EDUCATIONAL MONOGRAPHS

PUBLISHED BY THE

NEW YORK COLLEGE FOR THE TRAINING OF TEACHERS

NICHOLAS MURRAY BUTLER, EDITOR

VOL. II. No. 6. { Entered at the Post Office at New York City as second class matter. } WHOLE No. 12.

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CHARLES BARNARD

WITH AN INTRODUCTION BY

JOHN F. WOODHULL, A. B.,
Professor of Natural Science, New York College for the Training of Teachers

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INTRODUCTION.

TRAINING IN NATURAL SCIENCE AS AN ESSENTIAL FACTOR IN THE EDUCATION OF THE CITIZEN.

I. A WIDESPREAD MOVEMENT IN FAVOR OF IT.

Anyone who has noticed the topics of discussion upon the programmes of the various meetings of teachers, during the past year, cannot have failed to see that the subject of science teaching in the common schools is occupying the thoughts of educators very widely.

The programme of a meeting of a State Teachers' Association, announced for this month (October), contains five papers on the subject of science.

The American Institute of Instruction, at its annual meeting this year, devoted a whole half-day's session to the consideration of science teaching and finished by adopting the following resolution: "Resolved, That instruction in natural science by experimental methods should be given in schools of all grades; that in primary and grammar grades it should take the form of observation lessons, calculated to develop the spirit of investigation, so that by the time the pupil reaches the high school he will be prepared to begin more systematic study; that in the high school it should undertake to give a thorough training in scientific methods of studying Nature rather than a comprehensive knowledge of the whole realm of natural science."

During the year, President Gilman of Johns Hopkins University, in an address to the Woman's College of Baltimore, said: "A knowledge of the methods of scientific inquiry is also of great value—more valuable than the possession of a thousand facts. Science has its methods of procedure and its criteria which lead to the ascertainment of truth. Familiarity with these studies can be better acquired by the prolonged study of a single subject like chemistry or physics or astronomy than by ambulating the 'circle of the sciences' or endeavoring to get a smattering of all the 'ologies."

During the year, the American Society of Naturalists formulated its views as follows: "Instruction in Natural Science should commence in the lowest grades of the primary schools and should continue throughout the curriculum.

"In the lower grades the instruction should be chiefly by means of object lessons and the aim should be to awaken and guide the curiosity of the child in regard to natural phenomena rather than to present systematized bodies of fact and doctrine.

"More systematic instruction in the natural sciences should be given in the High School."

During the year, school superintendents in their annual reports have had much to say upon this subject and some school courses of study have been entirely remodeled for the sake of introducing instruction in natural science.

During the year, the New York College for the Training of Teachers has been making a careful study of the best methods of teaching natural science in the common schools and has put many of its conclusions into active operation.

II. THE NEED OF TRAINING IN SCIENCE.

That training in natural science is much needed in the education of the citizen is very evident.

The scientific method may be briefly formulated as follows: (1) careful experimenting, (2) careful observing, and (3) careful reasoning.

1. Careful experimenting. Life is full of experiments and it is also full of errors by careless experimenting. Nearly all of our conflicting opinions claim to be founded upon the experiences and the experiments of men. Faulty experiments merely serve the purpose of intrenching people more firmly in error, and hence experience ceases to be the best teacher for them. When an experiment fails, it is not Nature's fault, but that of the experimenter, and it ought not to be respectable for him to palliate his shortcomings by saying that he had bad "luck." The experimenter should know no such thing as "luck." Chance has long since been banished as an ancient myth.

Illustrations might be drawn from every phase of life to show the importance of careful experimenting. For example, doctors, nurses, and teachers of hygiene cannot take the responsibility of caring for the health of the citizen, he must learn to do it for himself, and yet so long as he remains a slip-shod experimenter he will learn nothing reliable.

2. *Careful observing.* Careless observing will of course go hand in hand with careless experimenting. But, should the citizen become ever so careful an experimenter, his conclusions would be worthless if his observations were careless. In cases where he is not observing artificial experiments but the phenomena of Nature, the accuracy of the results all depend upon careful observing. If people would acquire those habits of careful observing which are sure to grow out of that kind of training which Mr. Barnard has ably conducted for several years in the Chautauqua Field Club, a thousand heresies now current in the world with regard to the doings of Nature would forthwith be uprooted.

