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LABORATORY WORK IN PHYSICAL GEOGRAPHY IN SECONDARY SCHOOLS *

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THE geography of to-day or the "new geography" as it is called, burdened by its inheritance from the past and by its own shortcomings, has a reputation difficult to live down—that of being simply an information subject. Until very recently it was primarily what its definition implied—a description of the earth's surface—and although we have passed beyond the letter of this definition, the spirit still persistently lingers. Geography is still too widely taught as an information subject. The "six pages a day" method may acquaint a pupil with the words within the covers of his text book, but it will not teach him geography, and fortunately will no longer make it possible for him to present himself as a candidate for college entrance in physiography.

The day is long since past when instruction in chemistry, physics, or biology was confined to the printed page. The instructor in these sciences realizes the inadequacy of words in conveying ideas and the need of investigation on the part of the pupil that he may arrive at an understanding of the underlying principles.

This attitude is as essential to progress in geography as it is in biology. Geography, too, is a science, and must be granted the prerogatives of a science. The subject, correctly handled, has great possibilities for mental discipline; as it is often treated these possibilities are so obscured that they are visible only to those familiar with the field. We can scarcely wonder that the uninitiated still see in geography a mass of unrelated facts and refuse to give credence to the argument that its disciplinary value is equal to that of the other sciences.

Geography labors under more or less of a disadvantage, owing to the fact that its problems are not such as can be analyzed under the microscope or studied in the test tube. We cannot bring our material for study within the walls of the school room, nor can we go where we will in pursuit of geography. We are therefore forced to content ourselves, to some extent at least, with the shadow, the substance being unattainable, and with the laboratory rather than the field as our *locus operandi*.

To the laboratory then, and to laboratory work must be entrusted the task of so organizing the subject that the process of accumulating information may be accompanied by true mental discipline. When this is accom-

* Read before Earth Science Section, New York State Science Teachers' Association, 1904.

plished the less important task—that of establishing the position of geography among the other sciences—will require no advocates. Cause and effect have been operative in the past in determining the standing of geography and may be depended upon for the future.

In order to make laboratory work effective an elaborate equipment is not essential, but a realization of what may be accomplished by this method is absolutely necessary, that its end may not be defeated. That so-called "laboratory work" covers a multitude of sins at the present time may be seen by an examination of the laboratory note books presented by the candidates for admission to college. Many of these exercises have no place in such a category. Class discussions, bearing no evidence of investigation of any description on the part of the student, are frequently submitted. Exercises, performed by the teacher and copied by the pupils, are also presented, apparently with no intention to deceive either on the part of the instructor or the student, but rather from a misconception regarding the true meaning of laboratory work.

While the leaders in the field are agreed that there should be laboratory work and that it should be disciplinary in character, the greatest diversity of opinion prevails among them regarding the exact nature of this work and the best mode of presentation. This lack of agreement is made evident in the manuals which have been published within the last few years. The various possibilities in regard to the choice of material and in the method of treatment have not been weighed that some common ground might be reached, but each author has emphasized the subject or subjects for which he has some special preference. The result is a collection of books, no one of which should be used alone as a laboratory guide. Until we have a greater unanimity of opinion among those who would shape the destiny of geography we must not expect systematic, well-ordered work on the part of the teacher whose training has not given him a broad outlook over the subject, nor can we expect unsystematized work to result in well disciplined minds.

There is some excuse for the fact that the work is not well apportioned among the various departments that constitute physical geography. The subject, embracing "*The Earth as a Globe*," "*The Atmosphere*," "*The Ocean*," "*The Lands*" and "*The Distribution of Life*" is much too extensive to be covered from the laboratory standpoint or even with a sufficient amount of emphasis on laboratory work in the period of time usually allotted to it—i. e., one year, with three or four periods weekly of perhaps forty minutes each. This has been attempted for several years, the result being work too superficial to be satisfactory to the instructor, not

thorough enough to give the student a clear understanding of the subject, and less intensive than he is capable of performing.

In view of these conditions it seems desirable that some common method of elimination be adopted that in time we may arrive at a greater uniformity of treatment and at more satisfactory results. The basis of selection should naturally be that of true educational value primarily. It is therefore necessary that each department of geography be submitted to a critical examination, that its relative value from this standpoint may be determined.

