions and more useful combinations.

This changes the conditions of apprenticeship. The old seven-year term of apprenticeship was necessary when so much depended on nicety of manipulation. To-day the machine substitutes mechanical nicety and precision in place of skill of hand and eye. All that is required is a scientific knowledge of the machine and of the material that it works upon. Gladstone estimated, in 1870, that the productive power of England doubled once in seven years by the increase and improvement of machinery. The production of the people of the United States increased from twenty-five cents per day for each man, woman and child in 1850, to forty cents per day in 1880, chiefly by the introduction and use of machinery.

In view of the influence of science on our civilization it would seem important to introduce the pupils of our elementary schools to the results and methods of science as early as possible. This depends mainly upon the mathematics involved in science. Some sciences demand higher mathematics, and must be postponed until the high school or the college course. Nearly all the sciences, however, have qualitative and quantitative aspects that may be made of interest to the young pupil. This makes it possible to arrange a spiral course of study in natural science extending from the commencement of the primary course of study to the last year of the college. The first cycle deals with objects familiar to the experience of the child of seven years and teaches him how to observe and classify. In teaching him classification it describes the results of observation and experiment thus far accumulated, and helps him to verify them by experiments of his own.

It is very important to have the scientific studies cover as fully as possible all the provinces of Nature. 1. There is the inorganic province, containing the two fields of astronomy and physics (including chemistry). 2. There is the organic province, containing the plant and the animal. Mr. Howe, in this work, has accordingly made his course a spiral one, ascending from a first cycle of lessons treating the four aspects of nature—1, stars and earth; 2, minerals and rocks; 3, plants; 4, animals—to a second, third, and fourth cycle, each adapted to a more advanced class of pupils. He has taken great pains to so grade the work that the pupils will be found ready at each step of progress to take up profitably the topics assigned. His happy selection of objects in the four fields of nature study here introduced insures the constant interest of the pupil; but the most valuable feature of this book is the detailed hints and directions to the teacher and pupil that will secure correct and accurate habits of scientific observation.

W. T. Harris.

Washington, D. C., *September, 1894.*

AUTHOR'S PREFACE.

ORIGINALLY prepared for Mrs. Alice Putnam and her training class in 1879, these lessons have since been used for fourteen years in my own classes and in a modified form presented many times to the teachers of Chicago and elsewhere. Long urged to put them in print, a year's leisure has enabled me to carefully revise them, and it is with an increased measure of confidence in their helpfulness that they are now presented to educators.

The result of this progressive, systematic work in science has been exceedingly satisfactory. Interest has rarely flagged, and the senses have been developed to a surprising degree. The hand has been trained in the art of experiment, and the mental powers have made a steady and healthy growth. An exactness and freedom in expression have been attained, and this is the truest index of a mind full of observed facts, and trained to the thoughtful consideration of matters presented. The advanced pupil has gone to the study of books with ease and profit.

Such substantial results alone would justify the time spent.

Moral Influences.—But this work has reached deeper and further. The inborn love of childhood for birds, flowers, and pretty stones has quickly responded to wise encouragement and become the present source of much happiness, and this of the purest sort. Incidentally tending to keep out low pleasures, it has been in many cases the prelude to the recreations of mature life.

Results Real.—That these fruits of science teaching are not chimerical, I have the assurance of those instructors under whom I have been so free to test these plans of work; the words of encouragement from parents; and, best of all, the lives of many pupils. To the advanced instructors of to-day the value of science teaching is no longer in question. That with the pleasurable acquiring of much useful knowledge, the senses can be quickened, the mental powers developed, and a loving interest in ever-present and pure things be fostered, which in mature life shall render us in a great degree independent of time, place, or man's device for needed recreation, is certainly all that need be said in its favor.

Time saved in the End.—Not even time is really an obstacle; for repeated experience has shown the ease and rapidity with which physics, physical geography, botany, etc., have been mastered after this elementary training.

The real trouble has lain in the way teachers were taught, the difficulty of getting material, and the haphazard, aimless method in which subjects were presented.

It is with a sincere wish to smooth away some of these very real obstacles, and aid those who desire to take up this delightful line of work, that I present the results of years of study as to the best order of presentation and the most easily obtained material which would answer the purpose aimed at. This has all stood the test of actual and repeated teaching to pupils and presentation to classes of teachers and others, except the first ten Steps, which I have worked out at the request of Col. F. W. Parker, seconded by many teachers of the lower grades.

Graded Work made possible.—I have also outlined the work in such a way as will enable a teacher to begin where his predecessor left off, with full knowledge of what has been done and a definite plan of what to do next; thus making it possible that the science work of a school may be systematic and progressive through all the grades.

Nor has my thought been entirely of the teacher. Two classes of children have especially appealed to me:

First. The children of the country districts, who spend their lives amid the scenes of nature and yet in maturity are, as Whittier says,

> "Blind to the beauty everywhere revealed,
> Treading the mayflowers with regardless feet;
> For them the song sparrow and the bobolink
> Sang not, nor winds made music in the leaves;
> For them in vain October's holocaust
> Burned, gold and crimson, over all the hills,
> The sacramental mystery of the woods."

Not only would untold happiness come into these lives if the love of innocent childhood for nature could be fostered till it broadened into the refining and elevating appreciation of the men and women, but the habits of scientific thought and inquiry would mean wealth besides.

Second. The children of the city see so little that is natural and so much that is artificial that their lives, never feeling the sweet influences which flow from communion with flowers, trees, and birds, acquire a restless, nervous mode of life which nothing but the saloon, gambling table, and theater can satisfy.

Even for these much might be done. By the co-operation of the park authorities or special greenhouses and supply depots with delivery wagons, the teacher in the city ward could have the needed flowers, frogs' eggs, etc., supplied. Nowhere else would such lessons be more appreciated, and the effect of the introduction of a few boxes of pots with sprouting morning-glory seed, or some pans of crayfish or frogs' eggs, in which each "street Arab" felt he had a share, would do wonders in the discipline, the work in language and drawing, to say nothing of the character.

To these two classes especially has my heart gone out in a desire that, with Whittier, I might

> "Invite the eye to see and heart to feel
> The beauty and the joy within their reach—
> Home and home loves, and the beatitudes
> Of nature free to all."

To Superintendents, School Boards, and Others in Authority.

Permit a disinterested student of school methods to offer some suggestions bearing on science work.

Deal generously with your Teachers.—Not only pay them well, but *trust* them. They will do better work if given the freedom to do it in their own way; and if unworthy of trust, they are unworthy the delicate and vital task of molding the characters of our children, and should be at once dismissed.

If a teacher desires, or is willing, to take fifteen or twenty minutes a day for a science lesson, aid her with the few dishes, window boxes, and specimens she may need; or, better still, place a small sum of money at her disposal to be strictly accounted for.

Apparatus.—Never buy an elaborate set and then seek a teacher to use it. Teachers differ, and will reach the same end in a number of ways. Hence, secure your teacher and let the apparatus he or she can best use be selected. Then keep the teacher if satisfactory.

Be patient if the teacher seems earnest in her work. Only very weak things grow in a day, and if really good work is being done, the substantial results must of necessity be slow in appearing. If the children are learning "to *think* to a conclusion," if they are becoming *observant*, if they are *interested* in their school and go home full of the things they have seen and done, do not criticise because those "things" are "bugs and weeds," nor complain because more words are not learned or arithmetical problems solved. The "words" may be meaningless and problems mechanical, but active, willing seeing and thinking is in the line of all that is desirable.

Teacher's Diary.—In engaging a teacher, have it understood that a brief diary of each subject taught shall be kept, and at the close of the year there be entered a complete list of all classes, what each had done during the year, where they left off, and what the plan is for the coming year. Deposit this in a safe place for whoever has the school next. Then, in case the calamity and incident loss of a change of teachers falls upon your school, the new one will be greatly helped to get her bearings, and at least a month's salary and progress be saved to your school and children.

E. G. Howe.

Champaign, Ill., *September, 1893.*

CHART,

Showing the work of each year, the relation of the different steps to each other, and brief suggestions as to how science is related to other work.

THE STARS AND EARTH.

MINERALS AND ROCKS.

PLANTS.

ANIMALS.

Read *across* for each *year's* work and down for each subject.

Roman numerals always indicate *steps.*

Year of Work.	*A.* The Stars and Earth.	*B.* Minerals and Rocks.
1st.	The Skies (general). II. Early winter. 10 lessons.	Metals sorted. III. Winter. 12 lessons.
2d.	The Moon. VII. Winter. 10 lessons.	Minerals sorted. VIII. Winter. 15 lessons.
3d.	The Earth. XVI. Spring. 20 lessons.	Minerals and Rocks sorted. XIV. Winter. 15 lessons. Pebbles. XV. Winter. 30 lessons.
4th.	The Earth (*continued*). XXII. Late spring. 20 lessons.	How Sharp Stones came to be. XX. Winter. 25 lessons. Plane Form and Color. XXI. Winter. 20 lessons.
5th.	The Solar System. XXIV. Early winter. 20 lessons.	Metals studied. XXV. Winter. 20 lessons. Solid Form. XXVI. Winter. 15 lessons.
6th.	Gravitation. XXX. Late fall. 20 lessons.	Molecule Lessons. XXXI. Winter. 60 lessons.
7th.	Light, Telescope, Spectroscope, Laplace. XXXV. Late fall. 30 lessons.	Crystals. XXXVI. Winter. 25 lessons. Minerals studied. XXXVII. Winter. 40 lessons.
8th.	The Early History of the Earth. XLI. Winter. 30 lessons.	Coins. XLII. Winter. 10 lessons. Earth - making. XLIII. Spring. 40 lessons.
9th.	Other Systems than Ours. XLVI. All through year. 20 lessons.	Rocks. XLVII. Winter. 50 lessons.

C. Plants.	*D.* Animals.
Sorting Seeds and Fruits. I. Autumn. 20 lessons. Buds. IV. Spring. 15 lessons.	Eight Home Animals. V. Early summer. 35 lessons.
Roots and Stems. VI. Autumn. 10 lessons. Typical Leaves. X. Early summer. 15 lessons.	Twenty-three Familiar Animals of Spring and Moral Lessons connected. IX. Spring. 50 lessons.
Trees. XII. Autumn. 12 les. Woods and Barks. XIII. Winter. 15 lessons. Flowers. XVII. Late spring. 25 lessons.	Thirty-three Foreign and Less Familiar Animals. XI. Autumn. 50 lessons.
Fruits studied. XVIII. Autumn. 25 lessons.	Boy studied. XIX. Early winter. 50 lessons.
The Life History of One Plant. "Morning-glory Lessons." XXIII. Autumn. 45 lessons.	Boy Study applied to a Series of Typical Animals. XXVII. Late spring. 50 lessons.
Relationships of Plants. XXVIII. Autumn. 30 lessons. (To man, see Step XXXII.)	Winter Quarters of Animals. XXIX. Late autumn. 20 lessons. Man at Home. XXXII. Spring. 40 lessons.
Winter Quarters of Plants. XXXIV. Autumn. 30 lessons.	Life Histories of Types. XXXVIII. Late spring. 40 lessons.
Parts and Structure of Fruits. XXXIX. Autumn. 20 lessons. Corn and Beans. XL. Autumn. 25 lessons.	Life Histories of Types (*continued*). XLIV. Spring. 40 lessons.
Important Families of Plants at Sight. XLV. Autumn. 25 lessons. Important Families. XLIX. Late spring. 25 lessons.	Animal Groups. XLVIII. Spring. 40 lessons.

Year of Work.	Feeling and Touch.	Hearing and Ear.	Seeing and Eye.
1st.	Sorting seeds. Sorting metals.	Animals.	Sorting of seeds, buds, and metals. Animals.
2d.	Minerals. Leaves (surface).	Animals.	Roots and stems. Minerals. Leaves. Animals.
3d.	Woods and barks. Rocks. Pebbles.	Animals.	Trees. Woods and bark. Rocks. Animals. Flowers.
4th.	Fruits. Boy (touch).	Boy's ear.	Fruits. Boy's eye. Form (plane). The earth.
5th.	Metals. Solids. Boy lessons.	Boy lessons.	Morning-glory. Metals. Solids. Boy lessons (eyes, etc.).
6th.	Animal lessons.	Molecules. Animal lessons.	Collections made.
7th.	Crystals. Minerals. Animal sensation.		Light and the eye. Crystals and minerals (optical). Plants. Animals.
8th.			
9th.			

Smell.	Taste.	Physiology, etc.
Seeds and fruits (odors). Buds (odors). Animals (nose).	Seeds and fruits tasted. Buds tasted. Animals—food and tongue.	Boy.
Roots and stems. Animals (nose). Leaves (odor).	Roots and stems tasted. Minerals—salt, etc. Animals—tongue and food. Leaves tasted.	Through animals.
Trees. Woods. Rocks (clay, etc.). Flowers.	Trees, woods, etc. Animals—tongue and food.	Through animals.
Fruits (know by smell). Boy's nose.	Fruits, by taste. Boy—tongue, and use of.	Boy—use and care of parts, etc.
M.-glory (use of odors). Metals. Boy lessons.	Morning-glory. Metals. Boy lessons.	Reproductive process illustrated in plant life. Boy lessons.
Plants (odors). Man.	Plants. Man.	Man (foods). Molecules. Plants (poisonous, etc.).
Minerals.	Minerals.	Winter quarters of plants. Animals (comparative).
		Fruits as food. Animals.
		Plants. Animals.

Year of Work.	Color.	Form.
1st.	Seeds and fruits. Comparison with standard colors. Metals (metallic). Animals (comparison).	Seeds and fruits. Skies. Metals. Buds.
2d.	Roots and stems. Minerals. Leaves. Animals (use of, etc.).	Roots and stems. Minerals. Leaves.
3d.	Minerals. Trees and woods. Flowers. Compare with standard. Animals.	Animals. Trees (top, etc.). Pebbles. Flowers.
4th.	Fruits. Compare with standard colors. Use of colors in other work.	Fruits. Variations in form. Plane form.
5th.	(Advertises, etc.) Morning-glory. Metallic, in metals. Use, to animals. Coloring diagrams, etc., in all.	Morning-glory (a guide). Solids.
6th.	Plants and insects. Animals (winter change). Man.	Plants. Molecules. Animals.
7th.	Winter quarters of plants. Minerals. Animals. Spectroscope, etc. (XXXV.)	Crystals. Minerals.
8th.		
9th.		

Number.	Size and Weight.
Seeds. Metals. Buds. Animals.	Seeds (comparison). Metals (relative).
Moon (months, etc.). Minerals (specimens of each, etc.). Leaves.	Minerals (relative). Leaves (relative).
Animals. Rocks. Flowers.	Rocks (relative). Pebbles (relative). Trees (relative). Flowers (relative).
Fruits. Boy. Form.	Fruits (comparative). Boy (sense of weight cultivated). Form and metric measure.
Morning-glory (parts, etc.). Solar system. Solids (measurements, etc.). Boy lessons.	Solar system. Metals. Solids.
Gravitation. Molecules.	Gravitation. Molecules (use of metric volume).
Stars and earth. Crystals. Minerals.	Crystals. Minerals.
Fruits. Coins. Earth-making.	The earth. Coins, etc.
Plants. Rocks. Animals.	Earth (specific gravity, volume, etc.). Rocks.

Year of Work.	Hand Training.	Drawing.
1st.	Seeds (touch). Skies (sewing star-groups, etc.). Metals (bend, etc.).	The skies.
2d.	Moon (pasting four phases, etc.). Minerals (hardness, etc.). Leaves (sew, mount, etc.).	Roots and stems. Leaves.
3d.	Woods. Rocks (labeled). The earth.	Earth (diagrams). Flowers.
4th.	Sharp stones. Plane form. The earth (charts).	Fruits. Plane form. Boy.
5th.	Morning-glory (in experiment). Metals. Solids made.	Morning-glory cards. Solar system (diagrams). Solid form and measure.
6th.	Gravitation (experiment). Molecules (experiment). Arranging collections.	Plants. Star work.
7th.	Plants. Star work. Crystals. Minerals.	Winter quarters of plants Star diagrams. Life histories of animals.
8th.		Fruits. Corn and beans lessons. Earth. Life histories of animals.
9th.		Illustrating plant families. Stars and earth (diagrams). Rocks. Animal groups.

Painting.	Modeling.
	Seeds and fruits. Eggs, etc., of animals.
Coloring sections of roots and stems. Leaves.	Model roots. Leaf impressions.
The earth (diagrams). Flowers.	Trees (peculiarities). Animals (special points). Pebbles.
Fruits. Boy. Form.	Fruits. Boy (special points of structure). Sharp stones. Form.
Cards and diagrams for morning-glory. Solar system.	Solar system. Solids.
Coloring of cards and drawings.	Winter quarters of animals. Man at home.
Coloring of all drawn work.	Plants in winter quarters. Crystals.
Colors in connection with all illustrating.	Fruits. Corn and beans lessons. Relief of the earth's surface.
Colors in connection with all drawn work.	Rock formations, etc. Plant families.

Year of Work.	Geography.	Chemistry.
1st.	Map and globe in sight and constantly referred to. Points of compass, etc., in skies.	Metals (elements). Animals.
2d.	Observe moon. Locate all places spoken of.	Minerals. Animals.
3d.	Locate places on globe and map. The earth (longitude, time). Relief of land, etc.	Animals.
4th.	Locate all places spoken of. The earth (latitude, seasons). Relief of land, etc.	Sharp stones. Boy (air, CO_2, etc.).
5th.	Locate places on map and globe. The earth as a member of the solar system.	Morning-glory. CO_2, etc. Metals. Candle flame, rusting, etc. Boy lessons.
6th.	Locate and read of places. Gravitation and the tides. Man at home. Distribution of plants.	Plants. Molecules.
7th.	Constant use of maps and globe. Distribution of mineral wealth shown. Climate.	Winter quarters of plants. Star work (spectrum, etc.). Crystals. Minerals.
8th.	Continued location of places. History connected with coins. Natural divisions.	Earth and earth-making. Plant lessons.
9th.	Distribution of plants and animals geographically.	Rocks.

PHYSICS.	IMAGINATION.
Skies. (Compare, etc.) Metals (magnet). Hardness, etc. Covering of buds. Animals.	Skies. Mental picturing.
The moon. Minerals. Animals.	Moon. Mental picturing.
Animals. Pebbles. Barometer, etc. Earth.	The description from memory of animals, trees, etc. Mental picturing of the processes in pebbles, etc.
Boy. Sharp stones. Light, heat, etc., in "the earth."	Trying to form mental concepts of the earth. Sharp stones. Mental pictures of processes, and examples.
Morning-glory. Experiments. Solar system. Metals. Boy.	Concepts of other worlds than ours, and their relations. Morning-glory work thought out. Solids.
Plants. Winter quarters of animals. Gravitation. Molecules.	Plants. (Conditions conceived.) Mental concepts of effects of gravitation. Work in molecular structure.
Winter quarters of plants. Stars. (Light, etc.) Crystals. Minerals.	Concise description cultivated. Concepts of light. Crystals.
Fruits. (Opening, etc.) Star work. Earth making.	Generalization begun. Mental concepts of earth's history and rock formations.
Star work. Rock making. Animal mechanism.	Generalizations continued. Expansion of astronomical ideas. Rock changes, etc.

Year of Work.	Language.	Reading.
1st.	Encourage the natural flow of talk about the objects, and only correct gross errors.	Read choice things bearing on the work. "Black Beauty," etc., to teach kindness to animals.
2d.	Encourage *description* of all objects. Commend conciseness and clearness, but criticise *very* little.	Choice selections read to class. Make connection between the *thing* to its picture, and then "word picture."
3d.	Let descriptions become more *exact*, and by constant exercise train in that direction.	Continue to link the object, its picture, and the word.
4th.	*Exact terms* will now be at command. Encourage terseness by their use.	Read to pupil, and then let him reread to himself. Class begin lists of books to read under guidance of teacher.
5th.	Morning-glory cards; signs and colors as indicating certain things. *Notes* will now give opportunity for brief and exact *written* description.	Stimulate by choice extracts. Pupils reread known stories.
6th.	Notes kept. Use of increased vocabulary in description, definition, etc.	Books of travel read. Sir Isaac Newton's life. Literature of missions to aid in knowledge of man at home.
7th.	Notes kept. Terse and exact description. Vocabulary of understood words increased.	Of Galileo and Laplace, Sir William Thompson, etc. Mineralogies consulted. Physics consulted.
8th.	Notes and description. Terse and exact generalization. Mental concepts of phenomena put into words.	Geologies, physiographies, botanies, etc., consulted, and best ones recommended. Book on coins.
9th.	Training in the comprehensive grasp of detail (expressed). Generalize. Notes, etc., kept.	Astronomies, geologies, and books on systematic botany and zoölogy consulted. Lives of Linnæus and Cuvier. Ecce Cœlum.

Use of Books.	Morals and Character.
Pictures shown. Teach care and neatness in use of; not to drop, tear, or soil.	Self-control in care and use of specimens, especially those good to eat. Character illustrated by animals.
Child find pictures to match objects. Teach how to cover; place for name, etc.	Self-control, especially in minerals. Kindness to animals. Character as typified by animals.
Continue to match things and pictures in books on science, etc.	Animals; continue to note the *desirable* traits. Self-control in care of specimens.
Match things with cuts and read descriptions. Teach child how to gather and care for his personal library.	Self-control in fruits. Boy. The earth. Inspiration of *great* subjects and vast distances, etc.
Consult for information. Teach use of index and glossary.	Morning-glory. Emphasize the beauty and wonder of plant reproduction. *Neatness* in notes and drawing. Honesty in care of specimens.
Use of maps and charts taught. Gazetteer and simple encyclopædia explained and used.	Care and neatness in drawing and coloring, notes, etc. Exactness and thought through experimenting. Reverence through gravitation. The brotherhood of man.
Dictionary used to define. Use of marginal and foot notes. Concordance, etc., taught.	Neatness and care in notes, etc. Advance in knowledge of reproductive functions through animal development.
Extend knowledge of desirable books. Show how to catalogue a library and to keep list of *loaned* books.	With the gradual unfolding of the wonderful and sublime in nature should be a deepening sense of the power and wisdom of the Crea-
Teach how to make some sort of *card catalogue* of topics. Use Dictionary of Authors and Familiar Quotations, etc.	tor, and the majesty of seemingly puny man. In the light of revelation this should develop into reverence and love to God.

SYSTEMATIC SCIENCE TEACHING.

INTRODUCTION.

Guiding Principles.

Certain principles have governed me in this work, a statement of which will throw light on the why and wherefor of what follows :

1. A child can be led to any height if the steps are made short enough.

2. The mental powers must have *exercise* to grow.

3. The senses are capable of cultivation, and will then increase our "correspondences."

4. The mind derives its ideas from the perceptions of the senses.

5. Ideas (i.e., suggestions) will manifest themselves in corresponding words and actions, or, as "seed thoughts," develop into new and original discoveries and inventions.

6. **Feeding.**—Childhood is the time to grow and fill up. In this stage the pupil should see and handle.

7. **Assimilation.**—In youth the more mature brain is able to act upon the gathered material of childhood, systematize. correlate, reason, and deduce. Pupils should be guided to *experiment* and *observation.*

8. **Reproduction.**—Maturity (as to its character) will be largely based on the resultants of (*a*) the accumulations of the child ; (*b*) the deductions of youth. Pupils should now be led to subjects involving *generalizations.*

9. The value of first impressions is so great that every care should be exercised to make them clear and accurate.

10. To be fixed, impressions must be repeated.

11. Things must be seen from different standpoints and in varied relations. Let the repeating involve this and be a new view as well as a review.

12. No subject is so profound but its central truths can be taught to very small children.

13. These "central truths" will become "seed thoughts," developing naturally with the child's growth, and serving as centers of attraction for related facts.

14. Work from the *simplest*, the *general*—and that within the child's experience—to the *complex*, *particular*, and unknown or *unobserved*.

15. Tell nothing which can be taught in any other way. Do nothing for the child that he can do for himself.

Hence, in the work which follows, I have endeavored to—

1. Get the child to see and handle a wisely chosen and comprehensive series of stones, plants, and animals.

2. Lead to closer observation, and thus increase his acquaintance.

3. Cultivate the powers of decision and still further widen the range of his acquaintance.

4. Systematize and observe the relation of things to each other.

Guided by these principles, I have arranged the work in science under four heads, as shown in the following outline. The relation of these topics to each other, and the school work in general, is shown in the chart.

A. The Stars and Earth.

An Outline of Work, and Reasons for the Same.

1. **A general look** at the skies, to introduce the subject (II).*

Learn some star groups which can always be seen, and their story in myth.

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* Roman numerals refer to the Step.

2. **The Moon.**—Our nearest neighbor, and an easily observed type of the earth. Her light, shape, motions, phases, the months, etc. (VII).

Some star groups seen early on summer evenings and their stories.

3. **The Earth.**—An application of the study of the moon. Shape, daily motion, time, longitude and its use, eclipses, etc. (XVI).

Easily observed constellations of spring and their stories in myth.

4. **The Earth.**—A continuation of 3. Her annual motion, the seasons, latitude and its use, the zodiac, etc. (XXII).

Six constellations of the zodiac learned and their stories in myth, etc.

5. **The Earth's Family Relations.**—Sun, planets, comets, etc. Their relative distance and size. The speed of light, etc. (XXIV).

The remaining six constellations of the zodiac and their stories.

6. **Gravitation.**—How these rapidly moving bodies are held together. Newton. The study of a sublime generalization, which also supplements the work on molecules, etc. Tides, falling stars, etc. (XXX).

The constellations and story of the Argonauts.

7. **More Light needed.**—The six preceding points have brought us to where the eye needs help. The study of *light*, *mirrors*, *lenses*, and the *telescope* (XXXV).

Some things the telescope reveals. What the spectroscope adds. Nebulæ and the theory of Laplace. Constellations and story of Perseus.

8. **The Earth's Early History.**—Application of the theory of Laplace to the study of the earth's form, motions, surface, rocks, etc., preparing for the succeeding steps on earth-making and rocks (XLI).

Use of telescopes and star maps to add to knowledge of heavens.

9. **Other Systems than ours.**—To extend and widen the grand conceptions of astronomy by study of parallax; distances of sun, moon, and some other suns and systems (XLVI).

Continue work with glass and maps, star lanterns, etc., to fix the interest.

B. The Mineral Kingdom.

An Outline of Work, and Reasons for the Same.

1. **Metals sorted.**—Many are already known to the child, and they make the simplest starting point. Prepare for 2, 8, 12, and 13 (III).

2. **Minerals sorted.**—More difficult than metals, and prepare for 3 and 12 (VIII).

3. **Rocks and Minerals sorted.**—An advance in work and new ideas (XIV).

Lead to and prepare for 14 and 15.

These lessons (1, 2, and 3) will have given the child a chance to see and handle a well-selected and typical set of material. Now proceed to narrow and intensify the observation.

4. **Pebbles**, and how they came to be. The work of moving water. Earth sculpture, etc. Lead to and prepare for 5, 6, and 14 (XV).

5. **How Sharp Stones are made, by Roots.**—The power of vegetable growth. Continues 4 and prepares for 14 (XX).

6. **Sharp Stones, by Frost.**—Power of expanding water. Continues 5, introduces to simple experimenting, and leads to 10, 11, and 14 (XX).

7. **Plane Figures and Color.**—This is required for the work in crystals, etc. The *metric* measure alone should be used to familiarize the pupils with this beautiful and scientific system (XXI).

8. **Metals studied.**—Review of 1; introduce more personal experiment and its recording. Prepare for 10, 12, and 13 (XXV).

9. **Solid Form.**—To prepare the way for 11, etc. (XXVI).

10. **Molecule Lessons.**—To give clear and correct concepts in physical matters; advance in art of experimenting and prepare the way for 11, 14, and 15 (XXXI).

11. **Crystals.**—An addition to the work of sharp stones by frost (6) and preparation for minerals (12) and rocks (14 and 15) (XXXVI).

12. **Minerals studied.**—Addition to 2 and 3, application of 9, 10, and 11, and preparation for 14 and 15. Exceedingly valuable in strengthening the powers of decision (XXXVII).

13. **Coins.**—Completes work on metals (1 and 8) and connects with man (XLII).

14. **Earth-making.**—Other ways of making sharp stones (5 and 6), and how the continents are leveled and sculptured and material for sediments made. Application and comprehensive review of molecules (10), and all physics. Preparation for 14 (XLIII).

15. **Rock Lessons.**—A continuation of earth-making (14) and completion of a systematic and experimental study of the mineral kingdom (XLVII).

C. Plants.

An Outline of Work, and Reasons for the Same.

(*a*) A Wide Acquaintance with Specimens.

1. To see and handle typical seeds and dry fruits of autumn (I).
2. To see and handle typical buds of spring (IV).
3. To see and handle stems and roots of autumn (VI).
4. To see and handle leaves of late spring (X).
5. To see and know common trees. The longevity of plants (XII).
6. To know woods and barks. A winter study (XIII).
7. To see and handle typical flowers. Spring (XVII).
8. To see and handle typical fruits. Autumn (XVIII).

(*b*) Closer Study and the Use of Organs and Products.

9. The life history of one plant (morning-glory). More exact work and experimental testing begun (XXIII).

10. Relationships of plants to each other, animals, earth, air, etc. A comprehensive review in new relations and to aid in knowledge of the earth (XXVIII).

(For the relations of plants to *man*, see Step XXXII.)

(*c*) Restudy of Parts under New Circumstances.

11. Winter quarters of plants. A study of the provisions the plant makes for renewed life in the spring (XXXIV).

12. Completes the review (under a new phase) of earlier steps by a more exact study of the **fruits** of autumn (XXXIX).

(*d*) Classification.

13. Corn and beans. A discovery through study of material of some of the leading points on which classification is based (XL).

14. To learn the peculiarities of some important families of plants and know them at sight. Application of all previous work (XLV).

15. Continues the learning to know important families of plants at sight (XLIX).

D. Animals.

An Outline of Work.

(*a*) See and Observe.

1. Step V.—Make the acquaintance of a few house animals. Series of *types* in descending order from best known (boy). Teach lessons in morals by emphasizing *good* traits.

2. Step IX.—Make the acquaintance of twenty-three native animals of the spring and early summer. Moral lessons continued.

3. Step XI.—Make the acquaintance of thirty-three foreign or less familiar animals, widely distributed geograph-

ically, to aid in correct mental concepts of different portions of the earth. Moral lessons.

(*b*) Lead to Closer Observation.

4. Step XIX.—Careful study of the best-known animal —a *boy*. Simple lessons in physiology and hygiene.

5. Step XXVII.—Application of what was learned of the boy to the study of a series of types.

(*c*) Animals in Relation to Surroundings.

6. Step XXIX.—Study of relations to weather and food under Winter Quarters. For their relation to *plants*, see Step XXVIII.

7. Step XXXII.—Man; geographical distribution, food, etc. To add new and correct concepts of different parts of the earth, and man's relations to his surroundings.

(*d*) Development.

8. Step XXXVIII.—Life histories of some common types, beginning with the lowest and working up.

9. Step XLIV.—Life histories continued.

(*e*) Classification.

10. Step XLVIII.—By the study of specimens lead to the recognition of the affinity of the various groups.

STEP I.—PLANTS.

SORTING OF SEEDS AND DRY FRUITS.

Object.—To see and handle wisely selected botanical material.

To exercise sight, touch, and smell.

To introduce ideas of size, weight, etc.

To introduce color.

Time.—The autumn will be best, as material is then abundant. About twenty lessons of fifteen minutes each, at such time of the daily session as the pupils need relaxation.

Material.—Gather as wide a range of specimens as can be procured, and keep in the stout bags that seedsmen use. If these have the bright pictures of the contents on them, as is now common, each will be readily known when wanted. Place the bags in a deep mouse-proof box, and in such order as to be readily found.

The *best* way to procure these specimens will be to begin the term before, and let the *pupils* hunt them up and fill the bags for you. Next best is to do it yourself. If both of these ways are impossible, send the list to some reliable seedsman, and, telling *just* what you want the seeds for, ask him to send "*old*," or mixed, seed as far as possible, and omit any which may be very expensive.

The following list is from my own collection:

FRUITS (90 of each).

Ash tree.
Bean pods.
Barley (grains).
Buckwheat.
Bur ("clot").

Black walnut, } with dried
Butternut, } flesh on.
Corn (grains of)—Sweet.
Black (Mexican).
Yellow (dent).

Corn—White (dent).
Red (field).
Striped (field).
Flint (yellow).
Pop (various kinds).
Elm tree.
Four-o'clock.
Maple (red and sugar).
Negundo (ash-leaved maple).
Oats.
Peanut (pods).
Pepper (whole black).
Pea pods.
Rice (whole).
Rye (grains).
Sunflower—Black.
Striped.
Spinach (prickly).
Wheat (grains).
(29 in all.)

IMPERFECT FRUITS (120 of each).

These are *less* than fruits and *more* than seed.

Acorns—Red oak.
Black oak.
White oak.
Burr oak.
Water oak.
Almonds.
Apricot stones.
Beechnuts.
Cherry stones.
Chestnuts.
Hickory nuts.
Hazelnuts.
Filberts.
Pignuts.
Pecan nuts.
Prune stones.
Plum stones.
Peach stones.
(18 in all.)

SEEDS (150 of each).

Beans—White (lima, case-knife, and common).
Black (wax).
Brown (Mohawk).
Yellow (early six weeks).
Purple (Gallega or champion bush).
Speckled (red valentine).
Red eye (China).
Canna.
Apple.
Brazil nuts.
Castor beans.
Cotton seed.
Coffee (whole and unroasted).
Cucumber, or muskmelon.
Chocolate beans.
Date seed.
Hemp.
Iris, or gladioli.
Lentils.
Morning-glory.
Orange.
Peas—blue and smooth (Alaska).

Peas—Yellow (First and Best).
 Green and wrinkled (American Wonder).
 Black-eyed (marrowfat).
 Sweet.
Pumpkin.
Piñon nut.
Squash.
Salsify.
Watermelon (black-seeded).
 (white-seeded).
 (sculptured-seeded).
 (35 in all.)

A collection of the entire fruits found under "Imperfect Fruits" and "Seeds" should be made and arranged with neat labels in some case, that the children may see and learn what has been removed. They will delight to aid in forming this, and gain much in interest and knowledge.

This list can be easily increased, while those difficult to procure can be omitted.

Trays and Boxes.—I have always used cardboard trays, 12 inches square and 2 inches deep. Both tray and cover were strengthened at the corners with cloth and covered with a dark bronze paper, as this wore well. These by the 100 cost 5 cents each. The little boxes to go in these larger trays were either 2⅜ inches square or 2⅜ × 2, and all ½ inch deep, bound on the edge with green paper, and cost $5 per 1,000. These made movable partitions in the tray, so that one or more could be lifted out with their contents or be rearranged as desired. Of the larger 25, and of the smaller 30, filled the tray.

Substitutes.—Many things will suggest themselves where these can not be had. Shallow boxes or box covers large enough to hold 20 to 30 small boxes will do well, and for these, pill, pen, match, screw boxes can be used, or other small boxes might be made by the pupils.

Each pupil will need a tray and 20 or 30 boxes.

Preparation of the Teacher.—Having procured the material and arranged it so that the wanted thing can be at once found, I would advise trying the following lessons. No matter how simple the lessons may seem, it is never safe to give them without having previously gone over the ground, as unexpected difficulties frequently arise, and the experience places the teacher in closer sympathy with the work of the pupil.

The Lessons.—Long experience in the use of mixed specimens for sorting has taught the great value of this exercise. In no other way have my pupils gained so fast or so clearly shown their individual needs. Brought into actual contact with the material, exercising all the senses but hearing, thrown on their own responsibility as to the work, with the result so obviously correct or incorrect, and the errors so easily made fruitful of gain, I can imagine no more powerful educational weapon. Furthermore, the ease with which the teacher can handle quite a large class; the durability of the outfit when once made; and last, but by no means least, the opportunity for drill in self-control (not to eat or keep specimens) and honesty, are points in its favor. Many ways of giving these lessons will present themselves to the experienced teacher. The following has worked well:

Plan of Work.—There will be a gain in presenting the subject thus:

1. Sort 5 fruits of trees (3 of each).
2. Sort 10 grains (3 of each).
3. Sort 10 other fruits (3 of each).
4. A talk about fruits.
5. 15 food seeds (5 of each), sorted.
6. 10 other seeds (5 of each), sorted.
7. Talk about seeds.
8. All imperfect fruits (4 of each), sorted.
9. Why not *fruits*?
10. Why not *seeds*?
11. Chicken game*: 6 of each fruit, 10 of each seed, and 8 of each imperfect fruit.
12. Gardener game: same assortment as 11.
13. Squirrel game: peanuts, beans, etc.
14. Blindman game: large and peculiar specimens.

* Explained beyond.

In giving these out, two things must be guarded against —first, that the number given of any one kind be suited to the capacity of the trays, and second, that the teacher know how many of each the pupil should return. Hence, in the individual work I have suggested 3 of fruits, 5 of seeds, and 4 of imperfect fruits; and for general work (games) these numbers doubled (10, 8, and 6). With a private key like this the teacher can tell at a glance whether *all* of any class of specimens have been returned or found, and still leave most pupils in enough uncertainty to secure that careful inspection of the material which is so desirable.

A day or two before the time has come to begin the series of lessons, invite (as a reward) several reliable pupils to aid you in getting ready. Suppose there are 30 in the class. Spread 30 trays about the room, and in each have 22 small boxes placed. Write the names of the 30 pupils on 30 cards or sheets of paper. Place 30 boxes on a table, and giving the ash fruits to one child, let him or her put 3 in each of the 30 boxes, and, returning, *look in each* to be sure it is done. Let the red-maple fruits be distributed in the same way by a second, the sugar-maple fruits by a third, the elm fruits by a fourth, and the black walnuts by a fifth. Each box or pile will now have 15 specimens in it. Place one of these collections in each of the 30 trays.

Lay out a second 30 boxes, and in each have the 30 "grains" placed (3 each of 10 kinds), and put these in a large tray ready to give out when the 5 tree fruits are sorted.

In 30 other boxes put the 30 "other fruits" (3 each of 10 kinds), and you are ready for the class to begin.

On the morrow have a talk with the class. Tell them that some of these specimens are good to eat, and ask how many think they *can* do as they want to and not eat or break them. Speak of the value of *self-control*, and that this is one important lesson to be learned from the sorting. Offer—it will not be accepted—to excuse any who feel they are too young or weak to resist the temptation.

Then tell them what to do.

1. Sort the tree fruits into boxes. When done, raise hand. If correct,

2. Sort grains into other boxes, and raise hand. If correct,

3. Sort other fruits, and raise hand.

4. Return tray with 25 boxes of 25 kinds of fruits to teacher, who will then know whether the eyes have been sharp, the fingers accurate, and the child able to control itself.

Give out the 30 trays with the 5 mixed tree fruits in them. Tray of grains on arm, pass among the busy pupils, and when one has finished a glance will tell whether he has 3 fruits in each of 5 boxes.

If correct, compliment him, and give the 10 grains to sort. If not correct, suggest where (not what) the mistake is, and let him try again. Some tact will be needed to keep up the courage of a pupil under repeated mistakes, but in no case let him feel he can depend on your doing it *for* him; but by easy steps lead him to feel the pleasure of self-achievement and learn to rely on himself. Above all things, do not let the pupils *help one another;* but show how it is the worst kind of robbery for one to take from another the chance to grow in skill and knowledge.

Thus let the work go on, each for him or her self, till time for the lesson to close. Give each the card with name to lay in the top of the tray, and have these gathered by rows and in order, so as to be quickly and correctly returned at the next lesson. Meanwhile, store them where no tampering will be possible. Continue the sorting the next lesson, till the first tray of 25 fruits is completed. Then receive the tray from the pupil and inspect it in his presence.

Do not spare commendation if all the specimens are there and correctly placed, especially dwelling on his *self-control* and *skill.* Request him to take a peanut pod and walnut to see how curiously the seeds are fixed inside, and notice the taste.

If anything is wrong, tell the child that he can come privately and tell you about it, and set the tray aside till such time. With young children gathered in a room together there will always be accidental losing, interference of mates, etc., as well as the possible error of those who counted out the specimens; hence I would advise in such cases—

1. The private chance to tell his story.
2. Prompt and hearty acceptance of it.
3. A written record made in his presence.
4. A chance to *prove* his innocence by sorting another box.

No one knows better than I the trouble and thought this plan involves; nor do any know better how well it pays.

Such things are the *turning points* in a child's life. Dare we neglect them? Let the little urchin who ate his peanuts and told you a lie about it find that you accept his word, and there is not one in ten thousand who will fail to exercise self-control the second trial, when your glad commendation will be such a delightful (and possibly unique) sensation that he will want to feel it again, and never will forget it.

The talk about fruits will depend for its character upon the teacher, and should only aim to connect the material with the daily life of the child.

Where have you seen this before? What is its use? etc., would be in the line of my thought.

One point to be emphasized is that the term "fruit" is appropriate only for the *entire ripened pistil.*

It matters not whether the protecting walls adhere tightly to the seed, as in the "grains" of corn and wheat, or are loose, as in the maple and sunflower; whether bare, like the bean pod, or surrounded by protecting parts, like the acorns (cup), nuts (bur or shuck), or stone fruits (peach and plum)—if *all* of a mature pistil and adhering parts is present, we have *a fruit.*

Seeds.—Having talked of fruits and put them away, proceed to sort seeds in two lots—"food" seeds and "general" seeds. Give 5 of each kind.

Talk on Seeds.—This will be like that on fruits; only the class can now see how the protecting parts have been stripped away, by comparing their specimens with the collection suggested under the list of seeds.

Imperfect Fruits.—Sort and talk of in the same way. Give only 4 of each kind, as many are large.

Why these are "imperfect" can be readily seen:

Why not, *seed* can be shown by opening some of the hard walls of nut or stone and showing the real "seed" inside.

The class will now have gained much real training and knowledge in a very enjoyable way. To further fix this, take up

The Chicken Game.—In a good-sized tray put 6 of each fruit, 10 of each seed, and 8 of each incomplete fruit. Mix these well, and put handfuls in enough trays so that all can easily get at them. Have a tray with *one* of each sort in it, and after telling how some chickens or birds like one thing and some another, let the pupils come one by one and choose a seed or fruit from the sample tray, and *name* it as what they "like best"; then go and find all those like it in the trays about the room. If they bring back the full number, let them choose another to gather. If not, have them look again.

When all have been gathered, mix them again for

The Gardener's Game.—Speak of how the gardener plants only one thing in a place, here peas, there beans, etc. "I am a gardener, and have unfortunately mixed all my seeds. Who will help me separate them?" Let each choose from the trays some one fruit or seed and bring it to you. Having told the name (or, if not known, been told it), let him go and gather the rest as before.

When all have been gathered, place the boxes in a large tray ready to put back into the bags.

Squirrel Game.—Shell some freshly roasted peanuts till you have 75 to 100 nuts, and wrap these separately in little papers. Take an equal number of common beans about the same size and wrap these in similar papers, being careful to keep them away from the scent of the peanuts. Tell the children how squirrels hide piles of nuts, and how they nose about in the leaves after others, finding them by *smell* rather than *sight*, and propose "we play squirrel." Now distribute the beans about the room or yard, or keep in a tray. Then do the same with the peanuts. Now let each child, without touching, choose one of these packages. When all have done so, let them be opened to see who smelled right, but in no case to *eat* till you say so. Seat any who *do* eat (as the flavor in the mouth will interfere with the smelling), and let the others try again till they think all the peanuts have been gathered. Then let the children report their success or failure by filing past the teacher and showing what they have. Take the beans and let them eat the nuts.

Vary this by using pieces of butternut, black walnut, or other rank-smelling nut in place of the peanuts.

Vary again by using peanuts in one set of papers and some other nut in the other. Let each choose two or three of some given kind and open before you. All mistaken nuts must be given up; others they can eat.

Blindman's Game.—Select a lot of the larger fruits and seeds and place in a bag. The class will by this time have learned the names of many kinds, so that on *feeling* in the bag they can tell what they have grasped *before* taking it out.

These and similar games will be fine fun for recess or other playtime, having no *compulsion* about taking part, but making it entirely voluntary. Few will want to be left out where there is something nice to eat.

Material put away.—After the lessons are completed—and be *sure* and not drag them along after interest flags—plenty of willing and competent fingers can be found to sort any mixed material and put all into the proper bags.

Replenish any which, like the nuts, may have been used, so that you can *feel sure all is ready for the next year's class.* Inclose in tight boxes, and it is best to paste paper over the cracks, or put in a large paper bag and paste up the top, as grain weevils, moths, etc., may cause damage.

What has been gained?

All have had a happy time, and other work has been lightened.

The eyes, noses, and fingers have been trained.

Exactness, order, perseverance, and self-control have been taught.

The difference between fruits and seeds noticed.

An acquaintance begun with the varied forms of plant life.

Much innocent recreation suggested and a corresponding amount of evil barred out.

Much more will have resulted from a wise teacher's work, but these samples will do.

For the next step in Plant work, see V.

Now *promptly* proceed with the next step—II.

STEP II.—THE SKIES.

(GENERAL.)

The object of these lessons, which are to run through all the years of school life, is—

1. To interest the child in *astronomy*, both for its own ennobling thoughts and its discipline of the mental powers.

2. To cultivate the *imaginative* powers by the attempts to *see* with the mental eye the movements of the planets, the formation of the earth, eclipses, etc.

3. To furnish true concepts of our own earth, its form and motions, etc., and thus aid in geography, geology, etc.

My experience has not extended below nine-year children, but no classes have ever shown greater interest and asked oftener for "*more*" than those who so readily drank in the sublime facts of astronomy. Even such conceptions as Laplace's nebular hypothesis, the parallax of Sirius or Arcturus, or the revelations of the spectroscope, seemed delightful tales, all the better because *true*, and to their young and nimble imaginations as real as anything else in this glorious universe.

As to its Influence on Reading.—A class of about twenty were having the lessons, and wanted to know where I found such things. I told them of Lockyer's Elements of Astronomy (American edition), which I admire for its terse and delightful simplicity, and in a few days eight little urchins were poring over copies they had bought, and others complained that their parents would not let them have the book—they were "*too young.*" Who can measure the influence on these pupils of an early acquired love for such grand things?

Hence it is with a perfect freedom from any sense of misgiving as to the feasibility or value of these lessons that I shall proceed to make suggestions which I am confident will prove valuable to all who, by nature or acquisition, love the stars, and would introduce their classes to "the heavens above." To that large class who, through failure in training, never have had this interest, I would confidently say: "Read Lockyer or some other simple astronomy, and see with your own eyes the constellations, the eclipses, phases of the moon, etc., and the *interest* will come.

The time needed for this step is very little; it can fill odd moments or be interwoven with other work, as the particular order at first will be immaterial.

Material has all been provided by the "Giver of all Good."

Preparation of the Teacher.—Has been indicated above.

The lessons of this first step will be very simple. Try to teach (during the year) the children to know—

1. The sun. (View it through smoked or colored glass.)
2. The moon.
3. What things always look round? (Spheres.)

Show this by having things brought that are called "round" (coins, buttons, paper circles, pencils, handle to broom, balls, etc.), and, holding them in different positions, let them see that the sphere is the only thing which always appears round.

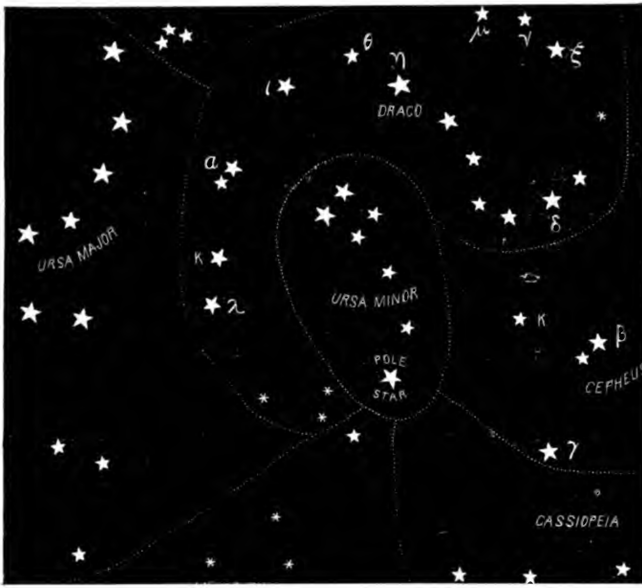
4. Call attention to stars.

5. Show some evening star—Venus or Jupiter—and notice that it *changes its position* among the other stars. The "evening star" is much used in Hiawatha. Read or tell.

6. Show the north or pole star, and let them see a compass or magnetized needle point toward it. What use is this to sailors away from land?

7. Dipper. From the north star it is easy to lead to the "pointers" and the rest of the "Dipper" and the Great Bear.

Give the children an account of the habits of the shepherds in the warm Eastern countries of "watching their flocks by night," and seeing the stars. (See Ben Hur, chap. **xi**; Luke ii, 8, etc.)



Let the class prick or sew the Dipper and north star.

The story of Callisto and her son might be told, if so desired. Juno changed the beautiful Callisto into a bear; who, seeing her son (a fine youth) one day, advanced to embrace him; when he, not knowing his mother in the form of a bear, was about to thrust his spear through her; to prevent which Jupiter snatched them both up to heaven and placed them among the stars as the Great and Little Bears.

Sew these on perforated cards; paste gilt stars on paper or draw a diagram. The north star will be included in such a diagram. If such cards are made and the children told *where* to look, much *home* work will be done, and the whole family interested. This will in great measure make up for the loss of observation lessons with the teacher, which lessons will often be almost impossible.

Next star work, Step VII.

STEP III.—SORTING OF METALS.

This is an introduction to the study of minerals and rocks. The general plan of work is indicated under the Outline (B).

As carried out in the progressive manner indicated, no other set of lessons have so evidently cultivated the powers of prompt decision.

Progress along this line has been truly wonderful, and I have valued the lessons correspondingly, seeing the great need in this country and age for the "prompt, decisive man."

Further, for some reason I do not clearly see, classes have been especially "willing workers" in these studies, and no counter-attraction has seemed able to prevent work at noon, recess, and after school, so great has been their desire to complete the course.

Supplies.—The following material will be needed:

TO SORT AND STUDY.	FOR REVIEW.
Iron: wire, sheet, and cast.	Nails, bolts, rivets, nuts, washers, etc.
Copper: wire and sheet.	Cent, rivets, washers, and utensils.
Lead: sheet.	Bullets, shot, and pipe.
Type metal: type.	Stereotype plates.
Brass: wire and sheet.	Screws, keys, chain, utensils.
Bronze: sheet.	One and two cent pieces, ornaments.
Gold: foil.	Coin, jewelry, etc.
Nickel: sheet.	Coin, ornaments, and utensils.
Silver: foil.	Coin, spoons, and ornaments.

TO SORT AND STUDY.	FOR REVIEW.
Tin: foil.	Dish, spoon, and utensils.
Zinc: sheet.	Galvanized wire, battery plate.
Steel: stout needle, bit of watch spring.	Knife, file, tools, compass, needles.

Where to get them.—Go to the tinsmith's or retail hard ware merchant, and get him to cut 50 pieces, 1½ inch long, of No. 26 wire of different metals; and of sheet metal, $\frac{1}{16}$ to $\frac{1}{32}$ inch thick by ¼ to ½ inch wide and 1½ inch long.

A piece of thin casting will give fragments of cast iron. Get old type at printer's.

Apply to the jeweler's and wholesale druggist's for the rest of the metals. Bronze and nickel, cut as above. Gold and silver can be of thinner foil, and cut in bits ⅛ by ¼ inch. Get as heavy tin foil as possible, but do *not* use tin plate, as it will mislead the pupils. Break the watch spring into bits 1½ to 2 inches long.

Magnets.—Get 30 small bar magnets at a toy store, or a kindly smith will cut off 30 bits of bar steel 2½ inches long, and some one can magnetize them on a dynamo or with a large magnet.

Wrap these specimens in plenty of soft paper and put in labeled boxes in a *dry* place.

Trays and Boxes.—Provide 30 shallow trays, also 450 small boxes, such as used in Step I. Place in each of the large trays as many of the little boxes as you have metals, and a child's name written in one. In a spare tray place as many boxes as you have pupils, and, taking the specimens, one after another, drop a piece in each box. Be sure each box has a *full set* of the metals, for some of the children may be inclined to keep or may lose the specimens, and should be held strictly responsible for the return of the entire set. Now let the teacher practice sorting the metals, studying to find ways to distinguish those which look alike, and then all is ready for the lesson.

Lesson given.—At the proper time, preferably when the school is a little tired with book work, let the trays with their little boxes be given out, and, after a few words, directing the pupils to place each *kind* of metal in a tray by itself, give each child one of the sets you have ready, and let him begin. Now pass among them, and when a child has finished sorting, the raised hand will call you. Suppose John raises his hand. With an eye to *shape*, all wires and all strips have been put together. *Commend* him, but not in such a way as to suggest his plan to others, and tell him to find other ways. Alice has sorted by *color*, and has gold and brass in one box; iron, lead, zinc, etc., in another. Commend her, but without indicating even the boxes which have errors, tell her to look *sharply* and see if she can find the mistake. Paul has been more careful, but has nickel, silver, and tin in one box; while sheet iron is separated from iron wire, and both from cast iron. Remind him that there may be several pieces of the same metal, but unlike in shape. Ralph has put one piece in each tray. Ask *why* he separated this from that, and if he has no reasons, let him try again. When you see that a child has done its best, suggest some new way, as color, bending, shape, or thickness, to separate them.

Promptly, a minute or two before the lesson has expired, take up the boxes and pile in a secure place, ready to return to each child his own at the next lesson.

So continue, introducing last of all the magnet. This will bring all the iron, nickel, and steel together. Now give each a pinch of iron filings, and, showing them how to stroke the *pointed* end of the needle on the *unmarked* end of the magnet, see if it picks up iron. It *does!* Now try the sheet iron. Only a little, if any. The iron wire? Does the same. Cast iron? Same. Nickel? Same. Watch spring? Many filings.

Now try your magnet on the filings. "Picks them *all* up!" Which of our pieces of magnetized metal are like the magnet? "Needle and spring." These we call *steel*, and the others, which do not keep their magnetism so well, are iron or nickel. Which is nickel?

Review.—How is each metal known?

Iron? Color (iron black). Does not keep its magnetism.

Copper is easy to bend, and *red.* (Copper red.)

Lead is very soft and *bluish* gray. (Lead color.)

Type metal is whitish and brittle.

Brass is yellow. (Brass yellow.)

Bronze is darker than brass. (Bronze yellow.)

Gold, beautiful yellow. (Gold yellow.)

Nickel is like iron, but *white.*

Silver is a beautiful white. (Silver white.)

Tin is white. (Tin white.)

Zinc is harder than lead, and grayish.

Steel becomes a magnet and is gray. (Steel gray.)

Change Sets.—When the metals are learned, let each arrange their sets neatly and return to the teacher, to see that all is right.

Let some trusty pupils take the trays, and, mixing all the specimens in each together, change the names, so that each child will have a new set to sort.

Sort Mixture.—Throw all the specimens in a tray together, and when well mixed give each child a spoonful to sort.

Select and put away.—Empty the trays of the small boxes and put them away for future use.

Place several of the shallow trays around the room, where they can be conveniently got at, and on each a handful of the mixed metals. At recess or after school ask, "Who will help me sort these metals to put away?" Charlie may take this tray and find for me the 30 (or whatever the number) pieces of *sheet iron.* Susan, you may gather the 30 pieces of *iron wire.* John, 30 pieces of *cast iron.* So send for each kind of specimen. When a set is returned, count, and if right, thank your little helper; if not, write on a slip of paper the number of missing specimens, and, putting it in an empty tray, let the child take it and try again, till all are sorted. Do not return these used specimens to your store boxes till they have been washed in strong soap suds, rubbed dry between pieces of flannel, and all spoiled specimens thrown out. (*Replace* if needed.)

If now they are wrapped again in soft dry paper and put in the same dry place, they will be as bright as new for the next time.

A little chalk or whiting will brighten them when rubbing with flannel, and a piece of oiled rag to finish the rubbing will still further help keep the brightness.

Application and Review.—Invite each to bring one metal thing to school the next day.

At the time invite each to tell what they have in a well-constructed sentence.

Teacher begin.—"I have a steel pen. I know it is steel, for I rubbed it on a magnet, and now iron is attracted by it." (Show.)

Teacher.—"Tom, what have you?"

Tom.—"I have a silver coin. I know it is silver by its white color."

If the class is interested, let them bring other things, and vary the exercise by asking one child to tell what another has brought, or otherwise connecting the lesson with metallic things mentioned in the lesson.

Remarks.—*Time:* Twelve lessons of twenty minutes each will be a fair average if the teacher is well prepared.

Cost: An outfit lasting a long time will cost from $5 to $8.

Results: For this outlay of time and money the pupil has—

1. Been pleased and his other work lightened.

2. Trained the "eye to see." (Color, shape, thickness, etc.)

3. Trained the hand to feel. (Bending and weight.)

4. Gained definite concepts of 12 important metals.

5. Experimentally gained several fundamental facts regarding magnets and their relation to metals.

6. Taken a lesson in the art of experimenting.
7. Advanced in honesty and obedience.
8. Advanced in the art of expression and illustration.
9. Strengthened his mental powers: (By attention.)
10. Prepared for work which is to follow.

He has not been told anything he could discover, himself, nor any of the interesting facts regarding metals and magnets which his teacher would so much like to tell, as the work given is difficult enough for his little powers, and those other things have been wisely reserved for future and more opportune use.

For next step in Minerals, see VIII.

STEP IV.—PLANTS.

Buds.

The last study in Plants was the sorting of seeds and fruits. For some reasons, it would be better to take *roots* and *stems* next, but they can be studied in the autumn, while buds can only be studied to advantage in the spring, and hence are taken up at this time.

Object.—To extend one's acquaintance with wisely selected botanical material.

To cultivate the senses.

To prepare for future work.

Time.—Spring is the best time. About fifteen lessons of fifteen minutes each will be needed, at such time of the day as the class may most need relaxation.

Material.—Must be fresh, and should cover the subject as fully as possible. The points I would suggest at this early stage are as follows:

Position.—End of branch: Hickory, horse-chestnut, etc.
Side of branch: Same, and cottonwood, etc.
Above leaf scar: Ash, apple, etc.
In leaf scar: Sumac and buttonwood.

Number.—Single: Hickory, cottonwood, etc.
Opposite: Ash, lilac.
Clustered: Cherry, red maple.

Covering.—Scaly: Apple, hazel, lilac.
Gummy: horse-chestnut, balm of Gilead.
Varnished: Willows, poplars.
Woolly: Sumac, hickory.
Buried: Sumac, locust, Osage orange.

Kind.—Leaf bud: Hazel, birch, blackberry.
Flower bud: Cherry, peach, hazel and birch (catkins), flowering almond.

This list of over 20 different buds will illustrate the above 14 points, but can vary according to the material at command.

To gather these.—Take a basket, sharp knife, and 25 bits of string, and (aided always by pupils, if possible) go into the garden, park, or wood. The land bordering railroad tracks is frequently mown, and abounds in fine young shoots of some things which can be cut without care. In parks and gardens, choose the suckers or side branches, so as not to injure the trees. Cut, for a class of thirty, 35 twigs, 4 to 6 inches long, of each kind, and tie at once in bundles.

Set these bundles on a damp cellar bottom, or better, in several inches of moist sand, till they are wanted; but do not crowd them or they will mold.

The day before the lessons begin, cut 30 pieces of string and lay them around a large table. On each lay a twig of (say) apple, counting as you proceed, so as to know that each string has a twig across it. Then take another kind and lay across the strings, till at last you have 30 bundles, each containing all the varieties of twigs you intend to give out. Tie these bundles and keep in a damp place till needed.

Preparation of the Teacher.—Read the chapter on buds in some good botany. Gather and work over the material as indicated above. Go through the following suggested lines of work with one of the bundles of twigs, and your interest will rarely fail to be aroused to the point where you will feel you have something delightful to show the pupils. Then you are ready for—

The Lessons.—1. Show the bundles of twigs to the class, and have a talk about where and how you got them. Explain what is going to be done: how the children in turn are to name something they notice, and then all are to pick out as many buds as they can which show the same thing. Ask them to be careful not to break off the buds, as after a while we intend to put them in water to see which will grow.