People are prone to mingle wild conjectures and hasty inferences with their observations in such a confused manner as to be almost hopeless. They have not the habit of confining themselves to what they actually observe, but imagination is used to supplement, to a very large degree, the use of their five senses. Hence people, who have a sincere desire to tell the truth, sometimes make sorry work of it, even when testifying under oath in court, and the reports of an event, which come from so-called eye witnesses, are apt to be very conflicting.

Conclusions growing out of careless observations must of necessity be wholly unreliable. If we would learn Nature's lessons we must acquire the habit of using our five senses accurately.

3. Careful reasoning. Facts unrelated teach no lessons. The ability of putting facts together to find out what they actually teach is quite within the child's powers, but nevertheless the *habit* of doing so is strangely wanting in everybody; and this is the serious defect of our methods of education.

A course of training in Natural Science is imperatively demanded in the education of the citizen to the end that he may correct that vicious habit of drawing hasty conclusions from careless observations of reckless experiments.

Professor Huxley gives an illustration somewhat as follows: A goes to court and swears that B picked his pocket. He is impatient with the careful investigation of facts which the law requires. "He knows that B is the guilty man because he saw him do it." Upon cross-examination, however, he is obliged to confess that all he really knows is that B stood next to him in a crowd and that he has lost some money. The fact is that C picked his pocket when he least suspected it.

Take an illustration from our relation to our neighbors. Gossip is wholly unscientific. A wild rumor—a mere suggestion of something derogatory to the character of another reaches our ears. Instead of applying the scientific method of investigation before arriving at a conclusion, we eagerly accept the rumor, build upon it whatever suits our imagination, and, without further evidence, give our verdict. Suppose a court of justice should proceed in that way! Could it maintain a reputation for fair judgment?

Oftentimes when a little investigation of facts would lead to a correct conclusion, men waste their time in a wearisome discussion of hypotheses, or a juggling of words and highsounding phrases, and content themselves with conclusions which can only claim to be plausible guesses.

Sects and parties are made most readily upon the subjects of which men are the most ignorant, and if anyone is sufficiently honest to confess his ignorance, he is branded as disloyal.

Science would teach men to practice common honesty in forming their conclusions. It would lead their minds to always hold open court, ready to receive further evidence.

People have great difficulty in drawing honest conclusions because they have so many preconceived notions. They perform experiments for the purpose of corroborating their ideas rather than for the purpose of gaining new ideas or correcting old ones; and, with careless habits of experimenting and careless habits of observing, it happens that their inferences are illogical and imaginary. In this way people deceive themselves until they believe whatever accords with their philosophy and reject all evidence to the contrary, though it be the unmistakable evidence of their own senses. Cæsar, in his commentaries of the Gallic Wars, remarks that "men believe most readily those things which they wish to," and the old proverb runs "A man convinced against his will is of the same opinion still." If a man can will to believe what he is convinced is not true, what inconsistency! The citizen needs a training in natural science that he may be cured of his whims. Lastly he needs this training that he may be freed from the bondage of over-credulity.

III. CRITICISMS UPON SOME OF THE PRESENT METHODS OF TEACHING NATURAL SCIENCE.

In geometry we demonstrate the first proposition before we try to understand the second, and so on, step by step, until we are able to comprehend the more difficult truths. Likewise, in the acquiring of scientific knowledge, we should begin with such things as we can easily demonstrate to be true. This helps us to see the next truth which lies beyond, and thus we follow that "soundest canon of instruction, to proceed from the known to the unknown."

The method of teaching science now in vogue in the public schools is more like teaching geometry by merely taking the captions of the propositions and omitting the demonstrations. The idea seems to be to give pupils a taste of all the subjects which men ever study. The food is altogether too difficult for them to digest; the result is they are made mental dyspeptics and not infrequently loathe it.

All good methods of science teaching are crowded out by the attempt to "ambulate" the whole field of zoölogy, physiology, botany, physics, chemistry, astronomy and geology within the ordinary limits of a high-school course.

Too much of the science teaching is beyond the comprehension of the pupils. They cannot retain interest long in that which they do not grasp. Pedantic essays about Nature's laws, delivered by youthful graduates, are the natural outgrowth of a course of instruction which is as abstruse as it is pharisaical.

Teachers persist in feeding their pupils upon the dry husks of science. Their study of the subject is made an empty process of cramming names.