The fundamental division of the subject, *The Earth as a Globe*, usually regarded with equal aversion by both instructor and pupils, lends itself admirably to laboratory treatment and so taught it is seen to be so full of vital problems that it is impossible to look upon it as a dry subject, or one which is pursued simply to fulfill a requirement. The pupils may regard it as difficult, for each point must be thoroughly grasped before further progress may be made, and before any truth becomes a permanent possession, close thinking and frequently a considerable power of visualization are required. This is "hard" in the process but its accomplishment illumines the subject as no amount of class discussion or assigned reading can succeed in doing, and that which would otherwise be true on the authority of the teacher or the text, becomes so to the understanding.

Perhaps the problems of greatest difficulty in the treatment of the Earth as a Globe are those based on the effects of the revolution of the earth about the sun. The distribution of light at different seasons and at different latitudes may be memorized, but memory work is so transparent that a modification of the usual form of the problem will expose it. If a pupil truly realizes the combined effects of revolution and the inclined axis, that axis may be inclined at any imaginary angle without causing confusion to his mind. If it be grasped, not memorized, that the inclination of the axis determines the width of the zones he will not be at a loss if he be confronted with an earth in which the axis has an inclination of 30° or 40° and the number and width of the various zones are left for him to determine. The varying lengths of day and night at different latitudes, as at the equator, the polar circles and the poles, another problem involving difficulties, when approached in the laboratory from the side of light distribution, needs little explanation on the part of the teacher.

These problems may be solved without an expensive laboratory equipment; a season apparatus is of course desirable as the basis for this work. If this cannot be secured, small globes, together with circles of illumina-

tion, cut from paper, will be found a good substitute; indeed, this should be used even if the more elaborate apparatus be available.

If time permitted it might be shown that it is possible to develop practically this entire subject in the laboratory, leaving for the lecture or discussion the summary, amplification and application of the results reached through individual work.

Another department well adapted to laboratory treatment is that of *The Atmosphere*, and no subject should be more thoroughly studied. The material for this work is always at hand, furnishing a field for investigation that cannot be surpassed.

In the study of the atmosphere the pupil is largely independent of the teacher except for guidance. A clearer conception of temperature distribution may be gained from the study of isothermal maps than from a lecture. The problems should be formulated with care by the teacher, but the solution should be left to the pupil. A similar mode of procedure in regard to the distribution of pressure will show not only the variation of pressure over the world but the reason for that variation, with the single exception regarding the cause of low pressure at the poles.

Familiarity with pressure should carry with it ability to cope with the next problem—that of the various wind systems. The pupil should be required to sketch the approximate direction of the winds in the various belts, not alone in the fundamental planetary system but in that of the terrestrial as well, judging of wind direction from his knowledge of the distribution of pressure and the direction of deflection. The results should be verified and corrections made when necessary. The study of the distribution of rainfall should be causal also, the interpretation of the rainfall map depending on the knowledge of wind direction and surface features.

The series of questions which follows indicates more definitely the mode of procedure recommended and the close causal relationship existing among these various topics. The problems are based on climatic maps which may be found in Longman's New School Atlas.

ISOTHERMS FOR JANUARY

1. Record the temperature of the eastern coast, the western coast and the interior of North America along the parallels of 30, 40, 50, 60 and $66\frac{1}{2}$ degrees.
2. Record the temperature of the eastern coast, the western coast and the interior of Eurasia along the parallels of 40, 50, 60 and $66\frac{1}{2}$ degrees.
3. Compare the temperature of the east and west coastal regions of North America; compare each coast with the interior; compare

the east and west coastal regions of Eurasia; compare each with the interior.

4. What is the trend of the isotherms in the interior of these continents? Over the adjacent oceans? Suggest the reason for their irregularity.
5. Where is the coldest land area found? What is its temperature? Where is the warmest land area found? Record its temperature.
6. Compare the trend of the isotherms in the northern and southern hemispheres. Explain.
7. On an outline map of the world indicate the position of the heat equator.

After a similar study of the distribution of temperature over the world for July, followed by that of the yearly average, the distribution of pressure is noted.

