

PHYSIOGRAPHY IN THE LABORATORY.

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It has been a question in my mind for some time as to why physiography occupies so small a place in the discussions of our science meetings. The question was answered a short time ago by the statement of one of the science men of our state that physiography has no legitimate place in the high school course; that it is a science adapted to those schools which are poor in laboratory equipment for botany and zoölogy, physics and chemistry in cities small enough to permit of out door study.

No one will deny that out of doors is the place to study physiography and that field work is as necessary to effective work along that line as it is to plant or animal ecology—as necessary, but not more so. That a subject so rich in information, stimulating to scientific investigation, broadening to one's knowledge of things met with in every day life, should be left out of the course of study because of the impracticability of field work seems, at best, unfortunate.

Botany and zoölogy both treat of life. Life principles are essentially the same in both. Plants and animals alike require air, water, food, heat and light to perform their life functions. Both grow and multiply; meet conditions favorable and unfavorable to their existence. Decrease of water, change of temperature, character of soil, topographic forms, influence animals and plants equally. Both meet unfavorable conditions in much the same ways—they adapt themselves to changed conditions, migrate, or die. Both meet essentially the same hindrances to migration, both use the same agencies.

Teach a pupil the foundation principles of one subject and he can, for himself, work out the other, while a bigger subject, one which is of wider interest, one which is met with in every phase of plant and animal life and one which the pupil must meet with again and again, remains a dark continent to him.

It is not my purpose to discuss the place which physiography does or should occupy in our schools. It is a subject which, I

believe, will make a place for itself in all our largest schools. Neither is it my purpose to outline a course of study. Each teacher of physiography who is also a student, is his own best judge of that, for the course in this as in ecology must be fitted to the place.

It is rather my purpose to make a plea for the better recognition of the science in our meetings, that teachers of physiography may gain strength and inspiration from contact and mingling of ideas, as do the teachers of other sciences. And that I may justify the presence of my subject on the program to show something of what can be done with the science of physiography, in schools where field work, for various reasons, is impracticable—what can be done with physiography in the laboratory.

The equipment may vary between as wide limits as that of a botanical or chemical laboratory. Tables where maps can be laid for study, where clay can be molded, where rocks, soils and minerals can be examined are the first requisites. Shelves for the keeping of specimens, cases for the preservation of maps from dust, a good globe and a choice collection of the best models; a large number of topographic maps—the typical and instructive sheets from all the states; the three-sheet map of the United States issued by the United States Geological Survey; a liberal collection of the common minerals and rocks from different regions of the United States; varieties of limestone, shale and sandstone, glacial boulders and conglomerates from our own state; coarse and fine grained granite and the minerals which compose it; rocks that show intrusions of different minerals; a collection of rocks from the source to the mouth of a stream showing wear on the surface; specimens that show stages in the development of sedimentary rocks; soils. The collection can not be too liberal. Photographs—best substitute for the object of study (a large collection from a variety of sources is easily obtained; the annual reports from the U. S. Geological Survey furnish excellent ones)—pictures from circulars and guide books issued by railway and steamship lines, and from the various periodicals; and last, a library chosen with special reference to the place which the subject occupies in the course, but including, always, the best elementary text books

on physical geography and geology. In its literature, at least, physiography may take first place among the high school sciences—in literature adapted to every stage of the pupil's advancement. And since physiography is always in the making, a scrap book, or, better, a folio where clippings properly mounted for use can be collected and kept, is a useful addition to the library. So much for the equipment of the laboratory. Its lasting quality is in itself a high recommendation. The pupil's own equipment consists of: a laboratory note book with drawing pad, pen, pencil, colored pencils and rule. He will need a hand lens during his study of rocks, rock-weathering and soils.