In botany, a list of names is given to define leaves as to their margins, another list to define them as to their bases, another list to define them as to their apices and still another list to define them as to their method of venation. Under the head of "observation lessons" the child is required to learn such things as are the last he would have use for if he were a specialist in botany. They are the fine points in the science, upon which wise men differ, and about which the scientific botanist cares very little. The little child cannot conceive a love for the common daisy as such, he must be taught to call it *crysanthemum lucanthemum.* He must learn an interminable list of botanical names and try to attach them to the proper flowers. In large cities, where flowers are not abundant, would it not be as well to teach the children the names in the city directory and then compel them to attach them to the people upon the streets?

In physiology, the children learn a mass of barren uninteresting facts. I need not specify in detail, but would suggest that, if the object is to memorize facts, after teaching the number of bones in the body with their names, we might add the number of rings in the trachea, the number of air-cells in the lungs, the number of hairs on the head and finish with the number of nails in the nearest board fence.

In zoölogy, the children must learn to say that the family cat belongs to the animal kingdom; branch, vertebrata; class, mammalia; order, carnivora; genus, felis; and species, domesticus. They must learn this sort of thing in order that they may pass their examinations,—the great end of school teaching.

In chemistry, the pupils must learn to say a few things about H_2SO_4, NaCl, Avogadro's hypothesis, Dalton's atomic theory, Mendelejeff's table, &c. No wonder they hate the study! In physics, the methods are quite as bad.

The schools in which the great mass of the citizens are taught have no means for teaching these subjects experimentally. In the few schools where experiments are performed let us inquire about their methods. There is a little "playing with test-tubes and precipitates" in chemistry and perhaps something is attempted in physics, but the pupils are not successful with many of the experiments which they try and they say that the teacher seldom makes his experiments turn out as the book requires; but then he is always ready with some explanation, and his delight is to bring out, at such a critical moment a wondrous machine from the show case and create sufficient amazement in the class to stifle any little suspicions of his incompetency which might be lurking there. After this feat has been performed, the machine goes back upon its shelf to remain until such time as it may be needed again to establish his dignity.

Those who champion the conventional apparatus, say "the best is poor enough; scientific accuracy requires the use of only the best,"—meaning by best, the most elaborate and most expensive.

In the first place, consider how small a proportion of the experiments usually mapped out for a course of physics or chemistry, are quantitative in their nature, or demand "instruments of precision." Surely scientific accuracy has nothing whatsoever to do with nine-tenths of the apparatus which occupies our show cases. Why then must it be of the most elaborate and most expensive sort? Very important reasons can be suggested why it should not be of that sort.

Experimental work in science has been debarred wholly from our public schools—even our most thoroughly equipped high schools—with very rare exceptions, on account of the great expense of apparatus, and it will always be debarred so long as it is supposed that this is the only kind of apparatus which should be used. It is folly to think that the average school board can spend the hundreds and thousands of dollars necessary for this equipment. For this reason it should not be expensive. There are reasons why it should not be elaborate.

Experiments should have the important purpose of rendering the subject more intelligible. This elaborate apparatus does not do it. Most pupils of high-school age fail to comprehend the machines and their minds are only confused thereby with reference to the principles. Artificial experiments, intended to explain natural phenomena ought not to be more incomprehensible than the phenomena themselves. A very serious charge might justly be brought against teachers for laying unnecessary burdens upon pupils by making the subjects of study much harder than they really are. Again, the elaborate apparatus requires a vast amount of time for its care and manipulation. Most of those who actually use it are persons who have assistants to do the work of preparation and manipulation. Pray, what could the public school teacher, who has every hour occupied both in school and out, do with this apparatus; except, indeed, to keep it locked up in a show case! Lastly the elaborate apparatus requires persons of a mechanical turn of mind to manipulate it successfully. For this reason, many of those who undertake to use it make lame experiments which have to be propped up with pedantic explanations, and many of those who find it stored away in their school buildings are careful never to bring it to light. When will the public schools be supplied with teachers having sufficient skill to use this apparatus?