ISOBARS FOR JANUARY

1. Locate the equatorial low pressure belt. What is the average temperature of this area? (See isothermal map for January). Where is the pressure lowest in this belt? What is the temperature of these areas?
2. Locate the barometric equator. Compare its position with that of the January heat equator.
3. Locate the north tropical belt of high pressure. Describe the temperature of this belt. Where is pressure highest? What is the temperature of this area?
4. Compare the south tropical high pressure belt in extent and continuity with the north tropical. Explain.
5. Describe the pressure about the poles.

After a similar study of the distribution of pressure for July and for the year the pupils should state what relationship they have discovered between temperature and pressure and what exception to this relationship apparently exists. This exception, low pressure at the poles, must be explained as the cause cannot be discovered in the laboratory.

The study of pressure is immediately followed by that of the wind systems.

WINDS

Planetary:

Draw a circle representing the earth. From your knowledge of the average distribution of pressure over the world for the year and of the law of deflection, show the approximate direction of the winds.

Verify from consultation of wind chart and correct errors.

Terrestrial:

Construct two diagrams showing the effect of the migration of the heat equator upon the planetary wind system.

(Diagrams should represent the distribution of winds for January and for July).

Moonsons:

Draw two outline maps of India. In each case represent the mathematical equator. On one map represent the heat equator for January and the consequent distribution of winds for the same month. On the second map represent the heat equator and winds for July. Verify as before and correct errors.

RAINFALL

1. Account for the amount of precipitation in regions of greatest and least rainfall.
(Consult map of winds and physical maps, as well as rainfall maps.)
2. Compare the extent of desert regions of the eastern and western hemispheres. Explain.
3. Locate the great trade wind deserts.
4. Explain the distribution of rainfall along the western coast of South America.
5. Compare the amount of rainfall east and west of the 100th meridian west of Greenwich. How have life conditions in this section been influenced by the amount of rainfall?
6. State the amount of rainfall of the Great Basin region of the United States. What influence has the light rainfall had upon the drainage of this section?

These exercises have been formulated to show the causal relationship existing between temperature and pressure, pressure and winds, winds and rainfall. They are typical, however, not only of the work on the atmosphere but also of that of the other departments of the subject, to the extent that they emphasize causes and consequences.

Neither department of geography which has been considered has held as prominent a place in secondary school education as has that of *The Lands*. We are told that this topic should be emphasized, for the land is the home of man and pupils must therefore be made familiar with it.

If this subject be examined from the standpoint of its educational value, we may not feel so confident that it is entitled to as much attention as it has received in the past. The field is so broad and is so detailed that to approach it through the laboratory is somewhat appalling unless the time

devoted to geography be greatly extended. Moreover, the laboratory seems to fail us here to some extent, for, instead of furnishing a field for the interpretation of the most difficult problems these must be reserved for the lecture. The simpler problems, such as the characteristic surface features of a plain, a plateau, a mountain, etc., may be studied with profit, also the various stages of development of these land forms. Only a comparatively small portion, however, of all that our texts usually require, can be taught in the laboratory. For example, the high school pupil is supposed to be familiar not only with the characteristics of plains in general, but with the divisions and subdivisions of plains. He must know not only coastal, alluvial, and lake plains, but the characteristics of narrow, broad, belted, belted inland, and embayed coastal plains. The distinguishing features of all of these various divisions and subdivisions cannot be arrived at successfully through the laboratory. It is difficult to see how a pupil could determine the development and the characteristics of a belted plain from map study. In considering the various classes of mountains similar difficulties are met with. The attempt to analyze the various forms from map study is unsatisfactory, for in most instances these forms are so modified that their characteristic features are obscured.

These same conditions exist to a sufficient degree in the various topics that must be considered to render laboratory work as the basis for class work practically impossible. Moreover the amount of detail necessary for the appreciation of many of these subjects is so great that it seems almost necessary for the text-book or for oral instruction to lead rather than for the laboratory. The chief function of laboratory work must therefore be that of illustration wherever it is possible to clarify a subject through the study of maps, models or photographs, or to summarize some portion of class work.