2. Give each a bundle to untie and examine. After a

few moments ask, "Who has noticed anything interesting?" We will suppose the answers to be as follows, although the *order* is of far less consequence than that it be *spontaneous:*

"These buds are sticky." Good! Each find how many twigs with "sticky" buds they have. Yes; two is right. How can we tell them apart? "These are *largest*, and have the buds in pairs." It is the horse-chestnut, whose large seed we had last year. And the other? "Its yellowish buds smell sweet." It is the balm of Gilead. Mary noticed that the horse-chestnut buds were in *pairs*. All look and pick out those that are the same. What is the name of this one with green buds? "Lilac." "We have it in our yard." Who notices something else? No, James; you have told something already, and I want others to have a chance. Kate thinks this locust has no buds. Can any one find other branches on which the buds do not show? Yes; they are buried in much the same way on the Osage orange. In one other, while the buds seemingly show, they are really hidden under a brown coverlid. Who can find it? Yes; the *sumac*. Now tie up your twigs quickly, placing in each, with the name *out*, this little wooden label, so that each may have his own bundle again at the next lesson.

3. Why have I placed the ends of these stems (show sumac, Osage orange, and locust) in water? "So that the buried buds will grow." Yes; and so that we can see them. "I have seen sprouted sumac buds." Have you, John? I am pleased to see that you remember, and soon we shall see if this also will sprout. "Will *all* these twigs sprout in water?" A bright question, Kate. You may come to me after school, and we will arrange to try it. (When she comes, tell her *fresh* twigs will be best, and for her to gather as many kinds as she can, and bring to-morrow. When brought, lay them in a wash-basin or pail of water, and cut the ends *freshly under water* and insert in an immersed bottle, so that the ends shall not for an *instant* even come to the air. Place in a north window.) Look carefully, and tell

me something new. "These buds are all hairy" (holding up the hickory twig). Yes. All find the same. It is the hickory, from which we get? "Nuts." Have we other hairy buds? (Find them.) What coverings have we now noticed? "Woolly, hairy, sticky, scaly." Can any one find another kind? "Varnished."

In this way follow the leading of the class till all points have been noted. The distinction between leaf and flower buds may require some picking to pieces or waiting for the buds in water to open.

A walk in the woods at recess or after school will add greatly to the value of the lessons.

Encourage the bringing of other buds, and keep jars of them about the room till they have opened and shown the leaves, flowers, pollen, etc.

Review.—None is needed in such hand and eye work, except such as would come from a walk in the woods, or from each finding and bringing twigs to name before the class or to have the class name.

Collections may be made and sewed on cards, but have all such work of *short duration*, so as to keep the interest fresh.

Material can not be kept, and should be given to the pupils in order to interest them at home.

Plant about the Yard.—When our school boards awake to their opportunities, an assortment of trees and shrubs to illustrate such things will be planted about the yard. Let the pupils obtain permission to set out such plants as "class" trees, to be added to in succeeding years by other classes.

For the next step in plant work, see VI, Stems and Roots.

STEP V.—ANIMALS.

INTRODUCTION: GENERAL CONSIDERATIONS.

The object and purpose of this branch of work is as follows:

1. The mental upbuilding which all true science gives.
2. To make our survey of nature complete, and to illustrate still further the wonderful interdependence which exists between minerals, plants, and animals.
3. Preparation for that greatest of all studies, man.
4. Chiefest, the direct development of right character through the consideration of the habits and actions of beings possessed of the will power which enables them to do or not to do; to which actions we can alone rightly apply such terms as *right*, *wrong*, just, noble, brave, tender or generous, social, patient, industrious, etc.

As we study the crystal, and admire the unvarying angles and firm adherence to its type through all the changing conditions of its surroundings, we see the power of chemical affinity to unite molecules of the same kind in orderly growth, and agree with wise Linnæus that "minerals grow," but we attach no *character* to such act, well knowing that the crystal has no power to *will* what it shall be or do.

So in the plant, growth takes place according to inherited laws, but there is an advance in its relations to its surroundings sufficient to warrant such a term as "sensitive" being applied to many leaves, tendrils, root tips, and other growing parts, which can even go so far as to exercise a kind of *choice*. This is well seen in the movements of tendrils, which avoid their *own* stems while seeking some proper support,* or in the actions of insectivorous plants, which seem able to discriminate between food (as an insect or bit of meat) and a piece of wire or sand.† Wonderful as this all is, there is still no real *character*, and the terms we apply to such things only derive meaning and force from analogy to the actions of ourselves and other animals.

Further, as the order by accretion of the crystal foreshadowed the growth of the plant, so the motion and sensitiveness of the plant foreshadows the purposeful action of the animal, where instinctive life culminates in the moral and intellectual development of man. Here at last do we find a true moral quality to actions, and from them judge of his or her *character*.

That this character be a *right one* is the all-important thing, for the individual, the nation, and the world. Without right character our education only makes an abler rogue; with it, the "noblest type of man."

How our schools shall best combine this character building with the learning commonly taught, is the greatest problem of the educators of to-day; and in the true study of animals I find a step toward its solution. While valuable lessons can be drawn from the mineral and the plant, they are instinctively recognized in the animal, which has the power to control its actions.

To become part and parcel of the pupil, impressions must be *repeated*—"line upon line, precept upon precept, here a little and there a little."

But that this repeating shall not become wearisome, that the mind be kept in that serene state of contentment so essential to receiving impressions, there must be a continual progress toward new views of a subject.

Here is one great gain from the study of the interdependence of minerals, plants, and animals, the study of all three being far more helpful than a threefold study of one.

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* Gray's How Plants behave, p. 18.

† How Plants behave, pp. 44, 45.

While repetition is needful, it must be judicious. The repeated use of strong substances—tobacco, alcohol, pepper, etc.—*blunts* the sense of taste, as the repeated blows on the poor donkey, or the handling of hot iron by the smith, makes callous the sense of feeling. The reverse is seen in the educated sensations of the tea-taster and the fingers of the blind reader.

Right here lies the explanation of the terse proverb, "Practice is better than precept." What teacher of any experience is there who does not know the power of *example!*

First and foremost, then, both in the study of animals and in the development of character, is the living, acting teacher, be he parent, playmate, friend, or instructor.

To re-enforce this powerful factor, by illustration and repetition, is the whole world of animal life about us.

As we **choose to develop desirable traits** and a noble character, it is plain that some animals will be more serviceable than others. Hence the necessity of careful choice; for this teaching should be *positive*, dwelling on desirable traits, actions, and habits, following George Washington's advice so far as to "say nothing of that about which you can speak no good."

For example, while emphasizing the skill and industry of the spider, I should ignore her bloodthirsty nature; and choose the harmless kangaroo as a type of the pouched marsupials rather than the sly and tricky opossum. Also, call attention to what an animal *has*, rather than to what it has *not*.

What animals to choose from among the 300,000 known shall be our first step in systematic work.

In this I have been governed by the following rules, and selected such as are—

1. Available—that is, the animal or portions of it, or its products, can be obtained with reasonable effort for illustration, and habits are either familiar or easily found described in common books.

2. Of marked and desirable traits, habits, or uses.

3. Typical of large or important classes.

4. Characteristic of different portions of the globe, in order that the study may introduce the idea of the geographical distribution of animals, and also aid the child in clear and accurate concepts of such portions of the earth.

5. The list, as a whole, must include and illustrate all points of structure, habit, use, character, etc., which it is desirable to bring before the child.

Adhering as closely to these rules as necessary compromises will permit, I have chosen the following list of animals; and as different localities will require a change, I have added desirable substitutes, but the name *first* in the list is my choice, and all that may be said hereafter refers to that in particular, whether it be true or not of the substitutes.

1. **Sponge.**—Common kind of the shops.

2. **Coral.**—The white, cellular kind is easily had, and is interesting from its geographical and literary connections.

3. **Starfish.**—Dried specimens of this type of the radiate structure are common. Alternate, sea urchin.

4. **Earthworms.**—Easily obtained and instructive.

5. **Clam.**—Hard-shelled (Venus). Easily obtained alive, or in paired shells; a type of the soft-bodied animals having the limy outside skeleton in *two* parts. Alternates, oyster or fresh-water clam.

6. **Land Snail.**—Type of the soft-bodied animals with the limy shell in one piece. Alternate, pond or sea snails.

7. **Crayfish.**—Valuable and common type of animals having an external jointed skeleton and ten legs. Easily found, and interesting for its illustrations of molting, carrying young, digging "wells" for water, and backward motion. Alternate, lobster or crab.

8. **Spider** (Garden).—Type of these interesting insects, having eight legs and no wings. Alternate, trapdoor or water spider.

9. **Termite.***—One of the true insects, having six legs and

* Do *not* call these relatives of the dragon flies "ants," but hold to the correct name in all work.

an outside horny, jointed skeleton. Exceedingly interesting in its habits. Alternate, aphis lion or ant lion.

10. **Mosquito Hawk.***—A powerful insect, preying from birth on others. Easily found in all stages and reared for observation.

11. **Locust** (Rocky Mountain or Old World).—These terrible plagues are of great interest. They represent cattle among insects, eating herbage voraciously from birth to death. The two outer wings are straight, while the gauzy under ones fold like fans. Alternate, "walking stick," cricket, or katydid.

12. "**Ants' Cows**" (Aphis).†—Easily obtained and true bugs, that subsist by drawing out the juices of the plants on which they live. Remarkable for their relations to ants, and their peculiar mode of multiplication. Alternate, cochineal bug.

13. **Squash Bug.**—A common example of those ill-odored insects whose wing covers are *thin* at the *tips* (Hemiptera), and whose mouth parts form a piercing beak to draw out the juices of the plant or animal they feed upon. Alternate, "water boatman" (Noctonecta).

14. **Plant Beetle** (Potato Beetle).—An example of insects with the outer wing covers hard and shell-like (Coleoptera), and meeting in a straight line down the back. Eggs, larva, and insect only too common. Alternate, dorbeetle.

15. **Oak Pruner.**—One of the "long horned" beetles which do so much damage to trees. Of exceedingly wonderful habits, and easily found in the dead twigs which fall. Alternate, peaweevil.

16. **Fire Beetle.**—One of the "soft-winged" beetles, remarkable for its light-giving powers. The "glow-worm" is the wingless female of the European variety. Alternate, spring beetle.

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* Not a "fly," and so I have chosen this name as more truly descriptive than "dragon fly."

† Not a "louse," and so avoid the old name of "plant lice."

17. **Tumble Beetles.**—These "dung" beetles are interesting on account of their curious habits and relationship to the sacred beetles (Scarabæi) of Egypt. Not difficult to find rolling their balls of dung in roads and pastures. Alternate, sexton beetle (Necrophorus).

18. **Mosquito.**—These delicate two-winged insects are members of the unappreciated fly family, which so benefits man by the prompt removal of refuse in the air and water. From the time its floating masses of eggs are laid on our pools and rain-water barrels till the "wigglers" hatch, the development is interesting and easily watched.

19. **Flesh Fly.**—This "pest" (?) is really very useful, and is easily studied, from the yellowish eggs laid on a dead animal or bit of meat, through the maggot and brown pupa stages, to the perfect fly in her beautiful green dress.

20. **Silk Moth.**—This valuable insect is the only one of its vast order which is directly helpful to man. While the silk moths do not fly, they are a type of the night-flying, scale-winged (Lepidoptera) insects; their antennæ are feather-like or hair-shaped, and the caterpillars spin silken cocoons. Alternate, cecropia moth.

21. **Sphinx Moth** (Tobacco or Tomato Caterpillar).—These are a type of the powerful twilight-flying Lepidoptera, whose antennæ are thickened in the *middle* and end in curved points. They never spin cocoons, but turn to naked pupæ in the ground or under some shelter. The name "sphinx" refers to the motionless attitude the caterpillar will assume for protection when disturbed. Alternate, woodbine caterpillar.

22. **Cabbage Butterfly.**—A common and easily studied type of this class of gay, day-flying Lepidoptera. The antennæ are clubbed at the end, the wings folded above the back when at rest, and the caterpillars never spin cocoons. Alternate, Asterias (on parsley, carrots, and other Umbelliferæ) or archippus of the milkweeds.

23. **Gall Insect.**—Galls are so common on oaks, roses, etc., that I have chosen these tiny relatives of the bees as a type

of the injurious division of the family. They have four gauzy wings (Hymenoptera). Alternate, Ichneumon insect.

24. **Mud Wasp.**—An interesting and easily studied type of the solitary wasps. Alternate, paper wasp.

25. **Honey Bee.**—A type of the social membrane-winged insects, which, because of its thoughtful provision for the future and for its young, ranks among the highest of all insects. Its habits are well known, and it is easily found for observation. Alternate, ant.

26. **Goldfish.**—Here a *backbone* is introduced. This fish is an easily kept example of the scaly, cold-blooded animals, whose limbs are not jointed limbs, but *rayed fins.* Also a type of fish having soft (not spiny) rays and smooth-edged (cycloid) scales. Alternate, cod or whitefish.

27. **Perch.**—This common fish is typical of those having a number of stiff spines in the back fin and comb-edged (ctenoid) scales. Alternate, sunfish.

28. **Frog.**—Common and easily kept example of the naked-skinned, cold-blooded animals with internal, bony, jointed skeletons. Especially advantageous to study in its development, from the egg through the tadpole stage to the adult. Alternate, toad.

29. **Garter Snake.**—Example of scaly, cold-blooded air-breather, having no limbs. Alternate, grass snake.

30. **Chameleon.**—Interesting type of the lizards, and differing from the snakes in having limbs.

31. **Mud Turtle.**—Common example of these curious reptiles. The turtle can in great measure take the place of the chameleon. Alternate, hawk-billed turtle.

32. **Ostrich.**—Type of the running birds, of interesting habits, literary and geographical relations. Feathers common.

33. **Sea Gull.**—Type of the long-winged birds. Common. Alternate, tern.

34. **Mallard Duck.**—Type of birds with strainerlike bills, of interesting habits. Its down useful. Alternate, common duck.

35. **Stork.**—Type of the wading birds, of interesting habits. Alternate, marabou stork.

36. **Cormorant.**—Type of the birds with three complete webs (totipalmate), and of especially interesting habits.

37. **Hen.**—Common and instructive type of the scratching birds. Young, active, and able to run about. Alternate, jungle fowl or grouse.

38. **Carrier Pigeon.**—Supplements the hen. Common, and of interest from its habits and reference to literature.

39. **Vulture.**—Type of the birds of prey which are so useful as scavengers. Flies by day.

40. **Owl.**—Type of the night-flying birds of prey. In structure, etc., supplements the vulture. Interesting habits.

41. **Woodpecker** (Red-Headed).—Common and interesting in habits, structure, and food. Alternate, "flicker."

42. **Humming Bird** (Ruby Throat).—This living jewel is easily seen about the flowers, and a type of its family.

43. **Barn Swallows.**—These birds of tireless wing are representative of those which catch their food while flying. Habits and literature interesting, and birds common. Alternate, chimney swift.

44. **Cow Blackbird.**—This common bird is a fair example of its family, but chosen mainly because of its curious habits of laying its eggs in other birds' nests and associating with cattle.

45. **Canary.**—Easily obtained type of the cone-billed, seed-eating, singing birds. Also interesting in contrast with the hen, etc., its young being helpless, and dependent on the care of the parents. Alternate, song sparrow.

46. **Robin.**—Type of the thrushes. Common, and helpful from its arrival in the spring to its migration in the fall. Alternate, bluebird.

47. **Kangaroo.**—Example of animal carrying the young in a *pouch.* Interesting from its habits and geographical relations. Alternate, opossum.

48. **Beaver.**—Exceedingly interesting and useful type of the gnawing animals.

49. **Squirrel.**—This animal is easily tamed and kept for observation. Supplements the beaver.

50. **Mole.**—Common example of the insect-eating animals, and of peculiar interest from its underground habits.

51. **Bat.**—This remarkable animal also lives on insects, but its night excursions and mode of feeding make it a great contrast to the mole. Nurses its young as all mammals do.

52. **Whalebone Whale.**—This sea giant is an example of a warm-blooded mammal, living in the sea and gathering its food in a very curious way. Alternate, sperm whale.

53. **Elephant of Asia.**—This huge and intelligent animal has much of interest in his habits and structure.

54. **Horse.**—Example of the single-toed animals. Familiar and useful.

55. **Camel.**—Of interesting habits and structure. Useful, and showing great adaptability to desert surroundings. Alternate, llama.

56. **Reindeer.**—Type of the solid-horned and even-toed cud-chewers. Interesting structurally and from its uses. Alternate, red deer.

57. **Cow.**—Type of the hollow-horned cud-chewers. Familiar and useful. Alternate, yak.

58. **Sheep.**—An example of the hollow-horned cud-chewers, with angular horns. Interesting for its typical habits and usefulness.

59. **Black Bear.**—Omnivorous, and places the whole foot on the ground in walking (plantigrade). Interesting habits, and supplements those flesh-eaters which follow. Alternate, white bear.

60. **St. Bernard Dog.**—So familiar and interesting in its habits as to need no commendation. Alternate, fox.

61. **Cat.**—Type of the flesh-eaters. So easily obtained and examined as to be of great help in teaching about animals. Claws retractile.

62. **Seal.**—A flesh-eating animal living in the sea and with paddles for limbs. Of great use and interest.

63. **Prehensile-tailed Monkey of South America.**—Interesting in its habits and representative of the order, while not introducing certain questions connected with the apes which are unsuited to this phase of the work.

64. **Boy.**—A common and well-known animal. Most familiar of any, and hence well suited to introduce the study of animals.

WHAT POINTS TO TEACH.

Having selected our representative animals, what to teach becomes the next question. I shall group the items under a series of heads, arranged in the order of presentation to the child. This order is of much importance. The following have been my guiding rules:

Arrange from the simplest, the general—and that *within the child's experience*—to the complex, particular, and unknown or unobserved. Also, so as to keep up a constant *review* by a progressive *new view* that brings up the old under new conditions. With these in mind, I should place—

1. **Where they live.**—In what country. (To be found on the map.) All.

In warm climate: Camel, elephant.
In cold climate: Reindeer, whale.
In the sea: Sponge, starfish.
In fresh water: Polliwog, goldfish, young mosquito.
Partly in water and partly on land: Frog, turtle.
In the earth: Mole, worm.
On dry land: Horse, cat.
On trees: Monkey, squirrel.
In the air: Swallow, mosquito hawk.

This locates the animal and clears the way.

2. **Feeling and Touch.**—Delicate in: nose, mole; fingers, monkey; wings, bat.

To find food: Coral's tentacles; spider "feels" his web.
To select food: Horse, by lips; worm.
To guide in moving about: Cat's whiskers; snail's feelers; bat.

3. **Ears and Hearing.**—Keen: Bat, cat.

Movable: Elephant, horse.

Outside ears: Bear, squirrel.

Ears concealed: Hen, woodpecker, frog.

4. **Eyes and Seeing.**—None: worm.

Buried: Mole.

On stalks and movable: Crayfish, snail.

How many: Beaver, spider, vulture.

Simple or compound: Duck, fly, mosquito hawk, spider, caterpillar.

Keen: Cat, vulture, robin.

See in dark: Cat, owl.

Location: Fish, frog, hen, owl, spider.

Lids—motion, and how many: Horse, canary, hen, fish, snake.

Pupil—shape and size: Cat (0), frog (<>), hen (o), horse (⊂⊃).

Tear: Boy, fish.

5. **Nose and Smell.**—Use of: Camel, elephant.

Hair on nose: Horse, sheep.

Keen: Fly, dog, mosquito.

Nostrils directed: Bear, frog, hen.

6. **Taste.**—Use of: Horse, sheep.

Where located: Boy.

The five senses put the animal in connection with the surroundings and determine, next, its

7. **Movements.**—Creep: Snail, caterpillar.

Crawl: Snake, worm.

Swim forward: Beaver, cormorant, fish, seal. Swim backward: Crayfish.

Dive: Frog, seal.

Walk: Cowbird, hen.

Walk on all fours: Reindeer, elephant.

Walk erect: Boy.

Walk on sole of foot: Boy, bear.

Walk on toes: Cat, sheep.

Runs: Dog, ostrich.
Gallop and canter: Horse.
Hop: Frog, kangaroo, locust, robin.
Climb: Chameleon, fly, monkey, woodpecker.
Fly swiftly: Dove, humming bird, swallow.
Fly noiselessly: Bat, owl.
Fly by night: Bat, moths, fire beetle.
Fly by day: Butterfly, mosquito hawk, vulture.
Scratch: Hen, dove.
Burrow: Mole, worm.

Organs are required to make these movements, and, using the word to cover the whole range of members helping, I place next—

8. **Limbs and Organs.**—Stinging tentacles: Coral.
Tube feet: Starfish.
Bristles: Worm.
Antennæ or "feelers": Butterfly, tumble beetle, sphinx moth.
Muscles: Clam.
Foot: Clam, snail.
Fins: Goldfish, perch.
Legs: None, snake.
  Sixteen, caterpillars.
  Ten, crayfish.
  Eight, spider.
  Six, plant beetle, fly.
  Four, cow, elephant, squirrel, mole.
  Two, boy, ostrich, robin.
Toes: Five in front and five behind, bear, chameleon.
  Five in front and four behind, cat, dog.
  Four, canary, hen, duck, woodpecker.
  Two, cow, camel, ostrich, reindeer.
  One, horse.
  Webbed, beaver, cormorant, duck, frog.
Tarsus: Robin.
Nails: None, frog.

Nails: Blunt, dog, hen, kangaroo.
Hoofs: Horse, reindeer, sheep.
Claws: Sharp, cat, owl.
Retractile, cat.
Hooks: Bat.
Wings: Four, squash bug, locust, mosquito hawk, sphinx moth.
Two, bat, dove, fly, stork, ostrich.
Long, gull, swallow.
Gauzy, bee, fly.
Scaly, butterfly, silk moth.
Shell-like, plant beetle, oak-pruner beetle.
Inner unlike outer, locust, tumble beetle, squash bug.
Arms: Monkey, boy.
Hand: Monkey, boy.
Flippers: Seal, whale.
Tail: Beaver, crayfish, dove, frog, perch, horse, kangaroo, monkey, woodpecker.

9. **Symmetry.**—This best follows limbs, and calls the pupil's attention to the important fact that there is in each animal an orderly arrangement of parts as regards form, size, and position.

An "above and below": Coral, starfish.
A "before and behind": Canary, squirrel.
The organs paired, and two sides alike: Cow, locust.
Body in two parts: Spider.
Body in three parts: Bee, wasp, fly.
Body in many parts: Caterpillar (13), worm.

Having noticed the organs of motion and their arrangement, the next thing will be an important object sought, which is—

10. **Food.**—Milk: Calf, kitten, colt.
Roots, bark, and twigs: Beaver, kangaroo, camel.
Herbage: Plant beetle, locust, caterpillar, reindeer, snail, sheep.
Fruit and seeds: Canary, squirrel.

Decaying wood: Oak pruner, termite.

Insects: Bat, chameleon, mosquito hawk, mole, swallow, woodpecker.

Fish: Cormorant, perch, gull, seal.

Small animals and birds: Owl, snake.

Both animal and vegetable food: Hen, bear, robin.

Everything which gets in its mouth: Coral, clam, sponge, whale.

Excrement and refuse: Crayfish, worm, tumble beetle, young mosquito.

Carrion: Fly, vulture.

Juices of plants or animals: Ants' cows, squash bug, mosquito, spider.

Nectar or pollen of flowers: Bee, butterfly, sphinx moth.

Water: Cow, camel.

Salt desired: Sheep, boy.

To handle and help prepare this food for swallowing, we have—

11. **Lips.**—To grasp food: Boy, horse.

To drink with: Cow, dove, hen.

Fleshy: Boy, cow.

A horny beak: Hen, owl, robin, humming bird, turtle.

12. **Tongue.**—Thick and fleshy: Boy, cow.

Horny: Fish, woodpecker.

Fastened in front: Frog.

Forked: Snake.

Used to pull in: Cow, woodpecker.

To scrape: Cat, snail.

To lap: Dog, cat.

To suck: Calf, lamb.

To catch: Chameleon, frog.

To move food in mouth: Horse, boy.

A coiled "tongue": Butterfly, sphinx moth.

A piercing beak: Ants' cows, mosquito, squash bug.

13. **Jaws and Teeth.**—Jaws move from side to side: Oak pruner, crayfish, caterpillar.

Jaws move up and down: Duck, dog.
Wide gape: Cat, snake, swallow.
Swallow food whole: Dove, snake.
Teeth to aid in catching: Perch, snake.
Teeth to gnaw and bite: Beaver, squirrel, cow.
Tearing teeth: Cat, seal.
Grinding teeth: Cow, reindeer.
Huge tusks to dig: Elephant.
All kinds of teeth: Bear, boy.
Teeth which grow throughout life: Beaver, squirrel.
Strainer to catch small prey: Duck, whale.
Chews cud: Cow, sheep.

The food thus prepared not only furnishes motive power, but heat as well, and we next notice—

14. **Temperature and Breathing.**—Breathe air in water by—

Gills in tail: Young mosquito.
Gills along sides: Clam, crayfish.
Gills in head: Goldfish, tadpole.
Through siphons: Clam.
By skin: Frog, coral.

Breathe air by lungs: Bat, cow, hen, horse, whale.
Breathe air by spiracles: Sphinx moth, caterpillar, mosquito.
Blood cold: Goldfish, turtle, snake.
Blood hot: Cat, hen, seal.
Blood red: Boy, hen.
Blood white: Worm.
Perspire: Dog, horse, boy.

Temperature and breathing will be modified by where the animal lives, and also by—

15. **Covering.**—Naked skin: Coral, frog.
Hard, limy shell: Clam, snail.
Jointed limy shell: Crayfish.
Jointed horny shell: Mosquito hawk, wasp.

Scales: Chameleon, goldfish, perch, snake, turtle.
Feathers: Cormorant, duck, hummer, owl, ostrich.
Hair: Camel, cow, reindeer, seal.
Horns: Cow, sheep.
Wool: Sheep.
Fur: Beaver, bat.
Thick fat: Bear, whale, seal.
Thicker in winter: Duck, horse.
Clothes: Boy, horse.
Oil glands: Duck.
Molting: Canary, cat, crayfish, caterpillar, snake.

Covering has various uses and is closely connected with or forms the—

16. **Skeleton.**—Horny and elastic: Sponge.
Limy and basal: Coral.
Limy and outside: Clam, snail.
Outside and jointed: Crayfish, mosquito hawk, wasp.
Inside, bony, and jointed: Hen, sheep, turtle.

Now, leaving the idea of a framework and support for the muscles, return to covering (15) in a restricted sense, and next consider—

17. **Color of.**—Skin: Coral, frog, wattles and comb of hen, caterpillar.
Shell: Snail, clam.
Horny skeleton: Plant beetle, fire beetle, wasp.
Scales: Goldfish, snake.
Feathers: Canary, humming bird, robin.
Hair: Cow, seal.
Horns: Cow.
Wings: Butterfly, moth, potato beetle.
Legs and feet: Duck, dove.
Bill: Duck, dove.
Teeth: Cat, elephant.
Eyes: Cat, dove, mosquito hawk.
Father: Rooster, woodpecker.

Mother: Hen, hummer, duck.
Eggs: Dove, robin, potato beetle, duck.
Changeable: Chameleon.

18. **Use of Color.**—There is frequently an evident purpose in this coloring. Allied with *shape* and *attitude* it may cause the animal to harmonize with its surroundings, or, on the other hand, render it conspicuous.

Concealed by color: Butterfly, crayfish, chameleon, frog, caterpillar, robin, snake.
By shape: Chameleon, caterpillar.
By attitude: Frog, sphinx caterpillar, butterfly.
In holes: Bat, crayfish.
In nests: Duck, woodpecker.

Conspicuous and attractive: Butterfly, woodpecker, light of fire beetle.

Should concealment fail, there are often other means of—

19. **Defense or Escape.**—Hard shell: Clam, turtle.
Bad odor: Squash bug.
Pinchers: Crayfish.
Sting: Bee, wasp.
Strong jaws: Soldier termite.
Spiny fins: Perch.
Wings: Robin.
Claws and beak: Hen, owl.
Teeth: Dog, elephant.
Claws and teeth: Cat.
Nose: Elephant.
Horns: Cow, reindeer.
Legs and feet: Horse, ostrich.
Tail: Horse, whale, kangaroo.
Swiftness: Fish, swallow.
Voice: Bear, dog, hen.

From §§ 1 to 16 we were concerned with the *individual* alone, but with color (17) there is evident a progressive overshadowing of the unit and a revealing of relations to *others*.

Color would be comparatively useless if the individual possessing it were the only one that had eyes. "Hiding" or "defense" would lack an object were the *individual* alone; and even "character" (as we understand it) is either relative or comparative. Advancing along the line of these new and higher relations, we next consider—

20. **Voice and Language.**—Touch: Blind people, ants, cows.

Signs and motions: Vulture, monkey.

Chirrup: Locust.

Buzzing: Fly, bee.

Whirring: Sphinx moth, humming bird.

Fluttering: Butterfly, dove.

Hum: Bee, mosquito.

Croak: Frog.

Hiss: Snake.

Quack: Duck.

Peep: Chicken.

"Song," cackle, remonstrance, cluck, chuckle, warning cry, soothing croon: Hen.

Coo: Dove.

Hoot: Owl.

Roar: Camel, ostrich.

Scream: Gull.

Chattering: Monkey, woodpecker.

Twitter: Swallow, humming bird.

Drumming: woodpecker.

Song: Canary, robin.

Bark: Squirrel, dog.

Slap: Beaver.

Clicking: Bat.

Spouting: Whale.

Trumpeting: Elephant.

Neigh, whinny, and snort: Horse.

Bleat: Sheep.

Moo, low, and bellow: Cow.

Growl: Bear, dog.

Howl: Dog, monkey.
Bark and whine: Dog.
Purr, mew, spit, and squall: Cat.
Laugh, talk, whistle, sing: Boy.
Cry, sigh, groan: Of sick or hurt.
Yawn and snore: Of sleepy.
Blush and smile: Of pleasure or disgrace.
Facial expression: The habitual becomes fixed.
Talk, command, joke, etc.: With the mouth and eyes.

Taken in connection with actions, these varied forms of expression form a wonderful index of the true character, and are a potent factor in determining whether the animal shall be—

21. **Solitary or Social.**—Solitary: Mosquito hawk, owl, spider, mud wasp.

Social in feeding: Coral, cowbird, cow, monkey, sheep.
Social in defense: Bees, termite.
Social in work: Bee, beaver, termite.
Social in play: Cat, woodpecker.
Social in voice: Frog, swallow, woodpecker, monkey.
Social in migrations: Locust, robin, stork, swallow.
Social in hibernation: Bat, frog.

Whether the animal be social or solitary, it will be best to next consider the results of their activity under—

22. **What they make.**—Burrows in earth: Tumble beetle, worm.

Wells: Crayfish.
Flytraps and houses: Spider.
Covered roads: Termite.
Galleries in wood: Termite, oak pruner.
Chambers in earth: Mole, termite.
Egg boats: Mosquito.
Silk houses: Silk moth.
Holes in leaves: Potato beetle, caterpillar.
Galls: Gall insect.

Wax cells: Bee.
Balls of excrement: Tumble beetle.
Mud cells: Wasp.
Down coverlets: Duck.
Huge, coarse nests: Stork.
Nests in the sand: Ostrich, turtle.
Nests on the ground: Duck, hen.
Nests on crags: Vulture.
Nests in trees: Humming bird, robin.
Nests in the hollows of trees: Owl, squirrel.
Mud nests: Robin, barn swallow.
Holes in trees for nests: Woodpecker.
Dams, houses, and slides: Beaver.
Homes in the ice: Seal.
Beds in tree tops: Monkey, squirrel.
Slimy tracks: Snail.
Houses, railroads, etc.: Men.

Much of this "making" is more or less directly connected with—

23. **Family Life.**—Choose mates for life: Dove, stork.

Build a house together: Beaver, robin, woodpecker, swallow.

Care for the young: Bee, black bear, crayfish, kangaroo.
Train the young: Cat.
Make room for others: Bee.
Divide the work: Bee, termite.

In this wonderfully beneficent institution we observe a still greater surrender of the individual will, and accommodation to others. Self-sacrifice reaches its highest development in and through the care and training of the—

24. **Young.**—These are produced by—

Buds: Coral.
Eggs: Potato beetle, hen.
  Hard shell: Hen, duck, ostrich.
  Round: Snail.

Oval: Hen, canary.
Cylindrical: Fly, potato beetle.
How many: Dove, hen, perch.
Laid singly: Hen, dove, wasp, butterfly.
Laid in masses: Frog, mosquito.
Laid in the water: Sponge, goldfish, mosquito.
Laid in the earth: Turtle, worm, locust.
Laid on food for young: Fly, butterfly, potato beetle.
Laid in food for young: Gall insect, tumble beetle.
Laid with prepared food: Mud wasp.
Deserted by mother: Cowbird, locust, snake.
Carried by mother: Crayfish.
Hatched by sun: Spider, snake, turtle.
Set on by mother: Canary, duck, owl.
Laid in other nests: Cowbird.
Born alive: Cat, sheep.

Names of the young—
Larva: Bee, locust.
Pupa: Butterfly, moth, fly, potato beetle.
Grub: Beetle.
Maggots: Fly.
Caterpillar: Butterfly, moth.
Tadpole: Frog.
Fry: Fish.
Ducklings: Duck.
Chickens of hen.
Squab: Dove.
Owlets: Owl.
Birdlings: Canary, robin.
Calf: Whale, cow.
Colt: Horse.
Lamb: Sheep.
Cub: Bear.
Puppies: Dog, seal.
Kittens: Cat.
Baby: Man.

Different kinds of young: Ants' cows, bees, termite.

Like parents in form: Goldfish, snake, hen, sheep.

Go through changes in form: Frog, mosquito, caterpillar, locust.

Have a resting (pupa) stage: Butterfly, hawk moth, potato beetle, fly.

At once active as soon as born and able to feed themselves: Cow, duck, locust, spider, turtle.

Weak, helpless, and dependent: Canary, dove, cat, cowbird.

Suckled by mother: Whale, bat, cat, dog, sheep, seal.

Inherit physical character of parent: Milch cow, race horse, dove.

Why the young need parents: Cat.

Informed by the senses of its surroundings, the resulting movements are largely decided by that remarkable faculty called—

25. **Instinct.**—Sentinels placed to watch: Beaver, ostrich, crow.

Flee away: Ostrich, kangaroo.

Hide: Cow, cat, duck, frog, hen, hummer, ostrich, turtle, coral.

Marks food and home: Bee, duck, squirrel.

Knows direction: Horse, dove, swallow, stork.

Weatherwise: Bee, swallow.

Forethought: Oak pruner, tumble beetle, bee, beaver, spider, squirrel.

In home building: Robin, swallow, beaver.

Young go straight to water: Duck, turtle.

Feign hurt: Duck.

Feign death: Potato beetle, squash bug.

Migrate: Robin, stork, swallow.

Hibernate: Black bear, frog, turtle.

From the acts performed under the guidance of this unquestioning and almost infallible faculty, as well as those determined by more advanced reason, we judge of—

26. **Character.**—This may be, emphasizing only desirable traits—

Fearless: Bee, dog, hen.
Industrious: Beaver, termite, bee.
Skillful: Termite, beaver.
Persevering: Spider, mosquito.
Patient: Cat, hen, robin, sheep.
Meek and gentle: Dove, sheep.
Tender: Dove, robin.
Watchful: Cat, dog, vulture.
Imitative: Monkey, sheep.
Neat: Cat.
Docile: Cormorant, horse.
Obedient: Elephant, dog.
Confiding: Stork, swallow.
Influenced by companions: Sheep, vulture.
Intelligent: Elephant, dog, wasp.
Affectionate: Dog.
Faithful: Dog.
Constant: Dove, stork.
Self-denying: Robin, hen.
Sympathetic: Monkey, swallow.
Helpful: Stork, dog.
Merry: Robin.
Truthful:
Generous:
Merciful:
Forgiving:
Thoughtful:
Reverent:
} Only God, and the boy or girl, man or woman, who is *Godlike*.

As with man: "He best serves himself who serves others." All the way down to the lowest animal, the faithful doing of the little daily duties not only accomplishes these, but also those monumental things for the race which shall endure for all time. We next notice—

27. **How they Serve.**—Help to form islands: Coral, star-fish, clam.

Prepare the soil for plants: Termite, worm, crayfish.

Remove decaying things in water: Crayfish, gull, mosquito.

Remove carrion and refuse: Tumble beetle, fly, stork, vulture.

Remove decaying wood: Woodpecker, termite.

Remove injurious insects: Bat, chameleon, mole, robin, snake, swallow, woodpecker.

Destroy injurious animals: Cat, owl.

Produce food for ants: Ants' cows.

Fertilize flowers: Bee, butterfly, moth.

Draws: Cow, elephant, horse, reindeer.

Carry: Camel, elephant, horse, dove.

Catch fish: Cormorant.

Scatter seeds: Cow, dove, squirrel, sheep.

Distribute animals: Duck.

Sing: Canary, robin.

Help others: A good example.

Closely connected with this, but separated for our purpose, is—

28. **What they give—**

Ornament:

- Wampum: Clam.
- Mother-of-pearl: Clam.
- Feathers: Humming bird, ostrich.
- Ivory: Elephant.

Clothing, etc.:

- Buttons: Cow, horse.
- Silk: Silk caterpillar.
- Down: Duck.
- Feathers: Duck, hen.
- Whalebone: Whale.
- Wool: Sheep.
- Hair: Camel, horse.
- Fur: Beaver, cat, seal.
- Skins: Bear, reindeer, sheep, seal.

Leather: Cow, sheep.
Horn: Cow, reindeer.
Sponge: Sponge.
Thread: Reindeer, seal.
Glue: Cow.

Food, etc.
Honey: Bee.
Shell fish: Clam, snail.
Fish: Perch.
Flesh: Turtle, bear.
Poultry: Duck, hen.
Eggs: Duck, hen, ostrich, turtle.
Mutton: Sheep.
Beef and veal: Cow.
Milk: Cow, horse, reindeer.
Butter: Cow.
Cheese: Cow.
Milk sugar: Cow.
Blubber: Seal, whale.

Light:
Wax: Bee.
Oil: Seal, whale.
Tallow: Cow, sheep.
Fire beetle.

Color, building material, etc.:
Deposits of niter: Bat.
Guano: Gull.
Galls: Gall insect.
Stone: Coral and clam.
Lime: Coral and clam.
Hair: Cow.

Life:
All young have parents.
"Come, let us with our children live."
Advice and precept.
Noble example.
Opportunity for experience.

> "Greater love hath no man than this, that a man lay down his life for his friend."

All this rearing and training of children, this "giving" and this "serving" is in great measure the privilege of middle life, when the matured powers are fresh and strong. This will have been to us an experience, and the experience will have developed character.

Right character being the most desirable thing, if we have lived aright it will indeed have been "good for us to be here." As a whole, our lives will have been happy and helpful, and if we love the young we shall wish them the same happy, helpful existence.

But something more than "wishes" are needed. The young are entitled to care and food ; to the training and advice which age and experience are able to impart; and, last but by no means least, to an *opportunity* to use the lessons received, and in their turn gain the upbuilding in character which only comes through experience.

Among the lower animals this is made certain by relentless Death, who beneficently sweeps out of existence the mature and aged, that the young may have a chance not only to do as well but to advance toward better things.

It might be supposed that man would here show his superiority to the brute creation, and by a thoughtful letting go his hold on business and power permit the young to have their needed day. Alas! who, candidly looking this question in the face, must not admit that it would never do to leave such an important matter to man's free will?

Here, then, with all its pain and trouble—do I see the need and reason for *death*. Taking nature as a whole, and leaving self out of the question, is it not, like all of God's plans for us, wise and beneficent in its operation? Death is bound to come to the child's notice sooner or later, and, while not forcing it upon him, I would gradually lead up to the thought outlined above, and teach that here, as always, "whatever is is best," and that "the servant is not above his Master," who declared: "It is expedient for you that I go away." Further in this it is not proper here to go, and I will only add that the "sorrow" was healed by the promise "I come again." The application needs no comment.

We have thus chosen a series of animals which are as far as possible—

1. Available.
2. Of marked and desirable traits and characters.
3. Typical of large classes.
4. Characteristic of different lands and oceans.
5. Fully illustrative of desirable points and lessons.

We have also grouped these points and lessons under heads arranged in a desirable sequence for work and each point illustrated by the one or several (but never many) animals which were fitted to bring it before the pupil.

These essential steps completed, we are now ready to present this to the pupils—emphasizing again that in this stage there is to be *no comparing*, *no generalizing*, *no telling*, but simply bringing animal after animal before the class and securing a notice of certain points or lessons which we have decided on as best to present in that particular case, assured by our carefully laid plan that all desirable points will in due time come before the class, and each will be repeated often enough to become fixed.

The work of the teacher will be to *present* the animal, or truthful representations to the class, and some *object* from or connected with it to aid in fixing the interest.

The work of the pupils will be to *see* and *tell* about, investigate, and, if they choose, question.

The results will be expressed by the pupil in terms of "I saw," "It looked," "I heard," "I felt," etc.

To this must be added "I read" or "Teacher read"; while only in rare cases must they be able to say "Teacher *told* me."

Does this mean much that can not be given? Omit it, then; for there is enough that can be given properly, and the rest will come in later, and, best of all, the child will not be spoiled for true work.

Having thus analyzed and outlined this very important branch of science, the real work of Step V follows.

(STEP V.—ANIMALS.)

Acquaintance with a Few Home Animals.

Object.—1. To learn the use of external organs from a boy.

2. To extend this to common animals.

3. To enforce moral lessons.

4. To teach various points in habit, structure, etc.

Time.—Of the school year—late spring and early summer. Of the day—when pupils need relaxation. About thirty-five lessons of ten to fifteen minutes each, and averaging three points a day.

Material.—The animals chosen for this step are all common and easily observed, so that live specimens can usually be examined. Some things will, however, need forethought.

1. Search the ditches in early spring for frogs' eggs to place in some wide-mouthed dish (as an earthen baking dish) to hatch, and simply let the pupils see them from day to day.

2. When digging the garden and flower beds, especially near where tomatoes stood, look for the naked brown pupa of the sphinx moth and take them to school for the children to see. Then bury in damp sand and cover with netting to catch the moths.

3. Have a jar with a few fish (of almost any kind) for the daily observation of the children.

4. Set a "school hen," if possible.

Preparation of teacher will consist in getting things to show to the class and in making his own observation on them first.

Books suggested for reference are Owens's Comparative Zoölogy, Romanes's Animal Intelligence, and The Riverside Natural History. Many other books contain things which these omit or give but briefly, but these are most generally useful.

The Lessons.—Make thorough preparation, so that no delay will occur in the class.

Push the work vigorously. The moment one point is clearly presented to the class drop it and take the next. An average of three points should be made each day, and to do this may mean a dozen topics on simple work in one day, and not all of a single one some other day.

I wish to particularly caution against confusing different kinds of animals. So many of the books for children seriously confuse and mislead by a number of anecdotes and statements about different species of some animal, all brought in together as though they were all true of one. Hence in these lessons, having decided to talk about some kind of land snail, say nothing about all the hundreds of other kinds. If about the mud wasp, talk only of that.

The Boy.—Children know more about their own organs than those of any other animal. Hence begin here, and bring out the following points in preparation for following work.*

1. Where do boys live? "On land." (All for this time.)

2. Can a boy feel? Where best. (Make tests on exposed parts.)

3. Can boys hear? What with?

How many ears? Where are they placed?

4. Can he see? What with?

Where are the eyes placed?

How many?

What shape is the pupil?

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* The numbers before each point refer to the twenty-eight headings before given: "1. To where they live; 2. To touch and feeling," etc.

How is the eye closed? How many lids to each?
Which way do the lids move?
Any other use for the lids? (Protect and moisten.)
How are the lids kept moist and from rubbing on the eye?

5. **Nose.**—Where placed?
Nostrils directed?
Use of smelling?

6. **Taste.**—Where located?
Why we have taste.

7. What ways of moving has a boy?
In what position does he "creep"?
How does he "swim"?
Position in "walking"?
How is the foot placed down in walking?
How does running differ?
How does he "climb"?

8. What limbs has a boy?
How many legs?
How many arms?
How many toes?
How many fingers?
How many nails?
Has he a thumb? What can he do with the thumb that he can not do with any finger? (Place it *opposite* to fingers.)

9. How are his legs and arms arranged? (In pairs.)
How about the eyes, ears, and nostrils?

10. What does he eat?
What is the natural drink?
Is salt desired?

11. Is the opening of the mouth across, or up and down?
Of what use are the lips?
How are the lips used in eating?
How in drinking?

12. Has a boy a tongue?
Where is it located? (Fills the middle of the mouth.)
Which end is fastened?

What uses can you observe for it ?

13. Which way do a boy's jaws move ?

Where are the teeth placed ?

How many ? Use ?

What three important ways of using them ?

Where are the "biting" teeth, and what is their shape ?

Where the "grinding" teeth ?

Where the "tearing" teeth ?

14. What does a boy breathe ?

Is his body warm, or cold ?

Of what color is the blood ?

Does he perspire ? When ?

15. What covering to the body ? (Skin.)

What extra covering to the head ?

How do we protect the naked skin from the weather ?

16. Are there hard parts to the body ?

Where are the bones ?

What do we call the place where bending motion occurs ? (Joints.)

17. Of what color is the skin ?

The hair ?

The teeth ?

The eyes ?

The nails ?

20. What sounds does he make ?

Meaning of a cry ?

What feeling does a laugh express ?

What is "talk" for ?

What is singing ?

When does he groan ?

When sigh ? When snore ?

Meaning of a yawn ?

What look comes over the face when pleased ?

How is shame expressed in the face ?

Can you tell anything of the feelings by the looks of the *eyes* ?

How do dumb people talk ?

How would you manage to get a drink, or some food, if among those who spoke a strange language?

Do anger, meanness, and untruth, show in the face?

Is there any danger that a scowl may become the *fixed* expression of the face?

21. Do boys like to be alone, or in company of others?

22. What do grown-up boys (men) make? (Confine this list to a limited time and the experience of the children.)

23. What persons make up a family?

What is the place they live in called?

What does the father do for the family?

What the mother?

How can brothers help?

And the sisters?

(Each teacher must work such a topic out in her own way, but *limit* the time, or it can become wearisome, and varying phases will constantly be coming up under other animals.)

24. What is a very young boy called?

Can he run about and get food as soon as born?

Would you think from his looks a baby was to be a man?

Having pushed this elementary and preparatory study of the boy to a brisk conclusion, at once proceed to consider the following points in a common type of the milk-giving animals.

The Cow (*No. 57*).

8. Notice that she has four legs and a cleft hoof with two toes.

9. Notice that the organs are arranged in pairs, and the two sides of the body alike.

10 and 11. She drinks water by means of *fleshy lips*.

12. Her tongue is thick and fleshy and used to draw the food in.

13. She has no upper biting teeth, but has stout *grinders*. She eats rapidly, and then at her leisure brings up the swallowed food again into the mouth and *chews* her *cud*.

14. She breathes air by *lungs*, and her breath is "sweet."

15. She is covered with hair, and has round *horns*.

17. Notice the color of her hair and horns.

19. She *defends* herself and calf with her horns.

20. Cows have a very expressive language, well understood by each other and by persons who are familiar with them. Much of it is untranslatable, but the following will illustrate: "Moo." This gentle call is used to the calf when near, and in an appealing tone to ask for food or water. "Lowing" is in a more vigorous tone and the call for its mates, the inquiry put to strange cattle, or the appeal to the keeper for food or water when he can not be seen. "Bellowing" is the language of rage or pain.

21. Cows are *social*, and much dislike isolation from their kind. If shut up alone, they will use their best efforts to escape, and, failing in that, stay on the side of the field nearest to other cattle. They will even form an attachment for other animals, as a horse or sheep with which they may be confined.

24. The young is called a calf, which is able soon after birth to walk and suckle. The power of *inheritance* is seen in the way the milk-giving powers of the Holsteins, the fawn-colored muzzle of the Jersey, or the flesh and fat producing powers of the shorthorns is transmitted. The *lesson* to draw from this will come later; only notice the *fact* now. Note the color and tenderness of the unused muscles in the veal of the calf.

27. The cow is of great service to man. In the Azores * I constantly saw cows employed to draw wagons, plow, harrow, and turn the mills for grinding meal and flour. They also aid plants to scatter their seed, as any cow's tail and legs will show who has been where burs, etc., were.

28. Not only does she "serve," but she gives much. Her

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* Always find a place or country on the map with the class. I have this end in view in all such references, and a steady and healthy gain will result in the knowledge of the earth's surface.

rich milk is a perfect food for us. On it, when standing, rises rich cream, composed of little globules of fat incased in cheesy envelopes. By dashing these about in a churn the cheesy coverings are broken, and the oil adheres together in masses which we call butter.

If the milk is curdled in a certain way, all the liquid "whey" drained out, and the "curd" salted, pressed, and kept a while to "cure," we have the rich yellow cheese.

From the yellowish, watery whey the Swiss separate a hard and not very sweet sugar, called milk sugar, which we are all familiar with in the form of pills and tablets.

When she is not needed for milk, the cow's flesh gives us the beef so common on our tables, and the fat is called tallow and used to make candles and soap.

The hair is taken off the *hide* and used to mix with lime and sand for mortar to plaster our houses.

The skin is then soaked in water with the ground-up bark of the oak or hemlock tree; which tans the raw hide into the firm leather of which boots and shoes are made.

The white bone buttons used on underclothing are partly her gift, and from her horns are made combs and other things. That nothing be lost, scraps of untanned hide, bits of horn, hoofs, and even bone are boiled, and out of them is dissolved a substance we call glue. In giving this point, bring a quart of milk and set it for cream. If different children are interested to compare the milk of their different cows, let them bring the new milk and set samples of each in equal-sized test tubes, and through the glass sides the thickness of the cream that rises can be judged.

Have samples of butter, cheese, milk sugar, beef, etc., brought by different pupils. Curdle some milk with rennet or a little acid and show the "curds" and "whey." Light a candle. Show some old plaster with the hair in it. Let the boys file or scrape a quart of oak bark, and, having steeped it well, put in a scrap of rawhide. Have bone buttons and glue brought. There will be no lack of interest in such work, and the only caution I have is: "Do not *tell* anything it is possible to show or have the class find out; and do not continue the work *too long*.

The Hen (No. 37).

Material needed: Get the butcher to save a lot of heads and legs (which they usually chop off and throw away), wash them well, dry, and give one of each to every two or three pupils. Get some pupil to bring a live hen in a box to have it for examination. A hen should also have been set about two weeks before this study begins.

3. Search for the concealed ear.

4. Find the 3 eyelids. Which way do they move? Gently touch the eye of a live hen with a feather and see her *wink*. Notice the *round* pupil. Can a hen look *forward* without turning her head?

5. Notice the nostrils, where they are, and which way directed.

7. A hen walks.

8. The hen has four toes, with blunt claws. From the toes up to the first joint is called the tarsus. Is it feathered, or not?

10. Her food is a mixed diet of seeds, fruits, insects, etc.

11. Her lips are a horny bill.

14. She breathes *air* by lungs, and her body is *warm* and blood *red*.

16. She has an inside, bony, jointed skeleton. (See a cooked chicken.)

17. Note the colors of both rooster and hen, and that the latter is less brilliant. Note the bright-red comb and wattles. Where are they?

19. She defends herself and young with claws and bill, aided by her cries.

20. Her *language* is varied and very expressive.

When well and soon to lay she goes about with a contented and continued set of notes, which I call her "*song.*"

The egg laid, she "*cackles*" her joy, and all join in congratulation.

She has a *scolding* note when disturbed on the nest, which may become a harsh cry of remonstrance.

When the "*peep*" of the chicks in the hatching eggs is heard, she has a gentle, *soothing croon* of encouragement, used later to quiet the chickens safely folded to the warm breast by her protecting wings. As her active little flock is led about, they are kept together and near her by the frequent "*cluck.*"

If food is discovered, all are called to share in it by the *chuckle* which accompanies the division of it with her bill.

A peculiar cry is given if danger (especially from above) appears, when all hasten to shelter.

22. Her *nest* is made low on the ground, or similar place.

24. The eggs are *oval* and have a *hard shell*, and are—if no one interferes—about as many as she can well keep warm.

They are laid *one at a time*, and in her efforts to get a nest full she will continue to lay for quite a while if the eggs are removed. The young are called *chickens*, and are *shaped* like the mother.

Call attention to the difference in color and tenderness between the meat of the *breast* and the *legs*. Which does she use the most?

Which need to be the strongest? Make the application to ourselves, that if we want any part to be *strong* we must *use* it.

25. A hen lays her eggs in what she supposes a *hidden* place.

26. She is *fearless* in defense, and will return again and again to the attack if she thinks hatching eggs or young are in danger. Her *patience* in setting three long weeks continuously to hatch the eggs is remarkable.

When the chickens are hatched, she is *self-denying* in her efforts to scratch up and break in pieces the food for her brood.

28. The hen well repays the care we give her by the

highly valuable food from her eggs. Her *feathers* are of use for beds and pillows, and her *flesh* is pleasant to the taste, and nourishing.

The Garter Snake (No. 29).

Procure a few small "garter" snakes and have them to pass around the class (or one at least, if the teacher has the courage). Handling first by the teacher, followed by the example of some courageous boy, will do much to remove the foolish fear so many have of our common snakes; but force no one to touch them, as serious consequences may result. A large snake in alcohol will aid.

Keep a snake in a covered jar for some days for the children to see, and if little talks be held at odd moments with those watching it, they will be ready for the lesson. A cast-off skin should also be had.

As an examination of the list will show, the following points are to be drawn out regarding the snake:

4. Has no eyelids.

7. Moves by crawling.

8. Its food consists of small animals and insects.

In spite of its occasionally eating some innocent frog or poor little birdling, it does a vast deal to rid us of classes of injurious animals (mice, etc.) and insects which feed at night and so escape birds. Hence I would teach that the common snakes are our *friends*, and should *not* be mercilessly killed when seen.

12. Notice the *forked* tongue.

12. Any one who has observed a snake swallowing a frog or bird must have wondered at the way the mouth can stretch. The bones are arranged something after the manner of a tin lunch box, which can shut up flat or open to full size. To aid in catching and swallowing its food, the mouth has little sharp teeth which slant backward. These can be felt with the finger or a pin.

14. Feel a live snake. Is it warm, or cold?

15. Note the covering of scales. How many rows.

counted across the back? When the snake's firm jacket of scales gets old and worn or too small, a new suit begins to grow under the old, which then becomes loose, and at last splits and peels off. Who ever saw one of these old skins? Here is one for those who have not.

17. Note the colors of the scales. Are they solid or in patches? 18. As you look into some grass or bushes, is all *equally* bright? How does the ground under a tree appear when the sun is shining? (Flecked with light and shade.) Can any one think of a use to the snake of his speckled coloring?

20. Snakes *hiss*.

24. The long, white eggs of the garter snake are laid under some sheltering clod of earth and deserted by the mother. No heat is needed to hatch them but that of the air and sun; and the young leave the soft shell looking very much like the mother.

27. Garter snakes crawl about on the ground at night and eat the insects which escape the notice of birds; hence they are of much service to us, and should no more be killed than a toad, which is so highly prized in European gardens as to be bought and let loose where needed.

The Frog (No. 28).

If the eggs were gathered in the ditches soon after the ice disappeared, and have been kept in wide, well-aired dishes of water to hatch, as suggested before, the pupils will have done a good deal of observing and be ready for this advance. Get one or two frogs of any common kind and confine them in some large glass dish by *tightly* covering with wire netting.

1. The frog lives partly on land and partly in the water. Where do the young live?

3. The ears have no *outside* opening.

4. The eyes are almost on top of the head, and stand out when open. How are they when closed? The *pupil* has a curiously angular look, and is called "rhomb-shaped."

5. The nostrils are on the upper tip of the snout and near the eyes.

7. The frog can dive and swim under water and *hop* on land.

8. Note that his webbed toes have *no* nails.

12. Note the fleshy tongue, fastened in front and thrown out to catch insects.

14. The frog breathes air. When moist the skin also aids; and if a frog can not keep his skin moist he soon dies. The young tadpoles living in the water have *gills.*

15. Note the naked skin.

17. What colors to the skin? How arranged?

18. When frightened from the bank of a pond or brook, what does the frog do? Who can think of a use for his green and white speckled coloring? His projecting eyes? His nostrils being so high up? *

20. Frogs croak. (See Whittier's "Barefoot Boy.")

21. Are social in their "concerts," and are also said to congregate together in the mud at the bottom of ponds when hibernating.

24. The eggs are laid all at once, in jellylike masses, often on the stems of water plants. The young are called "tadpoles," and breathe the air in fresh water by gills. These undergo exceedingly interesting metamorphoses before becoming frogs. Trace these changes through with the class, aiding by pictures. Help each child to secure one or two to take home and watch. It will interest the family and greatly aid the child.

25. The way a frog "instinctively" seeks a position where the colored spots of his back will protectively harmonize with his surroundings, and then, without making the slightest ripple, pushes his projecting eyes and nostrils just above the surface and comfortably lies there to await further developments, is very interesting, and will introduce

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* If the class *can not* think, in no case *tell* them. Such questions lie in the mind and develop unconsciously into a clear perception of the truth.

the children to some profoundly instructive phases of animal life.

Would not inquire the use of his white belly here, but await until the evident *need* of such an arrangement is seen in the perch.

As cold weather comes on, frogs bury themselves in the mud at the bottom of ponds and other still water and *hibernate* till early spring.

The Goldfish (*No. 26*).

Some of these pretty creatures should have been swimming and feeding in the school aquarium (a wash-bowl or other bowl, with a fence of wire screen about it to keep them from jumping out) for some weeks. If goldfish are not to be had, some of the small fishes found in brooks and ditches in early spring will do, but require more care to live.

Get a good-sized "sucker," or whitefish from the butcher about the time of the second lesson ; let the class see the fins, and let each have a few scales to examine and keep as specimens.

1. Goldfish live in the water.

4. The eyes are on the sides of the head and have no eyelids. Do they need tears to moisten their eyes ?

7. Fishes swim forward.

8. Their limbs are called fins. These fins are held and stiffened by little ribs called rays. Are the rays of this fish soft, or spiny ? How many fins ? How arranged ?

12. Place your finger in its mouth and note how hard the tongue is.

14. Find the gill openings on the sides of the head, and, raising them, see the delicate red *gills* with which the fish breathes the air in the water. Watch a live fish and see how the water is constantly kept moving over the gills. Is a live fish cold, or warm blooded ?

15. Goldfish are clothed with scales. Take a few, and note that the edge is *rounded*.

17. Observe the color of the scales.

19. How does a fish escape from an enemy?

24. The eggs are laid in the water among gravel, and the little fish are from the first shaped much like the mother.

The Sphinx Moth (No. 21).

I have chosen this moth, rather than the butterfly, because of its size and the comparatively few and simple points I wish to illustrate with it. As they are eminently injurious insects, it is with no compunctions that I advise catching several of the moths and killing them, for the pupils to examine.

Should they become dry and stiff, lay them on some support above a damp sheet of paper or sponge and cover with a tumbler or glass shade. The moist air will soon relax the organs and prevent their breaking when moved.

Have some pupa (as before advised) to show and hatch.

7. This moth flies in the twilight hours, and is often mistaken for a humming bird as it hovers over the flowers.

8. Has 16 legs to walk with when a caterpillar, but when grown it has only 6 legs, and 4 strong wings to fly with. Its antennæ are thickest in the *middle.*

9. The caterpillar has 13 segments to the body.

10. It feeds on leaves when a caterpillar, and on the nectar of flowers when a moth.

12. It has a long "tongue" to insert into the flowers and draw out the nectar with, which it carries coiled up like a spring when not in use.

13. The caterpillar has strong biting jaws, moving from side to side.

14. All its life it breathes through openings, called "spiracles," in its *sides.* See them on the caterpillar and enlarged in some cut or drawing.

17. Notice the color of the wings, and the way they are folded when at rest.

Notice the color of the caterpillar. Is it always the same?

18. Observe a moth at rest, and compare its color, markings, and ridgelike back with the color, lights and shades, and ridges of a piece of bark, crevice in wood, or bunch of dry twigs.

Again, study the lights and shades of a potato or tomato plant as it stands in the field, and see if there is any "imitation" in the colorings of the caterpillar.

Disturb a feeding caterpillar and see how long it will keep its motionless, sphinx-like attitude.

20. Notice the *whirring* sound which the moth makes when in flight.

24. The young is at first called a *caterpillar*. After eating all it needs and being fully grown, it burrows into the ground and changes to a curious brown *pupa*. This has a handlelike tongue-case and the places for the feelers, eyes, and wings can be distinguished. Although seemingly lifeless, changes go on under its brown covering and at last out comes a perfect *moth!*

27. It *serves* by carrying the pollen for the flowers. Some plants brought from other countries do not bear seed because the flowers are too deep for our insects to reach the nectar. What common flower in our gardens is much visited by these moths? (Petunia). See if you can find any others with long tubes visited by them.

Land Snail (No. 6).