Physiography is a big subject if we include the sun, moon and stars and all the planets of the solar system, but we need not reach out to Neptune to understand the simple principles of earth sculpture, the land forms as we see them, their origin and structure. No wider knowledge of physics and chemistry is needed as a basis for this than botany, and I shall endeavor to prove this by developing, in the laboratory, two subjects in physiography commonly dealt with in the field. And, in the laboratory exercises, I treat the subject as an elementary science, adapted to the first or second year.

That part of the earth with which all life comes most in conscious contact, perhaps, is the soil, the outer covering of the solid earth. What is it? Whence comes it? We have specimens in the laboratory. Unlike those of animals and plants, it costs nothing to preserve them. Specimens of sand, of clay, of humus from the forest, of muck and marl from the lakes; of glacial and alluvial deposits. Here is basis for comparison and contrast for study of structure and origin. Different stages of plant disintegration answer the question of the humus; the microscope reveals the nature of the sand and clay, while it shows the presence of a variety of elements in the glacial and alluvial soils.

The study of soils leads to the study of the materials which compose them. The study of sand leads to sandstone, of clay, to shale and impure limestone, while the materials found in certain glacial soils necessitate the study of granite. Again, comparison and contrast; tests for hardness, for porosity, for solubility in dilute acid.

It is found that dilute acid dissolves the cement which holds the sand grains together, leaving the separate grains to crumble. The pupil discovers that rubbing two pieces of sandstone together or a piece of sand and limestone causes crumbling of the softer rock. Movement of one rock over another brings about the same result. He finds, also, that a piece of limestone can be reduced to soil by simply breaking it into smaller and smaller pieces—crushing it in a mortar. The experiments are simple, but they have their value in being devised by pupils who were set to work out the problem of the soil. Now apply these experiments. The pupil has found that at least three processes may be concerned with the production of soil from rocks; solution and the consequent crumbling of the undissolved material, breaking or crushing, and grinding. What are nature's agencies? A series of experiments testing the solvent power of water on various minerals; experiments to prove that water penetrates rocks; that water, which drains through certain loose and coarse-grained rocks, carries material with it; prove that water is the great solvent. Experiment proves that a few drops of acid hastens the solvent action on some rocks. We know that animal and plant life exhale carbonic acid gas. It takes but a simple experiment to prove that this gas is soluble in water. Again apply. Moisture in the air dissolves the gas and nature therefore uses the weak carbonic acid to aid the water in disintegrating rocks. What are the agents for breaking and grinding? Fill a stone vessel with water and allow the water to freeze. The vessel breaks. Saturate a piece of shaly limestone with water and expose it to freezing temperature for a succession of nights. The rock will split into thin laminae. Heat a thin piece of rock and cool it quickly. Again, it breaks. And we have partially answered the question.

The pupil would get a mistaken idea of the time element were he to get his impressions from these experiments alone, just as he would if all his knowledge of a forest were derived from his laboratory work on stems and leaves. He is now ready for the library and the text on soils, rocks, and rock-weathering; for examination of specimens of rocks showing fresh surfaces and surfaces that have been exposed for a long time. A specimen which will show quickly

the different effects of dry and moist atmosphere is limestone in which nodules of iron pyrites are embedded.

But weathering does not include the other process of making soil—the grinding of rock surfaces together. There must be something which will move the rocks, and that something must itself be moving. Water, allowed to drop on coarse-grained sandstone, whose particles have been loosened by dissolving the cement, causes movement of the particles and a rubbing of the grains against each other. The water settles in the depressions where the most material has been dissolved, or it overflows at the lowest point, carrying the particles with it.

If the laboratory is in a well lighted basement, or if a basement is available for certain exercises, a large tank, a sprinkling can and a pile of sand will show this action on a larger scale; will show, too, what material is carried along the bottom of the stream that that is developed, and what is taken up and held in suspension by the water. The experiments prove only one thing, but that is fundamental—that water, moving water, is able to carry rock particles. Increase the force of the stream and the carrying power is increased. Examination of rocks collected from the mouth to the source of some stream with special reference to this subject proves the truth of the hypothesis that the grinding of material is accomplished by the materials themselves and that one of the agencies in moving the loosened materials is water.