In the second place, I cannot believe that "instruments of precision" and quantitative experiments have any proper place in the public schools,—not even in the most thoroughly equipped high schools—but only in the university where specialists begin their work. High school pupils cannot be expected to use that accuracy which is necessary to establish scientific laws. Their attempts, as a rule, do much to unsettle their confidence in such laws. "Accuracy is not a characteristic of the beginner, particularly of the young beginner. It is a growth, and must come at the end and not at the beginning. To insist upon accuracy at first would, therefore, be a great mistake. And it is seen to be more than ever a mistake when we remember that the stimulus of interest, of continued interest, is an absolute necessity in all mental activity; and that is sure to be destroyed by a pedantic and tiresome insistence on accuracy in early stages. It would be precisely the same mistake as we obstinately commit in the teaching of languages with all our wearisome exercises in grammar."[1] The kind of accuracy which can be cultivated is that which makes simple, illustrative experiments turn out correctly; but, in my judgment, "instruments of precision," suited to refined work, belong only in the hands of advanced workmen.

IV. THE METHOD USED IN THE NEW YORK COLLEGE FOR THE TRAINING OF TEACHERS.

The correct sort of training in natural science, like that in other departments, does not aim at the acquiring of certain facts, but the acquiring of certain habits of mind. The school cannot accomplish its purpose by simply giving information, it must teach the child how to study and then graduate him, leaving him to do the studying during the remainder of his life. How many citizens can remember the facts which they learned in school and recited glibly at the time. The year's examinations over and the summer vacation past, they went back to school to learn the same facts over again. This operation being repeated for several years, filled them with disgust, and, as soon as the law allowed, they went into business in preference to the school. The chief difference between the school graduate who is destined to be an ignorant man and the school graduate who is destined to be a learned man is not so much in the number of facts which each possesses as in the ability each has of acquiring facts and reasoning upon them. Nature is full of lessons, but one person is blind to them and goes on in stupid ignorance while another regards them and becomes a wise man. It is the province of the school to teach persons how to properly regard Nature's teachings;

[1] *Educational Times*, London, March 1, 1889.

how to make use of cyclopedias and books of reference; in general, how to gain knowledge from all the experiences and circumstances of life.

This college, where teachers are prepared for their profession, has connected with it, as a very important part of it, a Model School, consisting of four departments, Kindergarten, Primary, Grammar and High School. This Model School is maintained for two reasons; first, to give a concrete example of what the public schools should be, and second, to furnish an opportunity for the apprentice teachers to practice, under competent supervision, those methods of teaching in which they are being instructed. Natural Science is taught in all departments of this Model School.

In the lower grades, the purpose is to "arouse and guide the curiosity of the child," to "develop in him the spirit of investigation," so that, whether he goes up into the higher grades or out into life, he will go on to seek knowledge. The child is taught that, although older people may snub him for asking questions, Nature will not do so and, if he learns how to put questions to her, she will answer him not only kindly but truthfully. He is allowed the pleasure of seeking information, it is never forced upon him. This is wholly at variance with the prevailing custom of pouring in facts and requiring the children to memorize certain formulated doctrines of which they have no adequate conception. Schools will be carried on with much less friction and with vastly greater profit when teachers and school authorities learn that cramming facts from a text-book of science is as useless as it is loathsome to the pupils. Every one, who has undertaken to teach natural science in the higher grades by experimental methods, knows how the spirit of investigation seems to have been killed in them. Mental indigestion has long since spoiled their appetite.

Since, in lower grades, the purpose is not to "present systematized bodies of fact and doctrine," it makes very little difference from which of the sciences the topics are taken. The experiments of each lesson are arranged in logical order, so that the children may acquire the habit of connecting facts to see what they teach. For the same reason several lessons are connected into a series, but no attempt is made to survey the whole field of any one science with pupils of primary and grammar grades. Topics for experimental lessons should be chosen with reference to the special aptitude of the teacher, or the locality, or time of year, or general convenience. It is quite indifferent *what* the subject matter is—it is all-important *how* it is presented. Hence it is neither feasible nor desirable to make a course of study in elementary science to be executed in different schools and by different teachers.

A more systematic study of natural science is begun in the high school. Yet here it is not found to be practicable to sweep a very extensive field. Much more might be done if all the pupils in the high school had been through the training in natural science which is given in the lower grades, but a large number of the high school pupils of course are newly received, who have no training for high school science. The problem, how to deal with them, is very much like that which a teacher of English literature would have to encounter who found in the class pupils who could not read. Teaching science by the experimental method forbids covering so much of the subject as is mapped out in the usual high school course.

However much it might seem to be desirable to take the pupils out of doors to study Nature, it is not found to be practicable and so, by means of experiments, Nature is brought to them. For the most part, topics are chosen from those subjects which furnish the best opportunities for experiments. The experiments are made to stimulate the pupil, as much as possible, to study natural phenomena.