Hanging to the lower sides of stones, walls, or old logs will be found these snails, if any are to be found in the neighborhood. Under logs, among the decaying wood, will be found the round, white eggs.

Gather snails enough so that at least each pair of children can have one to watch. Should no land snails be found, look in ponds and ditches for the pond snails, which can well take their place, and keep a supply in an aquarium, to distribute in saucers of water when needed.

These latter will lay their eggs in jellylike masses on the glass or on objects in the water.

A supply of shells of either kind will be helpful, and are freshest if made by pouring boiling water on live snails and then pulling out the tough and contracted animal with pincers or a hook. Some may object to this as cruel, but it is far less so than the starving to death so commonly practiced by those who are trying to keep them. "Dead" shells can always be found about the haunts of snails, which will do fairly well.

What follows applies to the land snail. Pond snails differ in some ways.

2. Note the way a snail uses its tentacles to feel things about it.

4. See how curiously the eyes are placed, on the *ends* of the long feelers (tentacles); and how the snail *winks* by turning in the eye and end of the tentacle, like the turning of a glove finger inside out.

7. The snail *creeps* with a gliding motion, leaving a slimy trail behind.

8. The fleshy part on which it rests and by which it moves is called its "foot."

10. The land snail lives on the green parts of plants, and when numerous does great damage.

12. This food is rasped off with a most remarkable tongue, studded with hard teeth, set in regular rows. (See the illustrations in some book on Zoölogy.)

15 and 16. The soft body is covered with a limy shell, which is coiled and in one piece. (Drop a bit of shell in a little hydrochloric acid and see the dissolving of the limy matter.)

17. What colors has the shell, and how arranged?

24. The eggs of the land snail are *spherical*, and laid singly under logs or stones.

This ends the work of this step.

Review.—None is needed or desirable.

Material put away.—Take a shoe-box or similar box.

Label it "Step V" on the end, and in it place any things gathered for the lessons. Arrange so as to keep vermin out of any hair, skin, or feathers there may be, and put away for the next class.

Conclusions.—The children will now have had a look at eight animals. Their eyes have been opened to some things which they did not before notice; the way has been prepared for future work, and their vocabulary of understood words been increased. Next step in Animals, IX.

STEP VI.—PLANTS.

Roots and Stems.

Object.—Increased acquaintance with plants. Lessons in form and color.

Time.—In the fall of the year, when roots and stems are abundant and mature. About ten lessons, of fifteen or twenty minutes each, will be required; but in every case make the lessons progressive. Be sure each day is an advance on the days before, and when the material (or class) is exhausted, as promptly drop the subject and take up the next.

Material.—Will need to be mostly fresh, and gathered for each class. The children who have had the experience of the previous steps will be able to aid in gathering, and should have the chance.

The following is a list of points to illustrate, and material with which to do it:

Points and Material from which to choose.

Roots.—Tap (one main axis): Beans, melon, morning-glory, etc.

Conical: Carrot, parsnip.

Fusiform: Beet, radish, ruta baga.

Napiform: Most turnips, some beets.

Multiple (no main axis):

Fibrous (threadlike): Grains, plantain.

Tuberous (tuberlike): Dahlia, sweet potato.

Moniliform (necklacelike): White clover.

Air roots, for climbing and support: Ivy, trumpet creeper, Indian corn.

Stems.—Above ground: nearly all.

Shape—Round and solid: Almost any tree, rush.

Fluted and hollow: Equisetum and those of the carrot family.

Round and hollow: Grasses, grains, and bamboo.

Square: Those of mint family (catnip, salvia), etc.,

Triangular: Sedges.

Half round: Corn.

Joints (swollen): Grass, pinks, buckwheat, or smartweed.

Joints (separate): Equisetum ("scouring rush").

Bark—Smooth: Willows, etc.

Furrowed and ridged: Blackberry, cottonwood.

Prickles: Rose, gooseberry, blackberry.

Color—Red: Willow, rose, maple.

Yellow: Willow, grain.

Green: Fresh stems.

Gray: Ash.

Brown: Cherry, birch.

Smell: Balm of Gilead, pine, sassafras, locust, mint, etc.

Taste—Sweetish: Birch, locust, green corn, sugar-cane.

Bitter: Willows, cottonwood, poplar.

Spicy: Sassafras, mint.

Wood—In rings: Oak, etc.

In threads: Corn, etc.

Pith—Much: Sumac, elder, corn.

Little: Most woody stems.

Sap—Watery: Potato, etc.

Colored: Sumac, poppy, milkweed.

Gummy: Pine, fir.

Underground stems: Potatoes, Solomon's seal, sweet flag, crocus, gladiolus.

Where and how to gather Roots.—It is the early part of September. After school, invite a few pupils to go with you, and, taking a spade and basket, search the garden and fields for specimens. Choose one or two large and typical roots of each of the eight classes given, and bury in sand or moist (not *wet*, or it will stick) earth in the cellar till needed.

The Lessons.—1. Show the class a typical tap root. Let them tell all they can observe about it, being sure they notice the single main axis, none of whose branches approach it in size. Get them to name others, if they can, and each bring some root to-morrow.

2. Have some dishes or plates (paper pie plates do well, and are cheap and light). Let one after another hold up a root and tell about it—where found and how got, and what he notices. Lay the first root on a dish. If the class decides the second is like it, lay with the first; if not, place on another dish, and so on, grouping them as they come up. When the class have all finished, bring out some type from your collection which they have omitted, and, saying nothing, let them decide about it. Let each bring a different root to-morrow—if possible, unlike any brought.

3. Repeat yesterday's programme, and, if need be, add another type yourself, but a bright, interested class will not give you the chance to add many.

4. When all eight classes of roots are represented, and the children have *seen* and talked of them, the work advisable at this step is complete. Do *not* branch off into comparisons, structure, uses, or any of the other delightful lessons that might be taught; these will come up in a better connection later.

Where and how to get Stems.—Attended by several pupils with baskets, string for tying, and sharp knives and strong scissors to cut, go out into woods, orchards, fruit gardens, and parks. Have a list of one good example in each class as given under "Points." The following will cover all the points:

Grass: Select large, strong stems and cut between the joints with scissors.

Equisetum: Old, dry stems are best (cut between joints).

Catnip: Cut sections with scissors.

Sedge: Select sections of large flowering stems.

Corn: Strip off leaves and cut 3-inch pieces with scissors.
Blackberry: 3-inch bits of stem alike in color.
Red willow: 3-inch pieces.
Ash: Twigs.
Cherry: 3-inch suckers or twigs.
Sassafras: 3-inch pieces alike in color.
Locust: 3-inch twigs.
Sumac: Ends of twigs.
Pine: Twigs.

Oak: Select a dry stick 1 to 2 inches in diameter (stem of small tree best), and with a sharp saw cut off sections half an inch long. These will show the rings of wood well.

By adding wheat, parsnip (flower stalk), mint, pink, rose, and fir, nearly all the points will be illustrated twice. Gather enough for each child to have a complete assortment, and a few spare ones for teacher and new pupils.

Potatoes and crocus corms: Get or buy but have both.

The Lessons.—Adopt the sorting plan. When ready, give each child a set of specimens, either in a bundle (see Step IV) or in the large trays used for seed sorting. In either case provide a label for each, so that the careful and obedient shall not suffer from the picking to pieces and destruction of others.

This very destructiveness will seem an insurmountable obstacle to some teachers, but it will correct itself if judiciously left alone to bear its own fruit.

Give good advice, suggest the need of self-control in all that is done, and then the reckless pupils will find themselves needing the twig they broke, or unable to join with the rest in the study of pith or sap, because they so carelessly chewed up the specimens in tasting. Your warm recommendation of those who can return a complete and well-used set at the close will also be a prize to be coveted, and more and more sought as the lessons advance. Such pupils need help, and it is a teacher's privilege to use these opportunities to extend the helping hand.

Let the class examine the specimens a while, and then ask them in turn to tell what they have observed. As each speaks of something, have the others find the same specimen and see it for themselves. In this way all will observe together, and few errors will pass unchallenged.

Each point dwelt upon should be made the basis for sorting: Kate, for example, notices the red bark. How many red-barked twigs have we? When all can hold up two (willow and blackberry), ask, Are these the same?

"This one is smooth." It is the red-willow.

"This has prickles." The blackberry.

How many have prickles or thorns? How many have smooth bark? Who notices something new?

"A three-cornered stem." It is of a sedge.

Can you find others?

"No, but here is a square one."

Good! Are there other square stems? Who notices anything about this one?

"Hollow."

True enough. Are there other hollow stems?

"Two."

Hold them up and let us see how they differ.

"This is a fishing pole."

Why do you call it so, Ralph?

"You can take it to pieces and put it together like a fishing pole."

So you can! We call it "horsetail" also, because another part of the plant looks like a bunch of long, green hair. The others?

"This round stem is grass."

How many round stems have you?

In this way, aided by a cautious hint now and then as the pupils exhaust their resources, the whole ground will be covered in a helpful and pleasing manner.

Potatoes will sooner or later be called in question as a root and not a stem. Having brought out the fact that the "eyes" sprout, ask which of the roots had these eyes. They will be very apt to say "sweet potatoes." In any case, place the ends of the potato and the root they think like it in a dish of water to sprout, and see if it is so. They will then be ready to see a difference between roots and stems—stems having buds, especially at the end opposite to where they were fastened to the mother plant, while roots seldom have them except at the crown, where a piece of the true stem remains. The crocus can be shown to be a stem by carefully removing the dry coats and finding the buds. More differences will appear when leaves are taken up.

Now let the class find specimens and bring as formerly in the case of roots. This will connect the work with nature, and, while interesting the home circle, greatly aid the pupils.

Collections can be sewed on cards or made in any way the taste of the pupils may direct.

Color will be frequently spoken of in both roots and stems. Have a color chart or some standard to refer to.

Form.—The constant comparisons and the drawing which can be introduced will add much to the pupils' ideas, but let this be a secondary consideration—not expanding the lessons too much, or the point will be lost.

Language will flow naturally and readily under the inspiration of such work. The child has something to tell about, and the teacher need only look to the way it is told. Beware, however, of too constant criticism. It worries all, and to no profit, as the child can not take many thoughts at a time.

Review.—Would advise none. If taught correctly, there will be nothing which should be added now.

Material put away.—Give the children most of the things. Let them plant the crocus corms in the school garden. The oak sections can be saved, and in a box might be laid two of each kind of thing that will not decay, as reference may come up in other work, and even a dried-up twig be helpful at the moment.

The next step in Plants is X—Leaves. Would advise the teacher to see at once about the pressing of leaves and gathering of material there recommended.

STEP VII.—THE SKIES. (II. THE MOON.)

[*This is to continue the studies of Step II. Time, preparation of the teacher, etc., are spoken of there.*]

THE LESSONS.

1. **Sunshine.**—Notice this—its heat and light and where they come from.

Call attention to the *blessing* this sunshine is to plants and animals.

2. **Starshine.**—Is it like sunshine? (In giving *light.*) How unlike? (No appreciable heat.)

Talk of the uses of the stars shining in the sky.

3. **Moonshine.**—See the full moon, and that it is *opposite* to the sun—on the other side of the earth. Of what *use* is moonshine?

Notice the flaming looks of westerly windows at sunset; the reflection of lamps and the fire in mirrors; the apparent light in the windows of a house from the reflection of street lamps, head lights of locomotives, etc.; the lighting up of the clouds or smoke from the open doors of locomotives, rolling-mill or smelting-furnace chimneys, or the lights of a city.

These will show the results of *reflection*, and prepare for what follows.

4. **Moon's Face.**—Call attention to the dark patches on the full moon. Read or tell the story in Hiawatha showing what the Indians thought this "face" was.

5. The shape of the moon seems to *vary* (phases).* Let the pupils walk around a globe lighted by a dark lantern in

* See Lockyer, p. 122, and his Science Primer of Astronomy, p. 43, etc.

a dark room, and these shapes can be easily explained. Be sure, however, that they understand that the dark lantern is only a convenience, the sun really giving light in *all* directions.

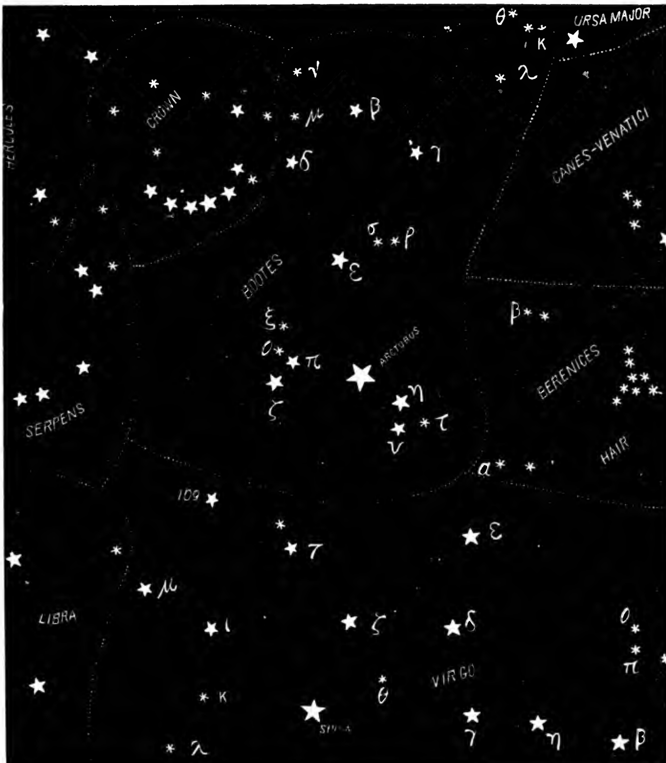
Next substitute a small lamp for the dark lantern, and have a small globe carried contrary to the movement of the hands of a watch around the lamp. If the class is gathered on one side of the room, the small globe (moon) will show these phases again and quite a correct idea will be obtained. Notice the *round shadow* cast by the ball on the wall.

6. **Motion of the Moon.**—The direction about the earth is shown in carrying the globe (moon) around the lamp in a direction *contrary* to the movement of the hands of a watch laid on its back.

7. **The Months.**—These are determined from this motion about the earth, and are nearly thirty days (Lockyer, p. 223). Let the class find this out by watching the time from new moon to new moon. While doing this, learn the *names* and *order*.

Thirty days hath September,
April, June, and November ;
All the rest have thirty-one,
Save February, which alone
Hath twenty-eight; and one day more
We add to it one year in four.

The *meaning* of these names is interesting: January is named in honor of Janus, the Roman god of the sun and year. He had two faces—one looking back on the past (old year), and one forward into the future (new year). February was named from a Roman feast in that month, and means *to purify*. March was named in honor of Mars, the god of war. April comes from a word meaning *to open*, in reference to the opening of the earth to the seed or the first bringing forth of new fruits. May is named from the goddess Maia, a daughter of Atlas (who was supposed to hold the world on his shoulders) and mother of the winged god Mercury. June was sacred to Juno, wife of Jupiter, and so queen of the gods. July was named in honor of Julius Cæsar; August, in honor of the Emperor Augustus. September from a word meaning "seventh," as it once was reckoned the seventh month. October means "eighth" for the same reason. November, means "ninth." December, from a word meaning "tenth."



8. Show the beautiful star *Arcturus*, by following the curve of the handle to the "dipper" in May to July.

9. Northern Crown can also be seen near Arcturus. With it is connected the story of Theseus, Ariadne, and the Minotaur whom he slew in the famous labyrinth built for King Minos in Crete.* Below is the head of the serpent.

As to whether myths shall be given children, each teacher must decide; but so many of these tales should be known to understand the allusions of our best writers, and the names are so interwoven with the constellations, that I shall refer to those known as adding much of interest to the study. Beware, however, that these tales of unworthy heroes, gods, and goddesses are in no degree placed on the same plane as the characters of the Bible.

Cards.—Let the class prick, sew, paste, draw, or color these constellations and add them to the groups of the previous step for *home* use. A neat portfolio or case might well be made to hold them all, and decorated on the outside with appropriate designs (when the study is completed and they have material to draw from).

Next step in The Skies, see XVI.

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* See Bulfinch's Age of Fable, pp. 184–201, in 1881 edition.

STEP VIII.—SORTING OF MINERALS.

The metals of Step III were more or less familiar to the child in the home life. Minerals are less so, and hence a step in advance.

For these lessons the same trays and boxes used before will be needed; also the following list of minerals, which experience has shown to be well arranged to cover the ground:

1. Sulphur (or brimstone).
2. Graphite (or stove blacking).
3. Galena.
4. Pyrite—"Fool's gold."
5. Rock salt.
6. Magnetite.
7. Hematite (red iron ore).
8. Limonite (brown iron ore).
9. Quartz crystal.
10. Quartz (glassy, rose, smoky, or milky).
11. Flint, jasper, or agate.
12. Asbestos.
13. Mica.
14. Feldspar.
15. Talc (soapstone or "French chalk").
16. Serpentine.
17. Calcite (rhomb crystal. Guard it carefully from getting scratched).
18. Chalk.

The fragments should be about the size of a hickory nut or English walnut. Get enough so that each pupil can have a complete set.

Sulphur, graphite, talc, and chalk can often be had at wholesale druggists', who will let you select the smaller pieces, and so save the waste from breaking larger.

Rock salt can be had at a "feed" store.

Magnetite, hematite, and limonite, at blast furnaces; the latter in the soil about iron springs.

Flint, jasper, agates, and quartz, along beaches. (Flint "flakes" are common wherever Indians used to camp.)

Asbestos and mica, of hardware or stove dealers.

Feldspar, in pebbles and bowlders.

The others will probably have to be purchased from some dealer in minerals, to whom send a list of what kinds and how many of each you want; explain the use you intend to make of them, and his prices will generally be reasonable.

Also get pieces of window glass, one to two inches square, at the paint store, similar bits of sheet copper at the tinsmith's, and small pieces of hard, unglazed tile at dealers in mantels and tile floors and hearths, or rough, white porcelain (broken lampshade, etc.) for "streak plates."

Specimens of the same mineral vary somewhat, hence, having obtained them, compare them in the following points, which will apply in most cases:

1. All are *minerals*, being homogeneous, like bread, sugar, or tallow.

2. **Color.**—Graphite, pyrite, galena, magnetite, and hematite have a metallic color (like metals).

Sulphur, rock salt, quartz, etc., are unmetallic.

3. **Streak.**—The following leave a mark when rubbed on white, unglazed tile: Sulphur to limonite (1 to 8) and talc to chalk (15 to 18).

4. **Hardness.**—Graphite, talc, and chalk can be scratched by the thumb nail (hardness of 1).

Sulphur, galena, rock salt, mica: thumb nail will not scratch, nor will they scratch copper (2 to 2 ½).

Magnetite, hematite, limonite, serpentine, and calcite scratch copper but not glass (3 to 5).

Pyrite, quartz, flint, and feldspar, scratch glass with more or less ease (6 and more).

5. **Magnetic.**—Magnetite.

6. Rock salt, quartz, mica, and calcite are more or less *transparent.*

Sulphur, and thin edges of others, *translucent.*

Graphite, galena, pyrite, etc., *opaque.*

7. Calcite (if transparent) when laid over writing makes it look double.

8. All those mentioned in 2 having metallic color also have the *luster* (shine) of metals.

Rock salt and quartz are glassy.

Sulphur is resinous.

Mica, feldspar, talc, and calcite have a pearly luster.

Serpentine is greasy.

Asbestos is silky.

Limonite, chalk, etc., are dull (no shine).

9. The careful breaking of fragments of the cheaper minerals with a hammer will well repay the cost and noise.

Sulphur, galena, rock salt, and calcite are brittle—crumble under gentle blows.

Magnetite, hematite and flint are often very tough—require hard blows.

Graphite, asbestos, and talc are flexible—gradually crush, like moist clay.

Mica is elastic—snaps back when bent.

10. Galena, rock salt, mica, feldspar, and calcite have perfect cleavage—break with smooth faces, straight edges, and regular angles.)

11. Asbestos is *fibrous* in structure.

Galena, rock salt, mica, etc., are more or less evidently made up of layers—*lamellar.*

Magnetite is often *granular.*

12. Galena (cubic), pyrite (cubic), rock salt (cubic), quartz (hexagonal), calcite (rhomb), should show the regular faces and angles of crystals. All these except quartz break into smaller cubes and rhombs.

13. Galena, pyrite, magnetite, hematite, and limonite will be *heavy.*

Sulphur, *light*.

Graphite and talc will feel *soapy*.

Asbestos feels *silky*, and others, including crystals, can be told by evident peculiarities of feeling.

14. Limonite and chalk will *adhere* to the tongue and smell of clay when wet.

15. Rock salt has *taste*, and is soluble in water.

16. Sulphur will *burn*.

The Lesson.—Take as many trays as you have pupils; place in each eighteen small boxes, and in each box one specimen of each of the eighteen minerals you have selected. This will enable you to see at a glance whether the full number of specimens is in the tray when given out or returned.

A. Give out the boxes, and encourage the children to discover ways of grouping (color, luster, weight, etc.). Pass among the class. Commend warmly any success, but do it so that others will not be tempted to copy. Smooth over failure and suggest as to fresh trial. Introduce the streak plate, copper, glass, and magnet, as mistakes or the advance of the pupil may require.

B. When by this individual work a majority of the class have made such tests and observations as they seem able to, turn it into a general exercise and review.

How many of your minerals look like metals?

How many are unmetallic?

How many leave a mark on streak plate?

How many do not?

Put those that will scratch glass in one box.

Of the rest, pick out those which scratch copper.

Now find those too hard to scratch with the thumb nail.

How many are left? Hold them up (3).

How many will the magnet pick up?

Put those through which you can read printed words together.

Now those which light comes through, but too dimly to read.

How many are opaque?

How many have a glassy look?
Can you find one that looks like rosin?
How many are pearly?
Can you find a greasy-looking specimen?
A silky one? Hold it up.
Are there any which have no shine?
How many broke easily when pounded?
Hold up those which crushed.
Hold up the one which sprang back when bent.
How many broke with smooth sides and straight edges?
Hold up a mineral composed of fibers.
Some made up of layers.
Are any made of granules stuck together?
How many are crystals?
Of these, how many are cubelike?
Hold up a six-sided crystal.
Hold up a rhomb.

Lay the rhomb on printed words; what do you see? Turn it slowly around and notice.

How many are heavy?
Which is the lightest one?
Hold up those which feel soapy.
Which feels silky?
Which two stick to your tongue?
Which tastes? How?
Which smell like clay?
How many will burn?

(Let names be incidental, and only given when asked for.)

C. Now remove the calcite (which will be injured) and chalk (which will soil the others), and empty several sets together in shallow trays. Place these in the windows or on the table, and let each child pick out a new set, using his magnet, tile, etc., to aid.

When it is done, bring to you for inspection. If correct, and all his tools are returned, take it and let him get another.

Should mistakes occur, let him correct them with the least possible help.

The brightest pupils can at last be permitted to show (not tell) the dull ones how to do the selecting.

Remarks.—Thus will end lessons full of new and helpful ideas. Especially have I found mineral work to result in considerate *decision*—a valuable trait for any one.

As to the pleasure from such work, try it and see!

Get eighteen cigar or candy boxes. Gum a label on the end and let volunteers who have proved their honesty sort the different kinds into them, and pile on some shelf for the next class.

If now some way can be presented for those willing to earn (by conduct, lessons, etc., but not money) a set to take home to "show" and "start a collection," another great point will be gained.

Time and Expense.—Fifteen lessons, of twenty minutes, will usually be enough. If all the specimens are bought, they will cost from 1 to 1½ cent each, or $6 to $9 for the 540 specimens; but the clear calcite and crystal of quartz will cost 5 to 8 cents each, and if the expense is too great, omit them or any others in my list, getting such as you can, and giving the lessons any way.

For next step in minerals, see XIV—Rocks.

STEP IX.—FURTHER ACQUAINTANCE AMONG ANIMALS.

Object.—Step V introduced us to the boy, and then to some typical animals found near home. This step is arranged to—

1. Extend the work done among *home* animals.
2. Introduce to forms more "wild" and still familiar.
3. To emphasize certain desirable traits for their bearing on human morals.
4. To extend the child's range of ideas and the exact use of words.

Time.—Late spring. About 50 lessons, of 15 minutes each, will be needed, averaging 5 points a day. This will require vigorous work and thorough preparation, but there will be added gain in both.

Material.—Gather wool and woolen cloths, and horse-hair cloth; the hoofs of a horse and sheep; skull of gnawing animal, to show the self-sharpening and continuously growing teeth; the skull of a woodpecker, if possible, with the long tongue bones; eggs of robin, woodpecker, dove, duck, and turtle; old nests of robin, woodpecker, swallow, dove, and mud wasp; skins of robin, woodpecker, hummer, owl, and shell of turtle; down of a duck and ctenoid scales of a large perchlike fish.

Sometimes things can not be obtained *fresh*, and to meet emergencies I have kept a stock of such hard-shelled animals as crayfish, crabs, beetles, etc., prepared with the following preserving fluid, which has not only preserved them from decay but also kept them *flexible*, so that the parts could be easily studied. Choose *fresh* specimens, and at once inject them with small syringe *full* of the fluid and lay on papers in shallow trays till the fluid is absorbed and the extra water has dried away. Then keep in boxes or drawers for use.

RECEIPT FOR GERMAN PRESERVING FLUID.—(From Popular Science News, Boston):

Water (rain water best) . . (by weight)	620	parts.
Borax	10	"
Sulphate of potassa	4	"
Salt	5	"
Nitrate of soda	3	"
Carbonate of potassa	9	"
Arsenious acid	2	"
Glycerin	300	"
Alcohol	50	"

The arsenious acid and carbonate of potassium are dissolved together by the aid of heat, and added to the solution of the other ingredients and filtered.

The Lessons and Preparation of the Teacher.—The animals chosen for this step are those best studied in late spring and early summer. If not found in the section where the lessons are taught, choose equivalent substitutes and omit those given.

The *order* in which they are to be taken up is immaterial. One will do as well as another to begin or end with, except as some will be easy to get early and others not appear till later. I have arranged them in the order found best for my own locality, placing the cat first, to refresh the memory of the class and get it in working order.

The following outline is for the aid of the *teacher*—not to be *read* or *told* nor even *seen* by the pupils.

Cat * (*No. 61* †).

1. Cats are land animals, and much dislike water.
2. A cat's *whiskers* are very sensitive to touch, and enable her to judge as to whether she can get through a hole, etc.
3. Her ears are large and her hearing *very* good.
4. Her eyes are large and keen. What shape is the

* Have one before the class.

† Numbers refer to chosen animals or " Points to Teach " of Step V.

pupil? Take a cat into a dark closet for a few moments and then bring her suddenly into the light, so that the class can see the pupil contract.

7. Note how a cat walks on her *toes.*

8. Her toes are 5 on front feet and 4 on hind feet.

Her *claws* are sharp and retractile.

10. She nourishes her kittens with milk.

12. Her tongue is *rough*, and is used to clean the meat from bones, dress her fur, and lap up liquid food.

13. Notice how *far back* her mouth is extended. This enables her to use her tearing teeth more freely.

14. Her blood is *warm.*

15. She sheds her hair every spring after the cold has passed, and gets a thinner coat for summer.

17. Her teeth are *white.* And eyes? How do they look in the dark?

19. If hurt or in danger, she defends herself and young with teeth, claws, and attitude.

20. Cats have quite a language. The *purr* of contented satisfaction and the asking *mew* are familiar. Among her own kind the debate may wax so warm as to cause *squalls* of displeasure and *spitting.*

21. Cats are *social* in their play, especially when young.

23. The kittens receive considerable training in the arts of cat life. See if the pupils have observed any cases of training.

24. The young are called *kittens*, and are born blind and very *dependent* on the mother's care. Why do young cats need parents?

25. The instinctive hiding of her kittens by a cat is very interesting, and common enough to be familiar to many children. If, when she supposes them safe, they are disturbed, she often carries them one by one to another place. This might be tested by some one of the class who has a cat with kittens at home.

26. The cat shows great *patience* in waiting for mice, etc., and when thus watching and preparing to spring is a

study for a painter. Her quick ears and keen eyes keep her well posted as to all that is going on, and I have selected her as an example of *watchfulness*. She is very *neat*. In connection with her habits of washing after meals can be told the fable of the sparrow rebuking the cat for not washing, and why they now always eat *first*.

27. Cats are *useful* as they destroy injurious rats, mice, etc.

28. They give *fur*, which is used for very handsome robes, etc.

The Crayfish (*No. 7*).*

Collect. Soon after the ice is out of the ditches and ponds, take an insect net (if one is not at hand, make a hoop of one end of a hickory branch, or anything that can be bent and fastened to a handle, and on it sew a shallow bag of fine meshed material), and, pushing it under leaves or grass in the water, work it about a few seconds and then lift it out and turn over into a wide pan (milk pan) of water. A surprising number of wonderful things will reward such search, which can be placed in a wide bowl at home and kept. Among them will be crayfish. Get enough of these so as to have a small one for every pair of pupils, and especially try to have one with *eggs*, which are laid very early in the spring and carried by the mother under her long abdomen. Provide deep dishes (bowls) of water to distribute them to the class in for the lesson, and then develop the following points:

4. Its eyes are on the ends of movable stalks.

7. It swims *backward*.

8. Has *ten* legs, and the tail is used to swim with.

10. Its food mainly consists of dead animals, etc., found in the water, although it will catch live food when able.

13. The jaws move from *side* to *side*.

14. It breathes the air in water by means of *gills* along

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* Read Chap. I in Huxley's Crayfish.

the sides of the body, which are protected by the overhanging edges of the shell.

15. The crayfish has a jointed, limy shell. (Test some bits in acid.)

16. This is its *skeleton*, and, being so hard and *outside*, it could not grow any bigger were it not that at times a soft new shell begins to grow under the old, which at last splits and is *cast off*, even to the covering of the eyes and joints of the big claws. (If a number of young crayfish are kept, this molting can frequently be observed.)

18. Note how the color of the crayfish harmonizes with its surroundings, and even *varies* according to where found.

19. When molested, it first attempts to escape and hide. Failing in this, it defends itself with its great pincers.

22. Crayfish *dig wells* to live in when the waters of pond or ditch dry away. These holes are dug deeper and deeper as the drought of summer comes on, and the clay is piled about the mouth of the hole, which on the prairies of the central United States must amount to quite a layer brought up each year.

Along streams they make holes in banks, and, their numbers being great, they become a by no means insignificant factor in the weakening of levees such as are along the Mississippi, and the filling of channels with mud.

23. The mother cares for the young for some time, they fleeing to the protection of her long abdomen when danger threatens.

24. The eggs are carried attached to the swimmerets of the mother till they hatch.

27. Crayfish aid plants by the fresh earth they bring to the surface, and help to keep the waters pure and sweet by removing all decaying matter.

The Robin (No. 46).

This is another early comer, and should be taken up at that time, although the subject can not be concluded till much later. The points to emphasize with this bird are—

4. Its *keen sight* for worms and caterpillars in the grass.

7. It *hops* on the ground.

8. Has *two* legs. The part of the leg from the toes to the joint is called the *tarsus.*

10. Its food is worms, caterpillars, and fruits.

11. Has a bill.

17. Note the color of the feathers and eggs; especially the upper side of the mother.

18. Notice how inconspicuous the mother robin is when in her nest.

20. Robins *sing*, and also have a call of alarm.

21. They are social in migration; gathering in flocks before going off in the fall, and appearing in companies in the spring.

22. They nest in *trees*, and use *mud* in the construction.

23. Both mother and father aid in constructing the nest.

24. The young are called birdlings.

25. An early comer, note how she instinctively builds a thick mud nest to better enable her to keep her eggs warm through the changes of weather. Are her eggs seen from above, or below? Is *blue* a good color under the circumstances and surroundings? Where are the robins in winter? Remember their food, and then try to think why they go away south in the fall.

26. Robins show great *patience* in setting on their eggs, and *tenderness* and *self-denial* in the care and labor for the helpless young. Have also chosen the robin as a type of *merry* good nature, the rollicking song seeming full of jollity.

27. Their *service* consists in destroying injurious insects and in pleasing with their cheerful song.

The Perch (No. 27).

This type of the fishes with toothed scales and spines in their fins should also be studied early in the season. Get some small ones for the class to examine at one of the lessons.

8. The perch has *spiny* rays to its *fins*. Note that the "tail" is a *fin*. How many fins? How arranged?

10. It eats other fish and water animals such as worms, crayfish, and frogs.

Lead the class to notice how the *white belly* of the perch (like the frog) causes it to resemble the openings among the water plants when looking up from *below*, and so is a protection from foes in the water.

12 and 13. Notice the *horny* tongue, and by inserting the finger where *teeth* are found and which way they point. What are such teeth for?

15. The scales of the perch have *comblike edges*.

19. The spiny fins aid the perch by preventing in some measure its being swallowed by other fish.

24. The mother lays a great many eggs at the bottom of the water and leaves them to whatever chance may happen.

28. Perch are useful as food.

The Turtle (No. 31).

Choose some common native kind. If possible, have some live specimens before the school for some time before the lessons. A shell, also some eggs preserved in alcohol, will aid.

1. The turtle lives partly in water and partly on land.

11. Its lips are a *horny beak* to seize its food with.

14. Its blood is *cold*.

15. Its covering, large scales.

16. Its skeleton is *inside*, bony, and jointed. This point is aimed mainly to correct the frequent idea that a turtle's shell is its *skeleton*; but the large scales overlie the broad flattened ribs, which are truly internal. The way the head, tail, and legs can be drawn in is proof enough of *joints*.

19. The defense of the turtle is his hard shell. Why does he not run away?

20. The eggs are laid in holes dug in the sand at night, and with extreme caution for fear of discovery.

24. The eggs are hatched by the heat of the sun, and the young are active as soon as hatched.

25. Turtles retreat at the approach of cold weather to the bottoms of ponds, etc., where, buried in mud, they *hibernate.* The young are said to *always* take a "bee line" for the nearest water (even when invisible) on hatching from their nest in the sand.

28. Both eggs and flesh are eaten.

The Mole (No. 50).

This animal is said by some to burrow in the soft earth under leaves, etc., all winter long. In any case he begins operations very early. Get good pictures, and then draw out what the class may have observed.

1. The mole lives *in* the ground.

2. The sense of touch in its *nose* is very delicate. Why?

4. The eyes are sunk in the fur and skin and are almost useless. Why?

7. It burrows *in* the ground.

8. Note the powerful front feet and legs to force its passage with.

10. Its food consists of worms, grubs, and insects; also seeds found in the earth.

22. It makes quite complicated galleries and chambers in the earth not only for food, but for its home: also the ridges so troublesome in lawns.

27. It serves by destroying grubs and injurious insects.

*The Worm (No. 4).**

1. The worm lives in the earth and feeds on the surface at night.

2. It selects its food by *feeling.*

4. Has no eyes.

7. *Crawls* along the surface or *burrows* in the earth.

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* See the first 128 pages of Darwin's Vegetable Mold.

8. Its under side is armed with backward pointed *bristles* by means of which it moves.

9. Its body is made up of *many* similar rings.

10. Its food is the decaying matter in the earth it swallows or which it may find in the ground.

14. Its blood is *white.*

22. It makes burrows in the earth and piles of "castings" on the surface. It would much interest even small children to collect the castings each day from a square yard or rod of ground and after a month or season estimate the amount brought to the surface by these interesting animals.

24. The eggs are laid in the earth.

27. They *serve*, by preparing soft holes for the roots of plants to follow and by bringing fresh earth to the surface.

The Mallard Duck (No. 34).

Find a good picture of this, and procure some down; also the heads and feet of some common ducks for the class to examine. A live duck in a coop will aid, if one can be had for a few days during the lessons.

4. The eyes are *simple.*

8. Has *4 toes.* Is the hind one on the same level as the rest? Three toes have *webs* between them. How many toes turn *forward*?

13. Its jaws move *up* and *down*, and its bill has *plates* along the edges which form a *strainer* to hold the little water animals on which it feeds.

15. Its covering is of *feathers*, which on the breast become very thick and fine, to protect the duck from the chill of the cold water it is on so much. The plumage varies with the season of the year, being thicker in winter. At the roots of the tail are the two *oil glands* from which the duck presses oil with her bill, and thus dresses her feathers to keep the water from wetting them.

16. Note the color of the *bill*, *feet*, and *eggs.* Which is the brightest colored, the duck or the drake?

18. Of what use is the duck's tame color to her?

Once, when a boy, I was chasing a horse in a closely cropped pasture. The grass was so short that it was no protection to anything which desired to hide, but as I was running along I almost stepped upon a duck on her nest. She at once flew a few feet away and then began to flutter and struggle on the ground as though unable to fly, evidently hoping to attract my attention from her nest. This was on a low ant-hill, and held 17 newly hatched ducklings. For several weeks that large bird must have set in that exposed place, people and animals frequently passing near, without being discovered. Was green a favorable color for the eggs while she was laying?

20. Ducks *quack.*

22. They nest on the ground.

24. They lay *hard-shelled* eggs, on which the mother *sets.* How long?

The young are called *ducklings.* Little ducks are able to run about, swim, and feed almost as soon as hatched.

25. This hiding by *exposure* I have frequently observed in ducks, they instinctively trusting to harmonious surroundings and a certain freedom from search which an improbable location gives. In this connection call attention to the care with which a laying duck must mark the surroundings of her nest to be able to find it again, especially in the dusk of evening or early morning. As illustrating this point, I remember blundering on a teal's nest in a swampy place where the thousands of grassy tussocks looked as much alike as haycocks. The duck was away, and her greenish eggs were beautifully covered with a coverlet of down she had drawn over from the sides. Only the merest accident could discover such a nest, and how the duck ever found it in the night I can not imagine.

Young ducks instinctively make for the water. This is especially remarkable when they have been hatched by a *hen,* who does everything she can to dissuade them from it.

Perhaps some of the pupils may be able to set some duck's eggs under a hen, and then let the class *see* this.

27. Ducks are supposed to carry snails, water animals, and seeds in the mud on their feet from one place to another, especially to islands.

28. They give *down*, and *feathers*, *eggs*, and *flesh*.

The Redheaded Woodpecker (No. 41).

Procure, if possible, a section of some small tree with a nest in it. Also some eggs, a skin, and a skull, showing the tongue and curious bones which move it. Illustrations are plenty and can be used in addition.

3. How does he know where to drill for a grub? Those who have slept in a log cabin in the pineries and heard the noise the borers in the logs make, will have but little question that he *hears* them at work. Instinct teaches where to listen—in dead wood—and then, aided doubtless by the bones of the bill and head (as a watch placed between the teeth sounds louder), the rasping of the borer is heard.

7. He *climbs* the trunks of trees.

8. Note the sharp *claws* to cling to the bark; the *toes* (2 in front and 2 behind) and the stiff *tail feathers* to brace back on while at work.

10. His food consists of boring grubs and some other insects; also fruits, such as apples and cherries.

12. His tongue is extensile and barbed. When thrust into the hole after the grub it serves to draw it out into the bill. The bones by which this is accomplished are fastened above at the base of the bill and are remarkable in their operation. At the same time note the strong, chisel-shaped *bill*.

18. Note the brilliant and *similar* coloring of both male and female. The use is doubtless to *attract* each other. How does the mother hide while setting? See how the woodpecker got his red head in Hiawatha's fight with "Pearl Feather."

20. Woodpeckers have a *cry* which they often use, and also seem to amuse themselves by "*drumming*" on some dry and resonant limb.

21. They seem *social* in their play and chattering.

22. They *make holes* in the dead wood of trees and in buildings.

23. Mates take turns in working at the hole for the nest, and the chips are carefully carried away and dropped at a distance, lest the nest be discovered.

27. They *serve* by destroying injurious insects and hastening the decay of dead wood.

The Sheep (No. 58).

Provide some wool from a sheep, and woolen cloth. Also some leather (ordinary "chamois" skin) and a horn.

5. Note the *hairy* nose.

6. *Taste* has much to do in guiding a sheep regarding proper food.

7. It walks on its *toes*, and has a divided hoof.

10. Eats *vegetable* food, and chews its *cud.* Is very fond of *salt.*

12. The lamb uses its tongue to *suckle.*

15. Its covering is called *wool.* Its horns are not round, but *angular.*

16. The skeleton is inside, bony, and jointed.

20. Sheep *bleat.*

21. They are social in feeding.

24. The young are called *lambs*, and resemble the parent in form.

26. In character the sheep is the type of *patience*, *meekness*, and *gentleness.* In a long acquaintance with them, I never heard one make a sound of complaint, even when worried by dogs, roughly handled in the washing, or hurt severely in the paring away of the hoofs affected with "foot rot," the treatment for "scab," or when cut by the shearers.

Although on rare occasions some old buck will make the attack, I have never seen anything like aggression and their resistance to wrong consists almost wholly in *attitude*—a facing of the danger till its approach causes flight.

"Gentle as a lamb" is as expressive as it is possible to make words.*

Another trait worthy of notice is the way they *follow* companions. What one does, the rest do—be it stand and look, run, jump over an obstacle, etc. It is said that if sheep are going through a gate and the first ones are made to jump over some bar, the rest will take the same jump, even though the bar be removed! On the contrary, once *without* a leader, they do not seem to know which way to turn, and are easily lost.

27. Sheep aid in scattering the seeds of many plants.

28. They give *wool*, *skins*, *leather*, mutton, and tallow. In eastern countries the skins are made into water bags or wine "bottles."

The Carrier Dove † (*No. 38*).

This bird is exceedingly interesting in many ways, and a valuable one to study not only for its own sake but more for the symbolism connected with it. Have some live ones in the class, and if some of the boys will arrange a trap to catch them at their roost, messages can be tied under the wing or around the bare part of the leg and carried home by the bird. Some eggs should also be obtained.

7. The dove *flies* very swiftly, often traveling more than a mile a minute.

8. The dove has *two wings* and a broad tail to guide it in flight and check its descent in alighting. Its tail is *rounded* on the end.

11. Doves drink with a *steady drawing* in, like a horse.

13. The food is swallowed *whole*.

17. Note the color of *legs*, *bill*, *eyes*, and *eggs*.

20. Doves *coo*. They also strike the wings in flight and make a *fluttering* noise.

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* See Psalm xxiii, Isaiah liii, and John x.

† The words "dove" and "pigeon" are not quite synonymous, but because "dove" is so commonly used in literature and so nearly correct, I would always use it with the children.

24. They lay only *two* eggs at a time, and those on *different* days. The young are called *squabs*, and are hatched in a very *helpless* condition and tenderly fed with moistened food from the crops of the parent. The different breeds of doves show in a marked way how parents can transmit *physical* characters to their young. "Pouters," "fantails," "tumblers" and "carriers" each have the distinguishing features which the squabs inherit.

25. The "homing" instinct in the dove is very interesting.

26. The dove is constantly referred to in literature as "gentle" and "tender." These traits quickly become apparent when these birds are observed in their habits. They mate *for life*, and are *constant* to each other. The mate feeds the mother while hatching, and even assists in that duty, while both unite in feeding the young with softened food from their own crops.*

27. Doves, by their habits of flying long distances for food, carrying it home in their crops and afterwards feeding their young, are great distributors of seeds, especially to islands.

The "carriers" also serve to carry messages. To do this they must have been recently carried from their home to the place whence the message is to go. This is written on thin paper and wrapped around the leg and tied, or placed in a quill or tube and tied under the wing. On reaching their cote the message should be soon removed, or the bird may destroy it with its bill.

A Plant Beetle (No. 14).

These beetles will be easily found by examining young potato plants. Gather enough potato beetles for the class, and pick off some leaves with the orange-colored eggs fastened on the under side. Let the class now notice or find out that—

* See Romanes's Animal Intelligence, p. 271.

8. They have *six* legs, and *shell-like* wing covers. The under pair of wings are *membranous*, and the end curiously folded *forward.*

10. They live on vegetable food.

17. Note the *colors* of the wing covers, wings, and eggs.

22. They *make* holes in leaves.

24. The young are hatched from *cylindrical* eggs, which the mother beetle knows enough to lay *on the food plant*, and which are called *grubs*. After these have eaten all they need, they burrow a little way into the earth and turn into a resting stage called a *pupa.*

25. They feign death when disturbed, falling to the ground and lying still for some time.

The Owl (No. 40).

If possible have a live one, or a skin. Add to this good pictures. Lead the class to notice—

3. Its hearing is keen, and greatly aids it in finding its prey.

4. Owls can *see in the dark*. What about the eye aids in this? The eyes are in the front of the head, and directed well forward.

7. The flight is *noiseless.*

8. The claws are *hooked* and *sharp.*

10. Its food consists of small animals and birds, such as mice, rats, etc., which it catches.

11. Its bill is hooked and strong.

15. Its covering is of *feathers*, which are very *soft*, and render its noiseless flight possible.

19. It defends itself with claws and beak.

20. Owls hoot.

21. Like all predatory animals, it is *solitary* in its habits.

22. Makes a nest in the hollow of a tree or bank.

24. The white eggs are *set on* by the mother, and the young are called *owlets.*

27. It is of great service to man by destroying injurious animals, and should never be killed in sport nor its eggs destroyed.

The Mosquito (No. 18).

Whenever the weather becomes warm and these pests appear, look on the tops of exposed rain-water tubs or still pools for the curious egg boats the mosquito lays, which look like flakes of soot floating on the water. If possible, by chance finds and by exposing pans of water (tell the pupils how to do it), have enough eggs so that each child can have a bunch in a clean bottle of rain water. Cork or cover the bottles to keep the mosquitoes from escaping, and, having labeled each one, set them about the room to await developments. Meanwhile go on with some other piece of work. Have two or three perfectly sweet bottles filled with the same rain water at the same time, but cover *without* any eggs in the water. After the eggs have hatched and gone through their changes, take up the study and dwell upon these points:

1. The young live in fresh (not salt) water.

5. Mosquitoes can *smell* well. My own experience in the matter is this: One hot night in summer a trapdoor on the top of a high roof was opened to let out the warm air in the house. This air to one in the draught of such an opening has a decided odor and, ere we were aware of it mosquitoes came pouring down into the chambers.

10. Mosquitoes live on the blood of animals. The young devour decaying matters in the water.

12. This is obtained by aid of a sharp *piercing beak*, which they thrust into the animal and draw out the blood.

14. The young breathe air while in the water by means of curious tubelike organs. The larva (first stage from the egg) has this on the *end* of the body, and when air is needed the " wiggler " comes up, and, placing the opening at the surface, takes in the needed supply.

In the pupa stage these breathing tubes are in the *back*, and the little animal jerks itself to where the tubes can reach the surface and breathes as before.

20. Mosquitoes *hum* or "sing."

22. The mother arranges her eggs so that they float on the

water, and the perfect insect makes a *boat* of its cast-off pupa skin, on which to rest while the wings expand and dry.

24. The eggs are laid in *masses* on the *water*, and the young are *unlike* the parent and go through a complete metamorphosis, in which *both* larva and pupa are *active*.

26. The *perseverance* of the mosquito has been overlooked. The way it disregards all rebuffs and ill-treatment, even to abusive language, is worthy of remark and of a better cause. Emphasize this trait of *untiring persistence*, for it is a noble quality in any one.

27. After the time that has elapsed since the eggs were put to hatch in the bottles, those *without* eggs will be found more or less *offensive* in smell, and the others with larvæ in them not so. The reason will be plain. Mosquitoes are of inestimable benefit in the larval state, especially in swampy districts, for *removing decaying substances* in the water and so preventing disease.

The Horse (No. 54).

We now take this common and useful type of the one toed animals. Some horsehair cloth, such as is used on furniture, some articles (buttons, rings, knife-handles, etc.) of bone, and a piece of leather, will do to cluster the interest around. Develop these points:

1. The horse is a *land* animal.

2. He can select his food in the dark by *feeling* with his lips.

3. His ears are *movable.*

4. He has *two* eyelids, which move *up* and *down.* The *pupil* of his eye is an *up-and-down oval* in shape.

5. The nose is *bare of hair*.

6. Taste aids in deciding whether food shall be eaten or rejected.

7. A horse can *trot*, *canter* (moderate), and *gallop* (rapid and violent motion).

8. Has *single* toes, covered with a strong *hoof.* His *tail* is long, and used to brush off annoying insects.

10. The colt *sucks milk.*

11. The lips are to *grasp* the food.

12. The fleshy tongue is to *move* the food about in the mouth and keep it between the grinding teeth.

14. Breathes *air* by *lungs.* The horse *perspires* when heated.

15. His hair is *thicker* in *winter* and he *sheds* it in the spring. When driven hard and obliged to stand he needs blanketing.

19. Uses his *heels* and *tail* in defense, although some *bite.*

20. His voice finds expression in the *neigh* of inquiry, the *whinny* for young or food, and the *snort* of fear.

24. The young is called a *colt.* Here again the *inheritance* of physical qualities is seen in breeds of horses, such as the swift "trotter," the powerful dray horse, or the tiny Shetland pony.

25. Horses have a very remarkable *sense* of *direction.*

Anecdotes of this can be found in books. The following I will add from my own experience:

Caught with a team of horses in a terrific storm of wind and rain one day, soon after sunset, I was unable to see my way home across a broad meadow in which were deep and dangerous ditches.

Unhitching my horses from the wagon, I attempted to drive them home, but after some minutes of hurried travel in a direction supposed to be away from the wagon, I was surprised to find myself *back* near it again. The horses had required constant efforts on my part to keep them "*straight*" (according to my idea). I now started off again and let them go without guidance, and they safely took me to the bridges across the ditches and home, although there was no beaten track to follow.

Another case was that of a horse purchased by my father. A river with no bridge or ferry lay between the horse's home and my father's farm; hence the road taken was around by a bridge. After months of service as a work horse, Charlie (as he was called) broke out of the pasture one night and disappeared. Search led to his recovery within a short distance of his former home, to which he went by a *direct* road—swimming the river—and which he would doubtless have reached had he not been caught lunching in a cornfield by the roadside.

26. The horse is a very *docile* animal.

27. Horses serve by *drawing* and *carrying* loads.

28. They give *bone* for various articles, *hair* for cloth. hides for *leather*, and in some countries (France) the *flesh* is eaten, while in others (Tartary) the *milk* is used for food.

The Mud Wasp (No. 24).

This shiny, black, solitary insect is quite common in most portions of the country, and can be found building her mud nests in outhouses, barns, etc. Procure at least one wasp and cells enough for all the class. Notice these points:

9. The body is in *3 parts.*

15. Has a *horny, jointed, outside* skeleton.

17. Its color is black.

19. It defends itself with its *sting.*

21. The mud wasp is *solitary* in its life and labors.

22 and 24. Having constructed its *cell* of *mud*, the mother wasp lays *one* egg at the back, and then proceeds to hunt for spiders to fill it, so that the young may have food. These spiders it is wise enough to sting so as to paralyze but not kill, and having thus stored the cell with food which will keep fresh, it plasters up the end and then proceeds to build another. In opening the mud cells the children will often find other things than young wasps and paralyzed spiders, for other insects find the store of spiders before the cell is closed and lay their eggs on them.

26. The wasp shows great *intelligence* in the construction of its nest and in providing food for its young.

The Barn Swallow (No. 43).

As the spring days grow warmer and summer approaches the swallows will return from their winter wandering in the south. As soon as they have come, begin to have the children search about their homes for signs of the mud nests under the eaves or in the barns, and when all have had a chance to see the birds at work, begin the lessons. Bank swallows or chimney swifts can replace the barn swallow, although the latter is my choice. The points to be developed are:

1. The swallow is almost constantly flying in the air.

7. It flies *swiftly* and easily.

8. Has *long* wings and a forked tail.

10. Its food consists entirely of insects caught as it flies.

13. Its mouth extends *far back* and opens very wide. Why?

19. The swallow's only means of defense is its *swiftness.*

20. Swallows "*twitter*," and in this talk and in work are—

21. Social. Which gets cold the quickest, a small thing or a large one? Did you ever try to button gloves, coat, or clothes when the fingers were cold? How does cold affect the motions of animals? (Stiffens.) Why can we safely handle hives of bees or even nests of hornets on a cool morning? I have seen my mother sweep the flies from a ceiling on a cool morning and then brush them up in a dustpan. Why did they not fly off? In the fall the swallows gather in flocks and go away toward the south. Who can tell me one reason for their doing so?*

The varying heights at which they can be seen seeking food are doubtless due to the air being warmer close to the ground at one time, and that warm currents are blowing higher up at another.

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* When we consider the extreme delicacy of the small insects the swallows feed upon, and how *quickly* such slender, gauzy things must stiffen with the cold, and be obliged to retreat to the shelter of the grass or trees where the swallow can not find them, the *wonder* is that these birds can find food as early and late in day and year as they do.

22. Barn swallows build nests of *mud*. Where? The mud is brought in its bill by both male and female and placed in position on the growing nest, each layer being allowed time to harden before the birds add another or trust their weight upon it. The different layers are stuck together with the gluey saliva of the birds. Sheltered under the protecting eaves of the building or ledge of rock, the rain can not wash them down.

25. Swallows exhibit instinct of a high grade. Their ability to traverse wide bodies of water to distant winter homes and find their way back in the spring is *wonderful*. Their selection of a sheltered place to build their frail nest, their skill and knowledge in the use of clay for building, the character of the nest itself, with air-tight sides the better to protect their sensitive young, and the adaptability they display in changed surroundings, are no less remarkable.

26. The swallow is *confiding* in her character, as shown by the way she trusts mankind; and *sympathetic*, as shown in the way a whole colony will aid one of their kind in distress.*

27. Swallows destroy hosts of injurious insects, and by their graceful flight and brisk twitterings are very companionable.

The Mosquito-hawk (*Libellula or Dragon-fly*) (*No. 10*).†

These powerful insects, living as they do on prey caught in the air, can exist only while food is found; hence should be studied during warm weather. For some reasons late spring is the most advantageous, as they are now hatching from the pupa state.

Gather a number of the larval forms from the water with a net, as suggested for crayfish, and keep them in an

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* Psalms lxxxiv, 3; Longfellow's "The Emperor's Bird's Nest"; Romanes's Animal Intelligence, pp. 295–318.

† See Riverside Natural History, vol. ii, pp. 147-149, and Tennyson's Two Voices, stanzas 3 to 5.

aquarium for the children to watch while feeding and making their last molt.

1. This insect lives in the *air* most of the time.

4. Has very large, *compound* eyes.

7. *Flies* by *day*.

8. Has *4* powerful wings.

10. Its food consists of live insects caught on the wing, of which it eats large numbers.

14. The young has its breathing apparatus in the *tail*, and breathes *air in water*.

15. Its covering is *horny* and *jointed*, which constitutes—

16. An *outside, jointed* skeleton.

17. Note the iridescent colors and the delicate cross lines between the divisions of the compound eye.

21. The mosquito hawk is *solitary* in its habits. Why?

The Cabbage Butterfly (No. 22).

By the last of May the cabbage and cauliflower leaves will be all too apt to show signs of having been *eaten*, and, if examined, the green caterpillars of this butterfly will be discovered, much resembling the ribs of the leaf in color and form. These bear confinement well. Have the pupils search for them, and each keep a couple in some fruit jar or large bottle or can which can be covered with netting. As the leaves become dry or are eaten up, fresh ones should be supplied, till the caterpillars are full grown and form their pupæ. Show the class how to make nets and catch some of the butterflies to examine. Lead them to notice these points:

7. The butterfly flies by *day*.

8. Its wings are covered with beautiful *scales*, so small as to seem like powder or dust. (Show some under a lens, or else by pictures.) Its antennæ are *clubbed* at the end.

The caterpillar has *16* legs.

10. Its food, when young, is the *leaves* of *plants*. (What plants?)

The butterfly feeds on the sweet *nectar* of flowers.

12. Its mouth parts, by which it draws in this nectar, are together called a "*tongue*," which is *coiled* when not in use.

15. The caterpillar has to change his covering of skin several times before fully grown. Why ?

17. Note the color of the *caterpillar* and the *wings* of the butterfly. Are the wings the same color below as above ? Which is most brilliant ? Which most "neutral" and subdued ?

18. Why is the cabbage caterpillar *green ?* Why long and cylindrical ? In what position does a butterfly hold its wings when at rest ? *Where* do they alight to rest at night or when not feeding ? Why are the under side of the wings marked with dark lines and dusted with black ? Does the folding of the wings when at rest seem to be of any use to the butterfly ?

20. Butterflies can only *flutter*.

22. Caterpillars make *holes in leaves*.

24. The eggs are laid *singly* on the *food* plant. The eggs hatch into *caterpillars*, which when full grown become *pupæ*—a *resting stage*, from which at last emerge the perfect butterfly, which is very unlike the caterpillar.

27. Butterflies are helpful to the flowers. As they go from one flower to another, they carry the pollen, and so aid in producing vigorous seed.

The Humming Bird—Ruby Throat (No. 42).

These dainty creatures will by this time in the year have been seen flashing about among the flowers.

A skin, nest, and eggs will greatly aid in the lessons. To these add pictures, colored if possible. Note the following points:

7. It *flies* very *swiftly*.

10. Feeds on small *insects* and the *nectar* of flowers.

11. It has a *long bill*.

15. Is covered with *feathers*.

17. Note the colors, and how changeable they are. Do they harmonize with its usual surroundings (flowers) ?

20. Humming birds are so called because of the *whirring* noise their wings make. They also "*twitter.*"

22. They nest on the limbs of trees.

25. The nest is cunningly placed so as to resemble a knot, and covered with lichens, or whatever may make it blend with its surroundings.

28. Beautiful jewelry and ornaments are made with their exquisite feathers.

The Fire Beetle (*No. 16*).

These insects may not appear in time for these lessons, being really summer insects. Have some pinned, also live specimens. The points to notice are:

7. They fly at night. A popular name is "lightning bug," and in poetry the most frequent designation is "firefly."

18. The "light" is to attract others of its kind.

24. The young are called *grubs*, and live among the roots of grass and in decaying leaves and wood, feeding on other larvæ, and on earthworms. One caught by me had (in the dark) spots of beautiful greenish light along the sides, which continued to show through all one winter.

28. Fire beetles give light. (See Barefoot Boy, by Whittier.)

The Squash Bug (*No. 13*).

This bug is large enough to show the parts easily, and can be found almost everywhere, both adult and young.

As soon as the squash vines have begun to run, get the children to take bottles or cans and search for the bugs near the roots of the vines, and for the young on the under side of leaves that have a brownish or withered look.

Place the young on an "island" in some big bowl so that they can not escape, and keep the bugs in screen-covered jars.

8. They have *4 wings*, the two upper *thin at the ends* and *crossed* on the back. The under wings are more gauzy.

10. They do great damage all their lives by sucking out the *juices* of the squash vines.

12. The mouth parts form a *piercing beak*, which the bug plunges into the leaf or stem to draw out the sap on which it lives. When not in use, this long beak is folded back on the breast, where it can easily be seen.

19. When handled or crushed these bugs emit a *disgusting* and *powerful odor*. Of what use is it to the bug?

25. When alarmed, these bugs fall to the ground and *feign dead* till they imagine the danger is past.

The Canary Bird (No. 45).

This type of the stout-billed, seed-eating singers can be studied at any time when the mother has eggs. Have a pair in a large breeding cage for the children to observe. Lead them to note the following points:

4. The canary has *3 eyelids*. Which way does each move?

8. It has *four toes*. Are they *on the same level*, and does the hind toe spring from the same portion of the tarsus as the front ones? Notice the "two undivided plates meeting in a sharp ridge behind" which form the back side of the tarsus (leg). How is the front side covered?

Which toe is the longest?*

Which toe has the longest claw? Is the tarsus feathered?

9. A canary has a "before and a behind" to its body.

10. It lives on *seeds*.

15. At regular times it *molts*—that is, new feathers begin to grow, like the "pin-feathers" of a hen, and when the new dress is grown enough the old feathers drop out one by one.

17. Note the colors of the feathers.

20. Canaries are *singing* birds.

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* A bird's toes are numbered 1, 2, 3, 4, beginning with the *hind* toe and ending with the *outer*.

24. The eggs laid by the mother are *oval* in shape, and she *sits on* them. The young, called *birdlings*, are very *weak*, *helpless*, and *dependent* on the care of the parents.

27. Canaries serve us by *singing*.

Review.—None is needed.

Material put away, as before suggested, being careful to sprinkle all feathers, skins, etc., with *plenty* of tobacco, which for twelve years has kept my collections entirely free from moths and other vermin. If the material for each step is kept together much time will be saved in future work.

Conclusions.—Twenty-three animals have been observed in a suggestive way.

In telling what they knew about these, the children have had most excellent practice in the art of description and expression, and the exact meanings of many new words have been brought to their notice. This comparison of ideas has stimulated them to closer and more intelligent observation.

From such work we can with confidence expect—

1. More free and exact expression.
2. More intelligent observation.
3. Clearer reasoning.
4. More kindly and considerate treatment of animals.
5. An increased and loving interest in Nature, of priceless value to young or old, and a *long* step toward the exclusion of *evil* by pre-occupation.