And by this simple experiment we are introduced to a large subject, the subject of erosion.

With the sprinkling can, the tank and various kinds of earth can be worked out in miniature all the principles of rain and stream erosion.

The tendency of the water to run off from all sides equally when the material is alike and the slope the same, the unequal cutting when materials are different; the movement of particles; the beginning of a valley; the gradual widening of a tiny gorge; the transportation of materials to lower levels; the caving in of banks—all these features can be seen by a careful manipulation of the sprinkling can and adjustment of the pile of earth. Introduce a layer of well packed clay and a new feature will be added; or

stones of varying size and miniature rapids will be formed when the stone is encountered by the down cutting. The working back of the valley, the development of tributaries, the dissection of the surfaces, all are typical of what nature is doing on a large scale outside. Let the water in the tank be lowered and the water from the can applied as before. Now it gathers in the channels made for it and runs off, carrying materials with it, which are deposited in the shallow water. The formation of deltas, the distribution of deposited materials, and the character of the surface can be studied. Let the water be lowered still more, and the deposited material becomes land surface; compare the old with the new—the rough dissected topography with the smooth surface of that which was deposited under water.

And all this time the note book must be the pupil's and the teacher's best friend. When work with the sand pile begins, drawing must, also. Surface and profile views of the small valleys developed at different stages of erosion must accompany the notes.

Now, time is well spent in the study of a few good models—relief maps, showing valleys in different stages of development; of photographs, of young valleys, valleys in early and late maturity, valleys in old age—all the characteristic features noted. A study of topographic maps, tracing the skeleton outline of any stream with its tributaries, showing the prevailing angle at which the tributaries enter the main stream; of a number of maps for exceptions to this angle, or trellised drainage; profile and cross-section drawings of valleys at various points from mouth to source.

But time does not permit of further detail. From the pile of earth in the basement, from models, photographs and maps, waterfalls, flood plains and meanders, deltas and distributaries, water gaps, lake-filling, mature and imperfect dissection by streams, hindrances to valley development, can be shown, definitely and clearly, in the laboratory by proper directions, outlines and questions from the teacher.

Again, we are ready for the library and the text, and the great river systems of the United States and of the world are open to the pupil's voyage of discovery.

I have endeavored to indicate by this, perhaps, too detailed

and elementary development of the subjects, weathering and erosion, the possibilities in physiography as a laboratory science. I would say, however, that no science has less need for a laboratory, for no science in the high school course has such easy access to abundant material in the field, everywhere. Even in a large city, stones in buildings are weathering, monuments are crumbling, rain is washing soil from streets where rock has been beaten to dust by horses' hoofs; water is running along the gutters carrying material with it; gulleys are formed where fresh earth is exposed; excavations reveal the character of the soil or rock beneath the surface. So that, while field work with the class may not be practicable, the class can always do field work, and physiography in the laboratory is for the pupil. Physiography in nature's laboratory—the great “out doors.”

THE GERMAN POTASH INDUSTRY.*

Prior to the nineteenth century the potassium salts were of greater commercial importance than those of sodium. While this order has been reversed since the invention of the LeBlanc process, yet the demand for potassium salts, chiefly for agricultural purposes, steadily increased until it became greater than the supply. This demand has been met by the discovery of the German deposits.

The region in which these deposits occur is a narrow one, lying between Halle and Magdeburg, Hildesheim and Bitterfeld. Between Magdeburg and Halle a large group of shafts has been sunk, and the center of the group is Stassfurt. In the thirteenth century salt springs and wells were known all through this region, and from them a certain amount of salt was obtained. In the seventeenth century these became the property of the Duchy of Anhalt and in 1796 came into the possession of the Prussian gov-

* Abstract of an address by Prof. Chas. R. Sanger, of Harvard University, made before the New England Association of Chemistry Teachers.