There is a distinct mental relaxation on the part of the pupils when land forms are reached. The weaker student who has found the preceding work beyond him, or practically so, is almost invariably able to cope with this department without great effort. The reason for this is apparent. The subject matter, though voluminous, is not difficult. The method of work, enforced by the nature of the subject, demands much less of the pupil, the close, sustained thinking which the previous work has required being no longer necessary, so small a portion of the work being really independent investigation.

In view of the fact that it is an impossibility to cover satisfactorily the entire course of physical geography as outlined for secondary schools by the leaders in the field, it would certainly seem advisable to cut down the re-

quirements on land forms decidedly for the reasons mentioned. If much of this subject were reserved for college and were studied after the student had some knowledge of geology, that the relation between structure and surface might be emphasized, its disciplinary value would be greatly increased.

It is therefore recommended that secondary work on land forms be confined to the larger features, leaving for more advanced study the careful analysis of these various forms; *i. e.*, the various classes of plains and their development should be studied, but not the subdivisions based on structure—as narrow, broad, and belted coastal plains; mountains and their development, but not block, folded, domed and massive mountains; plateaus and volcanoes, together with their development, but not the subdivisions of these forms. The two classes of shore lines should be emphasized, owing to the strong influence which they exert upon the development of human life. Many other topics belonging to the lands should be subjected to the same process of reduction. Rivers, for example, should be studied as young, mature and old, while their classification as consequent, subsequent, obsequent, antecedent, superimposed, engrafted, dismembered, etc., should be reserved for the college. By thus limiting the field an opportunity for better training would be afforded, for the subjects chosen might then be approached through the laboratory, time for investigation being adequate or approximately so, and the subject being of a nature to admit of laboratory treatment.

The next department of geography for consideration, *The Ocean*, has never held an important position in the course from the standpoint of the time devoted to it. Many of the problems to be considered, however, can with advantage be presented in the laboratory, the subject affording, therefore, an opportunity for some independent work that is valuable. The omission of two or three problems that must be largely descriptive on the part of the instructor, as that of the movement of water particles in a wave, or the detailed and involved explanation of tides, would certainly be no detriment to the course, and would afford an opportunity for the study of topics more valuable to secondary pupils, as those relating to the relationship between ocean temperatures and the movement of ocean waters, the dependence of the direction of ocean currents on the prevailing winds, etc.

The final department left for discussion is that of *The Distribution of Life*. If the work has been well done throughout, life relations have been constantly emphasized. The response of life to its environment, however, whether it be water, land or atmosphere, should be studied when that en-

vironment is studied, *i. e.*, when climate is considered, its effects upon life should be traced; when seashores are considered the influence of shore-lines upon the development of peoples naturally follows. If life relations be studied in connection with each topic considered throughout the work on *The Earth as a Globe, The Atmosphere, The Lands and The Ocean*, it will be found unnecessary to treat it as a separate department to be discussed after the completion of the study of the physical environment, as is customary.

Moreover, this department of physical geography is naturally impossible from the standpoint of the laboratory; and while the argument is not advanced that no mental discipline is involved in the pursuit of such a subject, the claim is made that less discipline results than where independent thought work is absolutely required.

Geography taught by the laboratory method must necessarily be stripped of much that is generally thought to be its most interesting side. If this were true it might still be worth the sacrifice. That the opinion is erroneous will be asserted by those who have investigated and fairly tested this method. The process of solving a problem for which there is a sufficient motive is always interesting to every active minded boy or girl.

The laboratory method, moreover, is disciplinary in its character, affording opportunity for pupils—"To proceed by observation and experiment, by guarded hypotheses and careful verification, from the known to the unknown, on the well-founded assumption of the uniformity of nature."

A student cannot pursue a subject in this manner without gaining a large fund of information which has some value. His chief gain, however, lies in the attitude of mind, which must follow the constant weighing of causes and consequences, in the independence which this work promotes, and in the power which results from the successful accomplishment of a task and the immediate application of the principle deduced to the interpretation of new problems.

And, lastly, geography taught by this method will make for itself a place among those established sciences whose aim is not information primarily, but an attitude of mind which the study of a science according to the methods of science alone can give.

THE SCOPE OF PHYSICAL GEOGRAPHY

The meaning and general scope of physical geography have never been better expressed than in the words, "the physical environment of man."—*Report of Committee on College Entrance Requirements, 1899.*