In Step XI we shall continue this helpful work.

STEP X.—PLANTS.

Leaves.

Object.—Step I brought seeds and fruits in their variety to the notice of the pupil, Step IV brought the variations of the bud before his eyes, and Step VI introduced him to the roots and stems. It is now desirable to have him observe the wonderful variety which the leaf displays, and thus gain—

1. Increased acquaintance with plants.
2. Exercise in touch, taste, and smell.
3. Practice in form and color.

Time.—Late spring or early summer is best, as the leaves are then perfect and have a reasonable degree of firmness and maturity. About fifteen lessons of fifteen or twenty minutes each will suffice, if the teacher is ready and the work steadily pushed to completion. Taken up in the closing days of school, it will serve to lighten the drudgery of the warm weather, and the collections will be very pretty to exhibit at the closing exercises. Moreover, interest awakened in the subject can be easily carried over to the recreations of the summer.

Material.—Can be dry or fresh. There are objections to both, as the dry are brittle and the fresh curl. The best way is to have *both*, using fresh leaves as far as they can be obtained, and having a dry stock of the rarer leaves to supplement with.

The following list of points or ideas regarding leaves is only given to put the teacher in possession of the key to the plan of work, but is in *no* case (except perhaps a normal class, and better not there) to be *taught*. It is only to show when the work desirable at this stage is complete.

In speaking of plants, I have used the common (English) names as given in Wood's Botanist and Florist.

Points to illustrate and Material to choose from.

Color.—Achyranthes, nasturtium, coleus, maple.

Shape.—Needles : of pine, fir, asparagus, cactus.

Linelike: Grass, sedge.

Lancelike: Snapdragon, lemon verbena, sweet William.

Egg-shaped: Lilac, apple.

Oval: Leaflets of rose, strawberry, and red clover.

One-sided: Basswood, begonia, elm.

Fleshy: Purslane, stonecrop.

Veins.—Parallel: Grass, carrion flower, lily, tradescantia.

Netted: Maple, apple, basswood.

Feather-veined: Lilac, apple, coleus.

Hand-veined: Maple, nasturtium, geranium.

Surface.—Smooth: Nasturtium, locust, lilac, lily.

Hairy: Strawberry, geranium, mullein.

Parts.—(Blade, petiole, and stipules): Rose, pansy, pea.

Tip.—Sharp: Grass, apple, lilac.

Rounded: Nasturtium, geranium, moneywort.

Notched: Achyranthes, tulip tree, leaflets of locust.

Base.—Rounded: Leaflets of rose and red clover, apple.

Heart-shaped: Morning-glory, geranium.

Arrow-shaped: Bindweed, smartweed.

Perforated: Honeysuckle, bellwort.

Shield-shaped: Nasturtium, water lily, mandrake, moneywort.

Margin.—Smooth: Lilac, lily, locust.

Sawlike: Rose, apple, strawberry, elm.

Lobed: Maple, rose geranium, oak.

Compound.—Featherlike: Rose, hickory, locust, honey locust.

Handlike: Strawberry, oxalis, woodbine, horse chestnut, lupine.

Petiole.—Long: Many leaves.

Short: Many leaves.

None: Grass, petunia, lily, many leaflets, tradescantia.
Flattened: Aspen and poplar.
Tendrils.—Green brier, pea.
Stipules.—Leaflike: Pansy, pea.
Tendrils: Green brier, carrion flower.
Thorns: Locust.
Smell.—Pine: Yarrow, coleus, geranium.

With the aid of the pupils gather enough for the whole class of the first one or two under each point. As each leaf will illustrate several points, this will require only 18 kinds. Take a strip of old sheeting or other thin cloth, and as the leaves are gathered, roll them in it, and, when finished, place the roll of cloth and leaves in a tin box or earthen jar, where they will keep fresh and smooth for several days. Save out one set for personal preparation.

Preparation of Teacher.—Read the chapter on leaves in any good botany and compare the material gathered with it. See that as many points as possible are covered, and sort your leaves according to each, keeping a memorandum of how many there are under each head.

The Lessons.

Before the lesson, sort the leaves into piles for the pupils, as suggested for buds and stems. Be sure the piles are exactly alike. They had better be rolled up again in the cloth till the time when they are needed.

What now do we wish to do? Briefly, to familiarize the children with some of the variations of the leaf, and train the observing powers by *seeing* and *handling* well-selected material.

As the material is perishable, work must be *pushed.*

1. Give each pupil a set of leaves.

2. Who can tell me something he notices? Yes, James, hold it up so that all can see your *red* leaf. Each find as many red leaves in your pile as you can. Who has seen something else? "This leaf has a stem." Good! Your eyes

are opening fast. Now each sort his leaves in two piles—one with and one without stems. Mary, how many have you with no stems? "5." That is right. John, how many *with* stems? "13." Kate, how many leaves have you altogether? "18." Right! Well, Peter, is this one leaf, or many? Hold it up, and all find the same. (Holds up a compound leaf.) Look carefully for a bud in the angle made by each little leaf and the stem it grows from. Do you find any? "No." Then it is *one* leaf, and the parts are called *leaflets*. What did we always find just below or around the bud when we studied stems? "A *scar*." What made the scar? "A falling leaf left it." What shall we always find just where a leaf joins the stem? "A bud." How can we tell a leaflet? "It has no bud." How many leaflets has this rose leaf? "5." "Mine has *seven*—5 large, and 2 little ones at the bottom." Sharp eyes again! But first let us sort out all the leaves having more than one part. How many, Kate? "3." Yes, rose, strawberry, and locust. They are called *compound* leaves. Jane's eyes found two *little* leaflets at the bottom of the rose. Do all see them? Things which grow out near the bottom of the leaf stalk are called *stipules*. Find how many leaves have stipules, Henry. "3." Has any one been able to find any more? (Sam)—"You told Kate there were only 3 compound leaves." Ah, I see the trouble—look *all* your leaves over. Ralph has another! Some one has *five*! Don't hold them up. Each try to find his own stipules. Has any one more than five? "No." Rachel may hold up her stipules. "But some of *those* stipules are not *little leaves*!" That is right, John; tell me what they are. "One has thorns, and another climbers." Do they grow out near the bottom of the leaf stalk, and differ from the blade of the leaf? "Yes." Then it matters not what they are *like*, they are always *stipules*. Let us learn these leaves. Who can name one? "This is a rose leaf." Tell us about it. "It has 5 leaflets and 2 stipules." "This is a strawberry leaf." Describe it. "The strawberry leaf has only 3 leaflets and 2 little stipules." "This pansy leaf has one part and two *large* leafy stipules." No one seems to know the others. The one with many leaflets is from the locust. How would you know it? "By its *thorns* for stipules." "Each leaflet even has little thorns." Yes, it is a very interesting leaf. This other leaf, with *tendrils* for stipules, is the green brier. What do you notice about it? "It is bigger." Yes; anything else? "Has only one leaflet." Well said! When a leaf has only "one leaflet" we call it a *simple* leaf. Anything else about the green-brier leaf? "These lines or ridges on the back stick up a good deal." Those are called the *veins* of the leaf. Hold it up to the light, and see how they look. "They all run side by side, from the stem to the end." Bright boy! Henry has indeed made a discovery. But we must close for this time. Here is a label for each of you. Lay your leaves in a smooth, neat pile, and at the signal all may march by me, and give me your leaves to roll up in this damp cloth, to keep them till to-morrow. How many think that they can find some of the things talked of to-day, and bring them to-morrow? (Almost every hand.) I am glad that you feel such interest in this work, for it will make you wiser and happier every day you live.

3. *Review* before beginning a new lesson. These are some of the ways in which it can be done:

Who can *draw* anything we talked of yesterday? (Class tell what the drawings represent.)

Who has found and can *show* me something we talked of? (Class again tell what it is.)

Who can *describe* something, and see if we can find out their thought?

Who can *tell* anything?

4. Continue the work in this way till all the points regarding a leaf have been brought out. The daily gathering by the pupils will add much to the interest and make the "home connection." Have them bring old magazines and *press* perfect leaves of medium size. Encourage them by the offer of paper to mount them on, or

the gift of a rare or curious leaf or two from your own store.*

Mounting is best done thus:

1. The leaves must be *thoroughly* dry. Have gum ready.

2. Lay down a card and select and arrange on it the leaves that you wish to group or that look tastefully.

3. By wetting a finger lift a leaf and put a drop of gum on the paper where the *middle* of the leaf was, and then drop the leaf on the gum. When all on the sheet have gum under them, lay another card over all and *rub* over each leaf. This will spread the gum, and it is seldom that any will show at the edges. Put a weight on that sheet, and paste another. Before they are dry, repile the sheets, as they may occasionally stick a little. Keep under pressure till thoroughly dry. Neat portfolios can be made, or the cards be made into book form with tape. Leaves might be pasted on both sides, and then the cards arranged to fold like the albums of views sold by newsdealers.

"**Blue Prints.**"—These have proved a great source of happiness in the limited trial I have given them, and I feel sure can be used in much school work. The paper—"ferro-prussiate"—can be purchased of dealers in photographic supplies at a cost of about 15 cents per 100, 2 × 2½-inch pieces made from the trimmings which are usually thrown away; or "homemade" at a *very* small cost by following the directions in almost any book on photography.† Let each child find a piece of thick clear glass about 4 inches square. Plate glass is best, but broken pieces of common window glass will do.

At an appropriate time give the school a lesson on—

How to make "Nature Prints."—Choose some thin leaf (pressed or fresh), a book, smooth board, or sunny window ledge, and a piece of clean glass. Take a piece of the sensi-

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* Send to some wholesale paper house and have some thin cardboard cut; the expense is very light.

† Arthur Hope's Amateur Photographer's Handbook is excellent.

tive paper from its protecting envelope, lay it quickly, colored side up, on the book or other smooth support, place the leaf in a graceful position upon it, and lay the glass over to hold it close to the paper while the printing is being done. All this is best done in the shade of some corner. Place it now in bright sunshine till the paper around the leaf is of a brownish-blue color. Then remove the paper and quickly dip it face down into a basin of clean water. After five to ten minutes soaking the whites will be washed clear, and with a final rinsing in clean water the prints can be hung up to dry.

Names (or other marks) of the leaf or child can be printed by writing with ink on a small slip of thin paper, to be laid (writing *up*) on one corner of the blue paper at the same time as the leaf. Now let the presentation of a good leaf and slip of glass, with a book to place the blue paper in till the moment of use, be all that is required for the pupil to receive a piece of paper and try a print himself.

When that is made and dry, let him bring it for inspection (and help if he has failed), and try again.

Printing frames like those used in photography are very convenient, and some of the boys might make them easily.

Review, if need be, with new and unseen material gathered by the pupils, but do not let the work *drag*. When the majority of the class have learned the lesson, let them reap the merited reward and be excused from going over the dry bones again.

Material put away.—There will not be much. Shallow boxes (handkerchief or glove boxes from the store are good) are best. Should time permit, the advanced pupils can be set to work pressing 30 or 40 nice leaves of each kind for you to use next time.

The next step in Plants is XII—Trees.

STEP XI.—ANIMALS.

FOREIGN OR LESS FAMILIAR, BUT TYPICAL AND USEFUL.

Object.—1. To study those types which are less familiar or more difficult.

2. Increase true geographical concepts.

3. To observe the *autumn* aspect of animal life.

4. To continue the work of the previous steps.

Time.—Begin at once on the opening of school in the fall.* It will be a grand review of the summer's experiences, and aid the pupils by its ease and interest to make a graceful transition from active out-of-door life to schoolroom work. Have the lessons at such time of the session as the children are most restless and the greatest freedom can be given. About fifty lessons of twenty minutes each will be required, which will be an average of six points a day.

Material.—For a class of thirty, procure, *as far as possible*—

Coral—15 fragments of some kind.

Sponge—30 small ones (at wholesale druggist's).

Starfish—15 dried specimens.

Clam shells—30 mated pairs (from some eating-house or fish store) and some "wampum."

Twigs of oak tree cut off by the "pruner" beetle (under trees).

Locusts—40 specimens in alcohol.

Silk—raw, cocoons, cloth, etc.

Galls—30 of some one kind, and samples of as many kinds as can be found.

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* Should there be danger that the fruits for the next step (trees) disappear, these lessons can be stopped at the chameleon and continued later.

Honeycomb, and several mounted drones and workers.
Chameleon—alive or in alcohol.
Ostrich plume.
Skins of gull and cowbird.
Nest of some bird with cowbird egg in it.
Beaver gnawings.
Bat skin.
Whalebone and oil.
Ivory (ornament or in any shape).
Camel's-hair brush, cloth, etc.
Seal skin (bits from the furrier).
Pictures illustrating the animals and their surroundings.

Preparation of the Teacher.—Gather material and go through the lessons beforehand. Should it be impossible to illustrate any point, omit it, rather than tell anything the child can reasonably expect to find out, although in the case of foreign animals more help will need to be given than with natives. As in previous steps, the order in which the animals are taken up is immaterial, and convenience must dictate. Lose no time waiting, and, if need be, defer such as can not be illustrated with reasonable effort till some other time. The order given has been arranged to take up *first* those most apt to disappear through frost, etc. In all work, adhere strictly to the particular animal in hand, and not confuse and mislead by bringing in things regarding other species.

The Lessons.—See suggestions regarding these preceding Step V, and firmly adhere to the rule not to tell anything it is possible to avoid. What follows is for the aid of the *teacher*, to be in no case (except illustrative anecdote) *read to* or *by* the pupil. To illustrate my meaning, I will give the way I should take up the

Meat Fly (*No. 19*).*

Having found some small dead animal or bird, or, failing, a bit of stale fresh meat, place it where these flies can "blow" it, call the children's attention to the big greenish flies, and later to the eggs laid on the meat.

When all have seen the eggs, place the date, to the *hour*, on the blackboard, and, if possible, add the time they hatch (often in three or four hours).

Leave this flesh and maggots where the class can watch them, and proceed with other work during the few days it will take for the maggots to pupate and hatch into flies.† Kill enough of the flies (in alcohol) so that each child can have one, and save the pupa skins. Then draw out these points:

4. Have flies eyes? How many? Examine them carefully, and tell me how they look. (Crossed by fine lines.) Each little space between these lines is considered *one eye*, and when many are thus gathered together it forms a *compound* eye. Look at this picture of a fly's eye magnified.

5. Can meat flies smell? What reason have you to think so? One day I noticed many of these flies on the screens of the kitchen windows, and, on entering, found the room full of the odor from a piece of tainted meat that was boiling. Would the sense of smell be helpful to these flies? "Yes, aid in finding a place to lay their eggs."

7. Can these flies walk up a wall? Try to see the feet of one on the other side of a pane of glass.

8. How many legs has a fly? "Six." How many wings? "Two." What kind of wings? "Gauzy."

9. How many parts to the body? "Three."

10. What do these flies live upon? "Decaying meat." We call this *carrion*.

20. Flies make what sounds? "Buzzing."

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* All numbers refer to the list of chosen animals or selected points in Step V.

† See Harris's Insects, p. 614.

24. Of what shape are the eggs? "Cylindrical." Where are they laid? "On food for young." What name do we give to young flies? "Maggots." Where did the brown, seedlike things we saw come from? "The maggots turned into them." Did they seem to be alive? "No." Were they really dead maggots? "No, for flies hatched from them." What are the stages in a fly's life? "The egg, the soft white maggot, the resting brown pupa, and the fly."

27. Who can think of an important service flies do for us? "Remove carrion." When we carelessly leave food uncovered, is it the fly's *fault* or a *merit* that she promptly lays eggs? Suppose no flies were about? "Would pollute the air for a long time." What happened in the case of our mouse? "Seemed to *dry up* and *disappear*, all but the skin and bones." What really happened? "Maggots *ate up* the decaying flesh."

Remarks.—Many will doubtless think that I have omitted too many interesting and instructive things. No one is more fully conscious of the fact than I, but it is deliberately done, and for a good reason. This much all can take and remember; and interest will be awakened, and in future years, when more observing has been done and maturity obtained, will come the time to complete the work.

The Tumble Beetle (No. 17).

September is a little late to find these remarkable insects at their work, but it varies with the season.

Search should be made for them in the dusk of evening, or by a lantern around the manure of cows in a pasture. Should the insects be found, lift the whole mass of manure and beetles with a large shovel and place gently on earth in a wide box previously prepared, and then cover with wire screen. This can be placed in the school yard for observation, although but little can be seen unless watched at night. After the beetles have buried their balls, drop a few (beetles) in alcohol. Removing one *side* from the box, carefully dig away the earth till one or two balls are found. Open these to find the grub inside, where the egg was placed by the mother.

If more balls are examined later the grub will be found to have become a pupa. Much of this work and study can be done by the pupils out of school hours, and be just as good "fun" as cheating at marbles or splitting each other's tops. Now take up the study and note—

8. The *antennæ* are composed of *plates* at the end, and are probably the complicated "noses." The *inside* wings are different from the shelly outer ones.

10. Its food is the *excrement* of animals.

22. It kneads the excrement into *balls* with its shovel-like head, inserts an egg in the center, and then two or more unite in rolling this ball to a *hole* they have dug for its reception and cover it with earth.

24. The egg, thus placed *in* a mass of *food*, soon hatches to a *grub*, which eats a home for itself in the ball.

25. Remarkable instinct is thus shown in *providing for the young.*

27. They serve by the removal of excrement. Now point out Egypt on the map and, showing a real scarabæus, or the picture of one,* tell the class how that old nation *worshiped* this beetle, seeing in the "ball" a model of the *earth*, in certain projections about the head the rays of the sacred *sun*, in the 30 joints of the feet the *days* of the month; and in the development of the perfect beetle from its mummylike pupa the looked-for *resurrection.*

The Aphides, or Ants' Cows (*No. 12*).

Tell the children how they look, or aid in the search till some are found, and they will follow the matter up and find plenty of colonies. The question, "Are they *really* cows to the ants?" will set many eyes to work, and soon the class will be in possession of the answers to the following points:

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* See Riverside Natural History, vol. ii, p. 374.

10. Their food is the *sap* of plants.

12. The mouth parts form a *piercing beak.*

20. They understand the *touch* of the ants.

24. There are *different kinds* of young, some winged and some not.

27. They feed the ants with a sweet liquid made out of the sap they suck in, and also cause deformed places on the leaves where they are fixed. Now find Mexico on a map, and pictures of the cochineal bug,* and show the class a relative of our aphis. Show a few grains of cochineal from the druggist's, and some *red candy* colored with it. Soak some powdered cochineal in water and see the color.

The Garden Spider (No. 8).

Call the attention of the class to these animals and their curious webs. After some observing has been done these points can be drawn out—

2. A spider knows when something is in her web by *feeling* the jerks of the struggling creature.

4. A spider has *8 simple* eyes on the *top* of its head.

8. Has *8 legs*, and *no* wings.

9. There are *two* parts to the body.

10. Its food consists of the *juices* of insects.

21. Spiders are *solitary* in their habits. Why?

22. They make *homes*, and *traps* to catch their prey, with a kind of silken material they can give out.

24. The eggs are protected by a covering of web and hatched by the heat of the sun. The young are *active* as soon as hatched.

25. The spider shows great *forethought* in its web and home and the care of its eggs. Only those who have examined a web can appreciate the skill with which a favorable location is selected, the web laid out, constructed, and repaired. The simple problem of keeping it *tightly stretched*, by means of guy ropes, to objects at irregular

* Riverside Natural History, vol. ii, p. 218.

distances, is in itself a serious problem, and yet the spider does it with apparent ease.

26. These and other accomplishments have well entitled the spider to be called ingenious and persevering. Read the story of Bruce and the Spider, and Isaiah lix, 5.

A suggestive illustration will be my experience in raising caterpillars in a large empty room one summer to study their growth. My greatest trials came from the spiders, which seemed to abound. Every little while some choice caterpillar would escape, and I was sure to find it wound up in webs and dead. Some of these victims were as large as one's little finger, and yet not only were they captured and killed by their tiny foes, but were *raised* at times to the under side of a chair board, some *30 inches from the floor!*

What a chance I missed, when my disgust at the loss caused me to brush the webs and all away before I had seen how such a feat was done!

The Bat (*No. 51*).

These hibernate early in the fall, and should be studied before that time. Search for them in hollow trees, caves, or the dark corners of roofs, etc. Call the children's attention to them as they fly about in the dusk after food. The following points are to be illustrated by it:

2. Its sense of feeling is very acute, and aids it in its flight to avoid obstacles. Bats have been blinded and let loose in crooked passages and spaces with obstacles hung in them, and not only did they avoid the obstacles and turn corners in safety, but they chose resting places and found holes to escape just as well as those not blinded.*

3. The *ears* are very large. Doubtless much of the bat's knowledge of its surroundings comes through its *hearing*.

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* W. S. Dallas, in Studies of Animated Nature, Humboldt Lib., No. 84, and Riverside Natural History, Bats.

The buzzing insect, the reflected sounds from obstacles in the way, the cries of its comrades, while so *inaudible* to us that we speak of "bats on noiseless wing," still may be very distinct to the more finely organized ears of a bat.

7. Their flight is *noiseless* to us, and at *night*.

8. They have *two* wings, with *hooks* at the joints to hang by.

10. Their food consists of night-flying *insects*, caught on the wing.

14. They breathe air by lungs.

15. Are clad in *fur*.

20. The voice is a kind of shrill "*clicking*," pitched so high as to be inaudible to some human ears.

21. They are social in *hibernation*.

24. The one or two young are *nursed* by the mother.

27. Bats are perfectly harmless, and of great service to man in destroying insects at night.

28. Bats make rich deposits of "peter dirt," from which much saltpeter is obtained in times of need for gunpowder, etc.

Bats habitually hide in vast multitudes in caves and under ledges of rock where rain never falls. Their droppings accumulate from year to year and form layers of earth strongly impregnated with saltpeter. This is leached out by water, crystallized, and used.*

The Locust (No. 11).

These will be found laying their eggs in cracks in the ground, so that all stages can be found, from the perfect insect with wings, through the active but wingless larvæ, to the unhatched egg. Set the pupils to watching them several days before the work is taken up, and if a number of adult insects can be confined in a box of earth they will lay their eggs, which can be observed in hatching next spring. Develop these points:

* See History of Mammoth Cave, etc.

7. Locusts *jump.*

8. Note the powerful *hind legs;* the two *straight* wing covers, which give them the name of "orthoptera," and the *gauzy* under wings, *folded like a fan.*

9. Lead the class to notice that the *two sides* of the body are *alike.*

10. From birth to death its food is *herbage.*

20. Its voice is a *chirrup.*

21. They are *social* in *migration.* The terrible results of these are well described in Exodus x, 4–19; Joel ii, 2–9; and Riverside Natural History, vol. ii, pp. 195–201. Locate *Palestine, Egypt, Nebraska.*

24. The eggs are laid *in the earth* and *deserted* by the mother. The larvæ and pupæ are both *active* and able to *feed themselves.*

28. They are caught by Arabs (locate Arabia), in bags. A hole is dug in the ground and thoroughly heated by a fire. The locusts are then emptied into the hot hole and covered with a bag and some sand and left to bake. After breaking off the wings they are said to be very good food, tasting like roasted nuts.

The Bee (No. 25).

While buckwheat and golden-rod are in bloom it is a good time to study this wonderful insect.

Visit some hive, and let the pupils see them at work, and, if possible, see the *inside.* If an open box of honey is set in the school window, and two or three captured bees permitted to fill themselves at it, the school will be much interested to see how these will "take a bee line" home and return with others. Refer the boys to some account of the way to find "bee trees," and they will enjoy the sport of tracking the bees to their homes. If possible, have a queen cell to show; otherwise get pictures. After some observing, develop these points:

8. Has *4 membranous* wings.

9. Body in *three* parts.

10. Food, the nectar and pollen of flowers. How many kinds of flowers does a bee visit each trip?

19. Has a *sting* for defense.

20. Bees *buzz* and *hum.*

21. Bees are *social* in *defense*, and will attack an intruder in swarms. Also social in work, each seeming to help the rest in the care of young, building cells, etc.

22. Bees make wax, and construct cells with it for their honey and young.

23. They are remarkable for the care shown to the young, and are for this reason ranked among the highest insects.

Another trait of their family life is the way they *make room for others.* When a hive is prosperous, young bees are hatching out rapidly, and food is plenty, the workers construct some of the large, vertical queen cells. An egg is placed in each and the larva fed with royal food. When fully grown the larvæ stop eating, and the workers then close up the cells while the pupæ are changing into queen bees. When one of these is nearly ready to come out, she sets up a "piping" noise, and if the weather is fair and all propitious, the old queen leaves the hive, followed by nearly all the grown bees then at home. After the swarm has gathered in the air they dash away to a new home.

From the directness with which this is sought, it seems probable that it is selected beforehand. A young queen now hatches, and with the remaining old bees and the hatching new ones continues the life of the old hive. The stores of an ownerless swarm constitute "wild honey."

24. The young bees, which require such constant care and feeding from the workers, are called *larvæ.* These are of *three kinds*—found in three different kinds of cells, and called queens, drones, and workers.

25. The *instinct* of bees is closely akin to reason. Before leaving food a bee *observes* the place so as to return to it.

They are *weatherwise*, and should rain threaten will not swarm. They show great *forethought* in their building of queen cells in anticipation of swarming, in their storing food for winter, selecting a place for the swarm to go to, etc.* How does the bee teach us the young and helpless should be treated? Do kindness and forbearance show *greatness* and *nobility* of character? Do *you* "rank high"?

26. From this remarkable history it is easy to see the force of "busy as a bee."

27. Bees render important service by carrying the pollen for the fertilization of flowers.

28. They give honey.

The Moth and Caterpillar (No. 20).

These can well be studied in connection with some of our native species, such as the Cecropia. It is remarkable that the silk moth is the only member of the vast number of scale-winged insects which is directly serviceable to man. All other butterflies and moths are classed as injurious.

Find some of the large, silk-making caterpillars,† and let the children observe them for a few days. Then note such of the following points as the opportunities of the class will permit:

The caterpillar has—

4. *Simple* eyes.
7. It *creeps*.
8. Has 16 legs.
9. Has 13 rings or parts to the body.
10. Eats *vegetable* food.
13. Its jaws move from *side to side*.
14. Breathes by *spiracles* along the sides.
22. They make silken cocoons.

The moths—

7. Fly at *night*.
8. Have *4 scaly* wings and *feathered* antennæ.
17. Note the colors of the upper and under sides.

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* See Romanes's Animal Intelligence, chap. iv.

† See Harris's Injurious Insects, pp. 380–397.

24. The caterpillar *changes* to a resting pupa inside the cocoon it has spun.

Now locate Japan or China, and by specimens and pictures give some idea of the important silk industry and the silk moth.

The Gray Squirrel (No. 49).

Have, if possible, a live one in a cage for the children to watch its motions, way of feeding, etc. The following points are to be brought out with it:

1. It lives in trees.

3. Its ears are *external.*

6. Has *four* legs.

9. Has "a *before* and a *behind.*"

10. Its food is of nuts, seeds, and fruits. How does it manage to get the meat out of a nut?

13. Has *gnawing* teeth, which *grow constantly.* Why?

20. Squirrels *bark.*

22. They make their nests in the hollows of trees, and *beds* of twigs and leaves in the tree tops for summer.

25. Instinct causes the squirrel to hide little stores of food in the leaves or mold of the forest till they are needed. A wonderful *memory* seems to guide it to this long-buried food, even though the drifting leaves may have changed the looks of the place, or snow cover all in its uniform mantle.

27. It is easy to see how this habit of hiding seeds and nuts in the ground causes the squirrel to be an active agent in helping plants get their *seeds scattered* and planted in new places.

The Clam—Hard-shelled (No. 5).

Select the hard-shelled "Venus" for this work because to the majority it will be most accessible and has siphons; but by a little change in the points chosen to teach, any of the fresh-water clams of our rivers and ponds will do. Have mated shells for each pair of pupils. Mates are exactly alike in size and coloration both without and within; hence if shells are gathered, they can be scrubbed clean with a stiff brush, and then, while wet, laying all the right-hand and left-hand halves in separate rows, begin to select by *color* and mate them, tying each pair together with soft twine and a "surgeon's" knot.

At least once during the lesson have some fresh clams opened to show the parts.*

8. See the *one* fleshy foot.

See the *two muscles* which run across from shell to shell to close them. See the "muscle impressions" on the cleaned shells.

10. Note the two pairs of *feelers* just above the foot. These gather the food as it sweeps by them in the currents of water the clam takes in. Can it be very choice in its selection of food?

14. Note the two *siphons* at the rear end, through which water can be had even when the clam is buried in the mud. Also the pair of delicate *gills* on each side, which take the air from the water as it circulates over them.

15. Its covering is a hard, *limy shell* in *two* parts.

16. The skeleton is *outside* the *soft*, boneless body.

17. Note the purple color along the edges of the inside of most shells. This purple portion formed the most valuable kind of "wampum," which the Indians used for ornament and money.

19. The clam has a hard shell for defense.

27. They serve by growing limy shells, which aid in making limestones and islands.

28. Clams give food. (Tell of a New England clambake.) Also the shells give wampum, and material for buttons, etc.,

The Oak Pruner (No. 15).

Search under the oak trees for fallen twigs whose ends look as though they have been cut off in a turning lathe. In the center of the cut will be seen a hole plugged full

* See Riverside Natural History, p. 276 of vol. i.

of shreds of wood. If the twig is now split lengthwise, a chamber will be opened, and lying in it a white grub or (if late in the season) a curious pupa. The life history of this beetle is so interesting that I have chosen it to illustrate these points:

8. The oak pruner beetle has two *shelly* wing-covers "meeting in a *straight line* down the back." The under wings are gauzy.

9. There are 13 *segments* to the body of the larva.

10. The young beetle (grub) lives on the wood of live twigs of the oak tree.

13. The jaws move from *side* to *side.*

22. The larvæ make galleries in wood, tearing away the pith and fibers with their strong jaws and eating them.

25. Although the mother beetle does not eat wood, instinct causes her to lay her eggs on young twigs of the oak; and although the grub has had no instruction or experience, it cunningly arranges to get down to the ground *by cutting off the branch*, all but the bark, which holds the twig till the grub has retreated into its chamber and closed the opening with chips! The wind or sleet of winter then brings it down.

*Gall Insect (No. 23).**

As the leaves fall, the curious galls on various plants become easy to see. Gather enough for the class of some one kind—the big "oak apples," the hard, bulletlike galls which cluster on the bur and white oak twigs, or some other kind. Give these galls to the class to open and observe. Notice—

22. Gall insects cause galls to grow while in the *larval* stage.

24. The mother lays the eggs in the food the young are to need.

28. Galls are used to make *ink.* Rub a wet knife on a

* Harris's Injurious Insects, pp. 543–548.

gall and it will be *blackened.* Crush up a lot of hard galls and steep in hot water. Pour off the liquid, and add some pieces of sulphate of iron.

Keep some galls in paper or wooden boxes till next year, and see what the gall insect is like.

Let the class see how many *kinds* of galls they can find.

The Cow Blackbird (No. 44).

A "last year's bird's nest" is proverbial for a valueless thing; nevertheless, if the pupils are given a hint that often some of the nests found in thick bushes are *two* or even *three storied*, and have a very curious history, they will set about the search with eager curiosity. Tell them to be very careful in their examinations, and bring the nest to you without damage or taking out any eggs they may find therein. If possible, see the birds about cattle, and observe that—

7. Cowbirds walk.

21. They are social in feeding.

24. Their eggs are laid singly in the nests of other birds and deserted by the mother. The young hatch sooner than the eggs it is with, and the stout birdling takes the food which should go to the rightful children. These frequently starve, or are pushed out of the nest by the greedy intruder.

The finches and sparrows whom it is apt to impose its eggs upon are frequently smart enough to build a nest over the egg and thus outwit the cowbird. I have seen one case where this had been done *twice*, and a three-storied nest resulted.

The Gull (No. 33).

This type of the long-winged birds can be seen over any large body of water, while the terns are common about inland ponds and lakes, to replace it if need be. Have a skin, if possible, to measure.

8. Gulls have long wings.

10. Their food is *fish.*

20. Their voice is a kind of "scream."

26. They show great *endurance* on the wing, seeming never to tire.

27. They serve by eating up all weak or disabled fish and other things in the sea, and thus aiding to keep it sweet and pure.

28. They aid in forming valuable deposits of guano, such as are found on the islands of the rainless districts west of South America and Africa.* Locate Chincha Islands, and tell the class something of them.

The American Chameleon (No. 30).†

While live specimens of these can hardly be obtained in the north, they have some points connected with them which necessitates their study in these lessons.

Have a live one in a large cage, if possible; otherwise get pictures and alcoholic specimens.

1. Locate on the map some southern country or place where the animal lives—say St. Augustine or New Orleans.

7. This lizard can *climb* with ease on trees and walls. Has *5* toes in front and *5* behind.

10. Its food consists of *insects*.

12. Its food is caught by a tongue which can be quickly darted out.

15. It is covered with *scales*.

17. This animal has a most remarkable power of *changing its color* to harmonize with its surroundings. It is white below, and above can assume shades varying from emerald green to a dark bronze. Why is it white below? What color will it become when on a leaf? When in a shady place?

18. How will this power be an *advantage* to the animal?

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* See Guano and Guano Islands in encyclopædia.

† See Riverside Natural History, p. 420, of vol. iii.

How will its long and slender toes and tail help to conceal it?

27. This lizard is very *useful* to us in destroying injurious insects.

The Beaver (No. 48).

Try, if possible, to get some specimens of his gnawing and a piece of natural fur; also pictures of it, and its houses and dams.

1. Find in Michigan, Wisconsin, or other Northern State, some town, lake, bay, or river which in its name bears trace of the beaver having been there.

4. Has *two* eyes.

7. *Swims forward.*

8. Has *webbed* toes and a very broad tail to swim with.

10. Its food is the bark and twigs of trees.

13. It has broad, chisel-shaped teeth in front to cut out pieces of wood and gnaw bark. As these must wear away fast through such constant use, they *grow constantly.*

15. Its covering is of fine *fur*, overlaid by coarse *hair*.

20. Beavers signal to each other by a *slap* of the broad tail.

21. They are social in work, and all aid in the construction of their dams, etc.*

22. They make ponds by building a dam across brooks and small rivers. In these ponds they construct piles of roots, sticks, and mud, and in these excavate chambers for a home to live in. If the banks are suitable, they burrow up into them, so as to have a place of escape in case their houses are injured. They also make slides down banks, to get themselves and their food to the water.

23. The family life is marked, and the home is built and inhabited by the parents and their offspring.

25. The intelligence of the beaver is very great, as shown in *sentinels* being placed on watch to give the alarm in case

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* Romanes's Animal Intelligence, p. 367, etc.

of danger; the *forethought* shown in building dams, storing food at the bottom where it can be got in winter, and other ways.

26. Its *industry* in working has become proverbial in "working like a beaver." They are *skillful* in the way they construct their houses and dams.

28. They give a valuable *fur*.

The Black Bear (*No. 59*).*

Little besides pictures can be hoped for in the way of illustrations. The following points must therefore be developed from such a source:

1. Locate North America as its home.
4. Which way are the nostrils directed ? (Forwards.)
7. The bear walks on the *whole* foot.
8. Its toes are five and five.
10. Its diet is a *mixed* one. Tell some stories of his exploits in varying his diet.
13. To adapt it for such a diet it has *all kinds* of teeth.
15. Under its heavy coat of hair it lays on a thick layer of *fat* in the fall.
19. Bears *growl* as one way of *defense*.
23. Bears have great attachment for their young, and will defend them at all hazard. So marked is this as to become proverbial in "cross as a bear," "like a she bear," etc.†
24. Little bears are called *cubs*.
25. Bears become very fat in the fall, and then as cold weather comes on, crawl into some cave or hollow tree, curl up in a ball, and, with the nose between the paws, go into a kind of sleep (which lasts till spring) called *hibernation*. During this time no food is eaten.
28. The bear gives a valuable *skin*, also its *flesh* for food.

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* Riverside Natural History, pp. 376–378 of vol. v.

† See Hosea xiii, 8: Proverbs xvii, 12; II Samuel xvii, 8; and accounts of bears in books.

*The Reindeer (No. 56).**

This interesting and useful animal can well follow the bear. Secure good pictures of it and its home.

1. Locate (on a map hung before the children) Lapland and Finland, and show pictures. The climate is *cold*, and the ground covered with snow much of the year.

7. It walks and trots on *all fours*.

8. Has *two* toes on each foot, which are placed on the snow or ground, but has an extra pair higher and behind the others, to keep it from sinking so easily in snow, mud, or moss. These toes, especially the front ones, are clad in large, broad-bottomed *hoofs*, which meet on their inner edges, forming a "*divided*" hoof.

10. Its food consists of herbage in the short summer, and twigs of trees and a kind of lichen, for which it digs in the snow with its broad feet in the winter.

13. It has stout, *grinding* teeth to cut up twigs, etc.

15. It is covered with a thick coat of hair.

19. Its *horns* are used for defense. These are *solid*, and *fall off* each winter, new ones *growing again* in the spring.

27. The reindeer is used to draw sleds, and sometimes to carry loads.

28. It is almost indispensable to the people who live in the north of Europe and Asia. Its milk is used for food and cheese. From its skins are made tents, clothing, rope, etc. The flesh is used for food; the fat for lights; the stomach and intestines for food, windows, and waterproof garments; the sinews for thread; and the bones and horns for needles, tools, etc.

The Ringed Seal (No. 62).

This animal is to the Eskimo what the reindeer is to the Lap. Get pictures of the ringed or the harp seal, as the most useful ones, and confine the study to the animal chosen.

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* Riverside Natural History, vol. v, pp. 305–308.

1. Find Greenland on the map, as its home is in the sea about there.

7. It *swims* in the water, and *dives*.

8. Has *flippers* to swim with.

10. The food is *fish*, caught by the seal in the water.

13. The teeth are for *tearing* and *cutting* flesh.

14. Its blood is *warm*.

15. Its covering is a close and thick coat of stiff hair. Under the skin is a layer of fat to keep it warm.

17. The color of the ringed seal is brownish above and yellowish white below. How will this harmonize with dirty ice, snow, and foaming water ?

22. This seal is said to form an "igloo" or domed cavity in the ice, where it can come up and in safety breathe.

25. The young seals are called puppies, and are born and kept in the igloo, where they are safe from harm. The mother suckles these pups.

28. What do these pretty creatures give to the Eskimo ? Fur skins for clothing, boats, and bedding; blood and flesh to eat; oil for fire and lights; stomach and intestines for clothing, windows, bags, and floats for harpoons; sinews for thread and cord ; and bone for tools !

*The Whalebone Whale (No. 52).**

This huge animal will form an interesting contrast to the seal, and continue our studies of northern life. Procure some genuine whale bone and oil; also good pictures of the animal and the arctic regions.

1. Point out on a map and show pictures of the cold, ice-clad waters of the north Atlantic, Pacific, and Arctic Oceans. They live in these waters.

8. The whale swims by aid of its huge *tail* and two *flippers*. Which way is the tail flattened ?

10. Strange as it may seem the food of this mighty beast

* Riverside Natural History, vol. v, pp. 195–208.

consists of *small animals* which live near the surface of the sea.*

13. These tiny creatures are secured by means of the whalebone *strainer* this whale has in its mouth. Opening the huge mouth, the whale swims along near the surface till a quantity of food is collected, and then, by closing the mouth and raising the head, the water is got rid of, the small animals being retained by the plates of whalebone, and the food swallowed.

14. This whale has to come to the surface at intervals of ten to twenty minutes to expire the impure air from its *lungs* and take in fresh air. The warm breath from the lungs coming in contact with the cool air forms a column of *steam.* This "spouting" is not a jet of *water*, as many suppose.

15. To protect this warm-blooded animal from the chill of the cold water, it is covered with a *thick* layer of *blubber* or fat.

19. Whales are seldom aggressive, but in trying to escape, or in the death agony, their tails are dangerous, crushing a stout boat like an eggshell.

20. Whales have no voice, but make a *blowing* noise in spouting.

24. The young is called a *calf*, and is *suckled* by the mother, whose affection for her offspring is great.

28. The whalebone whale is much hunted for its valuable "bone" (which is not *bone* at all), and for the oil obtained from the thick layer of fat (blubber) which protects it from the cold.

The St. Bernard Dog (No. 60).

Among the many kinds, I have chosen this noble type because of his association with so much self-forgetful devotion to the needs of others.† The pass of St. Bernard, near

* Some of these can be found (pictured) under the names of Clione borealis and Limacina borealis among the lower mollusks.

† See an account of the pass of St. Bernard in some encyclopædia.

Mt. Blanc, was for centuries the highway between western Europe and sunny Italy. Its highest point being over 8,000 feet above the sea, severe snow-storms are of frequent occurrence ; and with the stream of travelers coming and going, it is not at all strange that many of these, overtaken, chilled, and bewildered by the snow, should lose their lives. A desire to aid such people led to the founding of the Hospice of St. Bernard and the self-denying labors of the monks. Here the docile and intelligent dog found ample room to show his character, which has gained new luster by the test.

Having got pictures of the Alpine passes, etc., and given a little account of the pass, its monks and dogs, take up the following points:

1. Locate the pass of St. Bernard.

5. Speak of the dog's *keen* sense of smell. Why very useful ?

7. The dog can *run.*

8. Has *five* toes in front and *four* behind, and *blunt* nails.

12. Water and liquid food is *lapped* up.

13. The jaws move *up* and *down.*

14. Dogs do *not* perspire.

19. A dog defends himself by his threatening *voice* and his *teeth.*

20. Dogs *growl*, *bark*, *howl*, and *whine.*

24. Young dogs are called *puppies*, and are suckled by the mother.

26. Dogs are *fearless*, and those of St. Bernard have at times lost their own lives in braving the storm on their errands of mercy. They are *watchful*, hence their use as guards. Are also *intelligent*, *affectionate*, *obedient*, and *faithful.* Let these traits be illustrated by anecdote * and from the pupils' own experience.

27. How they *serve* will now be evident.

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* Some aid will be obtained from Romanes's Animal Intelligence, but he seems to have overlooked much in the dog.

The Elephant of Asia (*No. 53*).*

Procure some *ivory*, and good pictures both of the animal and its Indian home.

1. Locate some *place* in India of which a picture can be shown. Elephants live in *warm* climates.

3. Has very *large* ears, which are *movable.*

5. The nose of an elephant is *very long*, and is called a proboscis. Why does he need such a long nose?

7. He *walks* on all *fours.*

8. Has *four* legs.

13. Has huge *tusks* among his teeth. These are used to uproot bushes and small trees for food.

17. Ivory is yellowish white in color.

19. An elephant defends himself with *tusks* and *trunk.*

20. Has a kind of "trumpeting" voice.

26. The *intelligence* of the elephant is marked.† Select one or two anecdotes to illustrate this. Is also *obedient*, and will kneel and do various acts at the command of its driver.

27. Elephants are used to *carry* (people and baggage, timber, etc.), *lift*, and do various services for man.

28. They give the *ivory* of their huge tusks.

The Arabian Camel (*No. 55*).‡

1. Lives in *hot* climates. Locate some place which can be shown in a picture.

5. The nose can be *closed* against sand, etc.

8. The foot has *two* toes, under which is a broad cushion common to both, which keeps them from sinking in the sand.

10. Its food consists of *twigs* and the *scant herbage* of the desert. On these it can thrive, while an abundance of

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* Riverside Natural History, vol. v, pp. 215–225.

† Romanes, p. 396 *et seq.*

‡ Riverside Natural History, vol. v, p. 279 *et seq.*

the food suited to a cow is apt to make it sick. It drinks *water*, and its stomach is so constructed as to hold a supply, so that a camel can go for three days over the hot, dry desert, without drinking. Its *hump* grows large when it has plenty of food, and smaller when it fasts, being a kind of storehouse.

15. The covering is of *hair*.

20. Its voice is a *roar*.

26. The *endurance* of hunger and thirst by the camel is remarkable, and is due to its curious adaptation to the life it leads.

27. Camels are used to carry persons and loads; hence the name "the ship of the desert."

28. They give hair for brushes, shawls, and many other things.

The Ostrich of Africa (*No. 32*).*

Get an ostrich plume, an eggshell, and some pictures of it and its native country. Develop the following points:

1. Locate the Sahara Desert as one of the places these birds inhabit.

7. It *runs* swiftly. Note how necessary this is to enable it to go for food.

8. Has *two* legs, and *two* toes on each foot. Its wings are too short for flying.

10. The food consists of herbage and seeds, but it has a strange habit of picking up anything *bright* it may see.

15. Has beautiful silky *plumes* among its feathers.

19. Defends itself by *kicking*.

20. Makes a *roaring* noise.

22. Make holes in the sand for its eggs.

24. The eggs have a *hard* shell, and are left in the hot sand by day, but the birds sit on them at night.

25. Instinct teaches the ostrich to hide her eggs in the hot sand, and she must have a good knowledge of locality

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* Riverside Natural History, vol. iv, p. 33 *et seq.*

to find them again; also to place *sentinels* on watch, and to *run away* on the approach of danger.

28. Ostriches give valuable *plumes*, and their eggs are used for food.

*The Kangaroo (No. 47).**

This curious animal, unique in many ways, will also introduce the pupils to that land where everything is so unlike the rest of the earth. Only *pictures* can be had to illustrate.

1. Show Australia on the map.

7. The kangaroo *hops.*

8. Note the *stout* hind legs and the *long* nails; also its powerful tail to jump with.

10. Its food is herbage, and in the dry season it digs up the roots of grass, etc., with its curious lower teeth.

19. In defense the kangaroo mainly relies on its long and rapid jumps, but it will fight with the claws of its hind feet and its powerful tail.

23. The care of its young is most remarkable. Very small when born, the mother carries and suckles them in a *pouch* till able to care for themselves.

25. The kangaroo, in common with most animals, instinctively *flees* when danger threatens.

The Vulture (No. 39).†

Any one of these birds will do, but having with the camel introduced a picture of the sandy plains of Arabia, and with the ostrich a scene in the deserts of Africa, I should advise the South American species. Having chosen one kind, say the condor, adhere *strictly* to that alone, and do not mislead and confuse by reference to *several* kinds. Pictures must be depended on.

1. Locate the great plains of South America—if possible,

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* Riverside Natural History, vol. iv, pp. 260–277.

† Ibid., vol. v, pp. 24–36.

on a relief map, or at least one colored to show them. Tell or read of the numerous animals which inhabit these vast areas, and of the frequent deaths which must occur from natural causes or the violence of other animals. What is to become of all this decaying flesh ?

4. Vultures have *two very keen* and far-seeing eyes.

7. Vultures fly by *day*, in circles high in the air; so that the country may be considered as under a network of concentric circles (draw on the board), on each of which a vulture is circling, but so high in the air as to look like a black speck in the sky.

10. Their food is the flesh of dead animals and is called *carrion.*

20. They understand each other's *motions.* When one sees a dead animal it begins to descend; the vultures within sight see him and follow; others farther off see these, and so in a short time hundreds will congregate, although not a half dozen were in sight.

22. They make nests on the crags of rocks.

26. Vultures are *watchful*, and *influenced* by *companions.*

27. They serve by removing carrion, and so preventing disease.

*The White Stork (No. 35).**

This bird has such extensive migrations as to be seen in many lands, but I should locate it in Holland. Get pictures of it and of Holland.

1. Locate *Holland* on a map before the class.

8. Has *two* wings.

21. They are social in *migration*, gathering before they fly away.

22. Construct huge, coarse nests on the *tops* of *houses* and buildings.

23. Storks choose mates *for life.*

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* See encyclopædias and books of travel in Holland.

25. Storks *gather* in the fall, and then *fly away* to warmer climes. They are very regular in these migrations, and *return* to the same nest year after year.

26. This affection of mates for each other has made them a type of *constancy*, and they show a *confiding* and trustful character in the way they choose to associate with men. Are also *helpful* in destroying insects, and by removing the offal from the streets and country where they live.

*The Termite (No. 9).**

This remarkable member of the mosquito-hawk family will introduce us to the region of Central Africa. It seems to be a very important insect in two ways: first, ranking with the stork, vulture, fly, and tumble beetle as a remover of decaying substances; and second, with the worm and crayfish as a gardener, preparing the soil for plants. Procure pictures.

1. Locate Africa on the map of the world, and then point out the central plateau region, where this insect is most abundant.

10. Its food is dead wood.

19. The "soldier" termites have powerful jaws with which to fight, and defend the rest of the colony.

21. They are *social* in work and defense, aiding each other in building, etc., and in repelling an attack on their huge dwellings.

22. The termites are great architects. They excavate with much skill tunnels in the wood they are devouring and make very extensive chambers and passage ways in the earth. What is dug away to form these underground dwellings is used above ground to form the huge conical hills so common in pictures, and, more remarkable still, to build *covered* roads up the trunks of trees so as to reach the dead branches above. Drummond speaks of these as being numerous

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* Riverside Natural History, vol. ii, pp. 142–147, and Drummond's Africa.

enough on the trees to give a decidedly reddish *tinge* to *the landscape.**

23. The occupations in a termite colony are divided between the huge "queen" who lays the eggs, the big-headed "soldiers" who fight, and the "workers," who perform the real labor of the family. Added to these are the males, who are gentlemen of leisure.

24. There are consequently *different kinds* of young.

26. Termite workers are very *industrious* and *skillful.*

27. They *serve* by clearing tropical forests of all dead vegetable material, wood, leaves, etc., and, by constantly bringing the deep soil to the surface, cultivate and change the soil for the plants, where no frost or worms ever act.

The Capuchin Monkey (*No. 63*).†

I have selected this representative of the monkeys because of its prehensile tail and its habitat in the forests of South America. Secure pictures of some of these monkeys and of the forests in which they live.

1. Show a map of the world and locate Brazil and the Amazon Valley. Here the capuchin lives in the tree tops.

2. Feeling is very delicate in the monkey's *finger tips.*

7. The capuchin *climbs* about in the trees, and is said to be able to jump long distances to another tree and catch itself by hands and tail.

8. The capuchin has *arms* ending in *hands* to climb with, and is also aided by its long *tail*, by which it can hang or by which it can grasp things as with a fifth hand.

20. It can make itself understood by *motions* and by loud cries and chattering.

21. These monkeys are *social* in all their habits, wandering through the trees in troops.

22. They break off branches of the trees and form nest-like beds in the tree tops.

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* Tropical Africa, p. 46.

† See Riverside Natural History, vol. v, pp. 505–507.

26. They are *sympathetic*, and will help each other when in distress, and show many almost human traits of character.*

The Cormorant (*No. 36*).†

This example of the birds with *three* webs to their feet will introduce the children to a scene in Chinese life.

Get pictures showing people fishing with birds, if possible.

1. Locate China, and then some river or lake where this method of fishing might be used.

7. The cormorant *swims* very rapidly under water as well as on the surface.

8. Has *three* complete *webs* to its toes.

10. Its food consists of live *fish*, caught by swimming after them.

15. It is covered with *feathers*.

26. The *docility* of the cormorant is shown in the way it learns to obey its owners and fish for them.

27. Cormorants *serve* as fishers for their masters.

The Starfish (*No. 3*).‡

The important point here is the radiate structure. Have dried specimens enough for the class. Note—

1. It lives in *salt water*.

7. Moves by its *tube feet*.

9. Has an *above* and *below*, the parts being arranged *in a circle* about a center.

10. The food consists of sea animals, like oysters. In feeding, it turns its stomach *inside out!*

27. It aids in gathering lime for stone, but it does much damage to oyster beds.

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* See Romanes's Animal Intelligence, p. 484, etc., for an account of this monkey.

† See Riverside Natural History, vol. iv, p. 191, etc.

‡ Riverside Natural History, vol. i, pp. 135–138 and 147–160.

*White Coral (No. 2).**

Let this interesting radiate introduce the class to the island life of the Pacific. Have fragments enough so that each can observe. Have pictures of atolls, and some limestone with fossil coral in it.

1. Locate some coral island in the Pacific—say Tahiti, of the Society Islands—of interest in connection with Cook's voyages and with missionary labors.

2. Coral animals secure their food by touch. Show a picture of the animal with tentacles extended, and give some idea of how these would wave about in the water, ready to touch any little animal or plant which might come along.

7. Coral animals can not move from place to place, but only expand and move the tentacles about in the water. When alarmed they contract to a rounded lump of flesh.

8. These tentacles have many little "lasso cells," † which *sting* and paralyze the prey so that the tentacles can secure and pass it to the mouth.

9. The coral animal has its parts *arranged* in a *circle*, and so has an "*above* and *below*" rather than a "before and behind."

10. Its food consists of whatever comes along, not too large to get in the mouth at the center of its tentacles. From this food it extracts the lime to grow its skeleton.

14. The coral animal takes air from the water by its *skin*.

15. It has no covering but the *naked skin*.

16. Its skeleton is limy, and at the *bottom* (basal). These run together in most corals, and form masses or branches. Lead the class to notice the little radiating plates of coral inside each tiny pit on a branch. The stomach hangs down in the center of these and the mouth opens *up*.

17. Show colored plates, if possible, of coral animals, and

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* See Riverside Natural History, vol. i, pp. 117–120.

† See vol. i, pps. 74 and 75 in Riverside Natural History.

speak of the wondrous beauty and brilliancy of these "sea *flowers*."

21. The coral can hardly be said to be *social*, except in the sense that a group grow and feed together.

22. Corals really *make* nothing. Do not so speak of them.

24. The young are often produced by the parent *dividing* in two, or a little one starting like a *bud* from one side and soon reaching its full growth.

27. Coral animals form (by *growing*, not by "making") masses of hard coral. The waves break and grind these into fragments, sand, and mud, which may form *islands*, dangerous *reefs* on which ships may be wrecked, or masses of hard *limestone*. Lime can be made by burning this stone. (Try some limestone and coral in two test tubes of hydrochloric acid, to show their similar behavior; also burn two pieces of the same substances in the fire, and then wet them, to show that they both form lime.)

*The Sponge (No. 1).**

Procure small sponges at the wholesale druggist's, enough for the class; also pictures of the fishery.

1. Locate some *place* where they grow—the Adriatic, or Florida coast.

Sponges live in *salt* water.

10. They take in the water, with its contained food, through the *side* openings, and then as it flows through all the channels the food and air are taken and the waste water escapes through the large holes at the *top*.

16. The skeleton is made of *horny* and *elastic fibers* running through the liverlike flesh.

24. The eggs pass into the currents of water and out at the top, developing to young in the open water.

28. The skeleton of horny fibers is the sponge we wash with.

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* Riverside Natural History, vol. i, pp. 49-65, and Hyatt's Guide on sponges.

Review.—None is desirable.

Conclusions.—This ends the animal work of three years. In observing these 64 types the pupils will have learned much of real value, and their eyes will have been opened to see things clearly and intelligently.

In adhering *strictly* to the animal in hand, and not trying to teach about all kinds of butterflies with the cabbage butterfly, nor about all seals with the ringed seal, much has been omitted, but I am sure it is best.

Material put away.—See previous steps for suggestions.

The next step in Animals is The Boy—XIX.

STEP XII.—PLANTS.

Trees.

Object.—Further acquaintance with plants.

Their period of life—annual, biennial, or perennial.

To know common trees.

Exercise of the eye.

Time.—So many trees are known "by their fruits" that autumn seems the very best time of the year. Recess, noon, after school, or Saturdays will alone give the chance for the rambles in the woods so desirable, and one great advantage will be that no one need come who does not wish to, and the teacher will be rid of some whose "room may be more enjoyable than their company." Still, by a little lunch, or some treat at the close of the lesson, most can be won over to willing and orderly attendance.

Should the work of the previous step (Animals) threaten to forbid this work by the frosts destroying the fruits, stop work on that when the native animals have been studied and take up this, as the foreign animals can just as well come later.

Material.—I am happy to be relieved from telling of any. "The groves were God's first temples," and it is only there that trees can be learned. Go wherever trees are found.

Preparation of the teacher will consist in learning to know and love the trees. Read Thanatopsis, Among the Trees, Evangeline, Hiawatha, Thomson's Seasons, etc.

Newhall's Trees of Northeast America will be found very helpful; also any good botany. With these in hand, go among the trees yourself and notice their characteristics till you know most of them at sight, as well as the peculiarities of bark, leaf, bud, and fruit.

The Lessons.—1. A few terms need illustration and explanation.

By specimens to show the class, and by blackboard work, see that all know what is meant by—

Trunk—the single stem of a tree.

Spray—the tips and smaller branches.

Head—the whole top; used in speaking of the *shape.*

Bark—covering.

Buds—no *definition* would be understood now.

Leaves—likewise.

Spines—sharp projections.

Fruit—that which contains the seed.

2. **Take a Walk.**—Let the class tell the names of any trees they may know. *Require a reason.* If they do not know the name, draw out the peculiarities and then tell it. Encourage the gathering of fruits, leaves, bark, buds, or anything by which the tree could be identified, and save for a collection or review.

In Illustration.—Time, a day in September. Children, instead of a game of ball to-day let us at recess see what trees there are about the school yard. What tree is this? "An elm." Yes. How do you know an elm? "I heard a man say it was an elm." We will improve on that. Look at the bark; how is it? "Gray." "Furrowed." How about the branches? "Big ones." "Lots of little twigs." "The ends spread out and hang over." First rate for beginners! Now look at the *leaves.* "Saw-edged." "Pointed." "One-sided." "Rough," etc.

What tree is this next one—an elm? (Maple.) "Oh, no, its leaves are different." How? "Broader, and with lobes." Any other difference? "The bark is not so much furrowed." "The branches are stiffer." "The top is rounder and not so spreading." It is the sugar maple. Do any of you remember the fruit? "Here is some." "It spins round and round when it falls." Yes, we call the thin leaflike projection a *wing*.

I am going to gather some of these curious winged fruits and a leaf for *my* collection. Who wants to do the same?

Our time is up! How many trees have we learned? (Two.) To-morrow we will learn some more.

3. In some such way as the above—a way which will be peculiar to each teacher—continue the work till 40 to 50 of the trees are well known and can be described from memory by the children.

Review.—Have pupils bring leaves, fruits, buds, bark, or anything *characteristic*, and let the school tell what it came from.

Another method can be made a *game*. Take turns in *describing* trees, and the rest guess what is thought of.

A third way is to take turns in telling the *one* or very fewest things by which a tree can be distinguished.

With a *warning* that the following is in no wise to be used without verification (as there are exceptions) and *never taught*, I will give some of the points I have found useful to me, arranging the trees in nearly their botanical rank, beginning with the *highest*.

I shall give the most distinctive point *first*, and suppose the place and time to be latitude 42° in eastern United States, and in September.

1. Tulip tree: Square-ended leaves and smooth, columnar trunk.

2. Linden: Winged fruit stalk; one-sided leaves; tough inner bark.

3. Sumac: Blunt branches and sunken buds; compound leaves, bright-colored in fall.

4. Red maple: Clustered and reddish buds; flowers and young fruit before the lobed leaves come.

5. Sugar maple: Late hanging fruit; round head; lobed leaves.

6. Ash-leaved maple: Trifoliate leaves and maplelike fruit.

7. Horse-chestnut: Fruit and leaves; gummy buds in pairs.

8. Common locust: Compound leaves with thorny stipules; fruit.

9. Honey locust: Branched thorns; compound leaves; huge, curled pods.

10. Crab apple: Beautiful blossoms; green, sour fruit; low-headed tree.

11. Mountain ash: Red or orange clusters of fruit; compound leaves.

12. Pear: Fruit; pyramid form and glossy leaves.

13. Apple (cultivated): Fruit; low head and leaves.

14. Plum: Fruit; stone *flattened*; crooked branches.

15. Cherry: Fruit; stone *round*; bark.

16. Peach: Fruit; stone *furrowed*; leaves.

17. Sweet gum: Clustered fruits; maplelike leaves, bright in fall.

18. Persimmon: Fruit and leaves.

19. Catalpa. Pencil-like fruit; broad leaves (opposite or in threes).

20. Ash: Winged fruits; compound leaves opposite.

21. Sassafras: Peculiar lobed leaves; spicy bark.

22. White elm: Spreading top; smooth buds; one-sided, serrate leaves.

23. Red elm: Red, hairy buds; larger leaves and fruit; "slippery" inner bark.

24. Osage orange: Fruit; thorns; glossy leaves; milky juice and orange-colored roots.

25. Buttonwood: base of huge leaf stalks covering the buds; balls; bark.

26. Black walnut: Round fruit; compound leaves.

27. Butternut: Oblong, sticky fruit; compound, sticky leaves.

28. Shagbark hickory: Fruit, and five leaflets; scaly bark.

29. Pignut hickory: Thin-shelled, bitter fruit; seven leaflets.

30. Red oak: Saucerlike cup and large acorn; smooth stripes on bark.

31. Black oak: Toplike cup and small acorn; black bark in knobs.

32. White oak: Long acorn in handsome cup; bark scaly; leaves with *rounded* lobes.

33. Burr oak: Fringed cup; sweet acorn; furrowed bark; end lobe of leaf largest.

34. Swamp white oak: Acorns in pairs on a long stem; scaly bark curls.

35. Chestnut: Fruit; leaf.

36. Beech: Fruit; leaf.

37. Hop hornbeam: Hoplike fruit cluster; elmlike leaves.

38. Iron wood: Lobed scales to fruit cluster.

39. White birch: Bark; catkinlike clusters of small winged fruits.

40. Sweet birch: Cherrylike, spicy bark.

41. Golden willow: Yellow bark; one scale over bud; narrow leaves.

42. White willow: Gray bark; one bud scale; narrow leaves.

43. Silver-leaf poplar: Leaves green above and silvery below; several bud scales.

44. Aspen: Whitish bark; thin, rounded leaves on flattened stems.

45. Cotton wood: Broad leaf, angled twigs.

46. Lombardy poplar: Spiry form; small diamond-shaped leaf.

47. White pine: Five needles in a bundle; scales of cone *thickened* at tip.

48. Scotch pine: Two bluish-green, short needles in a bundle.

49. Austrian pine: Two long, dark-green needles in a bundle.

50. Fir: Erect cones; flat, spreading needles scattered singly.

51. Norway spruce: Large hanging cones; scattered needles, point all ways.

52. Hemlock: Small, hanging cones; flat spray; needles in two rows.

53. Larch: Many needles in a cluster; fall off each year; erect cones.

54. Red cedar: Bluish berries; sharp, prickly spray.

55. Arbor vitæ: Flat branches; cones few scaled, and only two seeds under each.

56. White cedar: Cones roundish, and with four to eight seeds under each.

An examination of this list will show how it re-enforces and in many ways fills out and extends the work before done on buds, stems, and leaves.