The phenomena of the kitchen, of the home, of the street, of the shop, of the sky, etc., are paralleled, to a certain extent, and the pupils are thus induced to notice these things outside of school and to seek their causes. By means of experiments, it is easy to make a graduated course in science, which could not be done so well in Nature. Nature does many things on such a large scale, or in such a complex manner as to baffle the pupil's powers of observation. A few simple experiments may often put the pupil in the way of comprehending the phenomena.

Experiments are, for the most part, performed with familiar objects, which cost very little money and very little time and skill for manipulation. Pupils are taught to construct their own apparatus so far as there seems to be educational value in that sort of work, and, in most cases, the products of their work unquestionably fulfil the purpose for which they were constructed much better than the expensive and cumbersome apparatus which usually has no better mission than to occupy a show-case.

The mistake is frequently made of supposing that home-made apparatus is intended to illustrate or parallel the apparatus of the market—to merely take the place of a cheap substitute. Nothing could be more erroneous. Its purpose is to illustrate scientific principles in the most direct manner, and this seldom requires any imitation of that apparatus which, has so long excited awe and admiration but has signally failed to elucidate the principles for the average pupil. The home-made apparatus interposes less between the mind and the idea which we wish the mind to grasp. By its simplicity it brings the possibility of teaching by experiments in the lower grades.

The student takes a more lively interest in it and understands it better because he makes it himself (to enliven interest and open the understanding are the main purposes of experimenting). Although it may be made as simple as desired, it may also be made to call into exercise skill and the inventive talent to an unlimited extent.—Herein lies the manual training argument.

The time is fast approaching when thousands of dollars raised by taxes shall not be tied up in expensive apparatus to be locked up in show cases, shall not be expended in paying the salaries of teachers who rejoice in involving natural science in mystery, but shall be spent in procuring for the citizen that knowledge of Nature which shall guide him to wisdom and happiness.

Graphic Methods in Teaching.

The Chautauqua Town and Country Club was started in 1885 as a branch of the Chautauqua Literary and Scientific Circle and continued in active operation till 1889. During that time about two thousand pupils were connected with the school. Owing to the very great expense attending the instruction given in the Club it was discontinued in 1889 after having shown that the study of nature can be made of great interest to young people who are rightly trained to see and repeat the simple facts of nature that may come under their observation. The methods used in the school have been copied both in public and private schools, and under able teachers have been greatly extended and improved. The school thus served, in a small way, to point to what seems to be a direct and simple method of training young people to observe and to inspire in them the scientific spirit of research. In this sense, the Club may not have been wholly useless. The writer, having devised the system of instruction used in the school and having observed its results in many hundreds of pupils, may perhaps be in a position to offer a few suggestions to teachers and others interested in the scientific training of young people.

The objects sought in the schools were the collecting of facts by direct observation of nature and the making of systematic records of the observed facts. Indirectly, the further object sought was to train the child in habits of precision, carefulness, punctuality and that spirit of absolute truthfulness that forms the basis of the scientific spirit. The aim was to make the child absolutely sure of his facts, to get the real facts and to record things precisely as he found them. No books were used in the school beyond the three books of instruction prepared for the Club and such books for the advanced pupils as might help out their observations in nature. The books prepared for the Club were simply designed to show how to study certain classes of facts that might be observed in the study of the weather, the soil and our more common plants. All the pupils were required to report in detail the facts they observed and many of the records of observations were made in the form of graphic diagrams. This idea of making graphic statements of observations proved to be of very great value in many ways and was always a source of interest to the pupils themselves.

Two elements appear in every series of observations—time and the actual phenomena under observation. The mere looking about in an aimless way, seeing a bird here, a beetle there, a peculiar flower or a curious pebble in another place is of very little value. To simply wander through the fields and make notes of things to be seen, while it may be very entertaining and healthful in a sanitary sense, is really of very little help to the child in the way of training. He will see more than the child who stays at home and the work of writing down his observations may be useful in teaching composition and may also be helpful in cultivating the memory, yet the knowledge gained is essentially fragmentary and the records of observations will certainly have very little scientific value either in themselves or as a course of training. The excursion by the beach or in the woods, the field-day out of doors should be encouraged, yet it must be noticed that such walks abroad cannot compare in educational value with a regular and systematic study of some one thing in nature extended over a definite period of time. The mere collecting of isolated facts, the mere recording of haphazard observations can never be as helpful as the observing of a regular order of events in nature. Moreover, all observations of natural phenomena should be so recorded that the records themselves may be made the subjects of comparison and study. It is far better to give a child a handful of white beans, and let him make a thorough and exhaustive study of the seeds under varying conditions of temperature, moisture and light than to let him wander aimlessly through the woods and bring home eggs, flowers, stones and insects in a confused and confusing collection of unrelated specimens.