Autumn colors will come up under this head, and an interesting and instructive exercise will be the comparing of these colors with the color chart and placing the names of the trees on the board, each in the proper color.

When this table is completed it will be helpful to trace the colors certain trees—maples, sumac, poplar, gum, etc.—pass through from the green of summer to the brown of winter.

Collections of fruits, leaves, and buds can be made which are very interesting, and it should be a matter of pride to each succeeding class to add to the school collection. In making this collection, and in the study of trees, the subject of barks and woods will come up, and should now be taken, as given in Step XIII.

STEP XIII.—PLANTS.

Woods and Barks.

Object.—To continue the work of the previous step. To learn different woods at sight.

Time of the year—October, or following Step XII. Some of it will be out-of-door work; but much can be done in the schoolroom. About 15 lessons of 15 to 20 minutes each.

Material.—The great thing is to have it *well seasoned.* Green woods crack and curl so in drying as to be very discouraging. Round sticks, with the bark on, 2 to 3 inches in diameter, are best. Search for native woods in piles and brush heaps. If green, put them up in some loft or over a furnace to season. Always have the name plainly written on one end of the stick—by preference the *upper*, as it then indicates not only the kind of wood, but which end grew uppermost. In cutting down a small tree to get a stick, always mark the north side, as there is often a difference in the growth on sides toward or away from the sun; also, if a limb, mark the upper side.

Lumber yards, cabinet makers, and dealers in material for scroll sawing, veneers, and parquetry floors can furnish the common woods used in house construction and furnishing.* Would advise applying to the *nearest* worker in woods. Tell him just what you want and what it is for, and you will be surprised to find how kindly all feel toward any

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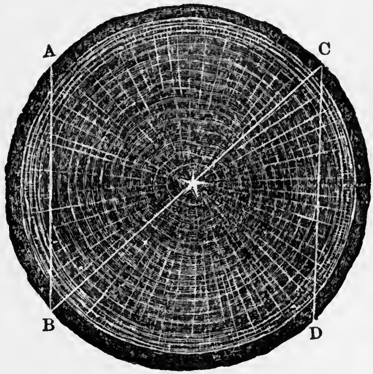
* Charles W. Spurr, of 35 Bedford Street, Boston, will send "24 varieties of natural woods" for 10 cents, and John Wilkinson Co., of Chicago, will send 20 samples of scroll-sawing woods for 30 cents, which could be cut up for sorting, etc. Many other dealers will probably do the same.

project to help the children. Discard from purchase all fancy and dyed woods, except for mere sorting.

How to prepare the Specimens.—Having procured the material (with the bark on, if possible), cut across the grain, with a sharp saw, into pieces $1\frac{1}{2}$ to 2 inches long. Then, standing these pieces on end upon some firm block of wood, take a broad chisel, sharp hatchet, or strong knife, and split off a slice of wood and bark, $\frac{1}{6}$ to $\frac{1}{8}$ of its diameter, from two opposite sides, as shown in Fig. 1. Then split the remainder in two along the line *BC*. We shall now have a comparatively small specimen, showing good-sized surfaces, of—



1. The bark.
2. The tangential section (flat side of ring).
3. The radial section (through center).
4. The cross section (end, with its bark, sapwood, heartwood, and pith).

Each section of the round stick will thus make two specimens. Provide enough of each wood for the whole class and label on one end. These can be left rough or sandpapered smooth, and oiled or varnished with *white* varnish, which will not change the color of the wood.

At the druggist's can be had a few woods and barks not included in the above, such as chips of Brazil, logwood, and quassia; the barks of slippery elm, cinchona, sassafras, and cinnamon; also tan bark (oak or hemlock) and cork.

Preparation of the Teacher.—This will mainly consist in getting the material together and practicing with named specimens till they can be recognized at sight.

The following are some of the points the pupils will notice:

Bark: surface; thickness; color of; outer or inner; taste; tough or brittle.

Wood: color of; sapwood or heartwood; coarse or fine grained; soft or hard; light or heavy; rings of growth; age; medullary rays ("silver grain"); smell and taste.

Pith: where; much or little; color.

The Lessons.—As in trees, so here the *name* is an important factor, and the work must differ somewhat from much of that which precedes.

1. Give the trays used for seeds (Step I), etc., and collect and distribute as there suggested.

2. Give a couple of easily distinguished woods, and while discussing learn the names.

3. Give two or three easily known woods and learn about them.

4. Review the names of those given and add more, gradually giving those which resemble the ones first given.

5. When all the woods and barks have been examined, let the class bring wooden articles and name the wood. Samples could be loaned to enable the child to identify furniture, etc., at home.

6. Encourage the gathering of private collections by the offer of a rare wood to any one who will bring a certain number (say 15) of correctly labeled specimens; two rare woods for 20, and so on.

Sorting.—Where native woods can not be had or the pupils are small, profitable lessons might be had by simply giving handfuls of the thin mixed pieces from the stores to sort (and let the names go).

Matching might be made a helpful exercise by placing named woods where the children could bring clothespins, shoe pegs, pencils, butter plates, baskets, fruit crates, barrel staves, box boards, pieces of molding, kindling, etc., to compare and name.

In sloyd and manual training classes much beautiful and interesting work might be done by the use of a variety of woods for inlaid work, and for the various articles made; also in the neat cutting and surfacing of cabinet sets of specimens, which could show each wood under different modes of filling and finishing.

Material put away.—Use boxes which can be placed on the shelves of the storeroom or closet, and whose labels will enable anything wanted to be at once found. Scented woods—camphor wood, sandalwood, and those having taste should be kept in separate and tight boxes. Woods at all green or wet had better be hung up in bags or open baskets where they can dry without molding or discoloration.

The next step in Plant work will be XVII—Flowers.

STEP XIV.—ROCKS.

SORTING OF ROCKS.

The child has made the acquaintance of Metals (III) and Minerals (VIII).

This step is to let him see the rocks which result from the mixing of minerals, and which differ in the following respects:

1. Rocks are like nut candy or fruit cake (fragments differ) rather than sugar or bread.

2. While they contain crystals, they do not, as a whole, crystallize.

3. While minerals are usually in small masses or scattered crystals, rocks form great layers of the earth's crust or whole mountains.

Material.—Go to the quarry or stone yard for all you can find, and buy the rest (see Step VIII). As far as possible, have the pieces about ½ to 1 inch square and thin (flakes rather than chunks). This will save weight, and at the same time show the structure. Get the following as indicated:

1. Pumice (at store).
2. Cellular lava or slag.
3. Obsidian (or glassy slag at iron furnace).
4. Amygdaloid.
5. Slate (roofing).
6. Red sandstone (at stone yard).
7. White sandstone (at stone yard).
8. Gray sandstone (at stone yard).
9. Conglomerate (pudding stone) or concrete.
10. Red granite (at stone yard—coarse-grained).
11. Gray granite (at stone yard—coarse-grained).

12. Porphyry (of any kind).
13. Gneiss (let pieces show the bedding).
14. Mica schist and other schists (at stone yard).
15. Limestone (with fossils in it).
16. White marble.
17. Shell marble.
18. Hard coal.

Add any minerals from VIII which the children can distinguish in the above rocks, as mica (19), feldspar (20), quartz (21), etc.

Other rocks can be substituted if they illustrate the four classes represented by 1–4 (volcanic), 5–9 (sedimentary), 10–14 (metamorphic), and 15–18 (organically formed).

Preparation of Teacher.—Your specimens before you, examine the rocks in order, with no aid but such as the children will have (eyes and specimens); try to see what they will and no more.

As I write these suggestions I fully realize the struggle it will cost you to keep silent about all the interesting things there are to be told, but that word "told" lets out the whole mischief—the class is not ready for it. If you will look at the other lessons to follow you will find how all will come in at the proper time; and before giving any of this work, I would advise that the whole course be examined.

Two things more are needed. With a punch such as is used to make holes in leather, about ¼ to ⅛ inch in diameter, cut from thin "folding" or other paper some little disks for labels, and do up in packages of 30 or 40.

For a cement, the following receipt by Prof. Winchell (in his Excursions) is much better than mucilage. For a class, take of

Gum arabic	4 oz.
Fine starch	3 oz.
White sugar	1 oz.

Mix and pulverize in some way, put in a deep tin dish, and add 4 times its bulk of water. After standing till the gum is dissolved, suspend in a dish of hot water to cook till clear and as thick as molasses. A lump of camphor or 20 cloves cooked in it will prevent souring and mold.

Keep in a fruit jar, to use as required. Small clam shells or squares of glass make good dishes for the class, and wooden toothpicks instead of brushes.

With the help of the children count exactly 30 pieces of each specimen into boxes or pieces of paper, and into each of the 30 shallow trays used for minerals place little boxes enough for the number of specimens you have (say 21).

The Lessons.—*A*. Number the specimens. Give a package of 30 specimens, as many little labels, and a dish of cement to each child, for a lesson in the numbering of minerals.

1. Place the specimens in rows before you, the poorest side up (so that when arranged the numbers will be out of sight).

2. On each place a little cement, choosing *hollows* to put it in.

3. Wet the end of a toothpick or pencil, and pick up one little disk of paper after another and lightly place it on the cement.

4. With a handkerchief or cloth firmly press each label on to its specimen.

5. Put the specimens carefully away to dry, and the next day, with a pen, place a neat "1" on all the pumice, "2" on the obsidian, and so to the 21st.

B. Give out the trays with the empty boxes, and have the children put the boxes in order.

(Let the teacher or a quick pupil take the boxes of any absentees and arrange as the class does.)

C. Give out specimens. There are, for example, 30 trays of boxes in position on the seats. Take 30 specimens of No. 1 (pumice), and as you pass up one aisle and down the next drop a piece in each upper left-hand box. That you have no specimens left as you leave the last box is proof that each child has one.

Call the attention of the class to what you have done and how, and then let a pupil take No. 2 (obsidian) and place it in the box to the right of the pumice.

When sure he understands, give No. 3 to a second child to follow after the first, and so on until all are given out.

D. Let each child's tray have his *name* in some easily seen place, and gather them up in such orderly way as to be easily returned to each at the next lesson.

E. With the numbered specimens before each child have a talk about what they observe. I should try in the end to have had the following things noticed:

1. Light and white.
2. Full of holes.
3. Glassy and with sharp edges.
4. With roundish spots or holes.
5. Splits in thin, even layers; smells of clay.
6. Reddish; made of different colored sand grains.
7. Gray; made of different colored sand grains.
8. White; made of different colored sand grains.
9. Pebbles stuck together.
10. Reddish; made of glassy specks (what mineral?); pink pieces with smooth faces (what mineral?); and scales of shining mica, such as we have in our stoves.
11. Whitish; otherwise the same.
12. Sharp-cornered specks scattered over it.
13. Much like 10, but shows lines of bedding; very likely has little red (garnet) or other colored specks in it.
14. Very shiny, with much mica (No. 19) and some glassy specks (21); is also apt to have other minerals in it.
15. Grayish, with shells (or crinoid stems) stuck in it.
16. White, and sparkles in sun like loaf sugar.
17. Shells, etc., in it; sparkles like 16.
18. Black and shining; surface in hills and hollows.

That most of them are made of several minerals put together.

That none are in crystal form.

That many are used for buildings, streets, sidewalks, etc.

Review.—*A.* Question (see *B* in Minerals).

B. Each child tell how he would know any particular specimen (as mica schist, white sandstone, etc.).

C. Now provide a pail of water and let each child put in his specimens (to soak off labels and freshen), when they can see that pumice *floats* and the others sink. After school let some of the children take them out, rub off the labels still adhering, and place on boards to dry.

Place the mixed specimens about the room and let each child select 2 new sets (as in Minerals).

D. Put specimens away (see Minerals).

Next step see Pebbles—XV.

STEP XV.—MINERALS.

Pebbles.

So far* the child has simply *observed* a typical set of metals, minerals, and rocks.

He is now ready to examine more closely and see things in relation to other things.

As introductory to this the Pebble is well fitted.

Objects in View.—An introduction to the forces of Nature. Advance in the art of experiment. Preparation for what follows—i. e., to connect with Sharp Stones (Step XX). Preparation of "Earth Food," Morning-glory (Step XXIII). Preparation of Soil for Roots (Step XXVIII). Making and Sorting of Sediments (Step XLIII). Correct idea for Geography; of Earth Sculpture, etc.

Time.—25 to 30 lessons of 15 minutes each will be ample.

Material needed.—For a class of 30: 30 rounded pebbles, of varying size, color, shape, and structure; 30 angular fragments of sandstone (mortar, tile, or brick will do); a mercurial barometer; 2 thermometers which read alike; 2 stout bottles (quart or more) with corks—pickle-bottles have proved best, being strong and wide-mouthed; a tin or other basin; a 100 cubic centimetre graduated cylinder; a porcelain evaporating dish (8 oz.) or bright tin dish; an alcohol lamp (4 oz.); a large funnel (8 oz.); and filter papers (25).

If these things can not be had, substitute a tall, wide-mouthed bottle of clear glass; a *tin* evaporating dish; make the alcohol lamp (see Step XXV); a tin funnel, with *thin* wad of cotton in tube.

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* Steps III and VIII.

Where to get.—Order of some dealer in chemical apparatus, or your druggist will get them.

Preparation of Teacher.—When your things are gathered, read the chapters on erosion and the work of moving water in some good geology.

Specimens in hand, go through the following suggestions, trying all the experiments and making the subject *your own.*

Then wrap the rounded pebbles up in paper, doing it in the proper way (a lesson to the class), as follows:

Tear a newspaper into oblongs (each leaf into 4). Lay the pile before you on the table, the *length* from front to back.

Place a pebble in the middle of the nearest half of the sheet.

Fold the nearest end over the pebble.

Fold the left side on to the right.

Fold the right side to the left.

Roll from you to the end of the paper.

Give the corners a squeeze.

A mineral, rock, fossil, or shell done up in this way is protected from injury in the best possible way, although of course delicate specimens must not be placed under heavy ones.

The Lessons.—Give each child a pebble wrapped in paper so that he can get it into his hand without *seeing* it. What can you tell about this by—

1. *Feeling?* Heavy, hard, cold, rounded, smooth, size, dry.
2. What more can we learn without looking?
   Smell? (None!) Breathe on it? (*Clay* smell perhaps.)
3. What more without looking?
   Hear? Listen. (Nothing!) Speak to it. (No answer.)
4. What else without looking?
   Taste? (None.)
5. Now *look* and see what you can tell.
   Color, form, structure (of grains or layers, etc.).

6. Where are rounded pebbles found?
   Seashore.
   Lake shore.
   Brooks.
   Rivers.
   Gravel pits.
   Tops of houses.
   Walks, etc.
   By waterfalls.

7. Let us now see how these pebbles got round.

(Give some angular pieces—size of hickory nut—of sandstone or hard mortar.)

In what respect are these like the pebble?

How do they differ?

Now drop the angular pieces into strong pickle or other bottle and set aside.

8. Take the class, if possible, to some sea or lake beach or to some brook to *observe.*

Do not *tell* them, but by questions or example lead them to note the motion of the water, the rubbing of the stones, etc.

If this is impossible, by *picture* and *description* give them as good an idea of ocean waves and beaches, rapid brooks, and dashing waterfalls, as you can.

9. Now talk about the most *familiar* place the pebbles are found (say the lake beach) and ask—

How does the lake make round pebbles?

(Record an expression from each on the board.)

Then by vote or criticism narrow the list down to those statements which wholly or in part express the thought that—

> "The lake makes round pebbles by the waves pushing them up and down the beach, so rubbing them against each other."

10. How can we prove this?

Get them to suggest "by putting water in the bottle with the sharp stones and shaking it."

What is the proper motion to give the bottle?

(Backward and forward.)

How shall we hold it?

(Slightly inclined like the sloping shore.)

Now let all have a turn, at recess or after school, in giving the stones at least an hour's *vigorous shaking;* turn water and all into a basin, stir violently, and put in a still place till next lesson. Then let class examine without disturbing, and question as to what they see. (Worn pebbles at the bottom; sand and mud *on* and *among* them; bottle scratched, etc.) Now strain through a fine cloth, rebottle water for future use, and, after drying, give a pebble and some wearings to each.

Have we shown how *lakes* do the *rounding?*

Are the stones as *heavy* as before? As *large?*

Why lighter and smaller?

What do we call the wearings? (Sand.)

Which settled quickest? (Pebbles.)

How do you know? (Sand and mud *on top.*)

What is mud? (Wet dust.) Dusty roads, marble making, etc.

Where did the mud come from?

11. Would the chipped-off sand grains be rounded or sharp?

Examine under a magnifying glass.

Why are they sharp?

If these were rolled or bumped by water what would happen? What would be *size* of wearings?

What would you call these? (Mud.)

Can you see the grains of mud?

Do you think *they* could wear?

What would be the size of *these* wearings?

If so *very* small, do you think it possible for them to be in *clear* water?

Let us see how we can prove this.

On washing day the wet clothes are hung on the line, and after a while are? (Dry.)

What is left hanging on the line? (Clothes.)

What has gone away? (Water.)

Where has the water gone? (Into the air.)

Here is a bottle of water. In it I drop a teaspoonful of salt, and now shake it. What has happened? (Salt has gone.) Where? (Into the water.) Yes—there are reasons for thinking there are very small *crevices* in water, just as there are between the apples in a barrel or the shot in this bottle, into which the salt has gone; only they are so very, *very* small no one has ever seen them, not even with the strongest magnifier.

What must be the size of the pieces of salt? (*Very* small.) Are they still *salt*? (Taste and see.) Yes—still salt, and we call such tiny parts of anything *molecules*. Try and remember it. Why can not we *see* these molecules? (Too small.) How can I get the salt back? (Boil away the water.) Let us put it in this dish and leave on the stove (register, etc.) till the water dries up, and see if the salt *is* left.

(When ready, show to the class.)

Was the salt left? I put in a teaspoonful. Let me scrape this together and measure. See—there is none lost!

Hold up the bottle of water from the shaken stones and ask: "Who can now tell me how to find whether very small pieces of wearings can be in clear water?"

Yes, "dry away the water." I will fill this evaporating dish and let the water dry away over this (lamp, stove, register, or any heat).

Were any in clear water? (Yes.)

How large are the pieces? (Very, *very*, VERY small!)

(Look in your mother's tea-kettle and see if you find any brownish "scale" on the sides, and bring some.)

12. Where *else* did we find pebbles?

"Ocean beach."

What kind of motion does the ocean have?

(Same as lake.)

How does it wear the pebbles? (Review lakes.)

What makes the waves move? (Wind.)

Yes, you can make some little waves by blowing on still water. Try it in a tub or washbowl, and see. Show map of world, and talk of the *great extent* of ocean beach, along most of which pebbles are being rolled and rubbed.

13. Are all rounded stones made so by lake or ocean ?

(Brooks and rivers.)

Is the motion the same as the lake ? (No, it is onward, not up and back.)

Try and illustrate this by taking pupils to some brook or river. Even the little rills from melting snow, gullies in walks from rain, or a crooked little channel in some bank, made by the pupils and water poured in at the top end, will throw much light on this subject.

14. What makes the rivers and brooks run ?

Talk of how *heavy* water is, getting all the examples the children can give to prove it. (Pails, tubs, bowls, wet clothing, etc.)

Here is a glass bowl. Is there anything in it ? "Empty," is it ? Is this room "empty" ? Move a fan and see. (Air.) *Is* the bowl "empty" ? "No; has air in it." Let us see if it is full, in every crack and corner, with air.

We will take this bottle. Is it empty ? (Air.) I will wrap this wet rag about the neck of this funnel, fit it tightly in the neck, and pour in water. It does not run in! Why ? (Already full of air.) Can air and water be in the same place at the same time ? (No.) I lift the funnel a little and in rushes the water. Why ? (Because the air could get out.)

Now for our bowl again. I will lay these pieces of rock in a pile on the bottom.

What happened to the air when I put the stones in ? (Some had to get out.)

Do the stones *fill* the bowl as the air did ? (No; they stay in a pile.)

We will take out the stones and pour in some *water*. Does it pile up like the stones ? Does it fill every part, as the air ? (No; it sinks to the bottom, as low down as it can get.)

We will set the bowl in this pan and imagine it a pretty lake up among the mountains. This water I pour in is a waterfall from the melting snow. See how our lake fills up. Does the water keep trying to get as low as it can? Now it is full and *runs over*. So it always does, and our brooks and rivers, waterfalls and rapids, are all water "spilling over" and trying to get as low as it can.

15. To give correct ideas of things seen on a map—

A. Hang up a map of the township or county the children live in. Find the little dot which represents their own town, and, by talking of the streets, houses, etc., transfer the conception of home surroundings to that black dot.

B. Get a "bird's-eye view" of some near city, and repeat the above.*

C. In the same way talk of the blue representation of the nearest lake or ocean.

D. Talk of the rain—how it runs off in little rills (too *small* to be on the map); these gather into brooks (show, if possible); brooks empty into rivers (find nearest).

E. Now hang up a map of the world, and by it place a globe.

Explain how inconvenient globes are to keep on account of the room they require, and that a map is the same as though the outside of a globe were peeled off (show orange), and, after some fixing to make the pieces meet,† it were pressed out *flat*.

F. On the big map find the locality of the places talked of in *A* to *D*, and then follow the largest river of *D* along to the sea or ocean.

G. Observe how much ocean there is, and trace rivers in other parts of the world.

16. **Whence and how the Rain comes.**—Hold a good-sized sponge before the class. There is one thing I want you to

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* Barnes's Geography (Illinois edition) has an excellent one of Chicago, which I have used.

† The expanded arctic regions on common maps will be explained by this.

see about this sponge. (Full of holes.) (Squeeze it as hard as possible.) Are the holes now larger, or smaller? (Smaller.)

I will place it in this glass dish of water. See how the water rises all through it. I lift it, and much water stays in. I squeeze it, and much of the water runs out. Why? (Holes made smaller.)

Now the sun warms the ocean and causes the water to rapidly dry away. Great numbers of tiny little bits of water are all the time rising from its surface into the air above and mixing with it.

They are so very small that no eye can see them, and the air they are in looks the same as in this room. The warm water also warms the air above it.

Remember the hot smoke from locomotives and chimneys, and tell me what hot air always tries to do. (Rise.) John may climb the stepladder and hold this thermometer (which means *heat measure*) near the ceiling for 2 minutes. Sam may hold this one near the floor for the same length of time. Now, where has the heat "meter" or measure shown the most heat? (At the top of the room.) Yes. The vapor of water is also very light—even lighter than the air—and, as it mixes with the warm air, both rise, just as you can see the hot air rise from a register or stove when the sun shines on them. Here is an instrument we have to tell us when the air is light or heavy. It is called a *barometer*, which means *weight measure*. Before I tell you about it, let me show you a few experiments. Here is a bent glass tube, open at both ends. I pour in some of this colored water, so that you can see the level in both tubes. How are they now? (The same in both.) What unseen thing is pressing on the water in each arm? (Air.) Yes. Air *has weight*. Suppose the air should press hardest on one surface. (The other would *rise*.) See if it does so when I *blow* into one. (Yes.) If the air were made *lighter* on one side? (The other would *fall*.) Let me suck out some air and you will see. (Yes.) Suppose there were *no* air on one side? (Would rise higher.) Yes, so high as to be very inconvenient. So in the barometer we use a *heavy* liquid called mercury. Our barometer is a bent glass tube, closed tightly at the upper end. This tube is then *filled* with mercury, so as to get every bit of air out, and, when ready, placed in this position in a frame. As the mercury falls in this long arm, what is left above it? (*Nothing*—only an empty space called a *vacuum;* for the closed top would not let the air flow in after the mercury.)

Now let us see what we have. What presses on the mercury in the open arm? (The air.) What in the closed arm? (Nothing.)

You see, then, it is like a scale—the air on one side balances the mercury on the other; and if the air grows heavier at any time, the mercury—? (Rises.) If the air becomes lighter—? (Mercury falls.)

When the air above the oceans becomes light from heat it will rise. Do you think it leaves a *hole* behind? How is it with the furnace? (Cold air goes in at the bottom as hot goes out at the top.) Where is the hot air in this room? (At the top.) I will open the window a little at both top and bottom, and having lighted this candle, hold it near the top. Which way is the flame blown? (Out.) Now see, when I hold it near the bottom. (In.) Just so the cool air below flows in to take the place of the rising vapor and warm air.

One thing more: Look at this picture of a high mountain in the tropics, as we call that part of the earth where the sun shines almost straight down. (Guyot's Physical Geography has a good one on page 102.) Talk about it, and lead them to notice from the vegetation and snowy top how it grows *colder* as you ascend.

As the warm air rises higher and higher what will happen to it? (Cool.) And when cool it will begin to—? (Fall.) Can it fall straight back? (No; the rising air behind will make it spread out like a tree top, and it will fall to both sides.) Let us represent this on the board. (See diagram in any physical geography.)

What do we call the flowing air about our feet, through a door or window? (Draught.) Never sit where you feel one; they are very dangerous to health. Who can tell what we call the great currents of air out of doors? Yes, *winds.* And what is it starts all these winds? (Sun.) And what do they carry? (Vapor of water.) Do you *see* any vapor in this room? (No.) Here is a glass, clean and dry. I pour in some ice water. See the outside; it grows dim and moist. John, come and look at it through this magnifier. (Little drops of water.)

Breathe on this cold looking-glass. (Drops of moisture again.) Now, warm air is like the unsqueezed sponge; it has plenty of room in it for vapor of water, but when cooled it is like *squeezing* the sponge. What happens? (Water has to get out.)

The air in this room and my breath are like which sponge? (Unsqueezed.) But when either comes against the cool glass? (Cooled, and has to leave some water.)

Why can you see the water on the glass and not in the air? (Some of the tiny bits of vapor have run together till large enough to be seen.) When the air comes against cool things out of doors and leaves moisture on a summer's night, you call it—? (Dew.) If this dew freezes, as in spring and fall—? (Frost.)

When you breathe out on a cold day what do you see? (Little cloud.) What, then, is a cloud in the sky? (Vapor turning back to water.) Suppose a cloud rested on the ground, what would you call it? (Fog or mist.) If air laden with vapor gets cooled, we see first—? (Cloud, fog, or mist.) If cooled more—? (Little bits of vapor keep getting together till too heavy to float, and then fall as *rain* or *snow.*) Just back to where we started!

Now have a careful review.

Brooks and rivers run to the ocean.

Warmed water rises in vapor, and, mixing with warmed air, both rise.

Cool air flows in to take its place.

As the mixture of vapor and air rises it cools, and, flowing both ways, begins to fall.

Cooling more, forms cloud, and from the cloud comes rain or snow.

These currents of air are *winds*, etc.

17. We now know more about the water that makes brooks and rivers.

Let me read you a poem about a brook. (Read Tennyson's The Brook, or Southey's Cataract of Lodore.) As the brook and river run on, what happens to the stones in them?

A man in a crowd tries to run, or suddenly stops; *you* try to run among desks or chairs; what happens? (Collisions and bruises.)

How with a stone in a swift brook?

What about the brook or river will make it move faster or slower? (Put answers on board.)

Bank, bed, straightness of channel, depth of water—take these up and discuss in detail.

Banks. What are *they*? How named?

Which is right? Left? What made of?

(Smooth stone, rough stone, sand, or mud.)

Bed. Level. Fall and rapids.

How will a *fall* act? (Whirlpool, stones round and round; illustrate with a basin and pebbles.)

Do they wear only themselves? (Potholes.)

How does a rapid differ from a fall?

How will *it* act on pebbles? Why *fast*?

Is there anything besides the *slope* of the bed which makes a stream run fast or slow? (*Windings.*)

How do they check the current?

Why would it be very hard to navigate *straight* rivers?

Depth. Talk of the varying effects of deep water or shallow, spring freshets and summer drought.

18. Does *all* water wear stones? Why do we see boats going out where the water is deep to pump up sand, when it lies in heaps on the shore?

Talk of the "clean, sharp sand" required by architects, and how mortar for plaster is made by pouring water (3 parts) on burned limestone (1 part), mixing sand (3 parts) and hair with it, and letting it lie a few days before using. Tell how the lime dissolves some of the sand and makes a *strong* cement to bind all into a hard mass. Which will be best for the lime to work on—sharp-cornered or rounded sand? (Sharp.) Why? (More surface for lime to act on.) Now answer my question about "pumped lake sand" being the best. Why sharper? (Waves could not roll and wear it as on the beach.)

19. Is this wearing confined to the pebbles and sand? At a waterfall the stones on the bottom wore each other, and what else? (The bed was hollowed out into a pothole.)

If water runs down a bank of sand or earth, what change? (Gully.)

How is the gully made? (Water washes away the earth.)

What does it do with it? (Spreads it out on the first level place.)

Between the gullies what are left? (Ridges.)

Suppose the bank were *rock*, how could it be cut away? (By the stones and sand in the water being dragged over it.)

Do you know any such places?*

What will become of the cut-away rock? (Settle in the lakes, etc.)

When the brooks and rivers have cut into or across the sides of mountain ranges, what will be left? (Peaks and ridges.)

Where the water has run will be— ? (Deep ravines.)

Where the wearings have filled up lakes or gentle slopes of the river valley will be— ? (Plains.)

Which would you choose for a farm?

Are farms mostly in the valleys and on plains?

Where would boats have to stop in going up a stream? (Falls.)

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* Teacher show pictures of the Colorado cañons, etc.

Where would be a good place to put water wheels and build factories?

Notice in your geography and reading if manufacturing and important cities *are* apt to be where the ships have to stop.

Thus, falling water not only rounds the pebbles and sand, but in dragging them along the bottoms of brooks and rivers also carves the face of the earth into mountains and valleys, makes good, level land, and turns the machinery of mills.

Does *all* water wear stones? (Only *moving* water.)

20. What do we call rounded pebbles? (Gravel.)

Still finer grains easily seen? (Sand.)

When too fine to see? (Mud, clay, dust.)

When black in color? (Earth or loam.)

See who can bring me some of each to-morrow.

21. What now have we learned from a rounded pebble?

"Made from sharp stones by being rubbed against other stones by moving water; making gravel, sand, mud, and some wearings so *very* fine as to be held in solution in water without affecting its clearness."

That the largest pieces settle *first*.

The kinds of banks and bed a river can have, and what they are called.

That the crookedness checks the current and allows boats to go up stream.

That when we want to find out about something we *remember* all we have seen, *think* about it, and try *experiments*.

That even a pebble or a grain of sand can be a pleasant *friend* if we only get acquainted.

Do you like science?

22. Give the children a *talk*, clearly reviewing the points made in a connected way.

23. Examine in some such way as this:

a. Beginning with *A*, each child may tell me *one* thing we have talked about.

b. To-morrow you may each *bring* something we have talked of and tell me about it.

c. Who will help me make a *collection* for the school? (Arrange and label neatly.)

Collection to illustrate:

"*Round pebbles.*"
6 sharp pieces of different things.
6 rounded pieces of different things.
Bottle of gravel.
Bottle of sand.
Bottle of clay.
Bottle of "earth food."

Time required—25 to 30 lessons of 20 minutes each.

As I review these lessons critically as to their adaptation to ordinary eight-year-old children, I can see no steps too long. I have tried to bring in nothing which was not intimately connected with the subject of pebbles, and so have left out many things to be taken up in other connections.

Hence I would strongly advise the teacher to take up the work just as given here, pushing it along energetically to a close, trusting to the review and future applications which I have in mind (see Objects in View at beginning) to set errors right and explain misunderstandings. Energetic work will require the time given and be much more satisfactory than *one half* more time spent in dallying.

As to the *results* of such a series of lessons, I think they can hardly be overestimated.

Next step, XX—Sharp Stones.

STEP XVI.—THE SKIES. (III. THE EARTH.)

A continuation and application of Steps II and VII, where the way was prepared for correct ideas of the shape, motions, and position of the earth.

The time needed for these lessons will be about 20 lessons of 10 to 15 minutes each, at such part of the school year as may seem best fitted. For the constellations, if the story of Hercules is followed out, some must be seen in April, and then on to May and June.

Material needed.—A globe, 8 to 12 inches in diameter, such as is common in schools.

A second small globe (mine is of paper), 3 or 4 inches in diameter, to suspend by a piece of twine.

Preparation of the Teacher.—Read the previous steps, and then, in Lockyer's Astronomy, or elsewhere, about the earth, trying the experiments and illustrations here given till they are familiar, or devising new methods, if better suited to the case.

THE LESSONS ON THE EARTH.

Its Shape.—(See Lockyer's Astronomy, page 82, and Primer, page 4, etc.)

1. Tell the story of Magellan, and on a globe trace his voyage of *circumnavigation*. Sew map and route.

2. Speak of the *horizon*, always appears to be round on the sea or on a level plain. Take a pair of dividers and apply them to a globe and then to other "round" objects. The sphere alone will be touched in all directions by the moving point of the divider at an equal distance from the

stationary foot. The same thing can be shown with a round apple and a carrot, by cutting off slices.

3. Illustrate on a globe the disappearance of ships at sea. A hill crossed from opposite directions by the pupils will also show this. Especially impress the fact that the *masts* of a ship or flagpole on a building are much the *smallest* and still seen farthest. (Sew or draw circle.)

4. **The Shadow of the Earth.**—The shadow of the moon was observed in the experiments on its motion. Does the moon ever get between the earth and sun? (Yes.) What will happen? (Shadow fall on the earth.) What shape will the round moon always appear against the bright sun? (Round.)

Now suppose the earth got between the sun and moon? (Would cast its shadow on the moon.) What do we call such occurrences, when either moon or earth get in the other's light? (Eclipses.) Who has ever seen one? Tell us about it. Read to the class or tell the story of some eclipse.*

Consult almanacs (with the class), and by no means miss *seeing* the first eclipse that occurs, having colored or smoked glass ready to protect the eyes, if of the sun. (Sew or draw it.)

5. The class will now be able to give reasons for calling the earth "round," and thus *review* the points made.

Daily Motion.—(See Primer, 10–18.)

What do we mean by morning? Noon? Night? Sunrise? Sunset? Do the shadows remain in the same place hour after hour?

We know the moon goes around us. Are we—is our earth—*still*, or *moving*?

The poets in olden times had queer notions,† as they

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* Whittier's Abraham Davenport is a noble poem about an eclipse. A book entitled The Chinese Slave Girl has a vivid account of the Chinese ideas and their efforts to drive away the monster that is eating up the sun. Lockyer's Astronomy (p. 133) has items of interest.

† See Bulfinch's Age of Fable (E. E. Hale's edition), pp. 3, 4, and 49, Phaeton.

seem to us. To them a flat, circular earth was surrounded by the river Ocean. The Dawn, Sun, and Moon arose out of the eastern Ocean and drove through the air, giving light to gods and men. Phœbus daily issued from his gorgeous temple in the east and drove the Chariot of the Sun through the heavens. The journey ended, he returned by a winged boat on the river Ocean, around the north side of the earth, to be ready to start again the next morning. The moon did the same. (Prick and sew or draw one of those early maps.)

Galileo's story will tell how recently (only about 250 years) most people believed that the world stood *still* and the sun *daily went around her!*

Galileo thought it was not so, although difficult to prove.

Beginning at the capital (find on a map) of our country, and measuring west straight round the earth, let us suppose the distance divided into 24 parts and posts set as marks where the meridians would run. These would then measure the distance—which way from Washington? (East or west.) Suppose the sun had just risen on the post at Washington, how long before it would rise at the next post west? (1 hour.) And at the next? (Another hour.) If we knew how many of these meridian posts a place was from us, could we tell the time there? Give me some examples.

Counting a meridian for each degree we have *360* of these meridians instead of 24, which is 15 times as many; hence each marks how much time? (4 minutes.)

Clocks and telling Time.—Here teach the divisions of a clock. (Prick, sew, or draw clock faces.)

How many times does the hour hand go round each day?

Teach the class to tell time by the clock and by the shadows.

The Days of the Week.—When our side of the earth is turned to the sun we call it—? (Day.)

When away from the sun—? (Night.)

When we have day, the children on the other side have—? (Night.)

What children and people go to bed as we get up?

Why does the sun seem to rise in the east and set in the west ? (Earth turns from west to east.)

The moon's revolution about the earth gave to mankind— ? (The division of time into months.)

The earth's revolution on its axis gives us— ? (Day and night.)

How many days in a month ? In a week ?

Name the days of the week, beginning with Sunday.*

Constellations.—I would advise those connected with the story of Hercules. (See Burritt's Geography of the Heavens, p. 104, or Bulfinch's Age of Fable, p. 175, etc.)

1. Find the *polestar.*
2. Pass to the "*Dipper*," or Great Bear.
3. From the tail of the Bear go to *Arcturus.*
4. Find the *Northern Crown* early some May evening (5th to 10th).
5. Directly east of this lies *Hercules*, wearing the lion's skin, and holding by one hand the terrible three-headed dog Cerberus, which he alone was able to tame.
6. Having aroused an interest in the story and constellation, at once—before the 15th of May—(in or near latitude 40°), look in the southwest for the *Sickle.* This is in the head and shoulders of the *Lion.*

If the line from the polestar to the two "pointers" in the Dipper be continued on, it will pass *between* the Sickle and bright Denebola in the tail of the Lion.

Having traced the Lion (which Hercules slew and whose skin he wears), look still farther southwest for the largest star (*Cor*) in the famous *Hydra* which Hercules destroyed.

7. Returning to Hercules, find the head of the *Dragon*—four stars forming almost a square, just north, between Hercules and the polestar.

When the head has been found, the coiled shape of the body and tail can be traced, lying around the Little Bear and between that and the "Dipper." This is supposed to repre-

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* If it seems best, the *meaning* of these names might be taken up.

sent the monster which guarded the famous "apples of Hesperides," and had to be slain before Hercules could get the apples.

These constellations, with the reading connected, will probably be enough. Sew, draw, or paste these groups so that the pupils can take them home to find again and interest the "home circle."

Next step in Skies—XXII, The Earth, continued.

STEP XVII.—PLANTS.

Flowers.

Object.—Roots, stems, buds, leaves, trees, barks, and woods have been brought before the pupil. To further advance this knowledge of plants is the object of these exercises in handling, observing, and gathering flowers.

Time.—The flowers of spring are much more simple in construction and advantageous for our purpose than those of autumn. The time of the day is immaterial, but should be when the school is in need of a little relaxation from study. Number of lessons will be about 25, of 20 minutes each.

Material should be mostly fresh. Have a tight tin box or pail to lay the freshly gathered flowers in, and they will keep in good shape for several days. Do *not* wet them, but lay a moist sponge, cloth, or paper in the bottom. The moisture evaporating from the specimens is retained by the tight box, and the saturated atmosphere soon stops further loss from the flowers.

The most important thing for the teacher is to have a definite plan of work, and to know each day *just what material* will be needed for the next lesson. The pupils can then do much of the work and be helped by its doing. The following list of points to cover and material to use has proved satisfactory with me, and will illustrate my idea:

1. Flowers that grow *singly:* Terminal—Tulip, hepatica, anemone. Axillary—Vinca, marsh marigold, and pansy.

2. Flowers clustered: Spring beauty, hyacinth, squirrel corn.

3. On stalks: Tulip, bloodroot, violets.

4. No stalks (sessile): The separate flowers of many clusters, as clover, etc.

5. Bracts: More or less leaflike organs on the peduncle, below or about a flower or cluster; green in anemone, hepatica, and dandelion; colored in Jack-in-the-pulpit, skunk cabbage, calla, painted cup, hydrangea, and cornel.

6. Head: Many sessile flowers in a close cluster—Clover, button bush. Often surrounded by bracts, so as to seem *one* flower—Dandelion, sunflower, hydrangea.

7. Spike: Many sessile flowers on the sides of a rachis—Plantain, mullein.

8. Catkin: A drooping spike—Willows, hazel, oaks, poplar.

9. Cone: A kind of spike peculiar to pines, larches, etc.

10. Spadix: A fleshy spike, usually surrounded by a large bract, called a spathe—Jack-in-the-pulpit, calla, etc.

11. Raceme: Spikelike, but each flower has a *stem*—Hyacinth, currant, locust, lily of the valley.

12. Corymb: The lower pedicles elongate, so as to make a *flat-topped* cluster—Crab apple, hawthorn.

13. Umbel: All the pedicles of the flat-topped cluster *equal in length*, as in golden Alexanders, sweet Cicely, and others of the carrot family.

Having now considered the flowers in their grouping, next take the parts of which each is composed.

14. The *end* of the *flower stalk* is called the *receptacle*, because it holds the other parts: Buttercup, sunflower, strawberry, corn (cob).

15. The growing parts of the flower are *protected* in the bud by—

Bracts: Hepatica, skunk cabbage, and dandelion.
Leaves: Bloodroot, marsh marigold, May apple.
Scales: Tulip bulb, hazel, pine cone.
Calyx: In the later flowering plants, as rose and morning glory.

Do flowers protected by a stout calyx have bracts, etc.? Why not?

16. Inside the protecting calyx or bracts is the more delicate and usually colored *corolla:* Tulip, hepatica, vinca, rose.

Can you find any *green* flowers?

17. Guarded by the corolla are the *stamens:* Tulip, May apple, rose.

How many are there?

What *parts* can you see? (Filament, anther, and pollen.)

Are any of these parts ever missing?

18. In the center of the flower and best protected of all is the *pistil:* Tulip, peony, columbine.

What parts can you see in the pistils of the apple? Fuchsia? Pea? (Stigma, style, ovary.)

Which is absent in the tulip and May apple? (Style.)

What do you find inside the ovary? ("Little young seeds," called *ovules.*)

What, now, are the four organs of a flower? ("Calyx, corolla, stamens, and pistil.")

19. A flower which has *all* these is said to be *complete.*

Can you find any complete flowers? (Rose, pea, apple, crassula.)

20. If any of these 4 parts are lacking, it is called—? (*Incomplete.*)

Can you find some without a true calyx? (Tulip, hepatica, anemone.)

Without stamens? (Part of the flowers of willows, ash, ash-leaved maple, hazel, oak, etc.)

Without pistils? (Remainder of the flowers of the last list—willow, ash, etc.)

21. A flower having *both* stamens and pistils is called *perfect:* Tulip, etc.

Can you find some *imperfect* ones? (Corn, willow, oak, ash, hazel, begonia.)

Can you find a plant bearing *both* kinds of imperfect flowers? (Corn, birch, oak, hazel, begonia, squash.)

Can you find plants with only *one* kind of imperfect flowers? (Willow, poplar, ash.)

Can you find flowers with *neither* stamens nor pistils? (Hydrangea, snowball, and many *double* flowers.)

22. Flowers which have the same *number* of organs of each kind are called *symmetrical.* The sedum used for rock work and an African plant (crassula) are perfectly symmetrical, and the various kinds of flax nearly so.*

23. Flowers having more or less of one set of organs than another are *unsymmetrical.*

Find 5 such. Find the most nearly symmetrical one you can.

What do you call a flower with *many* crowded petals? (Double.) Bring one.

24. If all the members of each set of organs are alike in *shape* and *size* the flower is *regular:* Tulip, hepatica, crassula, rose, pinks.

25. If some of the organs in a set differ in size or shape, the flower is *irregular:* Pea, mustard, violets, orchids, larkspur, nasturtium.

26. The ovary is a very important part of the flower, and if it is *free* from the other parts and stands alone it is *superior:* Tulip, cherry.

Can you find some "superior" ovaries?

27. But if the calyx or corolla grow to it and seem to rise from its top, the ovary is called *inferior:* Apple, squash, iris, crocus.

Find some "inferior" ovaries.

28. When the ovary is inferior the other parts grow to it. This growing together of different organs is called *adhesion:* Apple, iris, phlox.

29. Sometimes organs of the *same* kind grow together, which is called *cohesion.*

Can you find flowers with the sepals united? (Rose, pea.)

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* Pressed specimens of one of these should be made the year before, as they bloom too late for spring work. The crassula is hardy and a most remarkable plant, its flowers being typically *complete*, *perfect*, *symmetrical*, and *regular*, and all the parts *free*.

With the petals united? (Morning glory, phlox, honeysuckle.)

With the filaments of the stamens united? (Pea and hollyhock.)

With the anthers grown in a ring? (Sunflower, dandelion, lobelia.)

With the ovaries united? (Flax, tulip, morning glory, squash.)

30. When the organs neither adhere nor cohere they are said to be *free.*

Find some flowers with *all* the organs free. (Buttercups, hepatica, columbine, etc.; all the Ranunculus family.)

31. What colors can you find? (Compare with the color chart or some standard, and train to the exact use of terms.)

32. Count and see which color is most common.

Which color stands next in number?

33. Write on the blackboard the following heading and let the pupils fill it in. What rule do you observe?*

WHAT COLORS ARE FOUND IN THE SAME KIND OF FLOWER?

Red.	Orange and yellow.	Blue and violet.	White.
Rose.	*Rose.*	(?)	*Rose.*
Tulip.	*Tulip.*	(?)	*Tulip.*
(?)	*Crocus.*	*Crocus.*	*Crocus.*
(?)	*Violet.*	*Violet.*	*Violet.*
Phlox.	(?)	*Phlox.*	*Phlox.*
Pea.	(?)	*Pea.*	*Pea.*
Geranium.	(?)	*Geranium.*	*Geranium.*
Aster.	(?)	*Aster.*	*Aster.*
Verbena.	(?)	*Verbena.*	*Verbena.*
Dahlia.	*Dahlia.*	(?)	*Dahlia.*

34. What flowers are *fragrant*?

Make a list, and see which *color* is most common with fragrance. Which color is next?†

* Wood's Botany, p. 76. † Goodale's Physiological Botany, p. 454.

Try and find what time of day flowers are *most fragrant.*

35. What time of the day do different flowers open?

Let pupils draw a large clock dial on the board, and on the circumference write the names of flowers opposite the hour they opened.*

36. What leaves or flowers have *sleep movements*? Let the class report, and place their observations on the board. (White clover, oxalis, lupine, and several others.)

37. Should time permit and the class be equal to the task, would now develop the thought that a *flower* is simply a *modified branch*, whose stem (receptacle) has ceased to grow long, and whose *leaves* have changed into calyx, corolla, stamens, and pistils. Let the class gather the following series of specimens, to press and mount on cards, in the order given:

1. Leaves of hepatica and anemone.
2. Bracts of the same.
3. Green sepals of moss rose.
4. Colored bracts of hydrangea, cornel, or painted cup.
5. Petals of hepatica, anemone, and white water lily.
6. Stamen-tipped petals of water lily and petal-like stamens of double arbutelon.
7. Stamens of two plants of (6) and some snapdragon flowers.
8. Leaflike pistils from double cherry and flowering almond.
9. Pressed open pea pods and ripe seed pods of columbine and marsh marigold.
10. Sprouting leaf of bryophyllum.†
11. Branching head of mourning bride, where at times a *bud* develops from the receptacle and grows into a flower cluster.

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* See Wood's Class-Book, pp. 75, 76, or Goodale's Physiological Botany, p. 412.

† Bastin's College Botany, p. 70.

I have also observed the same development in a buttercup (*Acris*) and *Anemone thalictroides*.

With more or less of this series of specimens before them, I think a class can be led from the leaf to the pistil, and discover for themselves the relation of branch and flower.

These 37 "points" cover a great deal of ground, and introduce to the child's notice many new ideas; but the eye and hand will so aid the mind that there is no fear of surfeit when taken in such a progressive way.

Preparation of the Teacher.—This will mostly consist in going through the above outline, finding out where material can be had, and where pictures and illustrations are to be found to supplement the material. As the ground is gone over, *press examples* of each point, mount them on separate sheets of thin cardboard, and keep in a box or portfolio to show the class when any break in the fresh material occurs.

Consult Goodale's Physiological Botany, Chapters XIII and XIV, or some aid can be had from an ordinary Botany.

The Lessons.

Of these little more need be said.

Lesson 1 will need (for each pupil) a terminal flower (hepatica), an axillary flower (marsh marigold), a cluster (spring beauty), and some sessile flowers (clover head).

With these the first 3 points can be drawn out and illustrated; also bracts explained.

Now send the class home for old periodicals to press specimens in, and new examples of those studied.

Lesson 2: Examine what the pupils have brought, first making it a *review*. Do this with *every* lesson. Study bracts. (Many of the flowers given blossom about the same time, while the calla and hydrangea are common as house plants. Pictures will also aid. Class search for specimens.)

Lesson 3 can cover the "head" and composite flower of the dandelion.

Lesson 4: The spike, catkin, cone, and spadix follow easily, and can be taken together. Review as the work goes along.

Lesson 5: Teach the raceme, corymb, and umbel together, and review all. Introduce the idea of "receptacle," and let the class bring examples.

Lesson 6: Receptacle discussed and *protection* introduced.

Lesson 7: With some complete flower emphasize the four organs in one lesson, omitting all else in 15–18.*

Lesson 8: Return to complete the study of "corolla" and "stamens."

Lesson 9: Finish the pistil and "completeness" (19). Class hunt for examples of 19 and 20. Begin gathering and pressing material for 37. Try and have it all placed in press at one time so that it will be ready to mount.

Lesson 10: Fix the idea of "complete" and "incomplete," and introduce those of "perfect" and "imperfect."

Lesson 11: Review 19–21, and take up the topic of "symmetry" (22 and 23).

Lesson 12: Examine what pupils have brought (as *always*), and fix the idea of symmetry and introduce that of "regularity" (24 and 25).

Lesson 13: Complete "regularity," and review all up to 25.

Lesson 14: Examine "superior" and "inferior"; also "adhesion."

Lesson 15: Review terms of yesterday, and take up "cohesion." Class search for illustrations.

Lesson 16: Examine what the children have brought as a review of 29 and 30. Go on to colors, first studying the color chart and getting the class somewhat used to exact use of color terms. Class bring as wide a range of material as they can find.

Lesson 17: Continue color.

Lesson 18: Continue color, and introduce lists and tables of 32 and 33. Continue these till the end.

Lesson 19: Continue 32 and 33, and introduce the topic of "fragrance" (34).

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* See "Material."

Lesson 20: Call for additions to 32 and 33, and extend the lists to "fragrance." Introduce 35 and 36, and get "clock" and table of 36 started.

Lesson 21: Continue 32–36 and begin 37.

Lesson 22: Complete 32–36, and *decide* which colors are most common and which are most often found with odor. Also review the "clock" and plants that "prepare for bed."

Lesson 23: Spend in developing the idea of 37.

Lesson 24: A general *review*. Prepare and arrange specimens and collections for a *grand exhibition*. Invite parents and friends.

Lesson 25: Have a systematic exhibit of flowers in pots or vases, illustrating all that has been gone over. Also an exhibit of the pressed specimens of teacher and pupils.

No "review" that can be devised will bear comparison with the simple "showing" to friends the things they have studied about; and I will vouch for *very* well-pleased parents, pupils, and teacher after such an ending of such work.

Drawing and Color.—Whoever has charge of this work can make delightful and helpful use of flowers to draw and color from Nature. I would suggest that such work supplement the collection made, so that what the class can not obtain, or from its nature keep, can be in the form of drawings and color sketches. In my own work along this line I have found surprising progress in the *true* delineation of Nature. No "artistic" effect ever blinded my eyes to untruthful work, and I did all I could against the all too common sacrifice (in art and poetry) of *fact* to *fancy*—a sacrifice made all the more odious in that it is the result not of *necessity* but of sheer blindness to, or inexcusable ignorance of, "the beauty everywhere revealed."

Agassiz has left a clear statement of the value of this work in the saying, "A lead pencil makes a good microscope."

Two rules were all I could give my pupils—

1. "Look *carefully* at your specimen till you can see just how it looks with your eyes shut."

2. "Represent it on paper as exactly as possible, drawing the lines as they would appear if traced on a clear pane of glass placed over the object. Do not attempt to shade."

Cards or small sheets of good drawing paper I have found more convenient than books.

Some suggestions may aid in selecting work to draw and color—

Point 5: Green and colored bracts (hepatica and poinsettia).

Point 14: Receptacles of buttercup, sunflower, strawberry, and corn (cob).

Point 15: Illustrate "protection."

Point 17: Dissected morning glory to show corolla, stamens, and pistil.

Point 20: Incomplete flowers of hazel or oak.

Point 21: Imperfect flowers of begonia and snowball.

Point 22: Crassula—copy if need be from Botany.

Point 25: A dissected flower of mustard.

Point 33: All the colors found in one genus on a sheet to compare.

Point 36: Some copies of illustrations—*Desmodium gyrans*, "Venus's flytrap," etc.

Point 37: As much as time will permit.

Blue prints of many flowers (not too thick and bulky) are good. For directions, see Step X.

Material put away.—But little is to be done, and that easily. The teacher who gives these lessons will gradually gather a store of indispensable pressed specimens, pictures, etc. I have one word of advice: Do *not* let them get *scattered.* Have an album or box, plainly marked, and put everything you acquire into it and *keep it intact.*

I find it better to have *duplicate collections* and sets of illustrative material than to keep breaking up and restoring. The former plan means "always ready for use"; the latter, "*loss*, *work*, and *never ready.*"

Next step in plants is Fruits—XVIII.

STEP XVIII.—PLANTS.

FRUITS.

Object.—The study of these was begun in Step I. A more careful examination is now in order because of the age and experience of the pupils. Fruits also represent the *accomplishment* of the *purpose* for which all the previously studied parts were arranged, and can now be studied in that light.

Time.—Autumn is the time of fruits, and so the time to study them. The time of the day is immaterial, although at the close of school would be my choice. About 25 lessons, of 15 to 20 minutes each, will be needed.

Material.—This will consist of two kinds—that which will keep and that which must be fresh. Much of the former can be found in the list (or bags and boxes) of Step I.

The following is a list of the kinds of fruit it is desirable to bring before the child, arranged from the simple to the collective:

1. Akene: One free seed—Sunflower, clotbur.

2. Caryopsis: The one seed and its coats united—Corn, wheat, and all grain.

3. Samara: A *winged* akene—Maple, elm, ash.

4. Glans (nut): Akenes more or less inclosed in an involucre—Acorn, hazelnut, beechnut.

5. Cremocarp: The peculiar double akenes of the umbelliferæ—Sweet Cicely, parsnip.

6. Drupe: "Stone fruit"—Plum, peach, prune.

7. Tryma: Outer covering more woody than in the drupe, and seed cavity partly *two*-celled—Black walnut, hickory-nut.

8. Berry: Several seeds in a fleshy pulp—Grape, tomato.

9. Hesperidium: A berry with a leathery rind—Orange, banana.

10. Pepo: Hard-shelled berry—Squash, melon.

11. Pome: Several seeds inclosed in *cells* and surrounded by a fleshy *calyx*—Apple, pear.

(None of these eleven fruits open entirely.)

12. Follicle: A one-celled, dry seed pod, opening on *one* edge—Columbine, marsh marigold.

13. Legume: A one-celled, dry fruit, opening on *both* edges—Pea, bean, peanut.

14. Loment: A legume, breaking into short joints—Sainfoin, desmodium.

15. Cochlea: A coiled legume—Medicago (lucern or "snails").

16. Capsule: A *several*-celled (compound) fruit; opening—

- *a.* *Through* the partitions—Mallows, hollyhock.
- *b.* *Away* from the partitions—Morning-glory.
- *c.* By the walls (valves) splitting in the middle—Iris, lily.
- *d.* By chinks or holes (pores)—Poppy.
- *e.* By a lid coming off—Plantain, spring beauty, portulaca.
- *f.* By two *long* valves opening from the bottom up (silique)—Mustard, stocks.
- *g.* By two *short* valves opening upward (silicle)—Shepherd's purse.

17. Capsule with seeds on the *valves*—Violet, iris.

18. Capsule with seeds on a *central column*—Pink, primrose.

19. Etærio: Several drupelike pistils united—Raspberry, blackberry.

20. Strawberry: Many akenes *on* a fleshy receptacle.

21. Hip: Many akenes *in* a hollow receptacle—Rose.

Where the several pistils of a flower *cluster* have united—

22. Sorosis: Mulberry, pineapple.

23. Synconium: A hollow receptacle holding many united akenes—Fig.

24. Strobile: Scaly dry fruits form a flower cluster—Pine cone, hop.

Some other points should also come before the pupils to prepare for future steps.

25. Fruits with bright *colors*—Apple, cherry, mountain ash.

26. Fruits with pleasant *taste*—Peach, plum, etc.

27. Fruits with wings—Maple, elm.

28. Fruits with down (pappus)—Thistle, dandelion.

29. Fruits with hooks or bristles—Clotbur, bur grass, Spanish needles.

30. Fruits which *snap* open on drying—Balsam, geranium.

Also use the trays of Step I and thirty paper pie-plates. On each plate write a name (akene, etc.), and draw (or paste on) pictures illustrating the peculiarity of that fruit underneath.

Preparation of Teacher.—Take any good botany (Wood, Gray, Bastin, etc.) and read the chapters on fruits. Compare the illustrations with the list I have given, and try to gather as many specimens as possible under each.

When the whole ground has been gone over, and you have *seen the things* with your own eyes—have handled and examined each till its *structure* is familiar (the *name* is of no consequence just now)—you are ready to begin with the class. This preparation should be done in the summer, as the time after school opens in September will all be needed for the work, in order to finish before severe frost destroys some of the material and makes the work more difficult for the pupils.

The Lessons.

The teacher will have found *great gain* from the gathering of the various fruits, as suggested in "Preparation," and, that the pupils may have the same chance, should proceed as follows:

Lesson I: Give a brief review of the flower. Then ask: Who knows the sunflower? Who can bring me a "head" for to-morrow? (Accept several offers.) Who can bring an ear of ripe corn? (Again let several offer.) Who can remember the ash tree? Is the fruit on it now? (Yes.) Who will bring me enough ash fruits for all? Who can bring me enough hazelnuts in the husk for all? Show some of the largest cremocarps to be found in the neighborhood, and ask to have some like those brought. So go on till *every* child has something to bring on the morrow, and put the list on the board. Provide anything the class can not get.

Lesson II: Have some of the trays of Step I ready, and, as the children bring the things in the morning, let them be placed each by itself in them, and put some mark (in bright chalk) after the pupil's name on the board to indicate that he has *done what he agreed to.* At the time for the lesson give each—

1. A couple of sunflower fruits. Why are they called "fruits"? (One ripe pistil.) Are they dry fruits? Do they open of themselves? How many seeds in each? Is the seed loose inside, or do the walls adhere? (Except at one point.) Write "akene" on the board.

2. Next give grains of corn. Do they open of themselves? How many seeds in each? (One.) Is the seed separate from its coats? Write "caryopsis" on the board.

3. Give ash (or maple) fruits. How many seeds in each? Are they free, or not? (Free.) What is peculiar about it? (Wing.) Write "samara" in list.

4. Hazelnut in husk (or acorn in cup). Why is *all* this a fruit? (A ripe pistil and its adhering bracts.) Does it open naturally? How many seeds in the nut? (One.) Is it free? Write "glans."

This will be enough for the first day. Now review by having different pupils tell the peculiarities, and let the class volunteer to bring more new things (begin where Lesson I left off, and go on), and also other specimens of the kinds that have been studied.

Lesson III: Receive the things in the morning, as in Lesson II. Have the four illustrated and named pie-plates corresponding to the fruits in Lesson II on the desk, or somewhere that the children can examine them and compare the things they have brought.

At lesson time, first ask what each has brought like the things studied yesterday, and which they think they are, letting them be placed in the proper plate as disposed of.

5. Study the cremocarp. Lead the pupils to notice the peculiar way they are joined in pairs; that they are dry, indehiscent, one-seeded fruits, like the akene. Add *taste*, for which they are noted. Write name in the list on the board.*

6. Drupe. After studying exterior, open to see pulp. Eat pulp for *taste*, and then examine stone. Is it round, flattened, or furrowed? How many seeds inside? Are they free? How does the seed taste? etc.

Proceed in some such way as the above through the subject, securing the greatest possible help to the pupils by their—

(1) Bringing the specimens.

(2) Examining with you and the class.

(3) Searching for new examples of each kind to put on the paper plates, which should be set out as fast as the fruit is collected, and left on exhibition through the lessons.

Do *not* attempt to compare or generalize. No one knows better than I the temptation to do this, but I also know that this is not the place and time to do it. If the pupil can only *handle*, *see*, and *examine* the fruits (each by itself), a foundation will be laid of *exact knowledge* on which we can build great and enduring things in the future.

Reviews.—There are many ways to review after the entire list has been studied.†

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* These names are only a *convenience* and training in use of exact terms. Do not *require* the pupils to know them; only lead them to see what a help it is to have *one* word to include all that a long description could give.

† See "Sorting," in Minerals, etc.

Sorting.—1. Mix all the specimens on the plates and place in trays about the room; then send each child to gather all of some one kind of fruit.

2. Vary this by letting one after another describe some fruit from memory; if correct, find the plate or tray that has the corresponding description on it, and then gather the fruits which should go on it.

3. Mix in a bag, and let them tell the fruits by *feeling*.

4. Place some of the strong-scented kinds in cheesecloth bags (being careful to keep these bags away from each other), and let the pupils tell the fruits by *smelling*. A little crushing will often develop the odor.

5. Cut up in small, indistinguishable bits, and tell by *taste*.

6. Describe from memory, and let the class tell what is meant.

7. Making collections is always helpful work. Encourage it in some of the ways suggested in previous steps.

Drawing and Color Work.—The competent teacher in this department will find abundant material for helpful and interesting work, and have the added incentive of a *purpose* in its doing. Such work will also be a great aid in learning the structure of the fruits.

See suggestions under Flowers (Step XVII).

Geography Work.—Especially in cities, many foreign fruits will be brought. If *little* drawings of these are made by the children and colored, they can then be cut out and pinned on the map wherever they grow, and much true geography be taught.

Let the pupils find the fruits in the plates and charts of Guyot's Physical Geography, or one like it, and then find the places on the map. Such work can be varied in many ways, and is always enjoyed by the pupils, and is really the means of much exact study.

Fruit Festival.—"Harvest home," or some celebration of the kind, would delight all, and is one of the ways in which *country* children can enjoy themselves and make the very important "home connection."

Even in cities much could be done in the way of decorating the room in connection with readings and recitations.

Language Lessons and Literature.—The relation of science to these branches of work is already understood.

With their little heads full of observations and questions on interesting topics, only their expression will need direction.

Material put away.—The advice in Step I is all that is needed; only see that everything is ready for use again before it is put away.

The next step in plants is The Morning-Glory—XXIII.

STEP XIX.—ANIMALS.

THE BOY.

Object.—In Steps V, IX, and XI a general survey of the animal kingdom was taken as regards *externals.*

The time has now come to consider some of these matters more closely, and in their relation to *internal* organs. The thoughtful observation induced by the previous work will have fitted the pupils for this advance. As the ability to take care of one's self is of vital importance, I have always made this step a simple course in hygiene. There is no question as to the best animal for this work—it is *the boy.*

Time.—In the fall of the year, when it will interfere with no study requiring fresh material; of the day—when relaxation is needed. I have never known a pupil to go to sleep or be inattentive if the work is briskly pushed, as *all* work should be. About 40 lessons, of 15 to 20 minutes each, has been the longest course; as experience is gained, this can be lessened one third.

Material.—But little is needed, as live specimens are common!

Preparation of the Teacher.—Go through the lessons with some good physiology in hand, and arrange to have some *thing* to show or experiment to perform each day. *Use,* in what follows, always means *use to the boy.* For reference, I should choose Huxley's Elementary Lessons in Physiology and Martin's Human Body.

The Lessons.

1. Let the teacher introduce the subject in a few words, and then, touching the head, ask, What is this called?

So with the trunk, arms, and legs. Can compare them to the limbs and trunk of a tree.

2. What is the *shape* of the *trunk*? Let volunteers draw on the board a front view (like the body of a violin) and a cross section (oval). Call attention to the grace and elegance of the beautiful curves of an *erect* human body, and speak of ways this erect carriage can be secured—such as carrying things on the head or walking with a broomstick across the back and through the arms.

3. **Skin.**—What is the whole body covered with? Its *color*?

How does it *fit*? (As though made for the body.)

How does it *feel*? (Soft, warm, smooth, thin, etc.)

a. The skin is double.

Who has had a blister? How did the skin under it look? (Red.) That was the *true* skin. How did it feel when touched? What is one important use of the tough, outer skin? (To protect the inner.)

b. The outer skin continually wears away.

The tough covering of the true skin takes all the knocks and rubs. What must result? (Every time we wash our hands, and especially if we use soap and nail brush, some of this must be rubbed off. Notice how soon a pair of gloves made of tough leather begin to show wear.)

One illustration of this has always impressed me. When a boy, on my father's farm, we had a great deal of corn to husk. Dry corn husks are very rough and harsh, and sometimes the men would wear buckskin gloves to protect the hands. These stout gloves would *wear through* on the fingers in a few *days*' use, while the bare fingers, although they got very red and sensitive, could be used *weeks* and *months* without wearing out.

c. Feeling is a guard against injury.

When we came home after a day's husking we could hardly handle the silver spoon in our hot coffee or take up a hot biscuit, so sensitive was the worn skin. We might burn or cut ourselves very severely if it were not for *feeling*.

Stick two pins in a cork or piece of thick paper so as to have the heads one eighth of an inch apart, and then, closing the eyes, let some companion test the exposed parts of the body (back of hand, finger tips, face, lips, tongue, and cheeks), now touching with one and again with both pin heads, to find where feeling is most sensitive, and where you can distinguish between *one* and *two* points.

d. Oil glands to keep the skin soft.

Take a slip of paper the size of the finger, and rub the middle on the sides of the nose. Then begin at one end and write across it to observe the difference in the way the ink flows. Why does it flow less readily where the paper was rubbed? (Oily.) Did you ever think why, in writing, it is well to have another sheet of paper or a blotter under the fingers? Why will not an old blotter take up the ink readily? (Oily from much handling.)

e. Chapped Skin.—If you should dip your hand in oil and then in water, what would the oil do? (Separate, and rise to the top.)

Just so if our hands are much in water: the oil leaves them, and when dry the skin is apt to crack—sometimes so deeply as to bleed. How can we cure this? (Rub on glycerin or mutton tallow, or better, cocoanut-oil soap, to take the place of the lost oil.) What time of the day is it best to do this? (At night.) Why? (The least danger of hands being used again before they heal.)

4. **Hair.**—What grows from the skin?

Where is it *not* found? (Palms of hands, soles of feet, lips, etc.)

What color? (Varies.)

What shape? (Develop the idea of *cylindrical.* Straight or curly; long or short.)

Use? (To protect exposed parts and for beauty.)

Care of the hair? (Comb and brush frequently and rapidly; this warms it by friction and brings out the oil, which makes it glossy. Do not *wet* it often, or the oil and gloss will be lost.)

5. **Nails.**—Where are the nails located? (On upper side of finger and toe tips.)

Their color? (The *pink* is due to the red skin below.)

Their shape? (Curved sheets with rounded ends.) Let the class (*volunteers* always) draw the shape of a finger nail in as many ways as they can.

Can we *move* our nails like a cat?

Use? (To stiffen the ends of the fingers and enable us to pick up small things, etc.) What can you see on the nail? (Parallel lines.)

Do these suggest anything the nail may be considered as made of? (Parallel *hairs* grown together.)

Care of the Nails.—Scrub them with soap and a brush, keep neatly trimmed, and clean with a bone or ivory cleaner rather than with a sharp knife. Never *bite* them! Well-kept nails are a great addition to beauty.

6. **The Arms.**—Where are the shoulders?

What spring from them? How many arms have we?

Why are they *stiff*? (Bones in them.)

Can you see the bones? What is over them? (Skin and flesh.)

Where, then, are the bones? (*Inside the skin and flesh.*)

Are the bones all in one piece? (Distinguish "fore-arm.")

Can you bend the arm? How many ways can the arm move?

What do we call the places where this bending takes place? (Joints.)

What do we call the joint to a door? (Hinge.)

Are there "hinge" joints in our arms? (Elbow.)

Is the shoulder joint a hinge? (Show the class the hip joint from a boiled leg of mutton, of a dog, or some other animal.)

What name shall we give to such a joint? (Ball-and-socket.)

What ways does such a joint permit motion? (Nearly all ways.)

What joints, then, has the arm? (Ball-and-socket at shoulder and hinge at elbow.)

And the forearm? (Hinge joint at each end.)

Which way does the bent elbow point? (Backward.)

7. **Hands.**—What do we call the ends of the arms?

What is the general outline of the hands? (Oval.)

What do we call the place where they are fastened to the arm?

What kind of a joint is the wrist? (Hinge.)

Can the palm be held uppermost? See if you can find how the bones will permit this remarkable motion to be made.

How many joints in the whole hand? (14.) What kind of joints?

What parts to the hand can you name? (Palm, fingers, and thumb.)

Of what use are our hands? (Take food, hold things, etc.) *

8. **The Palm.**—Where is it? Shape? Notice the *lines* crossing it.

Is it hairy? Why best not hairy?

9. **The Fingers.**—How many? (4.)

Which is the first or "index" finger? (Next the thumb.) Second? (Middle.) Third or "ring"? Fourth? (Little.)

Which finger do you point with? (First.)

Which is the longest? (Middle.) The shortest? (Little.)

What shape are they? (Cylindrical.)

What do they spring from? (Palm.)

How many joints in each? What kind of joints?

What do they touch when flexed? (Palm.)

Are they webbed between?

Of what use are they? (To grasp and hold things.)

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* Dwell upon the *wonderfully* varied motion and adaptability of the human hand. Nothing else approaches it in all the animal kingdom, and man owes his advanced state of civilization largely to the capacity of his hand to carry out the bidding of his brain.

How are the ends protected and stiffened? (By nails.)

10. **Thumb.**—Where does the thumb spring from? (Wrist.)

How does it differ from the fingers? (Stouter, shorter, and one less joint.)

What motions has it? (Many.)

Can you easily touch the tip of each finger with it?

Because of this we are said to have an "*opposable thumb.*"

Of what use? (Meets the fingers in grasping and holding.)

11. **The Lower Limbs.**—Where do these spring from? (Lower end of trunk.)

What stiffens them? (Bones.)

Is the bone in one piece? Teach distinction of "thigh" and "leg."

What kind of joints has the thigh? (Ball-and-socket at hip, and hinge at knee.)

What joints has the leg? (Hinge at each end.)

Which way does the knee point? (Forward.) And the heel? (Backward.)

The knee is a very important joint, and injuries to it are apt to cause lameness, especially if the blood is impure.

Of what use are the lower limbs? (Walk, run, stand, etc.)

12. **The Feet.**—The leg ends in the ankle joint. This, like the wrist, is made up of several bones firmly bound together with gristle.

Whenever this gristle, by a sudden *twist* or wrench, is injured or torn away from any of these bones, a *sprain* results, which is not only painful but very apt to harden in healing and cause a *stiff* joint. Hence a "sprain" should be kept *quiet* and *carefully* tended. Active children need much courage to do this.

What is the general shape of the foot? (Wedge.)

Draw on the board the print a naked foot would make.

What happens when a shoe has a narrow toe or is too short? (Toes crowded against each other and "corns produced.")

What sort of heel should a shoe have? (Broad, low, and well back.)

What motion has the foot? (Up and down, mainly.)

It is used to—? (Stand and walk on.)

How are the toes directed? (Forward, and a little apart.)

Why does the heel project back? (Broader support.)

Of what use is the arched instep? (A spring, to lessen the jar to the body in walking and jumping.)

How is the foot put down? (The heel, ball, and toes resting on the ground.)

What *parts* can be named? (Heel, sole, instep, and toes.)

13. **Sole.**—Where is this? Of what use? (A soft, tough pad to protect the foot.)

14. **Toes.**—How many?

Of what use? (To propel the body forward in walking.)

Care of the Feet.—The feet should be kept *warm* and *dry*, and frequently bathed. Rubber boots or sandals are injurious to wear, except in the wet, and should be removed in the house. Never go to bed with cold feet. A hot-water bottle is cheaper than the doctor.

15. **The Muscles.**—How does raw beef look? (Red, and with a grain to it.)

Who has noticed fibers of boiled corned beef or chicken?

Stretch a thick bit of elastic; as it lengthens it becomes—? (Thinner.) As it shortens—? (Thicker.)

Hold the left forearm out straight, and, clasping the middle of the arm with the right hand, flex the forearm till the hand touches the shoulder. What do you notice? (A *swelling* of the arm.)

Grasp the calf of the leg with the hand and work the toes. (Motion.)

Clasp the forearm in the hand and work the fingers.

Under the skin and protected by it, lies our flesh. It is red like beef, and made of many little fibers bound into bundles by a tough tissue such as you often see in meat. The fibers are called "muscle fibers," and the bundles of these form the *muscles* of our body.

Muscle contracts and causes motion.

Muscles, like the India rubber, have the power of shortening in length and thickening in width or bulk, as you found in the arm. Most muscles are fastened to the bones, and when they contract *move the bones* and the limb they are in.

Where are the ends of the great muscle of the arm fastened? (To the bones of the arm at upper, and of the forearm at lower end.)

Where the muscles that move the fingers? (Forearm and fingers.)

Where the muscles which cause the leg and foot to swing forward on the knee? (To the thigh bone above, and, passing by a curious sliding bone (kneecap) over the knee, to the leg below.)

The bones are levers.

If a very heavy stone or log is to be overturned, how would you do it? (Use crowbar or some kind of a stiff bar to pry with.)

Such a stiff bar is called a *lever*, and that which moves it is called the *power*.

The first-class lever is like a crowbar when used to pry *up* by pushing *down* the other end.

Can you think of others? (A seesaw, a balance, a pump handle, a pair of scissors, a nutpick, a poker, a claw hammer drawing a nail, etc.)

Where is the weight or work to be done? (At one end.)

Where is the force or power applied? (At the other end.)

Can you make out any such levers among our bones? (The foot, when we tap on the floor with the toes.)

What power causes the motion? (The muscles.)

The second-class lever is like a bar used to pry a thing along.

Where is the weight or work? (In the middle.) And the power? (At the end.)

Can you think of other second-class levers? (Wheelbarrow, nutcracker.)

Can you discover second-class levers in the body? (The foot, when we rise on tiptoe or in walking.)

The third-class lever is like a pair of tongs.

Where is the weight or work? (At one end.) And the power? (In the middle.)

Name other third-class levers. (Fishing rod, sheep shears, pincers.)

What third-class levers in the body? (Forearm when being flexed; the body in raising a weight; the leg when anything is lifted on the toes, etc.)

How many classes of levers are there? (Three.)

Muscles wear out with use.

Each contraction, each motion results in some muscle tissue being destroyed.

Why does a man who works *very* hard grow thin and lean? (More loss than gain.)

Why are very poor people also thin? (Have not enough food.)

What has "food" to do with it? (The worn-out muscle tissue must be repaired, and food is necessary.)

Which is fattest—a moderately working or an idle horse? (Idle.)

Which is *strongest*? (The working horse.)

Should you think colts, lambs, and children would wear out much muscle? Why? (Play and move about so much.)

Why is this *best*? Yes, they are growing rapidly, and small muscles must develop into larger ones as the body grows.

Do boys, calves, colts, etc., *eat much*? Why do they need to?

If confined in any way so that they could not exercise, would their appetites be as good?

Why not? (Little waste, and so little call for food.)

Why do girls so often have poor appetites? (Don't exercise.)

Use of the muscles improves them.

From what has been said, does proper *use* seem to improve the muscles? Why?

Is moderate work, then, a *blessing*, or a *hardship*?

Let me impress this important truth. The proper use of any of the powers God has given us will *strengthen* them and *benefit* us.

How will disuse affect them? (Will grow weaker and weaker.)

How about overuse or improper use? (Will weaken.)

The mole doubtless once had eyes. Why has he lost them? (Not used.)

That giddy, thoughtless girl has a brain, but she won't use it. What will the end be? (Unable to think to any purpose.)

That boy is reading the fine and poor print of a trashy novel by a dim light. Will such use "improve" his sight?

Will reading of fights and wicked doings improve, or degrade?

How about *thinking* of evil things? (Strengthens the evil.)

From your own experience, do you find doing and thinking *really* makes it easier for you to do and think such things again?

How, then, should we always strive to do and think? (*Rightly.*)

As we have first to learn what *is* right, we see the need of such a book as the Bible and such a life as that of Christ. Study these, follow their teachings, and we shall not fail to do the most for ourselves and the world.*

Our telltale faces.

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* Such a poem as Longfellow's Psalm of Life or Bryant's Thanatopsis, and Miss Yonge's Book of Golden Deeds will be helpful in cultivating this thought.

Why is it that babies will go to some strangers and not to others?

Why are children afraid of some people and why do they confide in others?

Why do I consider it an honor for a stranger to trust me?

How does it happen that beggars will more often ask of some people than of others?

How do you suppose a conductor of a crowded train can tell, almost without fail, who have paid their fares?

Do you think the expression of the face changes with the thoughts?

Why do not people in the wrong look you full in the face?

Habitual expressions become fixed.

If, then, as I think all will agree, there is a constant play of expression on the face, recording much of the thoughts and purposes within, I have some important questions to ask.

If a boy exercises the *scowling* muscles, will they improve?

If that girl frequently uses the *sneering* muscles, will *they* improve?

What kind of an expression will that kind-hearted girl have when she is grown?

Will she be more, or less, beautiful?

Why is it that a liar does not look in your face when talking?

Is that manly expression of sternness with which a boy refuses to join in wrongdoing indicative of anything?

Can you tell by a girl's face whether she is studying or idling?

If 50 people — rogues, gamblers, impure, profane, or drunkards — and 50 others — kindly, unselfish, charitable, honest, and Christian people—could all be dressed exactly alike and then mixed together, how many mistakes would an ordinary person make in separating them again?

Remember, then, that your character will stamp itself on your face in spite of everything.

Which muscles will you choose to cultivate? Why?

16. **Food to repair Waste.**—If the muscles and skin, to say nothing of other parts of the body, are constantly wearing out, what must happen if we are to live and continue to exercise? (Repair.)

Did you ever hear of anything but a fairy castle that was built of *nothing*?

What, as far as you have observed, is needed to repair our bodies?

See what I am going to write on the board. Now name as many kinds of things we take into the body as you can, and tell me where to write them.

KINDS OF FOODS.

Never spoil.	*Spoil slowly.*	*Spoil quickly.*
Air	Oatmeal	Meat
Water	Bread	Fish
Salt	Butter and fat	Oysters
	Potatoes	Eggs
	Cake	Milk
	Fruits	
	Sugar	

Some of these belong in two columns—as butter, which is made from the cream of milk; if not well worked, the milk left in it quickly makes it spoil.

Our bodies are *wonderful* machines! All we have to do is to supply suitable material in proper amount, and the machine then proceeds to clean itself, oil itself, repair its breaks and worn parts, grow larger or even *new* parts as they are needed, and keep it all at a steady temperature!

Who can name another machine so "fearfully and wonderfully made"?

All the three classes of foods given are needful, and in order to understand what follows I will say this:

(1) Those that never spoil are not *real* foods, but only elements of the others.

(2) Those that spoil slowly—the *starch* of bread, fruits, and potatoes, the *fat* and butter and the *sugar*—mainly serve for *fuel* to keep us warm.

(3) Those that spoil quickly—meat, milk, eggs, etc.—can alone supply the material to build and repair nerve and muscle.

It is said that a dog will die inside of 50 days if fed on white bread and butter.* Why? (Not enough *building* material.)

Would the addition of *sugar* help him? (No, only heating food.)

How would candy do? (No better.)

Cake is mostly starch, fat, and sugar. Would that improve the dog much?

Would all this be equally true if we put the word "child" in place of "dog"?

What improvement could you suggest that would give the body a better diet? (Use some milk, meat, and egg in place of part of the fat and sugar.)

Having considered the kinds of foods needed, the next question is, *How* are these foods *procured* and *prepared* to nourish the body?

17. **The Eyes see the Food.**—Where are the eyes? (In the front of the head, on either side of the nose.)

How set? (In deep sockets.) Why? (Protection.)

What is the shape of the eye? (Globular.)

What parts can be seen? (Lids, ball, tear.)

What motions of the lids? Of the balls?

Observe some one else, and tell me how the movements of the balls differ from that of the lids. (Both always move exactly *together*.)

How many lids are there? Which way does the bottom one move?

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* See Hutchinson's Physiology, p. 63, quoted from Flint's Physiology.

Observe some one not thinking of it, and count the number of winks in a minute.

If you look fixedly (without winking) for a time, how do things appear? (Blurred.)

Can you see as well when facing a wind? How about winking? (Faster.)

What happens when one cries? (Tears roll down cheeks from inner corners of the eyes.)

Let me show you where the tears come from. (Show location of tear gland.)

These *glands*, as they are called, can strain much or little tear-fluid from the blood, according as it is needed.

How does it get from the gland to the inner corner of the eye? (Lids carry it.) When? (In *winking*.)

What will the closing lids do to the ball? (Moisten it.)

How did the wind or fixed look cause trouble? (Eye became *dry*.)

On the inside corner of the eye is a little *drain* to carry the extra tear-fluid into the nose.

Why did you blow your nose on coming in from the wind? (Less tear-fluid needed by eye, and so more ran to nose.)

After crying—? (Much ran into nose.)

Of what use are the lids? (Moisten and clean the ball, and protect.)

Of what use are the eyelashes? (Keep out dirt, screen from bright light, and for beauty.)

Use of the tears? (Moisten and cleanse ball.)

Use of the ball? (To see with.)

What change takes place in the eye on coming from dim to strong light? (Pupil contracts.)

Look at a book and then suddenly look at some distant thing. After a moment's look, return quickly to the book. What did you notice in each case? (Things blurred at *first*.)

Yes, the eye has to change a little in turning from near to far or far to near objects, just as a spyglass needs adjustment.

What did we call the things that caused the bones to move? (Muscles.)

It is the same in the movements and changes of the eye, and the eye muscles can become weary as well.

The iris is a circular curtain or shade floating in a liquid, and drawn back and forth by many little muscles.

When do these muscles contract? (In a dim light.)

What do they do in a strong light? (Those that close the opening contract.)

In a medium light? (Both sets are relaxed.)*

The lens of the eye is changed by muscles, being *flattened* when we look at distant things, and becoming more convex when we see near things.

Now you can answer some questions.

Why does reading by a dim light fatigue the eyes?

Why should we not look long at very *bright* lights?

Why does fine print fatigue the eye?

What kind of a light falls on a book through the window of a car passing buildings, other cars, or even with the smoke drifting by? (Constantly changing.)

How about the *distance* from the eye to the page when riding or moving in any way? (Changing.)

Why are such things bad for the eyes? (Constant changing fatigues.)

Some of our great men learned their lessons by the light of a fire or pine knot. Why was it a poor light? (Changeable.)

I never heard that their eyesight was poor. Why not? (They had few books to read, only read a little at a time, lived a simple life, with plenty of fresh air, and so were able to do such a thing and not suffer.)

How should we sit when reading? (With our backs or left shoulders toward a steady light, which is near and strong enough to enable us to see *easily*.)

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* Show the lens in some kind of an eye. If two are got, and one *boiled*, it can be dissected with greater ease, and help to an understanding of the natural one.

Have we any way of knowing that our eyes are being injured? (At first they *feel* strained and as though cobwebs were in them, and, if we continue in the wrong practice, become red and sore.)

Do you know any use for *pain*?

Eyebrows—where are they?

Which way do the hairs run? (Outward.)

Who has seen a person with a very sweaty face?

Where did the perspiration gather and drip or run? (End of nose and sides of face.)

Of what use are the eyebrows? (Keep sweat out of eyes by carrying it to the side.)

How does a tear *taste*?

18. **The Nose tests the Food.**—Having decided by its looks that a thing is good to eat, how do we get where it is? (Our feet carry us.)

How do we take and carry it to the mouth? (With the hand.)

Where is the nose? (Between the eyes and just above the mouth.)

What parts can you name! (Bridge, tip, nostrils.)

Is the "bridge" a straight, or curved, line?

Does it curve *out*, or in?

How do "tips" vary? Which way do they point?

How many nostrils are there?

Which way do they open? Toward what? (Mouth.)

What passes through them? (Air.)

Should this air contain odorous particles, we—? (Smell them.)

To give you an idea of how very small things the nose can smell, the following is told: Some musk was weighed very carefully and then exposed to the air. It kept giving out its odor for several *years*, but when again weighed it could not be discovered that it had *lost any* weight!

What uses for the nose? (Tear drain; to smell with, and so *guard* the mouth.)

If things smell badly are they good for food? (Not as a rule.)

19. **The Mouth.**—Where is the mouth ? (Just below the nose.)

Its shape ? (A *cross* slit.)

What parts can we name ? (Lips, teeth, tongue, saliva.)

Of what use is the mouth to us ? (Eat, talk, sing, etc.) *

20. **The Lips.**—What shape are the lips ? What color ?

What motions ? Are lips sensitive to touch and heat ?

Some muscles are not attached to bones. One of these surrounds the mouth, and by shortening puckers it up.

Of what use are the lips ? (To test the temperature of food; to *take* food, as from a spoon; to close the mouth in eating, impolite and rude not to; to drink, with by closing air tight about the dish or tube while the air behind is exhausted and the liquid flows in; and to aid in talking.) †

21. **The Tongue.**—Although the food has been examined by eye, nose, and lips, it is once more tested, that it may be rejected, if unsuitable, before the final swallowing makes it too late.

What receives the food after the lips have taken it ? (Tongue.)

Where does the tongue lie ? (In the center of the mouth, back of the teeth.)

How much of this space does it fill when the mouth is shut ? (*All.*)

Which end is fastened ? (Rear.)

What is its shape ?

What kind of a surface has it ?

Can you *feel* with it ?

Why can you not taste sand ? (Insoluble.)

How does the saliva aid in tasting ? (Dissolves the substance.)

A fruit often looks and smells nicely, but is decayed or wormy inside. How do we find it out ? (Taste.)

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* Learn Psalm xix, 14; Luke, vi, 45.

† Prov. x, 19, 21; xvii, 28; xxii, 11.

Sometimes, as in a pill, taste is not observed till it is crushed. How is the crushing done? (Teeth.)

What uses for the tongue? (Moves the food about in the mouth; tells if it is too hot; tastes, to see if it is "good"; and aids in talking.)

How would a blind person judge of his food? (Smell and taste.)

If very strong smells or tastes are experienced, can we observe weaker ones? (Not for a time.)

Suppose such violent sensations were often repeated—? (Taste and smell become *blunted* and unable to detect or enjoy delicate ones.)

Is it correct to use the word "enjoy" regarding taste and smell? (Certainly; all our healthy sensations, while useful and necessary, are also most certainly pleasing.)

Why did I ask my landlady, who made all the food "hot" with spice, pepper, and curry powder, if her other boarders *smoked?*

A workman of mine, who smoked almost all the time, was unable to taste or smell anything.

A pale, nervous man, sitting near me at dinner, added red pepper to salt on his oysters, and also vinegar and mustard. I inferred that he was a smoker.

Can you "eat your cake and keep it too"?

Which will *you* choose to be—sweet, clean, and enjoying the delightful tastes and odors of fruits, flowers, etc., or forfeit these, and make yourself disagreeable to clean people by smoking and chewing tobacco?

Aside from injuring himself and wasting his money, is it *right* for a man to make himself disagreeable to others?

Do taste and smell at first approve of tobacco?

Do you like the taste of beer? (Not at first.)

How does whisky or any strong liquor affect the sense of taste? (Very unpleasantly.)

How does the breath of a drinker smell? (Disagreeably.)

Does wine please the senses of sight, smell, and taste? (Yes.)

Why should we not drink that which is so pleasant?

(1) It leads to stronger drinks, and a drunkard's useless life and miserable grave.*

(2) It is *selfish*. There are too many hungry and poorly clad people in the world, too many heathen dying for want of the gospel, to use our money in drinking.

(3) Even though *we* may think ourselves strong enough to drink a little and then stop (although *many* smart men have tried it and found they were *not*), there are many about us who evidently can not control themselves, and it is our *duty to help these*.†

22. **The Teeth.**—Where are the teeth? (Just inside lips and cheeks.)

How arranged? (In two semicircles.)

What are they set in? (Gums.)

How many are there in each jaw?‡

If you have a cake to bite, which teeth do you use?

These are called cutting teeth or "incisors."

How many incisors in each jaw?

Let us write them: $i\,\frac{2-2}{2-2}$.

What does "i" stand for? Who can explain the $\frac{2-2}{2-2}$? (It means 2 teeth in each half of both jaws.)

If you have a bit of tough meat or cloth to tear, where do you take hold of it? (At corners of the mouth.)

Feel of these teeth. Are they like the incisors? (No, more pointed.)

We call these "canine" or tearing teeth. How many?

What does $c\,\frac{1-1}{1-1}$ mean?

If you have a hard candy or grain of popcorn to crush, where do you place it? (Between back teeth.)

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* Prov. xx, 1; xxiii, 29–32; Isaiah, xxviii, 7, 8.

† If proper, have the class commit to memory verses from Proverbs, and St. Paul's resolve in like case, Rom. xiv, 13–21.

‡ This will vary from 20 to 32, but in most 9-year children will be 24.

What puts it there? (Tongue.)

What kind of teeth are these "back teeth"? (Broad and large.)

How many in each jaw?

What shall we call them? (Grinders or molars.)

How shall I write them? $\left(m\,\frac{3-3}{3-3}.\right)$

Count up and see if this is the right number.

What color are the teeth?

Of what use? (Cut, tear, and grind food, and for beauty.)

Is the top of the tongue above or below the lower teeth? (Above.)

What lie close to the teeth on the outside? (Cheeks.)

If food slips off the tongue, where *must* it get? (Between the teeth, to be ground up.)

How does the saliva aid? (Softens and prepares the food.)

The tongue in the center and cheeks outside make a sort of *ditch* for the food to lie in while being ground.

A child's jaw is small.

How is he ever to get 32 large teeth in it? (As it grows, the small first teeth fall out, and more and larger ones come.)

If the second teeth are lost, will new ones come in? (No.)

It is *very* important that all food be well chewed, and the loss of the teeth is a serious matter.

How can the second teeth be lost? (Accident and decay.)

Accidents we can not help. How can decay be avoided? (By cleaning with a stiff brush and water after *each* meal.)

How can we tell that decay has gone far? (Toothache.)

What use for *feeling* in our teeth? (To aid in chewing, and to warn.)

If some hot water is dashed on cold glass, what is apt to happen? (Break.)

If hot glass is suddenly cooled? (Same.)

What has this to do with our teeth? (Bad to drink very hot or cold drinks, especially following each other.)

Is there any other way of cracking the "enamel," as the hard covering is called? (By biting nuts and hard things.)

Is this wise? (No, only ignorant or foolish people do so.) *

23. **Saliva.**†—What uses do we know for the saliva? (Dissolves for taste, and softens.)

There is another very important use.

Arrange some time with the children when experiments can be tried, and then proceed: Will suppose there are *10* in the class. Here is a can (large tin fruit-can will do well) of water which we will set to heat. Let us make 6 nearly equal-sized pieces of this bread (no crust), and 6 of the white, solid part of this boiled potato. Each take his notebook or a sheet of paper and draw what I do, having as many horizontal lines as we have test tubes (14 in this case, numbered 1 to 14).

No. of tube.	Put in it—	Result.
No. 1....	Sirup + copper test for sugar.........	
No. 2....	Starch (raw) + sugar test..	
No. 3....	Bread (crumbled) + " "	
No. 4....	Chewed bread (Alice) + " "	
No. 5....	" " (Sam) + " "	
No. 6....	" " (Paul) + " "	
No. 7....	" " (Mary) + " "	
No. 8....	" " (Ethel) + " "	
No. 9....	Potato (mashed) + " "	
No. 10....	Chewed potato (John) + " "	
No. 11....	" " (Kate) + " "	
No. 12....	" " (Hubert) + " "	
No. 13....	" " (Ralph) + " "	
No. 14....	" " (Amy) + " "	

* For the next point (saliva) the teacher will need some of Trommer's copper test for sugar. To 100 c. c. of water add 2 grammes each of copper sulphate and tartaric acid. To this solution add caustic-potash solution till it feels slippery to the fingers. Bottle and keep for use. Cork with a sound cork, smeared with vaseline, or do the same to a glass stopper.

† Let the teacher show pictures of the 3 pairs of glands which separate this from the blood.

Each will see now what he or she is to do.

Chew the bread or potato for 1 minute, and then spit the ground-up food and saliva into the test tube having your number on it, and stand it in the can of water.

While you are doing this I will fix the other 4 tubes.

Proceed to pour ¼ inch of sirup in No. 1; a bit of starch as large as a marble (powdered) in No. 2; crumble the bread fine and put in No. 3; and mash the potato for No. 9.

When the 14 tubes are ready, promptly pour 5 c. c. (2 inches) of the sugar test in each and set the can on to boil for 1 to 3 minutes, or till *some* of the solutions have turned brown. Then take it off the fire, examine, and fill in the column of "results," which should be, if all has gone right, as follows:

No. 1: Turned *brown.*

No. 2: Not, or but slightly, changed.

Nos. 3 and 9: Slightly brown.

Nos. 4 to 8 and 10 to 14: *Brown.*

Has sirup sugar in it?

What is the test for sugar? (Brown color.)

Does starch behave the same as sugar?

What is bread and potato mostly — starch, or sugar? (Starch.)

What proof? (Neither changed color much.)

Why did they change a little, as raw starch did not at all? (Cooked.)

Why did all the *chewed* food show so much change? (The saliva turned some of the *starch* to *sugar!*)

Yes, it is truly *wonderful* how rapidly this is done.

What is the other use for saliva? (To turn the starch of our food to sugar.)

Why is it important to chew our food *well?*

Why is it injurious to health to *spit* much?

Is it polite to spit on the floor or before people?

Tobacco users spit a great deal. What is another reason for not using tobacco?

24. **The Throat.**—If, after the tests of eyes, nose, and

tongue, aided by the teeth and saliva, we are still satisfied with the food, it is *swallowed.*

Can a boy, hanging head down, swallow? (Yes.)

Does the food *fall* down the throat? (No, there are more circular muscles, like those about the mouth and iris, to carry it down—or up.)

I once saw an instructive sight on a train. A boy and two ladies were eating some lunch, and a pie was brought out and cut in quarters—one for each, and one piece left over. The boy seemed afraid that one of the ladies would eat her piece first and have the extra piece, so he took one or two hasty bites and then crammed the rest all in his mouth at once and tried to swallow.

Did you ever see a hen work her head and neck when she has too big a mouthful? Well, he did the same; turned red, and then black in the face, as he tried to force it down, till I was really frightened. At last, with a heroic struggle and a gasp, he succeeded, and *at once* reached out a dirty hand and grunted "More"!

Suppose he had not been able to succeed—? (Would have strangled.)

Of the boy's conduct nothing good can be said, but what mistakes did he make? (Did not chew his food, and tried to swallow it in too large pieces.)

What is another reason for chewing the food fine and moistening it with saliva? (So that it can slip down the throat.)

25. **Stomach.***—This is a bag or pouch where the food first stops after its passage through the throat.

It is covered with a soft, velvety lining, and has muscles running around and lengthwise. (See tripe from cow's stomach.)

When food enters it the surface "blushes," and a sour fluid begins to ooze out, called *gastric juice.* This has power to *dissolve the real building-up foods*, such as meat, eggs,

* Have a piece of tripe to show.

milk, and fish, when *warm*, but can not touch starch or fats. As the gastric juice flows on to the food, the muscles running in both directions contract alternately, and so knead or churn the food, bringing all parts in contact with the soft, moist walls, which soak up and send into the blood some of the dissolved portion.

Why is food in *unchewed lumps* hard to digest? (Solvents can not get at it.)

Why is much ice water or *very cold* food injurious? (Cold stops digestion.)

Why should we be well clothed over the stomach? (To keep it warm so that it can work.)

Why is *too much* food at once harmful? (More than the stomach can handle.)

Why does milk "disagree" with many people? (They use it as water, and, being really a nourishing *food*, overload the stomach.)

Why do we have the "*stomach ache*"? (To let us know something is wrong.)

If from any cause—wrong food or a disordered stomach—food is not wanted, the stomach violently contracts and we—? (Vomit.)

Is it best it should throw off the food? (Yes, better than to keep it.)

After the food has remained long enough, a "doorkeeper" (pylorus) lets the finer portions first, and the coarser fragments later, out into the *intestine.*

26. **The Bowels or Intestines.**—But little can be said of these. Show some chart or cut, and notice how the "small" intestine succeeds the stomach and ends in the "large" intestine.

Here the starch, which was not changed (to what?) by the saliva, is turned to sugar, and the fats made into a milky fluid. After the intestines have soaked up all they can, the undigested lumps, which have been a source of trouble ever since they hurt in swallowing, and all refuse and useless matters, gather for ejection from the body by a "*movement* *of the bowels.*" That this be *regular* is of vital importance, for the mass of refuse rapidly decomposes and gives rise to headache and various disorders.

Such an important matter should not be omitted from any false idea of propriety, as often happens when a child, or even grown person among strangers, is ashamed to ask the way to the closet.

27. **The Outer Skin and Inner Lining of the Body are the Same.**—So much hinges on this, I should want the pupils to understand that the tough outer skin passes in at the lips and forms the delicate lining to the interior organs, and that which hurts *one* part of this *affects the others also.*

Why may wet feet result in a sore throat?

Why does improper food cause pimples?

Why may a chill to the skin result in a "cold"?

Why may a "wetting" result in earache or toothache?

Why is a hot-water bag good for the colic?

Why is it said the best place to wear lung protectors is *on the feet?* (Rubbers.)

28. **The Dissolved Food passes into the Blood.**—What was the first step in getting food to repair waste? (*See* it.)

The next? (Take it.) Next? (Nose tests.)

The next? (Put in lips.)

Then? (Bite and chew it.)

Then? (Tongue tests it.)

Then? (Saliva dissolves the starch.)

It is then— ? (Swallowed.)

What does the stomach do? (Dissolves the meat, etc., and soaks up some.)

The intestines? (Complete the solution of starch, fat, etc., and soak up.)

What is the color of blood? (Red.)

What is it like? (A watery fluid.)

What important thing does it contain? (Material to rebuild.)

Loaded with this it comes to the *right* side of the heart.*

29. **The Heart pumps the Blood all over the Body.**—Place the hand over the heart. Can you feel the beats?

Place the fingers of the right hand on the inside of the left wrist near the outer edge. (Pulse.)

Each count the beats in one minute, while sitting.

Count them again after running or exercise.

How are the beats of the heart and pulse related? (Same.)

What is "the pulse"? (Blood rushing to the hand from the heart.)

Feel the side of the neck and see if blood also rushes to the head.

When undressing, see if pulses can be found in the limbs.

30. **Stiff, Elastic Tubes, called Arteries,** carry the blood from the heart to the lungs and body. These keep dividing and dividing again till the branches are so "hairlike" as to be called capillaries.

Will a fine needle prick draw blood?

Does the skin or face look a *uniform* pink in blushing?

After heating or brisk rubbing does the skin look all red?

What do these things show as to the fineness of the capillaries?

Where are there none of these fine blood-vessels? (Hair, nails, and outer skin.)

Why is it needful that the blood go to every part? (To repair.)

How this repairing is done we can not now consider.

31. **Air.**—Where is air? (Everywhere.)

Is it of any use to us? (To breathe.)

Shut the dampers of a stove tightly. Will the fire burn?

If the openings in a lantern are closed—? (Goes out.)

Things must have air to burn. Let us try a beautiful experiment and learn some things about air.

Here is a shallow dish with a quart of water. In it I will stand this small bottle filled with sand. Why has it sand in

* The class will profit by the examination of a calf's or sheep's heart.

it? (So that it will not float and tip over.) If the bottle is less than 4 inches high, a crayon can be stuck in the neck. On the bottle I lay a small bit of tin (or any metal), and on that a piece of phosphorus the size of a pea. This is a very dangerous substance, and if handled with the fingers might take fire and burn them terribly; so I never touch it but with forceps, and always cut and keep it *under water*. See! the phosphorus is already smoking, as if ready to take fire. Here is a two-quart fruit jar, whose mouth is wide enough to go over the bottle standing in the water. With this all ready, I light the phosphorus and quickly invert the jar over it and push its mouth down below the surface of the water.

How it burns! What beautiful columns of white smoke! Now it has stopped burning, and see! the water is slowly rising in the jar! We will let it stand till the next lesson, and see how high the water will rise.

Now what do you notice? (Smoke all gone and water risen.)

Let us examine the air that is left. I will slip this piece of window glass under the mouth of the jar, so as to hold in the water and bottle of sand, while I gently turn it, mouth up, on the table.

What seems to be above the water? (Air.)

I light a match. Does it burn in air?

Gently sliding the sheet of glass off of part of the mouth, I put in the lighted match. (*Goes out.*)

Let us try again. (*Out* again!)

Is it really air? (No; will not help a match burn.)

Right! Air seems to be *one* gas, but is really *two*. One of these, called oxygen, helps things burn; while the other, called nitrogen, will not.

Which is now in the jar?

What became of the oxygen? (Was burned out by the phosphorus.)

What took its place as it burned out? (Water.)

How much O was there in the jar of air? (Measure the water.)

How much N? (The rest of the jar.)*

Air, then, is made of— ? (O and N mixed together.)

What part is O? (About one fifth.) Nitrogen? (Four fifths.)

Which of these gases helps things to burn? (Oxygen.)

32. **Carbon Dioxide** (CO_2).—Phosphorus, in uniting with O, formed fumes which disappeared in the water.

Do we see such fumes from a candle, wood fire, or oil lamp? (Not often.)

If the top of a lamp chimney is closed? (Goes out.)

Here is a wide-mouthed bottle. Into it I will lower this bit of lighted candle (by a wire twisted around it) and cover the mouth. Note what happens. (Burns fainter, flickers, and goes out.)

Light the candle and lower again. (*At once* goes out.)

Let me rinse out the bottle and try this again.

Before putting in the candle I will turn in this *lime-water.*†

What is above the water? (Air.) And air is composed of— ? (O and N.)

I will shake the air and water together.

Does O or N turn limewater milky? (No.)

Now I will lower the burning candle as before. When it has gone out, remove the candle and shake again.

How about the water now? (Milky.)

A gas came from the burning wax or tallow which we call *carbon dioxide* (or "CO_2" for short).

How does CO_2 behave with limewater? (Turns it milky.)

How is it like N? (Puts out a flame.)

This CO_2 comes from all burning and decaying wood, fat, starch, or flesh.

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* As the bottle and sand were in the jar before the mouth touched the water, their volume should be subtracted from the volume of N, which should be about *4 times* the O.

† Get some of the clear water above the lime in a mortar bed, or drop a piece of "stone lime," the size of an egg, into a large bottle of water and let it settle.

"*Choke damp*" is the name given to this CO_2 in coal mines, and many men have lost their lives by it.

33. **Water is made when Fats, Starch, etc., burn with Oxygen.**—When a kerosene lamp is first lighted, how does the chimney appear? (Dimmed by moisture.)

Hold a cold dry glass over a candle a moment. (Moist inside.)

I once knew a church where long pipes led from the large stoves through a cold upper room to the chimneys. There was great trouble from the black, watery stuff which dripped from the joints. Where did the water come from? (The fires.)

34. **The Nose is made to Breathe through.**—What use did we before find for the nose? (To test food.)

It is also intended to tell us about the air we breathe, and warn against impure air. The passages are narrow and moist, and there are hairs at the entrance.

I once visited an iron mine, where they burned oil for lights, and each of us carried a smoky lamp.

When I came out, my mustache below the nose was black with soot, and my nostrils so filled I had to wash them out.

Of what use was my nose? (Purified the air.)

Yes, all that smoke would have gone into my lungs had not the nose strained and purified the air.

How do the hairs help? (Check the air.)

And the moist, narrow passages? (Catch the dust, and warm and moisten the air ready for the delicate lungs.)

I think you can see now why we should *always*, when possible, breathe through our noses.

I have read that no one thing sends so many people to the graveyard as breathing through *the mouth.*

Keep trying till you learn to regularly breathe through the nose, especially when you first leave a warm room for the cold air of winter.

Do people that breathe through their noses *snore?*

35. **The Chest.***—After the air has passed the nose it enters the lungs. These are very important and very delicate. For their protection a kind of box is made by the stiff ribs, which is called the *chest.*

The ribs are kept apart in front by a flat bone called the *breastbone.* When young, this is thin and mostly gristle, so that it bends easily.

Suppose it does bend or double over? (Permits the ribs to press in and makes the chest *small.*)

This is a very serious thing, since much depends on a *full* and *ample chest.*

How is this bending apt to occur? (By growing children sitting in a doubled-up posture, bending over a desk, or by a lazy drooping of the shoulders.) †

How can the chest be expanded? (Stand and sit *erect.*)

Do you admire an erect carriage of the body?

How can this useful habit be acquired? (By trying and practicing. Walk erect and with the shoulders well back. Walk with a book on the head for 5 minutes each day. A cane across the back and through the bent arms also keeps the shoulders in position. Practice taking very *full* breaths.)

36. **The Lungs.**—Inside this stiff, protecting chest lie the two lungs. (Show pictures and diagrams.)

These are like huge and much-branched bunches of grapes, whose "stems" are *tubes* and "grapes" are hollow and thin-walled *bladders* filled with air.

In the walls of these bladders run a *multitude* of the little tubes we call capillaries.

What is in these capillaries? (Blood.)

How thick is the skin which separates the blood in the capillary from the air filling the bladder or "cell," as we call it? (*Very* thin.)

In such a case, where a warm liquid, like blood, is separated

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* Show diagrams and pictures.

† See the crooked breastbones of many chickens who have roosted too young.

from the air by a thin skin, we find it both gives to and receives from the air.

Let us first see what the blood *gains.*

37. **The Blood gains Oxygen in the Lungs.**—The blood comes from the right side of the heart, where we left it (28), to the lungs, and there, in addition to the food for repairing from the stomach, it gains oxygen and returns to the left side of the heart. From here it is sent flying to all parts of the body and skin. To do what? (Rebuild.) Yes, and something else.

38. **The Oxygen burns up the Worn-out Portions and keeps us warm.**—Coal is shoveled into the furnace several times a day.

Why does it not get full and stay so? (Burns out.)

What comes from burning coal? (CO_2, water, and ashes.)

What becomes of each? (CO_2 and steam go up chimney.)

The butcher brings meat, and the grocer flour, sugar, etc., day after day.

Why are they not told to stop? (Food continually eaten at table.)

Do any of you ever need new clothes? Why? (Wear out.)

Yes; the ashes must be shoveled out, and the old clothing cast aside, before new and fresh can be received.

Now, how often do we eat?

This food is dissolved, as we have seen, and passes into the blood to—? (Repair.)

Who can tell me what else must be done? (Worn-out parts removed.)

What does the blood contain besides building material? (Oxygen.)

Think of what we have talked of, and see if you can not tell me what happens. *Good!* That's it! The *oxygen burns out* the used-up tissue.

In doing this—in removing what is no longer needed—

what else is done which is very needful? (We are *kept warm.*)

Did you ever hear of anything more wonderful than these bodies of ours? Just think of it! After the muscles have done their work, the dead and used-up remains form part of the fuel to keep us warm!

Some one may wonder why we do not burn *all* up!

What is the difference between a live horse and a dead one? (The dead one quickly decays.)

Yes, the *life* in him would not let the oxygen cause decay, but as soon as the life is gone the oxygen begins to take him to pieces.

So it is only the used-up, "dead" portions of muscle and nerve which the oxygen in the blood can affect.

What did we find the oxygen of the air made out of fats, oils, meat, etc.? (CO_2 and water.)

Yes, and some other soluble things that we can not study now.

What kind of substances could the stomach absorb or soak up? (Dissolved.)

Yes; and will liquid water and gaseous CO_2 be carried by the blood as well?

39. **The Capillaries reunite to form Veins.**—Having done its repairing and gathered up the "ashes" from the burning which keeps us warm, the tiny capillaries unite and keep uniting to form the larger and larger *veins*, which are to return the impure blood to the heart.

Why do veins have no pulse? (No heart to directly pump into them.)

Why need they not be so strong as the arteries? (Only drains.)

To what side of the heart does the blood return? (Right.)

40. **How the Blood is purified in the Lungs.**—As the heart receives all this impure blood, what question naturally arises? (How are these impurities to be got rid of?)

Let us see. The blood now goes to— ? (The lungs.)

And there it gains— ? (O.)

Now in this world you may be sure that "there is no gain without corresponding loss."

What is it we wish the blood to lose? (CO_2 and water.)

Can any one suggest a way of testing the expired breath for these? (Very likely *not*, but give a chance.)

Here are test tubes (or little bottles), with limewater and a straw in each. Blow your breath gently through the straw, and let it bubble up through the limewater. What do you observe? What does it indicate?

Breathe on a clean, cold looking-glass or window pane. Is there water coming from the lungs? (*Show* one half pint of water, which is nearly the average daily amount from the lungs.)

Yes, as the O passes *into* the blood, the CO_2 and vapor of water pass *out*, and the blood is all the better for the exchange.

Why should we breathe *pure* air? (To supply O.)

Why breathe *deeply* and *full*? (So as to fill each cell of the lungs, and cause as quick and full an exchange as possible.)

Can we breathe deeply when bent over? (No; must be *erect*.)

Can we breathe deeply with tight clothing, like corsets, on?

Can we breathe deeply with a great weight of clothing on the hips?

Where should our clothing hang from? (Shoulders.)

Why should the air of occupied rooms be frequently changed? (To get rid of the CO_2 breathed out, and supply O.)

Why does impure air cause a poor appetite? (Waste not got rid of.)

Why are people who breathe bad air or take feeble breaths pale? (Blood does not get enough O.)

Why are they easily chilled? (The "fires" burn poorly.)

41. **How the Skin helps.**—Having got a fresh stock of O in exchange for part of its CO_2 and watery vapor, the blood goes back—to which side of the heart?

From there the arteries carry it through the body and also to the *skin.*

What does the skin give out? (Oil, to keep it soft.)

True enough, but what else? (*Perspiration.*)

What is that? (A salt-tasting watery fluid.)

What, then, does the blood get rid of in the skin? (Water and various salts.)

Here is a *quart* of water. Experiments have showed that to be about the amount daily given off from the skin. It is being given off all the time, although we only *see* it when it is forming faster than it can dry away.

42. **How the Body is kept from overheating.**—How hot are our bodies? (Test with a thermometer—98° F.)

Yes; if we place a thermometer *inside* the body—as under the tongue, or in a protected place, as the arm pit—we find, when *healthy*, our temperature is about 98° F.

If it fall even a little below this, we have a "chill."

If it rise a little above, we have a "fever."

Now, our bodies are often exposed to great heat, and still, in health, do not vary in temperature.

Bakers, it is said, will spend several minutes in the huge ovens hot enough to bake bread, and not be baked.

Men will work about iron furnaces, where it is *very* hot, and not get "in a fever."

In the heart of mountains, as when the Mont Cenis Tunnel was made between France and Italy,* the workmen found it *very* warm, and still, although very exhausting, their temperature remained the same.

We often work or play in the hot sun.

Who can think how our bodies are kept cool? (*Perspiration carries off the heat.*) Sweat is mostly— ? (Water.)

Is water well fitted to carry off heat? (The *best.*)

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* Find these on the map with the class.

What do we need often when perspiring freely? (Water to drink.)

As the cold water enters the stomach, how does *it* help? (Takes up the extra heat in getting warm.)

This warmed water goes into the blood and is sent to the skin to be again given off. But this is not the end of the cooling. Water not only takes a great deal of heat in warming, but when it comes to dry up—evaporate, as we call it—it takes a *great* deal more; more than *5 times* as much.

How does that help? (*Cools the skin as it dries away.*)

Let me give you an idea of how great this cooling is. Each hold his hand while with this dropper I place a drop of alcohol on the back. Rub it over the surface, and then gently blow to dry it away. How does it feel? (*Cold.*)

Here is a thermometer. It now stands at 68° F. I slip this little mitten of cotton cloth over the bulb, wet the cloth with ether (or alcohol), and put it in a draught, "fan" it, or wave it gently to and fro.

What is now happening to the ether? (Drying away.)

The mercury goes down and down—65°, 62°, 60°, etc.

What does this falling indicate? (Being cooled.)

What cools it? (The ether evaporating.)

Why is it dangerous to go with wet feet? (The heat is taken from them by the water.)

Why do we feel cool in a draught of air? (Evaporates the perspiration.)

Why does fanning cool us? (Hastens the evaporation.)

Why do we feel cooler after wiping the sweat from our faces?

Now, how is our body warmed? (Burning up of dead and worn-out material, and also unneeded fat, etc.)

How is it kept from "overheating"? (The skin, in freeing the blood of its extra water, also gets rid of heat as well.)

43. **Glands.**—What did the tear glands strain from the blood? (Tear-fluid.)

What, the 6 salivary glands? (Saliva.)

The glands of the stomach ? (Gastric juice.)

There are many other *very* important glands in the body, each separating some needed or some injurious substance from the blood.

Outside we found the oil glands to— ? (Oil hair and skin.)

Now look at the palms of the hands. What do you see crossing them ? (Many fine lines or ridges.)

If you could see these under a strong lens, rows of little openings (show picture) would appear along each. These are the mouths of the little coiled-up glands which take the perspiration from the blood.

44. **The Care of the Skin.**—What is being poured out upon the skin ? (Oil and perspiration.)

As the water dries away, what is left ? (Oil, salts, etc., and dead skin.)

How will these affect the mouths of the sweat glands ? (Stop them.)

Is it important they should be kept open ? (Very.)

How is it best done ? (By bathing.)

Who most need the bath—those who exercise much, or little ? (Little.)

Why ? (All the waste matter is left on the skin.)

How with those who exercise freely ? (Sweat more, and clothing removes it.)

When shall we bathe ? (Best on rising in the morning.)

Shall we use warm, or cold, water ? (Cold, if we are well.)

How shall we bathe ? (Combine *gymnastics* and the *bath*. Rub face, neck, arms, and chest *energetically* with the bare wet hands, and quickly rub dry with a coarse towel; then bathe the lower part of the body in the same way, and quickly dress.)

Do this daily in warm weather, and once in two days in the winter. Use plenty of *muscle* in the rubbing, and soap once a week.

45. **The Ears.**—One use of the lungs and mouth was to *talk*.

Do we talk to ourselves ?

How do others hear us ? (With their ears.)

These ears are, if possible, more wonderful than any other part of the body we have talked of, but we can not study them now. They need good care, however.

(1) At the end of the orifice is a very delicate part, easily injured; so follow the advice of a doctor, who said, "Never put *anything* into your ears smaller than *your elbow.*"

Do not poke pencils or things of that kind into the ear, and *never* fire a gun, cracker, or make any loud noise, close to an ear. It may ruin it for life.

(2) "Take heed *what* ye hear." Never listen to vulgar, profane talk, nor to bad things told of others. Do not choose people who talk in this manner for companions, nor stay in their company.

Follow General Washington's advice, and "never speak of a person unless you can speak well of him."

46. **Sleep and Rest.**—When do we sleep ? Why ? (Dark, and can't see to work or play.)

In what position ? (Lying down.)

Why is sleep needed ? (To rest and refresh us.)

When does the body wear out fastest ? (While working.)

When will it build up fastest ? (When asleep.)

Why will not *rest* or mere cessation from activity take the place of sleep ? (*Mind* active.)

Are *dreams* helpful ? (No; show mind is not resting.)

Why is it best to lie down ? (Easier for the heart to pump blood.)

Why do we need more covering when asleep ? (Slow-moving blood and slow breathing do not keep the body so warm.)

Do you know of any *reasons* for the old saying, "Early to bed and early to rise, makes a man healthy, wealthy, and wise" ?

Is night air as healthy as day air ? Have you ever *observed* anything to support your idea regarding this ?

Is there any good reason for the custom of sleeping *up-stairs?*

Should we sleep in *warm* rooms? Why not?

Should we sleep in the clothing worn during the day? Why not?

How shall we best ventilate a bedroom, so as to have fresh air but no draught? (Raise the lower sash an inch or two, and slip under it a lath or strip of board as long as the window is wide. This closes the opening at the bottom, and permits an even and gentle interchange of air at the middle. Never have openings on *opposite* sides of the room so that a wind can blow *across* the bed.)

What is the object of *rest?* (To fit ourselves for more work.)

What does recreate mean? (Re-create—make anew.)

Is recreation which keeps us up late at night and leaves us "tired out" the next morning, rightly named?

What do you think of the honesty of men or women, whose time is paid for by their employer, making a practice of being so engaged evenings as to be sleepy and "used up" the next day?

Does a student need much, or little, sleep?

Why is the Sabbath a wise provision for our best interests? (Because people need frequently to lay aside *entirely* the cares and business of every-day life.) *

47. **Character.**†—What do we mean by *character?* (What we really *are.*)

What do you understand by "truthful"? ‡

48. **A Baby.**—What is a very young child called?

Is he able to care for himself?

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* Learn Isaiah, lviii, 13, 14.

† Dwell here on *desirable* traits only.

‡ Let the class illustrate from their own experience; let the reading and language lessons of the day center around the thought, and perhaps read selections to the class which shall illustrate the power and beauty of *truth* in all things. Then take up other terms descriptive of character, for which see Character, in Step V.

Who does it for him?

What does he live on? (Milk.)

How long does it take him to get fully grown?

What sounds does a baby make?

How does he learn to talk? (By hearing and imitating.)

How does he learn to eat at the table?

How does he learn what is right and proper to do?

If he have a *bad* example set him—what?

What does this teach us regarding *our* conduct before those younger? (Should be *very* careful to speak and do *right.*)

Is a baby in the home any trouble?

Is it *worth* all the trouble it costs?

Review.—None is needed.

Material to put away.—Care for any bones, teeth, etc., which may have been gathered, and put where they can be had for the next class.

Concluding Remarks.—I fully realize how much ground is covered in this step, but I also know how fruitful of good these lessons have proved as an introduction to physiology and zoölogy, as well as stimulating to healthy habits of thought.

The next step in Animals is XXVII—The Boy lessons concluded.

STEP XX.

How Sharp Stones came to be.

[*A continuation of Pebbles—Step XIV, and preparation for future work.*]

Material.—But little needed.

Thirty pieces of shale or limestone, which has shown a tendency to split with the frost.

Thirty lumps of hard clay, size of hen's egg (such as is used in clay modeling will do).

Thirty hickory nuts, walnuts, or peach pits which have lain out all winter and begun to split.

A piece of rock showing cracks.

A cracked rock with a root which has grown in the crack.

A piece of shale, limestone, or even tile, which has been split by the frost.

Where to get such material can be known only to the teacher who has looked about, but the children will usually be able to gather it, and the cost be nothing.

Preparation of Teacher.—Go through the lessons carefully, trying the experiments and modifying them to suit your surroundings.

Substitute *local* illustrations for those given as far as possible.

The Lessons.—1. Refer back to the *pebbles* found on beaches and in brooks (Step XV).

These rounded pebbles were once—what? (Sharp stones.)

Made *pebbles* by what means? (Moving water.)

How did I get the pieces of sandstone we shook in a bottle? (Broke with a hammer.)

Let us see how Nature makes them.

2. Who has seen piles of stone where a foundation was to be put in or a wall built?

What do we call the piles Nature makes? (Cliffs, ledges, etc.)

Before to-morrow's lesson I wish you all to take a careful look at these piles or ledges, so as to be ready to tell me what you saw. If ledges can't be found, study some old *wall.*

Now, who can tell me something about a ledge? (Draw out all the class has observed, and then hold up a stone with cracks started, and lead them to notice the cracks.)

3. Have the class examine rocks out of doors and tell what the seams or fissures are filled with. (Earth, roots, water.)

4. If the cracks were made larger, what? (Try.)

Are these pieces sharp, or rounded?

How could Nature make sharp stones?

Do you know how she makes the fissures larger? (Roots, frost, etc.)

5. Yes. Roots *do* grow and burst stones.

(Tell of examples, or find and show, if possible.)

(See Boy Travelers in South America, p. 67, for a good illustration and account of the way roots tear down walls in the tropics. Find the place on the map and read to the class. Further and very helpful illustrations will be found in the wonderful History of a Squash in Harness, which, in growing, raised *4,000* pounds, and carried 5,000 for several days, till the apparatus broke!) *

Other examples there given of seeds, mushrooms, and roots should be talked of, if the children do not suggest them.

How can a root burst a rock? (By growing.)

Will the root be tight, or loose, in the crack?

Drive a long stake a foot in the ground and move it a few times, as the wind sways a tree.

What other great use from these roots expanding in the

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* See Observations on the Phenomena of Plant Life, by President W. S. Clarke, of the Massachusetts Agricultural College.

cracks of earth and rock? (Keeps roots tight, to hold the plant in place.)

6. But there are other ways of rending bodies asunder.

Here are some nuts which lay outdoors all winter. What do you notice? (Split open.)

Water pipes often burst in winter. What is the cause?

A fence that I used to know was set in wet clay ground, and year by year was lifted higher and higher, till it fell over. What made it rise? (When the surface of the wet ground froze it expanded and lifted the post, which was not frozen fast *below;* mud getting under the end, it could not settle back into place when the ground thawed. This, repeated year after year, lifted the posts so nearly out that the fence fell.)

Sometimes a barrel of rain water freezes when full. What happens? (Bursts or bulges up in the center.)

Let us consider why these things happen.

7. Why freezing water *bursts* things.

Here are some bits of rock candy and rock salt for each of you to *look* at. (I think you all have learned enough self-control not to *eat* them without permission.)

What do you see about them? (Smooth faces and straight edges.)

Does any one know how they came to be so? (Grew or formed themselves.)

Yes; they were not cut or ground into shape, but simply "grew."

Did you ever notice what *beautiful* things snowflakes are? (Class draw some.)

We call these regularly shaped pieces of ice or sugar or salt, *crystals.*

When these crystals fall lightly from the sky we say it— ? (Snows.)

If warmed, the snow— ? (Melts.)

Which takes up the most room—snow, or water?

Try, by filling a pail with dry snow, tamping it *full* and solid; then, when melted, let the class decide. Popcorn, measured before and after popping, makes a good illustration.

Why does the snow take more room ? (Don't fit together well.)

Why the water *less* room ? (Little drops fit together.)

Take a basin of ice-cold water (no ice *in* it), and, putting it out in the cold, see it freeze, being careful not to breathe on it.

Those frosty, fernlike things you saw growing out from the sides and running together were *crystals* of ice.

Did you ever see these crystals elsewhere ? (Frost on window panes, under "shell ice," or when dew freezes.)

Ice is all made up of these crystals. Explain to me why it *pushes* when freezing. (Crystals *must* have room to grow.)

8. To show how *hard* the water pushes when freezing, let me tell of a French officer who once took a bombshell of thick, strong iron, and filling it with water, screwed an iron plug into the hole, and put it out in the cold. The tiny drops or molecules began to get cold, and wanted to arrange themselves in crystals, but the strong iron would not give them room. As they got colder and colder in the long Canadian night, they kept trying harder and harder, till at last the iron walls gave way; but so quickly did every little molecule spring to its place to make crystals of ice that not a drop spilled, although some did get an inch or so beyond the crack before it froze. Try with a soda-water bottle and see if the ice fills the fissures between the edges of broken glass.

Here, again (as in the root growth), it is the united strength of millions of little things which can accomplish so much. *One* little molecule could never break a strong iron shell, but when all united in their efforts to get room to form crystals of ice, the iron ripped like a paper bag.

Now explain *fully* the cracked nuts.

The burst water pipes.

The lifted fence.

The bulged and burst bomb.

9. Can *you* tell me of any other things which freezing water has burst or broken ?

(Encourage each to tell of *one* thing and explain it if he can; otherwise discuss it with the class till it is understood. Also encourage the devising of experimental *tests* to be carried out by the pupil.)

If desired, the following illustrations can be given :

I have seen what was a lump of hard clay in the fall crumbling like cornmeal in the spring. What caused it ? Soak lumps of clay, and freeze, to test this.

If you brush the side of a sandstone house in the spring, many sand grains come off. Why ?

I have seen pieces of solid shale thrown out of a well or ditch in the fall, and in the spring they were split into layers. What did it ? Soak pieces of shale and put out to freeze. Thaw in water, and if not cracked freeze again, and so on till you succeed.

Small ponds often have wall-like banks of earth in low places, and the steeper banks covered more or less with stones. Who do you suppose took the trouble to do all this work ? (Ice.)

Yes; *freezing water* did it all.

What experiment can we try which will *prove* it ? (Bottle full of water out in the cold. Cracked stone soaked in water and frozen.)

What has *this* to do with sharp stones ?

10. **Review.**—Rocks have *cracks* or *seams.*

Seams are filled with *earth, water, and roots.*

(1) Roots exert great force—
 "Squash in harness."
 Roots in tropics.
 Sidewalks lifted and walls overturned.
 This expanding holds plants tightly in place.

(2) Water bursts things when it freezes—
 Nuts opened.
 Water pipes.
 Tilted sidewalks.

Walled ponds.

Clay and shale, stone, etc.

Experiments to show this is done by freezing.

Why water pushes.

Examples : Snow.

Bombshell.

Soda-water bottle.

11. Examine as in pebbles (Step XV, 23).

School collection to illustrate sharp stones—

1. Cracked rock, the seam full of earth.
2. Fissure with *root* in it.
3. Crystals of candy and salt.
4. Models or drawings of snow crystals.
5. Bottle of popcorn and same measure ***popped.***
6. Fragments of burst bottle, etc.
7. Split shale.
8. Split nuts or peach stones.
9. Crumbled clay.
10. Sand from house or wall.
11. Model (clay) of "walled pond."

Number these as suggested in Step XIV, and also add plain labels.

Time required—20 to 25 *brisk* lessons.

Next step XXI—Plane Form and Color.

STEP XXI.—PLANE FORM AND COLOR.

Object.—In trying to teach something about flowers, minerals, and other natural objects, I found such a deplorable ignorance and confusion of terms regarding both form and color that I was obliged to teach something of these before proceeding with other work.

While doing this I also added some knowledge of the use of drawing tools and the beautiful metric system of measure, which would be a boon to the world if universally adopted.

These weights and measures were used in all subsequent work, and will hereafter, in most cases, be so employed in this book. While I fully recognize the fact that the great advances in material and methods for early training in form and color have in a measure rendered these lessons needless, I feel that the necessity will still exist in many cases, and the use of tools and the metric system in nearly all; hence I shall give in this step such suggestions as I have tried and found to answer the ends in view, which are, briefly—

1. To give clear concepts of form and color for future work.
2. To train the eye and hand in use of tools and colors.
3. To familiarize with the metric system of measure and weight.

Time.—In late winter or early spring, as no out-of-door work is pressing, and the light is good.

Some 20 lessons of 30 minutes each.

Much of the work is in a degree *inventive*, and when a pupil gets into the spirit of the work he should not be compelled to break off too soon.

Material.—For each pupil have the following—

A good, hard pencil (H. Faber), cost..........	5	cents.
A 30-centimetre boxwood rule (Faber) cost....	15	"
A pair of pencil-pointed compasses ("Pen and Pencil"), cost	25	"
A box of *good* water colors. Box of 8 good colors, including carmine, orange, chrome, chrome yellow, emerald green, cobalt blue, and a good violet, with brushes, will cost..	75	"
A large envelope (for protection) and 24 sheets of best drawing paper (150×130 millimetres in size), cost......................	5	"

Some small pencils to fit the compasses should be had with them at no extra cost.

Each pupil should have the *same outfit* (except compasses), and if purchased by the dozen quite a reduction can be saved on the above prices.

India-rubber erasers will be needed at times; but from the *start* train the class to such exact, careful work that the erasing of a line will seldom occur. It can be done by wise handling, and its *moral* effects are even more valuable than the hand training.

Preparation of the Teacher.—But little is needed. I would advise—

1. A careful study of the class to be taught.

2. A *written* estimate of their needs and the ends to be accomplished.

3. The *doing by the teacher* of everything (in order) that the class is to do.

4. The lessons given.

As to books, my information was originally gathered from a variety of books and then tested by experiment till I found what I wanted. At present there is quite an available literature, among which I should still keep my old and tried friend, William George Spencer's Inventional Geometry—one of the Science Primers—and add Color in the Schoolroom (Bradley).

The Lessons.—The work that has been done along these lines is indicated under Color, Form, Drawing, etc., in the chart at the beginning of this volume. The child is now of an age when the muscles of the hand have the strength, and the mind the ability, to do more exact work.

1st. Give pencils, and teach how to sharpen with a flat point.

2d. Metric rules given, marked with owner's name, and explained. Tell the pupils of the great *need* which existed of some *uniform* system of weights and measures. Illustrations can be gathered from commercial transactions or customs.

In 1791 the French took steps to have some standard which could not be lost, and eminent scientists decided to take the *forty-millionth* part of a great circle of the earth. The earth was *considered* to be spheroid, and wise men were set to work to carefully measure 10° of the 360° of a great circle running through the poles clear around the earth. Being Frenchmen, they chose the meridian of Paris, and, beginning at Dunkirk, in the northern extremity of France, measured straight south to Barcelona, in Spain, nearly 700 miles. From this arc of 10° the length of 360° was figured, and one forty millionth part of it—called a "metre" (measure)—was found to be 39·37 of our inches.

The metre was divided into 10's (decimetres), these again into 10's (centimetres), and these 100's into 10's, called millimetres.

Let us write this table and compare it with United States money:

10 Mills	= 1 Cent (ct.)	10 Millimetres (mm.)	= 1 Centimetre (cm.)
10 Cents	= 1 Dime	10 Centimetres	= 1 Decimetre (dm.)
10 Dimes	= 1 Dollar ($)	10 Decimetres	= 1 Metre (m.)

Would it not be *splendid* if such a simple measure could take the place of our inches, feet, yards, rods, etc.!

Some of our coins are made by these metric measures. Let us test some with our rules. (The "nickel" is 2 cm. wide and 2 mm. thick.)

All come to the next lesson with very clean hands.

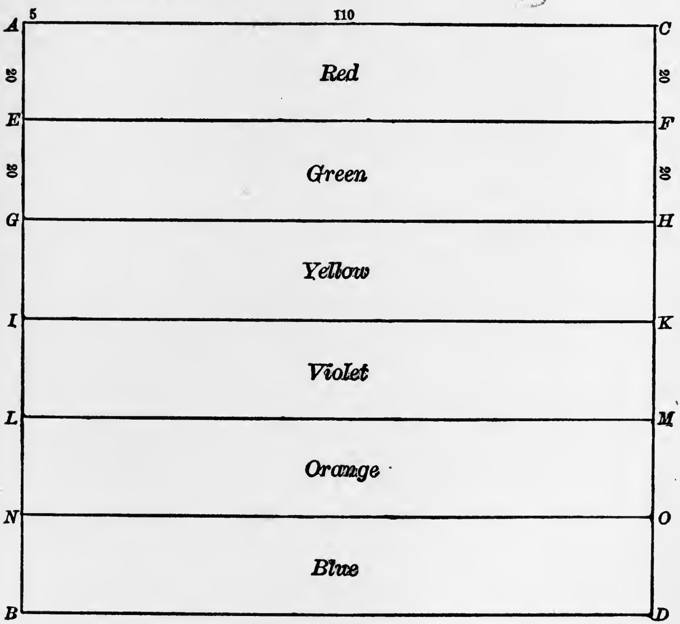
3d. Are the hands clean?

Here is some paper to draw on. Do not use it for anything except these lessons, and always put it back in the envelope when not in use, to keep it clean.

How long are the sheets? How wide?

What do they measure from corner to corner?

Let us draw Card 1.



Card 1.

Place the sheet with its *length* from left to right.

Place a "1" neatly in the upper right-hand corner.

All cards are to be numbered in that place.

See! I have outlined an enlarged card (make it just *ten* times larger, and use centimetres instead of millimetres in your measurements on the board) and will do just what I want you to do.

(1) Measure 5 mm. down from the upper edge and place a *light* dot.

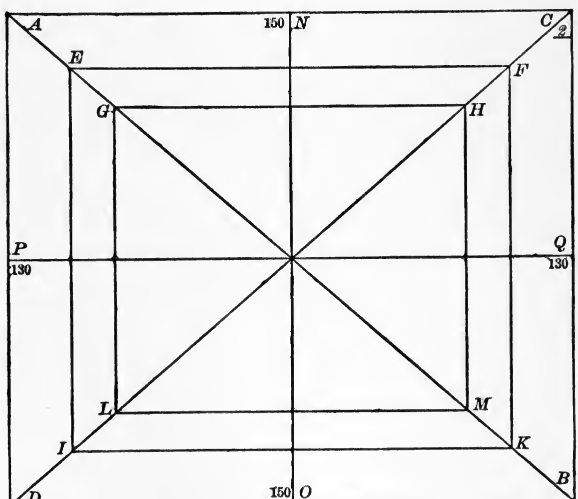
(2) Do this again near the other end of the upper edge.

(3) Lay your rulers below and the width of a pencil point away from these dots, with the 10-cm. mark exactly at the left-hand edge of the paper.

Is the marked edge of the rule toward and parallel with the upper edge of the paper? If so, all right.

(4) Holding the rule firmly, so that it shall not slip, begin at the 12-cm. mark on the left and draw a neat line to the 23-cm. mark on the right. Letter the line A C.

How many cm. from each end to the edge of card? (2.)



Card 2.

(5) Measure in from each end, near the bottom of the card, 2 cm. and mark.

(6) From A draw an up-and-down line 12 cm. long and parallel to the left edge of the paper. Place B at the lower end.

(7) From C draw a 12-cm. line parallel to the right edge. Letter it D.

(8) On A B and C D lay off 2 cm. lengths from the top down.

Is the last space exactly 2 cm.? If so, your work is right.

(9) Connect the points on each side by lines parallel to A C and ending *exactly* at the two perpendiculars, A B and C D.

4th.—**Draw Card 2.** (1) Measure paper.

(2) Draw *exactly* from corner to corner the diagonals A B and C D.

(3) From both top and bottom edges, close to the ends, mark 15, and then 10 mm.

(4) Lay ruler by the dots 15 mm. from the top (being careful to allow for the thickness of the pencil point), and draw along the ruler from one diagonal to another. Letter this line E F.

Is it exactly 15 mm. from the upper edge? If not, all that follows will come wrong.

(5) Parallel with E F draw G H, just in line with the 10-mm. dots.

(6) At the bottom, in the same way, draw L M and I K. See if they are right.

(7) Connect by neat and exact lines E to I, G to L, H to M, and F to K.

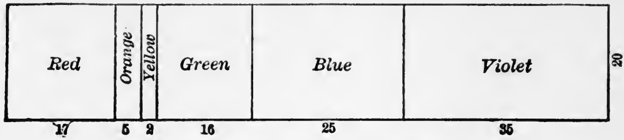
(8) Find the exact middle of A C and draw from there, through the center, N O.

(9) Find the exact middle of A D, and from there draw through the center P Q.

(10) Now measure all 16 lines (counting each half of a diagonal or cross line as one) and record the lengths in cm. or mm. This will *test* your work.

5th. **Draw Card 3.**

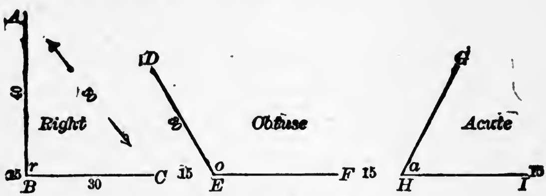
This shows the proportion in which the six principal colors are blended in white light.



Card 3.—Spectrum colors.

This will introduce mm. measurements; and as it is to be colored, no erasing should be done, and the lines should be *very* light, so as to practically disappear when the color is on.

6th. **Draw Card 4.**—***Angles.***



Card 4.—Angles.

This introduces the 3 kinds of angles.

(1) Draw the 3 base lines, B C, E F, and H I.

(2) A B can be made perpendicular to B C by the end of the paper.

Prove its correctness by measuring from A to C, which should be 5 cm.

(3) Draw D E, making the angle *larger* than the right angle.

(4) Draw G H, making the angle *less* than the right angle.

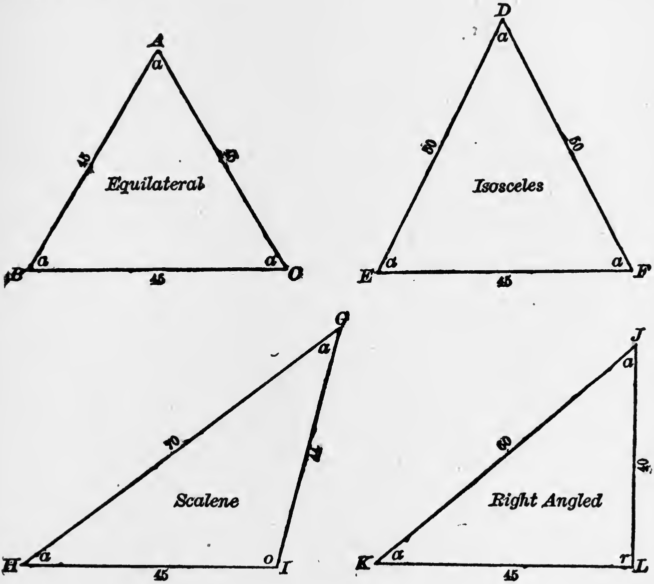
(5) Write the name of each angle neatly in it, and construct a key. r = right angle ; o = obtuse ; a = acute.

Hereafter an angle marked with an "r" is a— ? (*Right* angle.) If with an "o" ? (Is *obtuse.*) If with an "a" ? (Is *acute.*)

7th. Review angles. **Draw Card 5.**—*Triangles.*

(1) Draw base lines first.

(2) All things considered, would *not* introduce the compasses here.



Card 5.—Triangles.

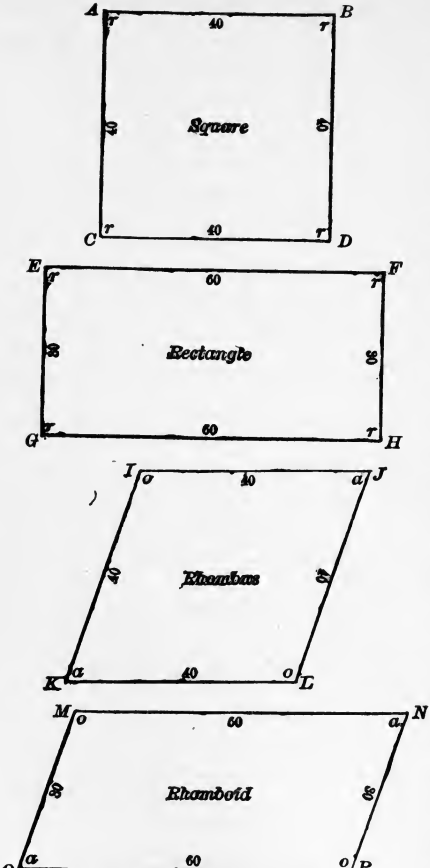
Let each child find the middle of the bases of the equilateral and isosceles triangles, and erect indefinite perpendiculars (*light* lines), to aid in constructing the triangles.

(3) Complete and name the triangles.

(4) Measure all sides, and write lengths in cm. or mm.

(5) Write in the "a's," "o's," and "r's," to show what kind of angles.

(6) Discuss *differences* and important points till the class has mastered triangles and knows the angles and relative length of side (where essential) of each.



Card 6.—Quadrilaterals.

8th. Review triangles. **Draw Card 6.**—*Quadrilaterals.*

(1) Locate all base lines.

(2) Make perpendiculars parallel to ends of paper and each other.*

(3) Draw the right-hand side of the rhomboid first, and then the other and sides of rhombus parallel to it.

(4) Letter and write in names, and prove correctness by measuring opposite sides.

(5) Discuss peculiarities and differences till the class knows the figures *well* and can tell about them or draw from memory.

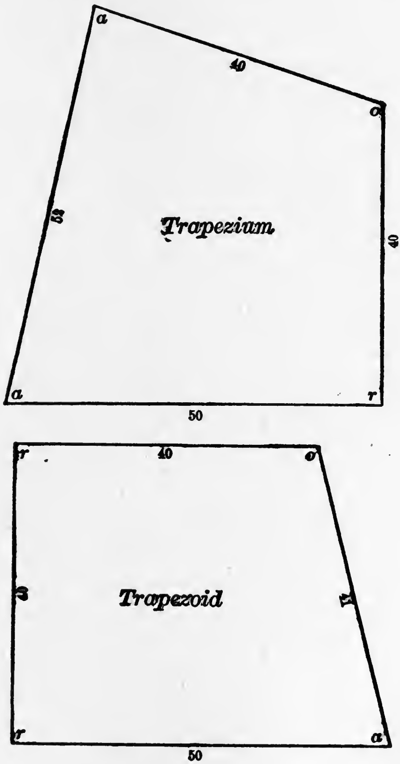
9th. Review

* Untold trouble will come from badly cut paper; but I never found but *one* package which was over ½ mm. out of the way. Still, in ordering, state that you wish it cut as accurately as folding paper, so that the sides can be depended on to be parallel.

quadrilaterals of Card 6, and **draw Card 7.**—*Quadrilaterals.*

Proceed as with Card 6.

Compare the six figures of Cards 5 and 6, and thoroughly learn the differences.



Card 7.—Quadrilaterals.

10. Review all quadrilaterals. **Draw Card 8.**—*Angles with two lines.*

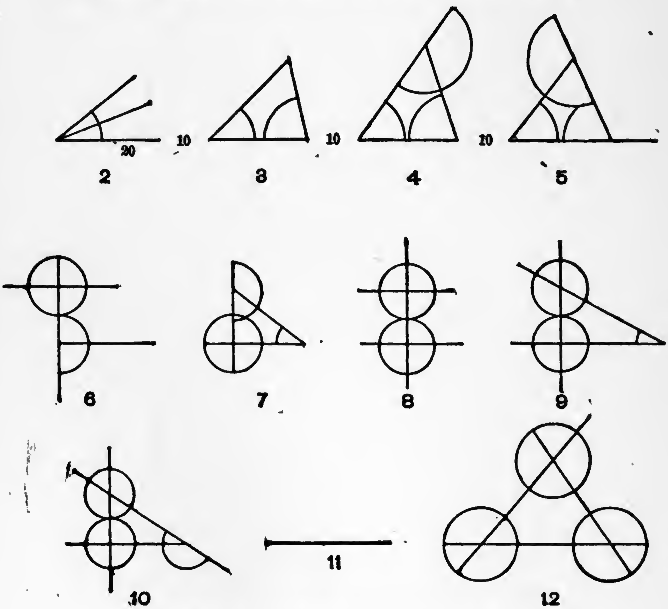
Card 8.—Angles with two lines.

(1) Draw base lines as given.

(2) Practice with the children (on the board) till they understand, and then let them use their own mode of making the angles.

11th. *How many angles can you make with 3 lines?* **Draw Card 9.**

(1) Eleven base lines drawn and numbered below.



Card 9.—Angles with three lines.

(2) Pupils work from 2 (fewest) up, using their own devices and leaving any they can not think of blank.

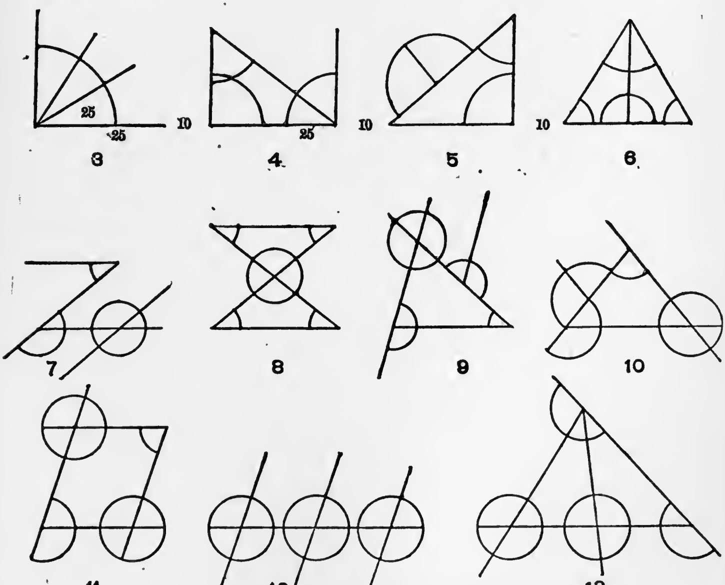
(3) Go over it in detail with the class, encouraging those needing help to make *original* arrangements of their own. I have practiced drawing little arcs about the angles and coloring in contrasted colors to make the counting easy. If this is *not* desirable, let the pupils place small and neat numbers in each angle from 1 up.

12th. *How many angles can be made with 4 straight lines?*

Draw Cards 10 and 11.

(1) Base lines drawn and numbered below; eleven on Card 10 and ten on Card 11.

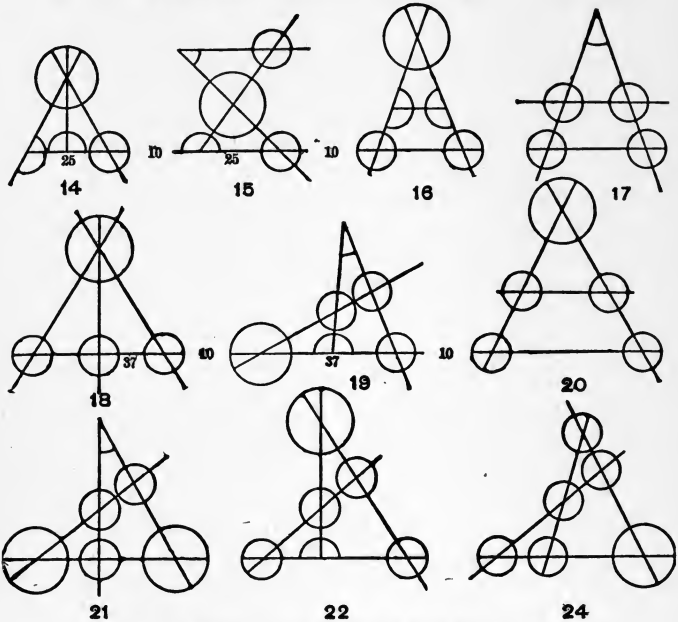
(2) Angles of 10 devised and neatly drawn. Aid as little as possible.



Card 10.—Angles with four lines.

(3) Angles of 11 devised and neatly drawn. Aid as little as possible.

(4) Comparison and correction of work.



Card 11.—Angles with four lines.

13th. *Coloring*, as a change of work and review.

(1) After marking with name of owner and explaining use of box, etc., all transfer some yellow to the upper right-hand mixing tray. Having enough evenly mixed color for the third space from the top on Card 1, proceed to give it an even wash, seeing that the pupils do it in the correct manner, with gently sloped paper, full brush, etc. I have chosen yellow to begin with, as the errors are less noticeable and the pupils will have a little experience before they begin to lay on heavy colors. Card 2, I have never colored.

(2) Now color the yellow space in Card 3 and one figure on 5 and 6.

(3) If it is decided to color the angles of cards 8 to 11, little arcs and circles must first be lightly drawn. This can be done by small coins, metal buttons, etc., or the dividers can be given and explained. I have tried to adopt some standard radius, but found the circles to intersect so often as to require the use of a wide discretion instead.

(4) Some instruction in the *harmony* of colors should also precede the coloring.

This I should not attempt here beyond leading the class to observe the relative amounts of each color in the spectrum and talking of Nature's combinations, which we admire.

The rule we evolve is this:

Angles.	*Color to use.*
Right (r), if one pair.	Red and green, orange and blue or yellow and violet.
Right (r), if two pairs.	Like single pair, but alternating the colors.
Obtuse (o).	Blue.
Very obtuse.	Violet.
Acute (a).	Orange.
Very acute.	Yellow.
Solitary.	Green.

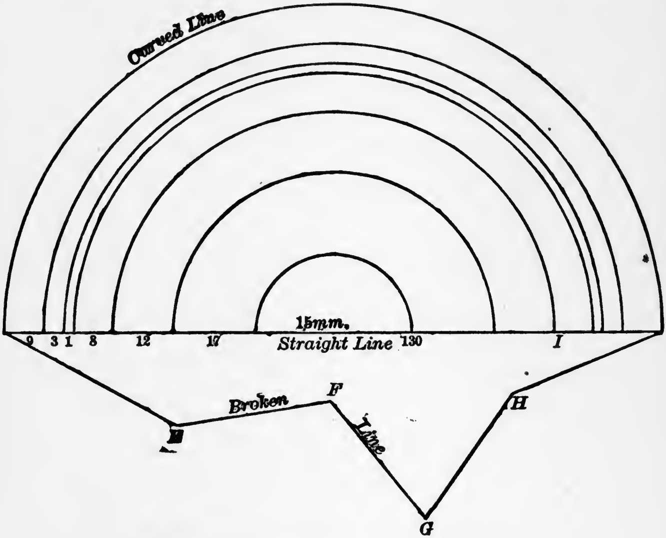
This plan has given satisfactory results, it being, however, understood that there was to be no *massing* of colors, but as far as possible a pleasing contrast and change, even in the adjacent parts of two figures.

(5) Having given the above help, leave the pupils to work out their own ideas as they may find time and return to Card 1. Mix some *green* in lower left-hand mixing pan, and color the space just above the yellow in 1; also space on 3, triangle on 5, and one figure on 6 or 7.

(7) So proceed till all are done.

The colors in the mixing spaces of the color-box cover should be in the order of the spectrum—red, orange, and yellow above, and green, blue, violet below. The colors on Card 1 will be contrasted and heaviest on the top and bottom, shading into quieter colors at the middle. This will have given practice in color enough for the present, so return to the drawing.

14th. Draw Card 12.—*Straight, broken, and curved lines.*



Card 12.—Lines and rainbow colors.

(1) Draw straight line and lay off distances on *one* side of center.

(2) Draw broken line (class make their own device).

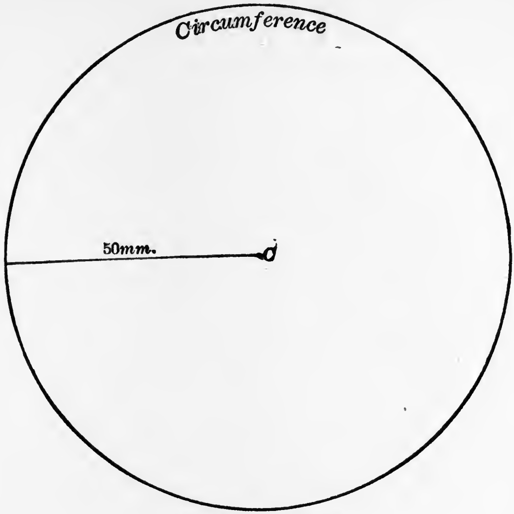
(3) Explain use of compass, and draw semicircles.

(4) Discuss till all new terms are understood.

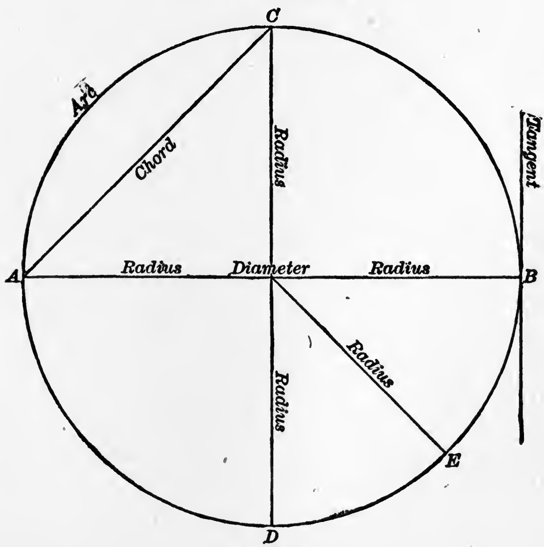
15th. Draw Card 13.—*Center and circumference.*

16th. Review 13 and draw Card 14.—*Diameter, radius, arc, chord, etc.* Measure and record lengths.

17th. Review 14 and draw Card 15.—*Proportion of colors in spectrum.*



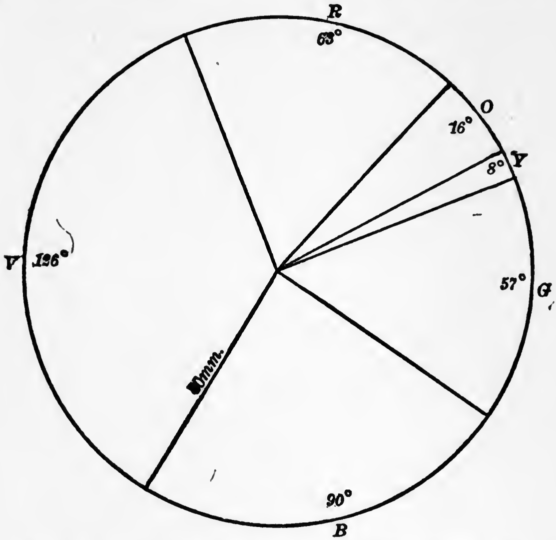
Card 13.—Circle.



Card 14.

(1) Draw circle.

(2) Make a dot on circumference, and, taking one chord after another from the rule, measure them off around the circle.



Card 15.—The proportion of the colors in white light.

(3) Draw radii and write table of degrees, etc., in upper left-hand corner. How many degrees (°) in a circle?

18th. Draw Card 16.—*Square.*

(1) Draw circle.

(2) Draw two diameters at right angles to each other.

(3) Connect extremities of diameters.

(4) Test accuracy by measuring.

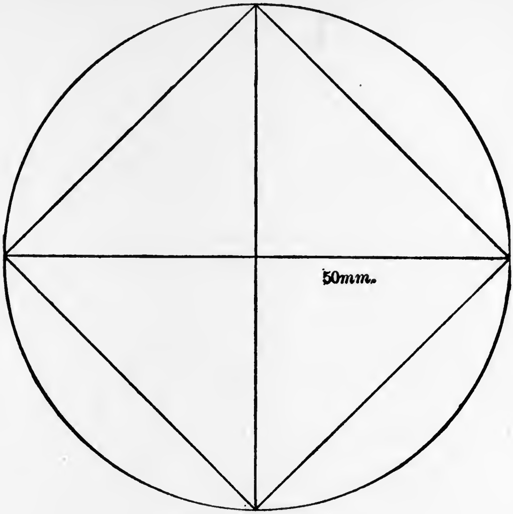
19th. Draw hexagon (Card 17).

(1) Draw circle.

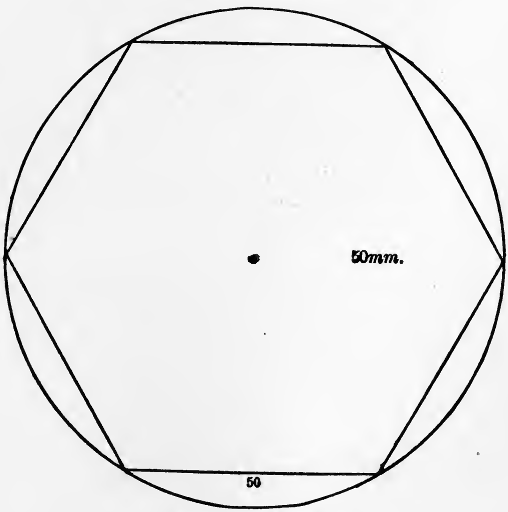
(2) Lay off radius as a chord 6 times on circumference.

(3) Connect points made with great care.

(4) Test by measuring. All six sides should be equal.



Card 16.—Square.

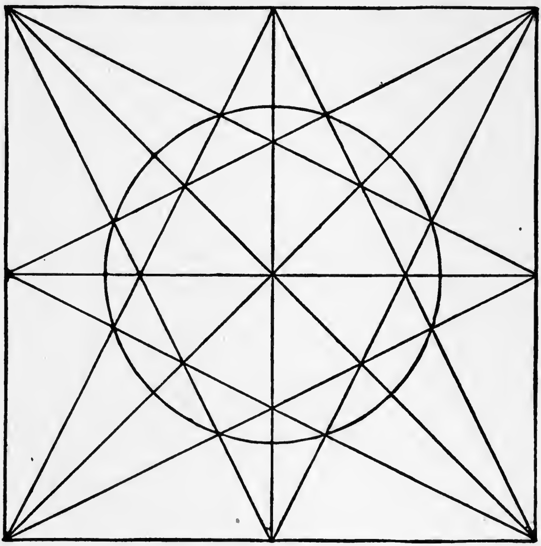


Card 17.—Hexagon.

20th. Review angles, triangles, quadrilaterals, and circle. Class combine straight and curved lines in an "*invention.*"

21st. Color Cards 12–15 and the invention. The others look neatest as they are.

22d. This completes the work undertaken, but classes have often done beautiful work afterward in making de-



Card 18.

signs, flags, etc., which were pinned up around the room. This, of course, took no school time, but being permitted as a reward for good work, tended to cultivate the *steady application* so much to be desired.

The interest in this work has never flagged, and if pushed *vigorously*—not hurry, but something definite *done* each day—the time taken is greatly disproportionate to the directions I have given, and 20 lessons of 30 minutes each will easily complete them.

Material put away.—If the drawing instruments, etc., belong to the school they must, of course, be safely guarded; but they should belong to the pupils.

Have some blank receipts made, and encourage the pupils to bring such things as they may not be using to you for safe keeping, they to have a receipt for the same.

The rules are especially apt to get nicked, and need care in using if for everyday work.

STEP XXII.—THE SKIES.

THE EARTH.—(*Continued.*)

The Lessons.—A brief review of the *daily* motion of the earth.

What does this turning on its axis give us? (Day and night; makes the sun and moon seem to rise and set and the stars appear to change their places.)

What ideas are suggested to you by the word Spring? Summer? Autumn? Winter? Year?

At the north pole the people are said to have *six months* of *day* and *six months* of *night*. How is it with our days and nights? (Vary in length.)

When is our longest day? (June 22d.)

Longest night? (December 22d.)

Does the sun always seem to rise in the same place—over the same tree, or house, or hill? (No.)

When does he rise most to the south? (December 22d.)

When is he most nearly overhead at noon? (June 22d.)

When does the sun shine farthest into a south window? (December.)

Why, in Step XVI, did we have to see the Sickle *early* in May? (Later on it sets before dark.)

If you watch the stars when you go to bed each night, do you see the same ones month after month?

How long do you think it would be before the same constellation appears again at the same hour? (One year.)

These are some of the things the peoples of the East had to puzzle over. Living so much out of doors, and often under the cloudless skies of the rainless regions of Arabia and Egypt, they *observed* these things, but had to think much before they got at the true answer.

Let us try some experiments which will help us. (See Astronomy Primer, pp. 19–39.)

1. Hang pictures, or, by preference, diagrams of the 12 constellations of the zodiac, around the room.*

Place a lamp at the center, and, with a large tack to represent a person on the globe, consider what must happen to bring into view the successive constellations. (Must *move around the sun.*)

2. Let the class learn the names and order of these 12 constellations. (See list at end of this step.) These were all well known to the ancients, and observed to follow each other (rise and set) in this order.

Which *way* does the earth then travel? (*Against* the hands of a watch.)

How long is it before we see the same group of stars again? (One *year.*)

3. See if any arrangement of the globe can be suggested *by the class* which will enable the unequal days and nights, the seeming approach and retreat of the sun, and the varying angle of its beams, to be illustrated or explained.

Many of them will have a vague idea of the *inclination of the axis* and will strive to express it.

When the idea is once before the class, the globe can be given the needed inclination ($23\frac{1}{2}°$) and the matter taken up in detail.

The ecliptic is well illustrated by Lockyer's balls floating on the surface of water (page 24, Primer).

What stars would be around the circle made by the water? (Constellations of the zodiac.)

Unequal days and nights are also shown in the same way, and afterward with the lamp and globe (Primer, pp. 26–33).

The six months day and night of the poles will be seen on the globe. Call attention to the arctic and antarctic circles which mark the *extreme* limit around each pole, of the region where the days or nights sometimes last *24*

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* Enlarge those of this book.

hours—i. e., the sun at one time does not come into sight *at all*, and at other times does not set. (Read Bayard Taylor, or other writer, on the Midnight Sun.)

Are these circles real or only imaginary?

There are other circles on the globe which mark other points of the sun's light. When he shines clear beyond the north pole, so that all the Eskimos within the arctic circle have no night, he is directly *overhead* to all who live on a circle 23½° north of the equator. Then he gets lower and lower to the Eskimos, till he seems from the north pole to go around in a circle on the horizon, and the days and nights become *equal* all over the earth; the sun is directly overhead to those living on the *equator*—a great circle running east and west around the earth, midway between the poles.

The earth now continues on its journey, the north pole turning more and more away from the sun, till the Eskimos within the arctic circle have nights of 24 hours and the people along the Tropic of Capricorn see the sun directly overhead.

How about the nights in the antarctic circle then? (None.)

Latitude.—Measure on a map the distances between the poles and arctic circles in both hemispheres.

What do you notice about them? (Everywhere equally distant from each other.)

Now test the distances between the arctic circles and Tropics of Cancer and Capricorn. Between the tropics and equator. (Everywhere the same.)

Such lines are called *parallels;* and, while the five circles we have talked of mark the directness of the sun's rays, or the lengths of days and nights, there are supposed to be *many* such lines to measure the *distance north or south of the equator* of any spot on the earth.

This distance is called its *latitude*, and is a great help to us in finding where an island or any feature of the earth belongs on the map or globe.

What did we call those lines running north and south? (Meridians.)

And they measured the distance— ? (East or west of some other meridian.)

Which was called its— ? (Longitude.)

Now, if a city—Chicago, for example—have its longitude (88° west from Greenwich) and latitude (42° north) found, it can be exactly located on a map.

If islands—the Azores, for example—have had their position carefully noted and correctly placed on a map or chart, a ship can steer straight to them, or even pass by in the dark without the danger of running upon the rocks.

These illustrations will give a slight idea of how helpful latitude and longitude are.

The Seasons.—These result from this yearly journey of the earth around the sun.

What do we get from the sun ? (Light and heat.)

When do we get the most heat—during the day or night ? (Day.)

What happens at night ? (Earth *cools*.)

Will the length of the day have any influence on the amount of heat we get ? (The *longer* the day the *more* heat our part of the earth will receive.)

Suppose the *nights* are long— ? (Will lose more than it receives in the short day.)

Why does snow melt quicker on the south side of a roof ?

On which bank of an east and west ravine would you seek the first flowers ? (North.) Why ? (Receives more direct rays of the sun.)

Why is the glass roof of a greenhouse or hotbed made to slant *toward* the sun ? (Direct rays can enter.)

Why is it so disagreeable to fish on the east side of a body of water in the afternoon of sunny days ? (Sunshine is *reflected* from the water.)

If not reflected, what would become of the heat and light ? (Enter the water.)

What time in the day will most enter ? (Noon—when the sun is overhead.)

Now for some *questions*—

Give two reasons why the weather grows *warmer* from February to June. (Days grow longer, and the earth is turning more and more directly toward the sun.)

How is it from August to December? (Growing cooler.)

Why? (Days grow shorter, and the rays of the sun are more slanting.)

Why are arctic winters so terribly cold? (*No* day to get heat in, and the earth gets cooler and cooler.)

Why are the short arctic summers so *very* hot? (Sun shines day after day without any night to cool in.)

Why is it always hot in the torrid zone? (Days are *all* long, and the surface of land and sea lies directly under the sun.)

What seasons will there correspond to our summer and winter? ("Wet" to summer and "dry" to winter.)

Read selections on the seasons.

Why are these frequently changing seasons a blessing to man?

What causes them? (Yearly revolution of the earth about the sun.)

Why do the days vary in length? (*Earth's axis* is *inclined* $23\frac{1}{2}°$.)

What results from that? (The north and south portions of the earth are alternately turned toward and away from the sun.)

What is the ecliptic? (The plane in which the earth and sun are.)

If you could see the stars and sun at the same time, in what constellations would the sun be seen moving in

April? Pisces, the Fishes.
May? Aries, the Ram.
June? Taurus, the Bull.
July? Gemini, the Twins.
August? Cancer, the Crab.
September? Leo, the Lion.

October ? Virgo, the Virgin.
November ? Libra, the Scales.
December ? Scorpio, the Scorpion.
January ? Sagittarius, the Archer.
February ? Capricornus, the Goat.
March ? Aquarius, the Waterman.

Review if need be as in (1) page 273.

Of these, *Leo* was found in the last step. Find it again May 20th, in the southwest.

In the south lies *Virgo*, and in the southeast *Libra*, or the Scales. With the Virgin and Scales is connected the story of the goddess Astræa, who lived in the "golden" age of innocence and happiness. As the succeeding ages of brass and iron saw mankind become more and more degraded, all the gods and goddesses left the earth, till Astræa alone remained. At last all innocence and purity took their departure, and the goddess of Justice, Astræa, was placed among the stars—the constellation of the Virgin, holding in one hand the Scales (Libra) and in the other the sword of Justice. (See Burritt, p. 82, or Bulfinch, 20, etc.)

In June the next constellation, *Scorpio*, will appear in the southeast.

A beautiful red star, Antares, is in this brilliant and easily traced group. Few constellations really look more like the thing they are named for. There is but little of interest in the history of this group. (See Burritt, 102.)

Early in July will appear in the southeast the next group of the zodiac—*Sagittarius*. This beautiful constellation is a prominent object in the south through the summer evenings. It is said to commemorate the famous man-horse or centaur Chiron, who was famous for his knowledge of medicine, music, and shooting. He educated the father of medicine, Æsculapius, and Apollo in music, and was also tutor of the heroes Hercules, Achilles, Jason, Æneas, and others. (See Burritt, 117; Bulfinch, 155; Greek Heroes; The Argonauts; or Hawthorne's Golden Fleece.)

Read or tell of some of these—by preference Æsculapius, Æneas, and Achilles, as the others will figure later, in connection with the Golden Fleece. Apollo and Hercules have already been spoken of.

Capricornus, the next constellation of the zodiac, will appear in the southeast in August. The stars are not brilliant, and the two in the head will be best to identify it by.

These six constellations should be drawn and marked with little gilt stars by each pupil for home reference. (See some star atlas.)

STEP XXIII.—PLANTS.

THE MORNING-GLORY, HOW IT GROWS.—THE LIFE HISTORY OF ONE PLANT.

Object.—A wide survey of plants in their varied forms having been had, it now becomes desirable to take up—

1. The careful study of an *individual plant*, to learn the use of its parts, its food, and mode of development.

2. To lead the pupil to more *exact* observation.

3. To introduce him to the art of *experimental* testing.

4. To re-enforce all this by training in *drawing* and *color* work.

Time.—Having tried all seasons, I find September and October the best, as the morning-glory then supplies flowers and fruit in abundance. About 45 lessons of 30 minutes each will be required, but some mature classes will do the work in 30. In any case, *push* the work steadily forward—no hurry, no delay, but a *definite* thing accomplished each lesson.

Material.—For this I have chosen from cheap and easily made things.

For a class of 30 pupils procure the following—

Morning-glory seed (fresh), ¼ pound (3,000 to 4,000 seeds).

Earthenware pots (3-inch, unglazed)—48.

Boxes, 3 inches deep and of a shape to hold 8 pots each, and set securely in the window seats—4.

Pebbles or potsherds to cover holes in pots—36.

Argand lamp chimneys—4.

Some cotton.

Sheet of looking-glass or bright tin (about 6 inches square).

Glass fruit jars with tops—2.

Tin cans with covers—4 (1-pound "baking powder").

Sound straws ("lemonade," or any good ones, 15 to 25 cm.* long)—100.

Fine cotton or linen cloth—60 pieces 3 cm. square.

Distilled water—1 gallon bottle full. (Rain or snow caught in clean pans will do.)

Funnel—1 6-inch glass (tin will do). (See Step XV for this and the following.)

Filter paper—24 pieces of 10- to 12-inch squares. (Thin light-brown wrapping paper will do.)

Evaporating dish (8-ounce porcelain or shallow pint dish of bright tin).

Alcohol lamp (4-ounce).

Wide-mouthed bottles (3-ounce)—3 dozen, and corks to fit.

Wide-mouthed bottles (8-ounce, of clear glass; "morphine" good)—30, and corks to fit.

Cheap tumblers (uncolored and smooth as possible)—3 dozen.

Thistle tubes—2, with 12-inch stems.

Sulphate of copper—1 pound.

Small candles—30 5-cm. bits.

Copper wire—36 pieces, 20 cm. long and as thick as a common pin.

Limewater—Gallon bottle full.†

Hydrochloric acid—A little.

Cards, for mounting, etc.—600 (10 × 15 cm.), of light cardboard.

The above will cost from three to seven dollars, but much is on hand (Step XV).

The other things needed can be procured as indicated in each point, being of slight cost and easily found.

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* Shall use the metric measures from this time on (see Step XXI), except where things may need to be ordered.

† Fill the bottle with water and drop in a teacupful of bits of the "stone lime" used by masons.

Arrange all these things (except the glassware and pots) in shoe or other convenient boxes, labeled on the end, so that what is wanted can be at *once* found even by a messenger.

Preparation of the Teacher.—This should begin in the previous *spring*, when plenty of morning-glory seed should be planted in good soil and trained on some kind of trellis. These will furnish a supply of fresh material, and, by covering a few times with a sheet, be protected from early frosts and last till the lessons are completed.

During the leisure of summer take the following outline of work and *thoroughly test* it, step by step. The morning-glory is unique in many ways, and, with a few trifling exceptions (lack of odor, being monopetalous, etc.), almost an ideal flower for this work; so that any one will enjoy and profit by this study. The teacher will thus have all the difficulties met and prepared for, material ready, and a knowledge of the subject which will do much toward the successful completion of the class work. For books to consult, Johnson's How Crops Grow and How Crops Feed have been exceedingly suggestive to me for twenty years. More recent books are Gray's Structural and Goodale's Physiological Botanies—books full of good things; but no *book* will take the place of the actual study of the *plant itself*. With *that* almost any recent botany will do.

The Lessons.—A general outline of the plan followed is this:

A. How to awaken the seeds (germination).
B. Parts and direction of growth. Cards 1, 2, and 3.
C. What the plant lives on. Card 4.
D. How the earth food is taken. Card 5.
E. How the air food is eaten. Cards 6 and 7.
F. Use of the parts and review. Card 8.
G. Growth in size (bud).
H. Flower and its parts. Cards 9 to 13.
I. Use of the organs of the flower. Cards 14 to 16.
J. Parts and uses of the seed. Card 17.

THE LIFE HISTORY OF ONE PLANT.

Tell nothing that illustrations and experiment can be made to answer. Press a series of specimens to illustrate the different periods of the plant life, and mount them neatly on cards, making drawings of what can not be so shown.

A.—How to awaken the Seeds.

1. Give each pupil a seed. Talk of the life so wonderfully hidden. How shall we awaken it? Put all the answers given on the board, and arrange for trying in earth. Tell each pupil to bring some neat stick to label his or her pot, and such other things as may be needed for the test they are to make. Provide some sand or earth.

2. As this lesson will be a busy one, have it at the close of school or recess.

a. Give each a pot; let him write his name on the side.

b. Give each a pebble or bit of broken pot to put in the bottom. Why?

c. Half fill each pot with damp sand (or earth which will not cake).

d. Stick in the wooden label each has brought.

e. Drop six seeds in each—2 in the center and 4 around the edge.

f. Fill the pots nearly full of earth, and set in the boxes in such order as to be readily distributed again.

g. Pack all the space between the pots with "excelsior," moss, or some substance which will keep the pots moist and also keep in shape when the pots are lifted out.

h. Now let each water his pot (gently) and put the boxes in the window seats.

3. Proceed in the following lesson or two with the special tests which have been suggested. These should include eight pots, with the same earth or sand as those planted by the class, and twenty seeds in each.

Test 1. Leave two *dry*. Water the other six and place—

Test 2. Two in an ice box or other *cold* place.

Test 3. Two in total *darkness.*

Test 4. Two where they will be in the light *all* the time.*

Test 5. Also plant twenty seeds in two pots each of *sawdust, brick dust, chaff, stiff clay, leaf mold*, and *coarse gravel* (water all of these), and give the same conditions as the class boxes of pots.

Test 6. Place a sponge in a saucer, and, after sprinkling forty seeds into the holes, water.

Test 7. Push loose plugs of cotton into the small end of four Argand chimneys as far as the neck. Sprinkle ten seeds in each; then stand them in some glass dish (aquarium, battery jar, or pitcher) so that they will *slant at about an angle of 45°.* Pour in water till the plugs of cotton begin to rise with the pressure from below.

Test 8. Now drop forty seeds *into the water* of the large dish.

The best way to carry out these tests will be to place a list on the board and let the child who suggests an experiment see to its carrying out, he or she taking care of one of the two pots, and some comrade—chosen from among those making no suggestions—the other.

All questions in the future regarding the points illustrated will be referred to the two pupils who have the matter in charge. A feeling of responsible authority will be awakened, greatly to the pupils' advantage.

The object of the "forty seeds" in each case is that each pupil may have a specimen at the close of the test to press, mount, and label. The "two pots" are partly to avoid overcrowding, and partly to enforce the lesson that no *single* scientific test is of much value, but should be substantiated and proved by repeating. Do not in any way lead the class to depend on *one isolated* test. Mistakes may occur.

A record of all these tests should be kept. My experience has been that pupils of 10 to 11 years have such hard work

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* A small lamp and reflector will give this, if no electric station, factory, or other place lighted all night can be found.

with the spelling and writing as to make the keeping of individual note books too slow and distracting. Would encourage all who *wish* to do so, but not require it. If, however, some bright pupil with a ready pen can keep a history of it all for the entire class, and make *drawings* of the results of each test, it will be a valuable thing. All can refer to it, and many, from the example set, will make one like it, greatly to *their* advantage. The work is now under full headway, and I never had a class whose interest was not complete in watching and tending such experiments.

4. While awaiting results, consider how these small seeds are to throw off the load of earth, etc., on top of them.

Have used these *illustrations:* Suppose you were on a load of hay and it tipped over and covered you up; how would you get out? Would you rather be lying on your back, or on your face? Suppose a stout boy should have a 40-pound hair mattress (in halves) piled on him; in what position could he throw off most?

An *experiment* one class tried, of planting weighed seeds in sand and plastering molding clay over them to be raised as the seeds sprouted, showed that, if a 75-pound boy was as strong as a morning-glory seed, he could lift *two carloads* (20 tons) of grain!*

The class will now be kept busy observing the results of the experiments and the curious way the seeds *back out.* Let each dig up one (as soon as it appears) from the side of his pot and press in some large magazine or book to mount it. Do this with a plant from each experiment as it is completed, and lay a label in with it to aid in the final mounting.

A danger will occur here, in ordinary school work, namely, all these interesting things may happen between Friday afternoon and the following Monday. There is no *rule* I can give to avoid this, but if the work begins Monday, the class will plant their seeds late on Tuesday, and the other trial

* Other examples of the force growing plants exert can be found under Sharp Stones—Step XX.

plantings Wednesday or Thursday. Ordinarily no fires will be had early in September, and, the nights being cool, the seeds will germinate slowly, so that, by watching the development a little and using quite warm water and the heat of all day's sun, if they have not sprouted by Friday—or placing in the shade and using cold water in case they start too soon —they will come along so as to complete the observations (and pressing of specimens) by the second Friday.

These conclusions will now be evident. To sprout—

(1) Seeds must have *moisture.* (*Dry* ones do not start.) Every seed store furnishes an illustration.

(2) Seeds must have *heat.* (Cold prevented.) Winter ?

(3) Seeds must have *air* (oxygen). (Those in water [not enough air] rotted.)

(4) *Anything* will do to plant in or on if it does not *cake* too hard.

(5) Light or darkness is immaterial to the *sprouting* seed.

(6) The seed *backed* out with great force.

B.—Parts and Direction of Growth.

5. When fully up, what parts can be seen ?

6. Which way do they grow ? Why were the little leaves folded over as the plant backed out ? (To avoid injury.) (See Fig. 1.)

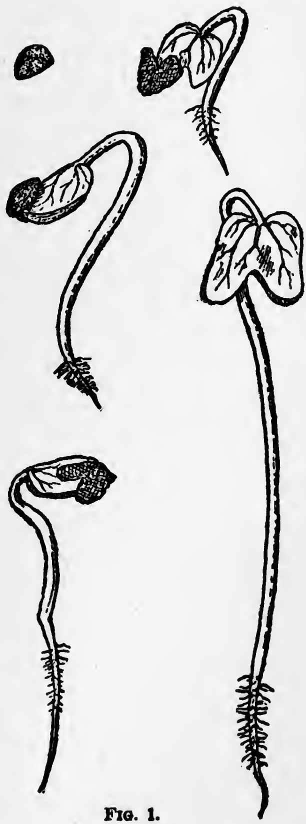

FIG. 1.

7. Are these—stem, leaves, and bud—*all* the parts? (Each dig a second plant from the side of his pot, and, after observing the *root*, press.) (See Fig. 2.)

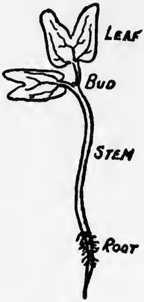

FIG. 2.

8. Which way does the root grow?

9. Do *all* our stems grow up? (Compare with each other.)

10. Do *all* the roots grow down?

11. Is it *always* so?

Let us see if we can get them to grow otherwise.

Get class to suggest experiments which will test this, and have them carried out in duplicate (or more) by members.

Illustrations helpful with me have been as follows:

(1) Those in the slanted lamp chimneys will be found pressing against the glass on opposite sides. *Turn the chimneys half round.* The roots will now be pointing upward and stems downward. Do they turn back? Give specimens to press when done.

(2) Pack cotton about the stems of a flourishing pot of plants to hold the earth, after removing from the pot, and suspend, tops *down*, by strings tied around. (See Fig. 3.)


FIG. 3.

(3) Sprout forty seeds between layers of cloth, and, as soon as the young root is 6 to 8 mm. long, give one to each child to tie a fine thread *gently* on the root near where it leaves the seed; an inch above it tie a little slip of paper with the child's name. Do this as quickly as may be, to avoid drying the root too much, and then let each child place his plant, *hanging root up*, inside a *wet* fruit jar, while the teacher screws on the top. Only

8 or 10 should be hung in one jar. The growing plantlet is now reversed, and in the moist air of the jar can grow as it wants to. Which way do the majority grow?* After 24 hours let each press (thread and all) his specimen. (See Fig. 4.)

Fig. 4.

(4) What do you think causes the tops to go *up* and roots *down*? (Get as many ideas from the class as you can and record them on the board. The answers will include some of the following:)

"The top grows up because the light, least earth, and least moisture are above."

"The root grows down to avoid the light, and toward the most earth and moisture."

Propose that we try to "fool" some seeds, and, by reversing these conditions, get them to grow the *other way*.

Take two baking-powder (or other) cans that have covers, and, standing them on the end of a stick of wood, punch twelve to twenty holes through each bottom with a long nail. Wet the bottoms, and proceed to—

a. Place 2 cm. of *dry* earth in the cans. (The *wet* holes will clog and hold it.)

b. Scatter 25 seeds in each.

c. Place on top 7 cm. of *moist* earth and add a little water.

d. Put on the covers tightly.

e. By strings hang the cans in the window, and under each place a piece of looking-glass or bright tin, to throw the sunlight strongly *up* on the perforated bottoms.

We now have light, dry earth and slight depth *below*, and darkness, most earth and moisture *above*. Await results, and give each child a specimen to press when the seeds have started—which way? (See Fig. 5.)

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* Between 9 o'clock and noon I have had such seedlings turn through 180° and the inverted top be again upright; but the seedling must be taken at *just* the right time, or it will not act so promptly.

C.—What the Plant Lives on.

Lead the class, by questions and illustrations, to see the need of *food*. Why are sick people weak and thin? Why are poor people often the same? A baby grows—what makes him?


FIG. 5.

12. What must our plants have, to grow? Let us see if we can find what its food is.

13. Place a bit of cake or apple at end of room and carefully note what a boy has to do to get and eat it. (Goes, reaches, takes in hand, puts to mouth, bites, chews, and swallows.)

14. Can a plant *go* and get food?

15. Let a child ask; have food brought and placed near him, and observe again: Can a plant ask?

16. Again place food near a child. Need he go hungry? Why not?

Need he *go*? Ask for it? Where must the food be if he need neither go nor ask? (Near.) Where must the plant's food be?

17. What things are "next to" our plants? (Earth, air, and water.)

18. Which part grows *down*? In what? Which parts grow *up*? In what?

D.—How the Earth Food is taken.

After John had food near him, what did he do? (Reached, took in hand, etc.)

19. Has a plant hands? Examine some that have grown in cloth, sponge, or cotton. (No.) Notice fine root hairs.

20. Is there any way to take food without hands? (Place a bit of apple or cake near each and see if he or she can eat it without hands. Speak of kittie, dog, calf, etc. Do plants have "mouths"?

21. (To give idea of things too small to be seen.) Show

very large apple (too big for a little child to bite). Smaller one more easily bitten. Piece, easily put in mouth. Suck water through straw, and, pulling out straw, let children look for the hole. Suck water through a straw with fine linen over end.

22. Might not the openings in the roots be too small to see?

23. What kinds of food can we take when our mouths are almost shut? (Water, milk, and broth.) We call such substances—? (Liquids.)

24. What kind of food must the plant have to take through its small mouths? But has it milk or broth near it? (Water.)

25. Can a plant live on *water*?

Give each child two well-washed 3-ounce bottles, and for the top of each let pupils prepare a square of cardboard with a hole in the center as large as a slate pencil. Take scissors and cut from one edge to the hole. Next give each two slips of gummed paper to stick on his bottles, and on one write "Pure water," on the other, "Earth food." Add his initials to identify by.

In the "pure water" bottle pour two inches of distilled water, and in the other a like amount of clear brook or well water.

Let the pupils now—from their own pots or any plants about the room which can be spared—each choose two plants as nearly *mates* as possible, and, after gently rinsing off the roots in water, to free from adhering earth, bend the cards gently, so as to let the stems of the plants into the central hole, and place roots down in the bottles.

Place these bottles in boxes and stand in the shade for a day, and then remove to a warm, sunny place, to see if both grow alike. At the end of a week compare the results of the whole class, when, if reasonable care has been taken, there will be a marked difference. Press the specimens at the end for Card 4. While these experiments are in progress proceed with the work.

What did the calf live on? Why is milk better than water? (Has food in it.)

26. Let us find if there is any food in the water our plant takes in. If caught in a shower, how would you get the water out of your clothes? Washing day? After the water was dried off, what would be left? (Clothes.) Now, milk is made of what two things? (Water and food.) Would you like to see some of the milk food? (Condensed milk, thick milk, cheese.) Where is the water our plant takes in? The food, then, must come from—? (Earth.) Let us see if we can get some of this earth food by passing water through earth.

Fold a square of filter paper twice, and, slipping the fingers into one side, insert it in the funnel and stand this in one of the 8-ounce bottles. Put a pint of *rich* earth (add a little hen manure or guano, if other rich compost can not be had) in the funnel and a pint of water. After this has run through, quickly return it to the earth and filter through again. Repeat at least twice, and then put the water—which should have no *solid* particles in it—in the evaporating dish, and set on a hot place to boil till only a spoonful is left. Then set it off in some *warm* place to slowly dry, and exhibit to the class. What is left? (Earth.) How did we get it? Is there food in the water from rich earth? Would each like a specimen of one kind of earth food to keep? (Look in the bottom of the tea-kettle at home, and get some pieces of "scale.")

27. What part of the plant takes in this earth food?

28. *How* does it take it in?

Here are some experiments to help answer this question:

a. Let each bring some fleshy root or fruit (beet, carrot, turnip, apple, etc.); with a knife (or apple corer) dig out a smooth hole in the center, as large as the thumb, being careful not to dig *through* in any direction. Wipe this hole out with a cloth or sponge. Is there any water in it? (No.) Let each stand a root or fruit up in some place, and then introduce a spoonful of dry granulated sugar and leave till next day. (See Fig. 6.)

b. Let each drop 2 untorn raisins or prunes into a 3-ounce bottle and cover with water.

c. In the morning tie pieces of soaked bladder (from butcher or tobacconist) tightly over the mouths of some thistle tubes, having first plugged the small end and *nearly* filled with a *strong* solution of $CuSO_4$ (copper sulphate), or even common salt. Now stand these, membrane down, in tumblers; unstop the plugged ends (now *up*), and fill the tumbler with water till the level of the liquid is the same inside and out. Watch these 3 experiments for 24 to 48 hours. (See Fig. 7.)

Fig. 6.

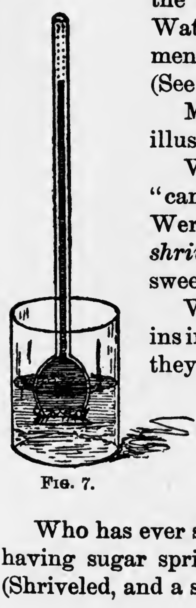

Fig. 7.

Meantime talk of some illustrations.

Who have ever had "canned" cherries to eat? Were they *plump*, or *shriveled*? (Plump.) Very sweet, or not? (Not.)

Who has seen the raisins in rice pudding? Were they plump, or shriveled? Is rice pudding very sweet? (No.)

If whole plums or cherries are preserved in a rich, thick sirup, are they plump? (No; *shriveled.*)

Who has ever seen currants or strawberries a while after having sugar sprinkled over them? How did they look? (Shriveled, and a sirup in the dish.)

Who has seen beef or pork packed in barrels? How was it done? (Meat closely packed, with dry salt around it.)

After it had lain a while, what change took place? (Meat was *floating* around in a lot of brine, and the pieces were smaller.)

Now let us look at our experiments.

What has happened to the sugar? (see *a*, above). (Is a sirup.) And the root or fruit—? (Is *shriveled*.)

How did this happen? (The sugar drew the water from the root.)

How about the prunes and raisins? (*b*.) (Swelled.)

And the liquid inside the thistle tubes—? (*c*.) (Has *risen*.)

Does any of the blue copper solution seem to have come *out*? (Yes.)

Does any water seem to have gone in? (Yes.)

What makes you think so? (Water rose in the tube.)

Which is *thickest*—water, or a solution of copper sulphate? (Copper sulphate.)

Which seems to pass through a skin *fastest*? (The thin liquid.)

Was there a *skin* to the raisins?

What was inside? (Pulp and grains of sugar.)

As a little water soaked through the skin, what happened to the sugar? (Dissolved.) Making what? (A thick sirup.)

Who can tell me why the raisins and prunes swelled? (The thickest liquid was *inside*, and the thin water flowed in faster than the thick sirup could flow out.)

Can you explain why the dry sugar in the carrot or apple became a sirup? (The moisture in the apple was drawn *out* to the sugar because it was thin, like water.)

"Why are canned cherries" plump? (The juice of the fruit is *thickest*.)

Raisins in rice pudding—? (Same reason.)

Preserved fruits and sugared strawberries—? (Shrivel because the juice is *thinnest*.)

Pork and beef— ? (The moisture in the meat is thinner than the brine.)

If, then, two different liquids are separated by a skin through which they can pass— ? (The *thinnest* goes through *fastest.*)

Now for the taking of the earth food by our plant.

Who has seen a kind of white fuzz covering roots ? (Yes, in several of our experiments.)

Now, *all* roots have that, only in digging them up out of the soil they are rubbed off or else covered with soil so as not to be seen. Each one of those little "root hairs" is a tiny sac full of "sap," as we call the juices of a plant. (See Fig. 8.)

What, then, is one way the plant "feeds" ? (The sap is *thickest*, and so the liquid earth food flows *in.*)

FIG. 8.

I thought you could answer that, after these experiments! Some day we shall learn more of this.

Two questions more before we leave this :

How would it do to water plants with *very* strong earth food ? (They could not take it in.)

Why should you be careful not to let the roots of a plant get *dry* ? (The drying quickly destroys the root hairs, and the plant can not feed.)

29. A plant, then, lives on— ? (Water and the earth dissolved in it.)

This is taken in by— ? (The little root hairs.)

Cards.—The specimens pressed will now be dry, and should be mounted and labeled. Number each card, neatly, in the *upper right-hand corner.*

On Card 1.—Mount the doubled-over seedling, and label, *Plant backing out.*

Card 2.—*A young plant and its parts.* Specimen from Point 7.

Card 3.—*The top grows up and the roots down.* All specimens from the experiments on this (Point 11).

Card 4.—*A plant can not live on pure water.* (25) Two specimens.

Card 5.—*How the root feeds.* Specimens of 28, and colored drawings of the experiments tried by the child: sugar in root; thistle tube and the blue copper sulphate rising in the stem; barrel of beef, and a *list* of the examples and illustrations given. Some pupils would be able to illustrate the entire list (28), but do not take class time, or delay for it.

E.—How is the Air Food eaten?

30. When I dried the water from the earth food, what was left? (Earth.)

Will earth burn? Try a piece of "scale." (No.)

Suppose I try some *real* earth. (Take a blacking-box cover or other shallow tin dish with no soldered joints; place some earth in it, and heat *strongly* over a gas jet or on a hot stove.) (No; earth does not burn.)

Suppose I mix some sawdust with it. (Try again, mixing *one tenth* earth with nine tenths dry sawdust.) Does it burn? (Yes.) All up? (No; the *earth* and some ashes are left behind.)

What becomes of most of the sawdust? (Goes off in smoke and gas.)

31. Show some dried leaves or parts of a morning-glory plant.

Is there any water in these? ("No," the class will probably say.)

What, then, is it that forms these dry plants?

What did the plant eat? (Water and earth.)

If there is no *water* in these, what do you think there *is*? (Earth.)

Will these dry plants burn? Try. ("Yes.")

Can these, then, be *all* earth?

Will water burn? (No.) Will earth? (No.)

But these *do!* What does it teach us about a plant's food? (It *must* be something besides water and earth.)

It certainly *seems* so. Let us see.

32. What is there next to the plant, besides water and earth ? (Air.)

What parts are in the air ? (Stem, leaves, and bud.)

Experiments.—Give each pupil an 8-ounce bottle with 2 cm. of limewater in it, an unsplit straw, piece of candle, and piece of copper wire. *All work together.*

a. This is limewater in your bottles, such as you can often see in a mortar (or plaster) bed. Is it clear ? (Yes.) Cork it and shake a little. Is it still clear ? (Yes.)* Does pure air change limewater ? (No.)

b. Twist one end of the wire twice around the candle, so as to make a holder for it, and then lower the unlighted candle into the bottle while I count 60. Remove the candle, cork the bottle, and shake again. Is it still quite clear ? (Yes.)

Does an unlighted candle change limewater ? (No.)

c. Light the candle and lower it into the bottle till the flame begins to grow dim and flicker, when *at once* remove it and cork the bottle. Shake again. (The limewater has turned *milky !*)

What made it do so ? (The burning candle.)

d. Wash out the bottle clean, and then put in more clear limewater.

When all are ready, each take a *long* breath and then *gently* and slowly blow the air through the straw into the limewater.

How does it look now ? (Very milky.)

e. If possible, inclose a mouse or some beetles in a little cage of wire netting and suspend them in a fruit jar over some fresh limewater for 15 minutes. Remove, close the bottle, and shake. (Milky.)

How does our breath and that of animals change limewater ? (Milky color.)

f. Tie a little bundle of dry leaves, straw, or shavings with a piece of copper wire ; moisten with a spoonful of

* Unless the air of your schoolroom is very impure.

alcohol, "to start it burning"; light, and lower in a fruit jar over some clear limewater. When the flame has burned a minute (or gone out), remove; cover the jar and shake. What? (Milky again.)

What do the candle and leaves turn into?

Some will say "smoke," and some say "air." Let us burn this candle in the open fruit jar for several minutes. Do you see any "smoke"? (No.) Remove the candle and cover the jar. What can you see in the jar? (Nothing.) Is it really empty? (No; full of air.) Will pure air change limewater? (No.) Pour in some limewater and shake. Was it pure air? (No.) Would you like a name for this airlike substance from our breath and the candle which turns limewater milky? The shortest and best is "CO_2 *gas.*" Let me make some another way, to learn more about it.

Put a teaspoonful of crushed limestone or marble into one of the 3-ounce bottles, and add water enough to cover it. Tie a wire around the neck, so that it can be lowered into a fruit jar. Have the fruit jar *clean* and *dry*. Now pour about a spoonful of hydrochloric acid on the stone, and at once lower the bottle into the jar and lay a card over the top. The class will be too much interested in watching the experiment to listen to anything else, so simply talk of how there is *much* of this CO_2 in the stone, which the strong acid is driving off, and it is the bubbles of this rising through the water which makes all the commotion. Can you see any "smoke" now?

After two or three minutes of brisk effervescence, light a match and slowly dip it down into the jar. If it *goes out*, the jar is full; if not, wait a minute and try again. When the extinguished match shows it is full of CO_2, light a candle and stand it in a second jar; gently lift out the bottle of stone and acid, and proceed *slowly* to pour the CO_2 gas (like water) on to the lighted candle. It goes out! Stop pouring, replace the stone-and-acid bottle, and cover the mouth again with the card. Lift out the candle, light, and lower again in its jar. Goes out! Repeat this, to see *how far down* it can be lowered before going out. Is CO_2 gas light, or heavy? Why heavy? (Sinks to the bottom of the jar and can be *poured* like water.) Who can tell me how I can find whether there is CO_2 gas in a jar? (Lower a lighted match or candle.) How can I prove this is the same gas as that from our breath or the lighted candle? (With limewater.)

Clean out jar No. 2, and pour in some limewater and (as at first) also some CO_2 gas and shake. (*Very* milky.) Is it the same? (Yes.) If need be, add a little more acid, and, replacing the small bottle in its jar, cover with the card and leave where the class can see. What does CO_2 gas *look* like? What can you tell me about it? (Heavier than air, puts out lights, and turns limewater milky.) This CO_2 gas is *very* important, and about it I have several interesting *stories*. Sometimes men have gone down into deep holes, where there was much decaying matter—wells or sewer openings—to work, and after a few moments have fallen down senseless and died, unless rescued and brought up to the pure air. How could they have found out whether there was CO_2 gas before going down? (Lowered a lantern.)

The CO_2 in this case came from—? (Decaying matter.)

A distillery is where alcohol and whisky are made. Cornmeal is cooked and then mixed with some yeast in huge tubs and left to *ferment*. During this fermentation a great deal of CO_2 gas comes bubbling off, and at times this has run over and filled some of the empty tubs. Suppose you were a workman sent to clean one of these tubs, not knowing it was full of CO_2 gas. Could you see the bottom? You let down a short ladder and descend into the tub. What happens?

What did the CO_2 in this case come from? (Fermentation.)

Many years ago a large number of Englishmen (146) were taken prisoners in India, and were crowded into a room only 20 feet square and having but two little windows for air. The next morning only 23 were alive. What was one cause of their death? (CO_2 gas.) From—? (Their breath.) This is often referred to as "The Black Hole of Calcutta."

I was once told of a stable boy who made a fire of charcoal in a pan and took it into his bedroom to warm himself. After a while he went to bed, and the next morning was found *dead*. What killed him? (CO_2 gas from the charcoal.) Do you suppose he had the windows open? How would that have helped him?

Sometimes stoves have a "damper," as it is called, in the pipe, and if this is turned across, none of the CO_2 from the burning coal can get up the pipe and out of doors, so it pours out into the room. Will it rise, or fall?

A mother was ironing, one day, in a close room, and put her baby on the floor to creep. After a while she noticed how still he was, and, looking around, saw him lying unconscious on the floor. Picking him up and bathing his face in cold water, he soon revived. What was the trouble? Where did the CO_2 come from?

The "Grotto del Cane," or Cave of the Dog, is a small cave near the volcano of Vesuvius, into which, it is said, people can walk in safety, but a dog soon falls in convulsions, recovering if taken to the open air. What is the matter? Where does the CO_2 gas come from? (The volcano.)

Now tell me what sources of CO_2 gas I have spoken of. (Decaying things, fermentation, breath of animals, fires and lights, and volcanoes.)

Let the teacher expand this thought till the class has some idea of the *enormous* quantity daily poured into the atmosphere. Why does it not *kill us*? Here is one of those wonderful and beautiful plans which we so constantly find in Nature—where seeming ill works great good.

First let us prove there is CO_2 *in the air* about us. What does it do to limewater? I will pour some limewater in these saucers and set them about the room. (Crust will form.)

Next, let us burn this little bundle of morning-glory leaves over some limewater in a clean jar. What is the result? (CO_2 gas comes from the burning.) Where could the leaf have got this? (*From the air.*)

33. How do *we* "eat air"? (Breathe through our noses.)

Has a *plant* noses? Examine leaves and stem. (None to be seen.)

Can you breathe through the tiny meshes of a handkerchief?

Just as in the roots we could not see the "mouths," so in the leaf we can not see the "noses," as they are *very*, *very* small. These noses take in CO_2 from the air. (See Fig. 9.)

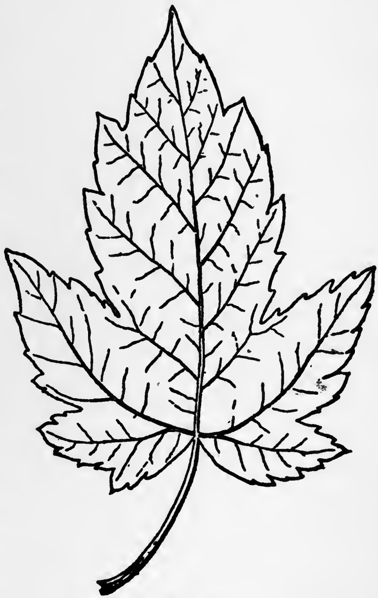

FIG. 9.

Press some morning-glory leaves, to mount on Card 6.

34. Expand the thought of the *multitude* of leaves at work making the air pure for us to breathe by consuming the CO_2. How, in the *winter*, when the leaves have fallen? (Winds drive it to countries where there *are* leaves.) *

In review.—What two foods have the plants?

What is each eaten by—water and earth? (Earth food eaten by the roots, and CO_2 gas by the leaves.)

Is anything else needed for the plant to grow?

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* Connect this with geography and the seasons—Step XXII—by finding the countries on the map toward the sun in the winter, etc.

Tell of how potato and other sprouts in a cellar reach out toward a window, and house plants turn—after what? (Sunlight.)

F.—Use of the Parts and Review.

35. Of what use is the *root?* (Takes in the earth food.)

Anything else? Picture what would happen if plants had no roots, and the confusion which would result from having nothing *to hold* them in their *place* and *position.*

36. What part just above the root? (Stem.) Where are the leaves? (On the stem.) What is the use of the stem? (To hold the leaves up in the sunlight and air.) Yes; and something else.

37. Arrange some cards, with several holes in the center, and, having filled the 8-ounce bottles almost full of water, cover with the card. Let each child now take his bottle and card to a sunny window and set it in a secure place. Divide the class into two divisions, and let "Division 1" insert the stems of leafy twigs through the holes of their cards, and then cover them by inverting perfectly dry and cool tumblers on the cards. Let "Division 2" strip off *all* the leaves from a corresponding set of twigs, and insert the leafless stems through the holes and cover with dry and cool glasses inverted on the cards. In the sunshine of a warm room five minutes will usually complete the experiment. What difference do you observe between the glasses? (Those over the leaves have moisture on them; the others not.)

Where did the moisture come from? (Leaves.)

Where did the leaves get it? (From the stems.)

Where do the stems of growing plants get the water? (Roots.)

What, then, is another use of the stem? (To carry earth food from the roots to the leaves.)

To see *how* the stem does this, let us try some *experiments.*

a. Each cut a strip of blotting paper 5 cm. long by 2 cm. wide. When all are ready, give the word, and each hold the end of the slip just in the surface of some ink for 60 seconds.

What has the ink done? (Crept up the paper.) (See Fig. 10.)

Save these slips for Card 7.

b. Give each pupil a 3-ounce bottle containing a little colored water (indigo, copper sulphate with ammonia, or aniline), and a bit of broken thermometer or fine glass tubing.

Stand the end of the tube in the liquid, and what happens? (Colored liquid *rises* in the tube.)

Blow it back and try this several times.

c. Take (teacher) a cork with a hole in it, through which draw a piece of lampwick. Moisten the entire wick with alcohol and light the upper end, while the lower rests in some alcohol.

How is the flame fed?

d. Let one corner of a towel rest in some water, while the other is held up high on some hook. Leave it over night.

e. Fill a lamp chimney full of bits of sponge, cotton, dry sawdust, or other porous substances, and stand it over night in a dish of water.

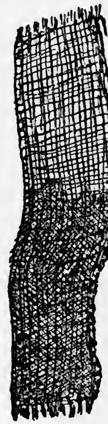

FIG. 10.

How did the *top* get wet?

f. Take equal-lengthed pieces of different dry woods (matches, etc.) and stand them (as they grew) in water for one or two days. Does the water creep up through them?

Now tell me one way the earth food has of getting from the root to the leaves. (Creeps up between the fibers of the stem, as in the lampwick, etc.)

Illustrate this on Card 7.

38. Now tell me two uses of the leaves. (To give out water and take in air food.)

G.—Growth in Size. Bud.

39. What parts have we studied? (Root, stem, and leaf.) Which way do they grow? What must the plant have to grow? What kinds of food does it eat? How does it eat these? What does food make *us* do? (Grow.) *How* do we grow? More hands, eyes, etc., or *larger?*

40. How does the *plant* grow? What parts did it begin with? (Four.) Has it any new kinds of parts? How about the *number?* (More.) (See Fig. 11.)

41. Whence have all these new parts come? (Give sprays of morning-glory vine to examine; they grow from the bud.)

42. What comes from the *bud?* (Stem, leaf, bud; stem, leaf, bud.) "*Helpful* parts."

43. How are these helpful parts arranged? (One above another.) Leaves—? (On stem.) Buds—? (In the angles of the leaves.)

44. Has every leaf a bud? How do you know your handkerchief? (By mark.) What is the mark of a leaf? (Bud.)

45. Complete review and summing up.

46. Any part *without a use?* So always, if we are wise enough to find it. (Card 8 made.)

H.—Flower and its Parts.

So far the plant has been growing in size and pushing out many roots, clothed with delicate root hairs, into the soil, and many leaves into the sunshine, to feed on the CO_2 and give out the surplus water. *What is it doing all this for?* (To make the air pure.) Yes; but plants always have their own ends to accomplish, although here again, as always in this wisely arranged world, "he best serves himself who serves others." What does the plant want to do *for itself?* Let us see.

47. What comes from a bud? ("Helpful parts"—stem, leaf, bud; stem, leaf, bud, etc.) What do we keep plants for in the winter? (Flowers.) Are these plants that flower

FIG. 11.

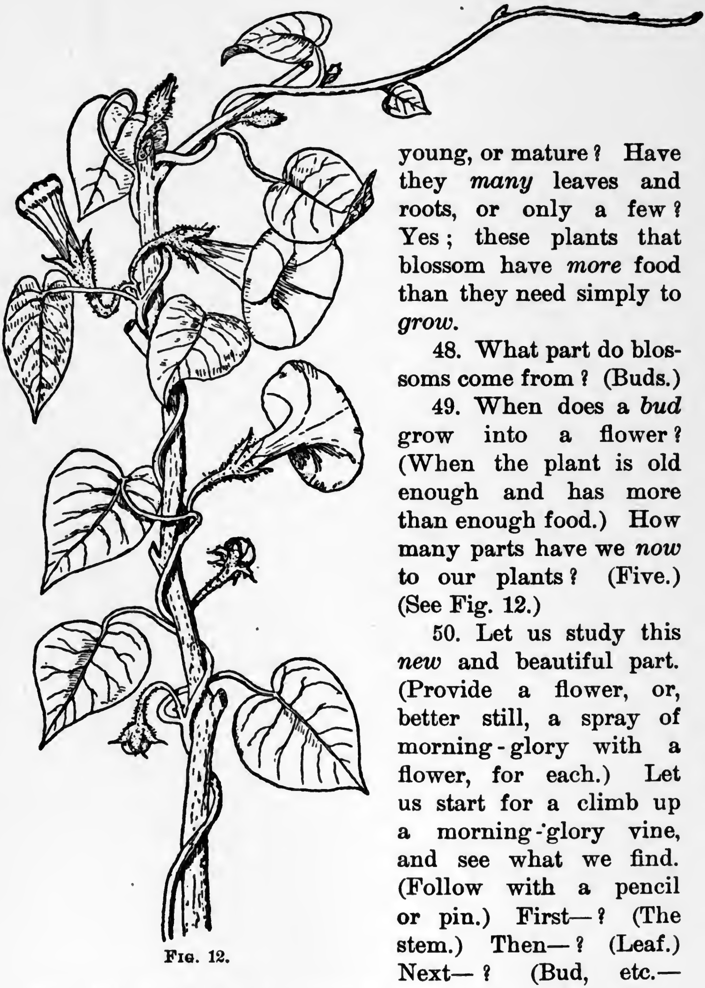

FIG. 12.

young, or mature? Have they *many* leaves and roots, or only a few? Yes; these plants that blossom have *more* food than they need simply to *grow*.

48. What part do blossoms come from? (Buds.)

49. When does a *bud* grow into a flower? (When the plant is old enough and has more than enough food.) How many parts have we *now* to our plants? (Five.) (See Fig. 12.)

50. Let us study this *new* and beautiful part. (Provide a flower, or, better still, a spray of morning-glory with a flower, for each.) Let us start for a climb up a morning-glory vine, and see what we find. (Follow with a pencil or pin.) First—? (The stem.) Then—? (Leaf.) Next—? (Bud, etc.—"helpful parts"—till we come to stem, leaf.) What is this? (*Another* stem, and just where a *bud* should be.) Let us fol-

low this. (Swollen place ; little, green, hairy leaves—delicate-colored leaves.) Go down into a deep cup. (Little hairy stems.) Let's climb one. (Hard work ; knob on top, and some nice little white grains to lunch on.) Climb down again. (Hill in middle; smooth pole on top.) Climb up, (Big, rough, *sticky* top, with some of the *white grains on it.*) A bee would find something *nice* in the bottom of the flower. What ? (Sweet nectar.)

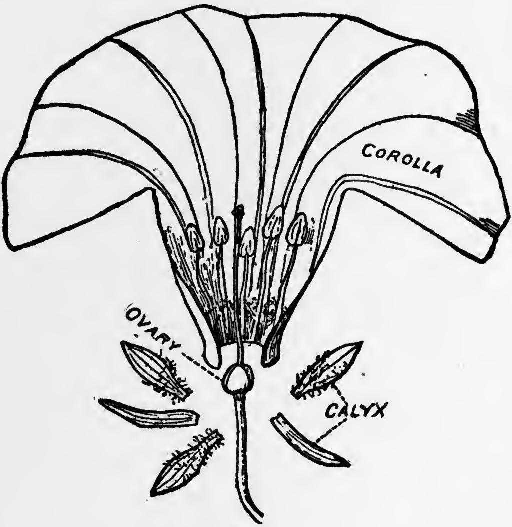

FIG. 13.

Press a flower (slit down one side to show the parts) for Card 9. (See Fig. 13.)

I.—Use of the Parts of Flower.

51. What part did we find first ? (Little green [calyx] leaves.) Of what use are they ? (Observe a *bud.*) Why in several pieces ? (So as to cover the delicate parts while

growing.) Ball cover, orange peel. Press calyx for Card 10. (See Fig. 14.)

52. (Corolla.) What next? Where? (Inside calyx.) In pieces like outside? (No.) Shape? Use? (To protect

FIG. 14.

FIG. 15.

more delicate parts.) Press corolla for Card 11. (See Fig. 15.)

53. (Stamens.) What inside the colored part? Parts? (Stalk, knob on top, white grains.) Shall soon see its use. Press stamens (5) for Card 12. (See Fig. 16.)

FIG. 16.

54. (Pistil.) What *next?* Where? Parts? (Hill at bottom [ovary], stalk, sticky top.) Examine hill. (Three chambers with little white ovules fastened to the sides—jewel box, baby in bed, etc.) How *beautiful* it all is! What can it all be for? We shall see. Press pistil for Card 13. (See Fig. 17.)

55. Show nearly ripe capsules with seed. Yes ; these ovules *can* be *seeds*, if plenty of the white dust gets on the sticky top and makes them grow. (Repeat and emphasize.)

56. Here are some interesting things to show you :

FIG. 17.

a. This is an ear of corn which I picked from a stalk that grew *alone* in the middle of a potato field. See! there are only a few scattered grains of corn on a big cob. All these little, dried-up, brown things between were once fresh and growing ovules. Why did they not develop into corn grains? (Wind blew the pollen away from its own high tassel, and no other stalks were near.)

b. Here is an ear of corn well covered with kernels. Did plenty of pollen fall on its silky stigmas? But how do you explain the *different colors* of the grains? Some are red, and the rest yellow, while here is an ear of sweet corn with scattered *black* grains. (Pollen from another kind of corn got on the stigmas.)

c. I once knew a man who wanted some cucumbers early in the spring ; so he planted the seeds in the rich, warm earth of a hothouse, and the vines grew rapidly and ran over everything, but not a cucumber set! There were lots of blossoms, of two kinds—one with the stigmas and tiny little cucumberlike ovaries, ready to grow into large ones; and others with lots and lots of golden-yellow pollen. But something was wrong, for the little cucumberlike ovaries kept turning yellow and dropping off. What was the trouble? (No pollen on the stigmas.) At last some one told the man to take a soft brush and dust the pollen on the stigmas, which he did, and had plenty of cucumbers.

d. Here are 5 green morning-glory seed pods for each of you. Open them by cutting a slice off the top, and count the growing seeds in each. How many do you find? ("6," "5," "3," "4," etc.) What is the highest number? (6.) Why do others have less?

Before we answer this let us arrange our cards and drawings.

Card 10.—With a little glue, gum on the pressed calyx. An *overcoat* picture might be cut out of some fashion book and added.

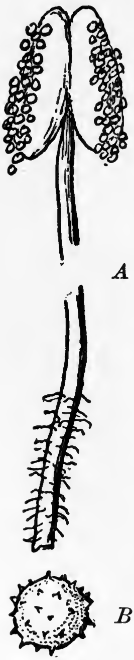

Fig. 18.—(× 10.)

What shall we write by the pressed calyx? What is its use?

Yes; we will write, *To protect*.

Card 11.—Gum on the pressed corolla. A *dress* might be added by the girls, and a suit of clothes by the boys. What shall we write? (*To protect*, again.)

Card 12.—Gum on the 5 stamens in a row near the top. What shall we write as the use of these? (*To give pollen.*)

This pollen is so important and curious that I want you to make some drawings of the grains as they would look under a microscope. You may copy these from the board. (See Fig. 18.) *A* is a magnified stamen. What does the parted filament show? (That it is too long to draw entire, and a portion has been left out.)

What does "× 10" under A and B mean? (Magnified or *multiplied* 10 times.)

B is one of the pollen grains from *A* more highly magnified.

What do you observe about it? (Round, and studded with little points.)

Let all who can get a magnifier examine the pollen of several morning-glory flowers, and tell me to-morrow whether all the grains resemble each other. These grains have two coats.

The outer is thick, except where the points are. The inner is thin, delicate, and elastic; and inside of all is a thick, liquid substance, which can *grow* if it has food.

The grain might be compared to a ball, covered first with thin India rubber, and over that a stout cover (like a base-ball) with perforations in it. Now try and think what will happen if the liquid inside *grows*. (As it grows it will press on the thin rubber coat, and this will *stretch out* at one of the perforations, like a protruding glove finger.) Good! and this protruding part is called a "*pollen tube.*" I will draw one, and we will letter it *C*. (See Fig. 19.) One thing more, and this card is done:

FIG. 19.

In the lower right-hand corner of the card place two little rectangles, 1 cm. long by 3 mm. wide. After one write, in neat letters, "Pollen," and after the second write "Cellular tissue."

It is very helpful, in drawings of this kind, to have some *color* which always represents the same thing. What is the color of morning-glory pollen and stamen? (White.) But our *paper* is white, so that will not do. What is the *usual* color of pollen? (Yellow.) Yes; and when you find time, you may color one little rectangle and the stamen itself the color of most leafy and other growing tissue—what? (Green.) Yes; and when it is dry, what will you color the other rectangle and the pollen grains of *A*, *B*, and *C*? (Yellow.)

What will be the word after the yellow rectangle? (Pollen.) And then, wherever we see *yellow*, we shall know it means— ? (Pollen.) And what does our key tell us is to be the color of all growing tissues? (Green.)

Card 13.—Gum the pressed pistil in the upper left-hand corner. Draw Fig. A in the center of the card, *ten times* larger than the real pistil. How many lobes to the flat stigma? (3.) (See Fig. 20.)

Cut a green capsule across, and find how many chambers. (3.)

B

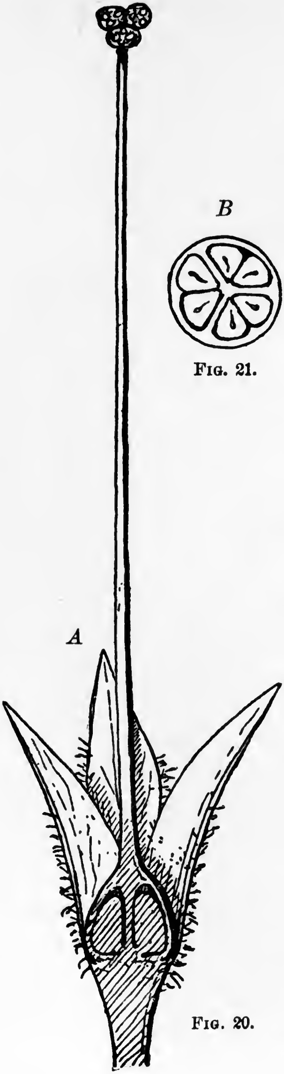

FIG. 21.

A

FIG. 20.

How many ovules in each? (2.)

Make a drawing (B) of it, multiplied 2 times. (See Fig. 21.)

Draw three little rectangles (for "key" colors), and after the second write "Cellular tissue," and after the third write "Ovules, or seeds." We will choose orange for ovules and seeds. Tissue is—? (Green.) After the first write "Pollen." What color? (Yellow.)

This card now shows us the parts of the pistil and the structure of the ovary.

Card 14.—Let the class copy from the board the following idealized diagram of the growing pollen tubes and their union with the ovules. (See Fig. 22.)

(*A*) represents the top end of the pistil with 3 pollen grains sticking on it. The stigma is moist with a slightly sweet liquid, and when the grains fall on it what happens? (It *sticks;* the liquid outside is *thinnest.* and enters the pollen grain, which begins to grow, and, pushing the thin inner coat before it through one of the thin places in the thick outer coat, projects as a *pollen tube.*) On which side will it be most apt to push through? (The moist, under side.) Now draw 2 tubes each about 5 cm. long and ending in the broken way which indicates there is more which is not shown. Let the third tube be only 2 cm. long. Fill in between them with the loose cells I have shown. Some

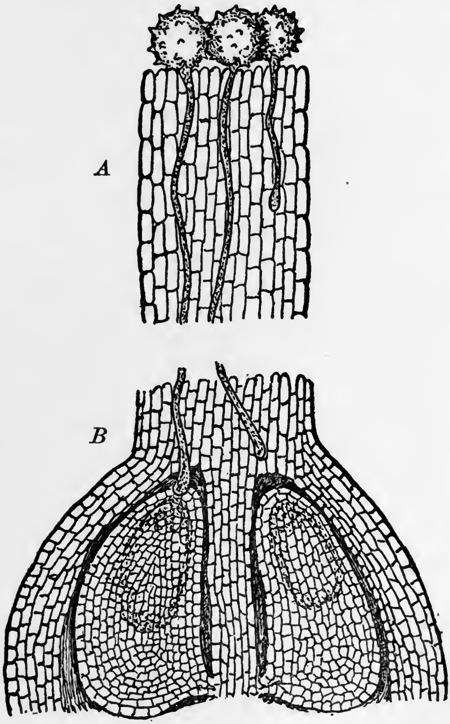

FIG. 22.

people think there is a *pipe* for the pollen tubes to grow down through ; but there is not, except that the cells do not fit closely, and the tubes find their way through the cracks. Imagine a well to be filled full of huge stones and then covered over with earth. If, now, a tree were planted over the stones, what would the roots do? (Follow the cracks between the stones.) And what would nourish them? (The moisture and earth food on and in the stones.) So the delicate pollen tubes push their way through the loose cells of the style, and these in turn nourish and protect them.

Now look at *B*, (Fig. 22). This represents an up-and-down section of the ovary. You see the partition wall to which the two ovules are attached, and the outer, protecting walls, which keep the delicate ovules from the drying and injury their exposure would cause. We will draw the walls first; then the ovules, with little openings on the upper sides. Now draw the ends of the two longest pollen tubes—one ending *in* the opening, and the other ending a little above it. Fill in the loose tissue of the style, and draw three little "key" rectangles. What shall we color them? (Green, orange, and yellow.) Yes; and name as on the other cards.

But little explanation is needed. The pollen tubes push down and down till—? (They enter the openings of the ovules.) Suppose they do enter—? (The ovules will then grow into *seeds*, able to sprout and produce new morning-glory plants.) Suppose no pollen falls on the stigma, it dries up, or anything prevents the tubes growing to and joining the ovules—? (They will at last die and shrivel up.) Just as we saw on—? (The ear of corn that grew alone.) Does it seem quite important that the pollen should get on the stigma?

57. How is it to get there? Examine several flowers. (Falls, or the wind blows it on.) But sometimes the stigma is *above*, and it can not fall, or the wind does not blow; what then? (The flower must have *help*.) Like the cucumbers in the greenhouse.

58. If you want help, how do you get it? Can flowers *talk*? How do business men get help? Do they run about *asking* people? (Advertise.) Read some "Help wanted" advertisements from paper. Then show colored, pictured, perfumed, and odd-shaped advertisements. Why not plain black and white? Why colored? pictures? queer shapes?

odors? (More apt to attract notice.) Why do people work for each other? (Pay.) Suppose, after working, they got no pay; would they work again? A poor man, with a large family, works, but gets no pay; will he work for that man again?

59. Our morning-glory flower evidently needs help. Can it talk? How can it let its wants be known? (Advertises.) How? (Bright colors and shapes.)

60. Who will work for a flower? Did you ever see anything at work about a flower? (Bees and butterflies.) Do you suppose *they* will work for nothing?

61. What has the flower to pay with? (Show honey in comb.) What is this? How did it get in these nice little cells? Who put it there? Where did the bee get it? Did he get it for nothing? What work did he do? (Pollen on sticky top.) Suppose he was lazy or dishonest; could he not take the honey without doing the work? (Examine the body of a bee. Note its big, hairy body. Note the *shape* of the flower and *position* of nectar. Have a boy with a shaggy coat try to get candy from a flour barrel without getting dusty.)

62. Where is the nectar in a flower? Now, as he crawls in to get the nectar, what must he get all over him? Can he help it? Does he get nectar enough in one flower? What, then, happens when he pushes his big, hairy body, all dusted with pollen, into the next flower? Is there any danger of his not doing the work? What *compels* him to do what the flower wants? (*Shape* of the flower and location of the nectar.)

63. Nectar differs in taste, and a bee likes to gather one kind at a time. How is he to know, among the many flowers, which to go to? What has the flower to guide him? (Color and shape.)

Only one of these. Let us try a game. Here are pieces of colored paper which we will lay all around the room (or yard). On each is the picture or name of some plant from which bees gather honey. Each pupil may choose some kind of honey to gather, and, when all have chosen, each may set out gathering and bring what he gets to me.

These slips can be prepared as follows:

a. Get a package of kindergarten folding papers (assorted colors).

b. Select 2 sheets each of some 13 well-contrasted colors.

c. On one of the sheets lay off two good-sized circles, a square, a rectangle, a rhomb, and a triangle; and then, laying this pattern on the pile of assorted colors, cut through all according to the lines laid out. There will then be 26 squares of 13 different colors, and so for the other shapes. Now cut one of the sets of 26 circles into *half circles*, and one set of these 26 half circles into *quadrants*.

d. Get some outside help to place on all the rhombs either the word "Basswood," or an outline sketch of the flower cluster (see almost any botany) ; on the squares put "Mint"; on the circles print or draw "Morning-glory"; on the triangles, "Buckwheat"; on the quadrants, "White clover"; on the oblongs, "Golden-rod"; and on the half circles, "Apple."

A variation of this would be to cut out bells (morning-glory), clover leaves, apple blossoms, and other shapes.

An *easier* way would be to lay out the triangle, square, etc., on a piece of firm writing paper the size of the colored paper to be cut ; then, inside the lines of each, make the proper drawing, writing (or both), in hectograph ink, and print the 26 sheets on the gelatin pad before cutting up.*

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* The hectograph has been a great help to me in many ways—printing outlines, maps, diagrams, examination questions, etc.

I have observed these rules in its use :

1. Moisten with a sponge (don't *rub*) before using.

2. After the sponge, lay successive sheets of newspaper or blotting paper on the surface to take up surplus water.

3. After printing *never wash.* Washing wastes the pad and leaves it uneven, while the ink soon sinks in and does *no harm.* In 12 hours the pad can be used again, and, by using one end or corner after another, it is seldom that a place can not be found to use.

A bee is only able to carry a certain amount home. What shall we call a "*load*" for us? (6 slips.)

Place on the board the names of all the plants which the class know of as being worked upon by bees; add, if need be, any they have omitted, and underscore those you have chosen. Let each now choose his or her "favorite kind of honey," and then go out in search of it. He will soon learn that it is *shape*, and not color, which guides the bee.

64. Now, what three ways for the pollen to get on the stigma? (Falls on; wind carries it, or bees and butterflies dust it on.) When the pollen is once sticking on the stigma, what happens? (Pollen tubes are pushed out and down through the protecting and guiding style to the ovules, which they unite with, and then the ovules grow and grow till they are—? (Seeds.)

65. *Complete cards.* Let us now take our cards again, and add what we have learned:

Card 1 shows—? (Review.) Anything to add?
Card 2 shows—? (Review.) Anything to add?
Card 3 shows—? (Review.) Anything to add?
Card 4 shows—? (Review.) Anything to add?
Card 5 shows—? (Review.) Anything to add?
Card 6 shows—? (Review.) Anything to add?
Card 7 shows—? (Review.) Anything to add?
Card 8 shows—? (Review.) Anything to add?
Card 9.—Have we found any new part?
Card 10.—Any new use for the calyx?

Card 11—Any new use for the corolla? (Yes; it advertises for help by its shape and colors; offers fine nectar pay, and by its shape compels the bees to do the work, and then guides them to other flowers of the same kind.)

We will record this on the cards.

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4. When the surface gets uneven, stand the tin tray over a kettle of boiling water till the gelatin is well melted. Pick out any specks or froth which may show, and set it in a *still*, *perfectly level* place to cool.

Card 12.—What does your card say as to the use of the stamens? (To give pollen.) Any other use? (No.)

Card 13.—Name the parts of the pistil. Tell the use of the sticky stigma. How is the style constructed? The ovary? Tell the "story" of a grain of pollen that got on the stigma. Tell the story of an ovule that grew into a seed.

Card 14.—Different ones may tell me what the drawings show. (Make it an exhaustive review.)

Card 15.—Each draw and color a flower or spray of morning-glory vine on this card. When done the very best you can, come to me for some of these transfer pictures of pretty bees, butterflies, and moths, which you can place as though they were after the nectar. Label the card "Bee and butterfly visiting the flower for nectar."

Card 16.—This is a hard card to *keep*. A good way is to build up the *edges* by taking one or two pieces of thick cardboard the size of the card, cutting out a square or oval as large as is needed to hold the dissected seed pod, and gumming the thick border left to the card. This will protect the parts gummed on. Give each a *perfect* seed capsule in a little box. What parts can you see? (Little, pointed remains of the style; 3 valves, which split off, and 6 black seeds in 3 curious chambers.) With a pencil make dots where these parts are to be; place a drop of strong glue on each dot, and then put the parts on the glue, press down, and set aside to dry. Label it "The ripe ovary and its parts."

66. Now, I think, we can answer the question asked under *H*, and tell me what the roots, stems, and leaves were all working for. *To build a plant that could bear seed!*

How wonderfully this is planned for, we have seen. What lessons it all has for *us*—that we "bear much fruit" in our daily lives, leaving the world brighter and better for our having lived. Read to the class Longfellow's Psalm of Life, as emphasizing this.

J.—Parts and Uses of the Seed.

67. We will now study this curious seed. What can you see about it? (Black outside, scar, shape.) These seeds are very hard. Let us soak them.*

Before examining the seeds, let us take these green capsules of the morning-glory and see what we find. Cut a slice off the top of one, and tell me what you see. (Six seeds in three chambers.) (See Fig. 23.)

Do you or have you ever noticed anything peculiar about the cut seeds? (White inside, with wavy green lines across.)

Gently squeeze the capsule, and see what happens. (*Little green plantlets come out from each seed.*) (See Fig.

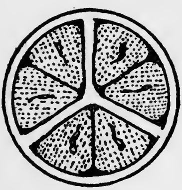

Fig. 23.

Fig. 24.

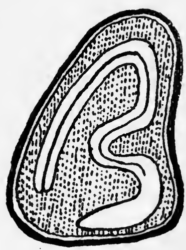

Fig. 25.

24.) Good! And how did they get there? (Grew.) True, but what *made* them grow? (Pollen tube.) What is around them? (A whitish jelly.)

Cut green seeds in various ways, and see how wonderfully the little plant is packed in the seed. (See Fig. 25.)

Now take Card 17, and make a drawing of "A cross section of ripe ovary, × 5 times."

68. Here are our soaked seeds. Open carefully with a pin, and see what you can find. (Black coat, white skin, two little leaves all crumpled up, a little white point, some jelly.)

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* Place in warm water 12 hours before wanted.

Place the little plant and black coat on Card 17 to dry, and label.

69. Allow some of the seeds to sprout one half inch, and then give to examine. Examine as before. Any new part? Anything gone? (Jelly.) Where is the black coat? Two little leaves? Little point? Where was all this plant before the seed sprouted? (Packed away in the seed, snug and tight.)

70. What is the use of having the little plant so snugly packed away? What happens to our plants in the fall? (Freeze.) Are the seeds killed, too? What will they do when it gets warm in the spring?

71. But how can a seed grow when it has neither roots nor leaves to feed by? Does it not need food? If you see a fat little boy growing bigger and bigger, do you think he has no food? But he is too small to work; how does he get it?

72. Do you think these seeds can start to grow without food? Were the second plants you had larger than those in the soaked seeds? How did they get larger? Then they do grow. Look and see if there is anything like food in the soaked seeds. (Jelly.) Yes, that is the food. Where was it before the seeds began to grow? Who packed it there? What a kind, thoughtful mother! What parts have we found to our seed? (5 fingers.) Now add to Card 17 a drawing of "a vertical section of morning-glory seed," and make a "key," adding brown for the little stem, which points straight toward what? (Scar.)

73. What kind of food must the kind mother have packed away? Speak of small space; could be no waste.

74. What kind of food did we find the plant must have to eat? But this is hard. What was needed besides warmth and air to make the seed sprout? Yes, water, to make the food thin for the little plant.

75. How does the little plant live after eating up all the jelly? (Review uses of roots and leaves.)

Review and Examination.—This will greatly aid pupils who, through sickness or other cause, have been absent and lost the thread of the work, and will hurt no one. Push it vigorously through, and mark on it, if marking must be done. There must be no *repetition.*

1. Each in succession tell me something about the morning-glory plant.

2. Each tell me of some illustration or experiment.

3. Each show and tell about something he has pressed or drawn.

The average of these three marks—one on pressing and mounting, one on drawing and color work, and one on interest and attention—will represent as fairly as possible the *real* work of the class.

Questions.—Where a class has seemed to need it, I have used the following set of questions, answered *orally:*

1. Describe the plant we have studied.
2. Describe its seed.
3. What conditions were found necessary to sprout it?
4. Proof that *earth* is not needed.
5. Proof that water is needed.
6. Proof that light is not needed.
7. Proof that they will not sprout without air.
8. Proof that warmth is needed.
9. How does the seed throw off the covering earth?
10. What parts to be seen when it is up?
11. Which way do these parts grow?
12. What do plants require in order to grow?
13. Where alone can this food be?
14. What things are "next to" the plant?
15. How do you know it can not live on *pure water*?
16. Where is the "earth food," and what is it composed of?
17. How can you prove there is earth in this earth food?
18. What part takes this in?
19. How could you prove the *leaves* can not do it?
20. Tell of experiments showing *how* the root feeds.
21. How do we know there must be some other food than earth food?

22. Where must this food be?
23. What do we call it? (CO_2 gas.)
24. How can you test for CO_2 in wells and holes?
25. How can you test for CO_2 in the air about us?
26. Where does it come from?
27. How does it affect people? Animals? Lights?
28. Why do we not die from it?
29. Where must the leaf be to feed on this? (In *sunshine.*)
30. What two foods has the plant?
31. Eaten by— ?
32. What besides food is needed to grow? (Heat and sunshine.)
33. Give 2 uses of the root.
34. Give 2 uses of the stem.
35. Give 3 uses of the leaves.
36. How can you show that leaves give off water?
37. How do plants increase in size? How do we?
38. Of what use is the bud?
39. What is the "mark" by which we can always tell a leaf?
40. What are Prof. Goodale's "helpful parts"?
41. Tell of a journey into a flower.
42. Name the 5 parts of a flower.
43. Describe the calyx, and tell its use.
44. Describe the corolla, and tell its uses. (4.)
45. Describe the stamens, and tell their use. (1.)
46. Describe the pistil and its use.
47. What *must* happen before the ovules can grow into seeds?
48. How is the pollen brought to the stigma?
49. How does a plant "advertise"?
50. Who or what will answer?
51. What has the flower to pay with?
52. How is the bee compelled to do the work?
53. What, then, are the uses of *shape*?
54. What the uses of *color*?

55. What the uses of nectar ?
56. What happens when the pollen is brought ?
57. What is the end and aim of a plant's life ?
58. How are the seeds packed in the ovary ?
59. What parts to a seed ?
60. What is the "scar" ?
61. Use of coats ?
62. How can a seed start to grow without leaves or roots ?
63. Use of the "jelly."
64. What is needed to start the seed ?
65. What does the little plant do when the jelly is gone ?
66. (For all.) How many have enjoyed this wonderful story of a plant's life ? (Rise.)
67. How many are glad it is *completed* ? (All *should* be.)

Material put away.—Wash up all glassware and place on the shelves. A little hydrochloric acid in some water, and turned from one bottle to another, will clean off the adhering lime from the limewater.

Should replace all used material (straws, cloth, etc.) so as to have all possible things in readiness for the next class, and, packing in the boxes, store in a safe place. Make notes *now* of any needs, suggestions, or changes that may seem desirable.

Should there be any prospect of a new teacher having the work, it will greatly aid him or her if you let some pupil make a list of the members of the class and their standing, to inclose with the material and your suggestions.

SYLLABUS OF
HOWE'S SYSTEMATIC SCIENCE TEACHING.

SUGGESTIONS TO THE STUDENT.

THE gain to *you* will be in direct proportion to the individual independent work you do with *things*.

Scorn aid unless absolutely required.

Choose some uniform paper (say eight by ten inches) for your notes and reports, that in the end all may be bound together.

Use *diagrams* and *sketches* (of leaves, fruits, crystals, etc.) in preference to word descriptions, both to save time and also to make identification more certain.

Ask questions only as a last resort, but if a point is uncertain do not hesitate to ask.

Study the topics at the suggested *time of the year*. They will prove needlessly difficult at other seasons.

COLLECT YOUR OWN MATERIAL.

Much is gained by the teacher or pupil in so doing. Should this be impossible, collections made under the author's direction can be bought by addressing Ralph B. Howe, Urbana, Ill.

If after use, the material is returned, the cost will be refunded, after deducting for such injury or loss as may have occurred and ten per cent for packing and labor.

First Month.—August.

EDITOR'S PREFACE.

1. Summarize Dr. Harris's argument for the teaching of science in the lower grades.

AUTHOR'S INTRODUCTION.

2. What results does experience show from direct contact with natural objects?
3. What is really the most valuable of these results?
4. How can satisfactory science work be made possible in graded schools?

CHART.

5. Into what four parallel lines does the author divide science work?
6. Name some of the interrelations of these four lines of work.

STEP XXIII. THE LIFE HISTORY OF ONE PLANT. Page 279.

7. What is the end sought in this step?
8. What books did you consult in your preparation?
9. Go through the subject experimentally (as arranged) and record notes of all experiments and questions answered.
10. Have you made the set of cards (page 315)?
11. Answer from memory (in writing) the sixty-seven questions on pages 319–321.

Second Month.—September.

STEP I. SORTING SEEDS AND FRUITS. Page 8.

1. Read the outline on plants (page 5) and draw up a summary of the progressive steps in the lessons arranged.
2. Write a list of the "fruits" you have gathered. Of the "imperfect fruits." Of the "seeds."
3. Did you sort them as directed (page 11)?

4. Define "fruit," "seed." Why were some called "imperfect"?
5. Did you try the four "games" (pages 15 and 16)? Was *your* sense of smell, taste, and touch sufficient for the test?

STEP XVIII. FRUITS. Page 200.

6. What is the object and best time to teach this step?
7. What reading have you done? (See Preparation, page 202.)
8. On large paper list the thirty varieties of fruits given on pages 200–202, and after each note the representative plants you have examined. (Make free use of drawing and color, as on page 205.)
9. Have you arranged the plates (or substitutes) of page 205 and sorted your collections as directed?
10. How can this step aid geography?

Third Month.—October.

STEP XII. TREES. Page 156.

1. What is the object of and best time to teach this step?
2. Have you been out among the trees to prepare?
3. Make a list of the trees you can recognize, and after each name write (*from memory*) the characteristics, as on pages 158–161. Make sketches of leaves, fruit, etc., as far as possible.
4. Rule a large sheet of paper with eight columns as below:

NAME OF TREE.	Bronze.	Crimson.	Scarlet.	Orange.	Yellow.	Brown.	Date of falling.

Observe the color changes of as many trees as you can, and record on this sheet the series of tints through which they pass, making note of any causes (frost, rain, hot sun, high wind, etc.) which induce *sudden* changes.

STEP VI. ROOTS AND STEMS. Page 75.

5. What is the object of and best time to teach this step?
6. What have you read on roots and stems?
7. Under the heads "Tap," "Multiple," and "Air" list the roots you have gathered.
8. Fill out the following table from a personal examination of the twenty stems listed on pages 77 and 78. Sketch and color when possible:

STEM (NAME).	Shape.	Bark.	Wood.	Pith.	Sap.	Buds.	Smell, taste.

9. What is the difference between a *root* and a *stem?*

Fourth Month.—November.

STEP XIII. WOODS. Page 162.

1. What is the object of and best time to teach this step?
2. Name the specimens you have prepared (see page 163).
3. List the woods you can recognize in a left-hand column, and after each write the characteristics by which it is distinguished.

Step II. The Skies. Page 18.

4. Write a brief outline of these lessons (see pages 2–4).
5. Show how they are related to geography.
6. How related to physics.
7. Why is interest in simple astronomy especially helpful to the young?
8. What books have you at command on the subject?
9. Sketch (from memory) and name the star groups given.

Step VII. The Moon. Page 81.

10. What have you read in preparation?
11. Write briefly *your own* observations and experiments on the nine points given (pages 81–84). Make sketches or diagrams where possible.

Fifth Month.—December.

Step III. Metals Sorted. Page 21.

1. Read the "Outline" (pages 4 and 5) of the mineral work and give a summary of the progressive sequence of the steps.
2. Make a tabular list of the metals you have gathered, and after each name give its characteristics.
3. Placing yourself as nearly as may be in the position of a *child*, sort a mixture and record the mistakes you made and how they were detected.
4. Have you a set of material ready to use in teaching?

Step VIII. Minerals Sorted. Page 85.

5. Take the named specimens and *see* in each the qualities given on pages 86–88. Study and read of them in Dana's or other mineralogy.

6. Get some one to privately make a mixture of varying numbers of specimens from each. Sort this mixture without reference to any aid, and then compare the result with named material.
7. Lay the eighteen minerals before you and with no other aid answer the questions "B" on pages 88 and 89.
8. Let some one make as difficult a mixture as possible and you sort as in "C," page 89. Repeat this, if need be, till it can be done without mistake.
9. Write the eighteen names in a column and (from memory) add the characteristics of each.

Step XIV. Rocks Sorted. Page 166.

10. Lay the rocks before you, arrange the names in a left-hand column, and (without aid from person or book) write after each the points by which you would recognize it.
11. With all available aids modify the above characteristics till you have reduced each description to the *fewest* terms which will determine the rock.
12. Number one set for a standard.
13. Compare your material with "E" on page 169, and study and handle the specimens till each kind is familiar.
14. Mix a number of unnamed rocks and sort. Record errors and how detected. Repeat till it can be done perfectly.
15. What is the difference between a *mineral* and a *rock?*

Sixth Month.—January.

Step XV. Pebbles. Page 171.

1. What is the purpose of this step?
2. What reading did you do in preparation?

3. Go through the lessons (pages 172–183), and in the order of the book write a brief record of your experimenting and answers.
4. Write a brief synopsis of the step, and compare it with 21 on page 183.
5. Take a walk in a hilly country and make a note of all illustrations you can observe.
6. What is the bearing of this step on geography?

STEP XX. SHARP STONES. Page 246.

7. Go through the lesson experimentally, and briefly record what you did and observed.
8. Write a brief synopsis of the step.
9. What is its relation to the pebble step?
10. Take a walk in the most favorable locality open to you and keep a memorandum of everything suggested by this or the pebble step.
11. Review the outline on pages 4 and 5, and state the special functions of inorganic material in education.
12. What advantages has it over plants and animals? What disadvantages?

STEP XXI. PLANE FORM AND COLOR. Page 252.

13. Why are form and color essential to good science work?
14. Write from memory the tables of metric length, weight, and liquid measure.
15. What would be the advantage of a uniform international system of weight and measure?
16. Read pages 255–270.
17. Draw the eighteen cards and color as suggested.
18. What gain would such a piece of work be to a class?

Seventh Month.—February.

Step IV. Buds. Page 27.

1. What is the object of and best time of the year to teach this step?
2. List the twigs you gathered under the fourteen heads of page 27.
3. Have you read up the subject of buds and branches in some good botany, and compared your material with the text?

ANIMALS.

4. Study the outline on pages 6 and 7, and read pages 31–34.
5. Write a synopsis of the animal lessons, giving reasons for each progressive step.
6. What may be one of the special functions of the study of animals in the development of the child?
7. Secure or visit the sixty-three types listed on pages 34–40 and make a careful study of each, verifying the points given (pages 40–57) by such material, books, and other aids.

Step V. Home Animals. Page 30.

8. Collect, observe, and experiment as suggested on the animals of this step and keep brief notes of all you observe and do, numbering them to correspond to the points under each animal.

Step IX. Animals. Page 91.

9. What is the object of and best time to teach this step?
10. Collect, observe, experiment, and verify by books or otherwise the work of this step. Keep an orderly record of such work, numbered to correspond to the book.

Eighth Month.—March.

STEP XI. FOREIGN AND LESS FAMILIAR ANIMALS. Page 124.

1. What is the purpose of and best time to teach this step?
2. Go through the lessons with specimens, material, and books in hand, and write a brief record of what you did and saw, numbering the notes to correspond to the book.

STEP XIX. THE BOY. Page 207.

3. What is the purpose of this step and when is it best taught?
4. Go through the lessons in an orderly manner, keeping notes (numbered to correspond to the forty-eight points) of the reading and experiments, also *your* answers to the questions.

Ninth Month.—April.

STEP XVII. FLOWERS. Page 190.

1. What is the purpose of and best time to teach this step?
2. Arrange the thirty-seven points of pages 191–195 in an orderly manner on large sheets of paper and then list after each the example of it gathered, adding such other observations as you may make. Sketch, draw, and color much as suggested on pages 198 and 199.

STEP X. LEAVES. Page 117.

3. Have you, specimens in hand, read the chapters in some good botany?

4. Write the names of the eighteen leaves you selected in a column at the left and head thirteen other columns with the topics of page 118. Opposite each leaf sketch or write what points it illustrates.
5. Did you press and mount a collection?
6. Send "blue prints" of any unknown leaves.

Tenth Month.—May.

STEP XVI. THE EARTH. Page 185.

1. Write a brief record of your experimental progress through the step.
2. Make correct sketches of the constellations of page 188 and name them.
3. What books have you read or referred to in this study?

STEP XXII. THE EARTH (*continued*). Page 272.

4. Write a brief record of your experimental progress through the step, answering the questions asked in the spirit of a child.
5. Review the previously given constellations and learn the six new ones.
6. Enlarge the six zodiacal constellations (on cards) sufficiently to be easily seen by a schoolroom full of children, and tell how it was done.

INDEX.

(1)

THE END.