To illustrate this more in detail the following study from the exercises used in the Club may be useful. This study is in the germination of seeds, and the work, while it may require several days of pretty close observation, has proved both instructive and entertaining to pupils of every age. One of the best reports of such a series of observations extending over two weeks was made by a boy only nine years of age.

One hundred seeds of the following plants were obtained: white beans, peas, radish, cabbage and mignonnette, and each kind was carefully counted twice and a record made of the day and hour of the beginning of the work. Ten seeds were then selected from each kind and placed out of doors in a dry place for twenty-four hours, beginning at 7 A. M. A thermometer was placed near them and a record made of the temperature at the start. Fourteen hours later the seeds were examined and an observation taken of the temperature. This was repeated twice in twenty-four hours for three days. In that time the temperature fell below freezing twice. The seeds, on examination at the end of the experiment, were apparently unchanged. Plainly a low temperature or a temperature below freezing and above zero (Fahr.) had no effect on the dry seeds. This is a fact observed. A low temperature produces no effect on dry seeds.

The experiment is now repeated under new conditions. The ten seeds of each kind were placed in separate saucers or shallow dishes holding sufficient water to keep them just covered. There are now two elements to be considered—the temperature and the presence of moisture. Observations were made at precisely 7 A. M. and 9 P. M. and a record made of the temperature and the condition of the seeds. This was continued for seven days. New facts were obtained from this experiment. The seeds swell and seem to begin to germinate, but at the end of the seven days the seeds are apparently dead and even beginning to decay. The new facts obtained are these: Moisture causes seeds to swell as if about to germinate, but under the influence of a low temperature they die and decay.

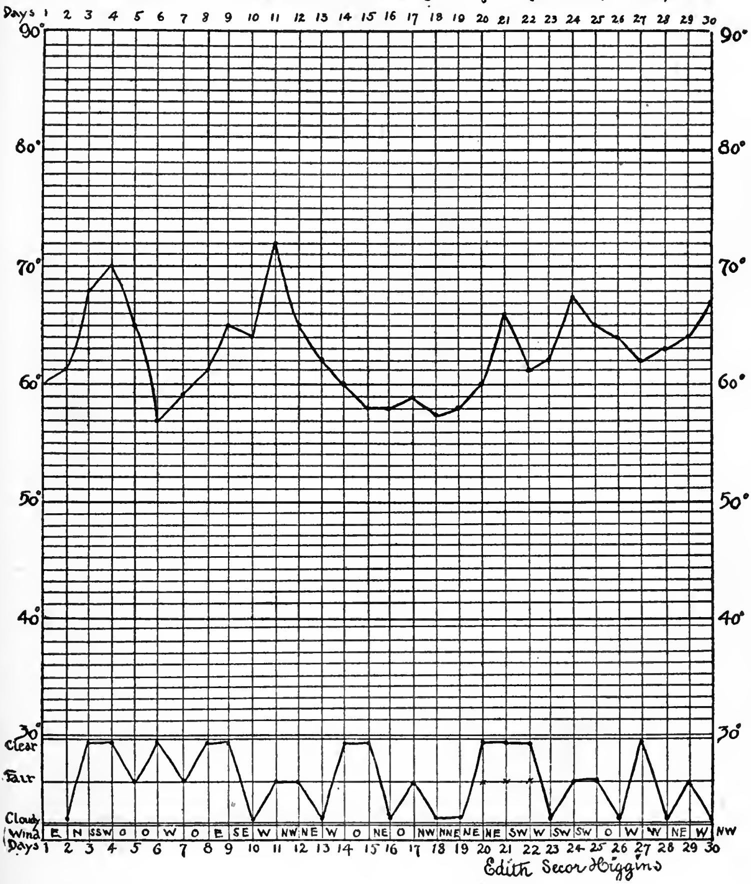
Ten more seeds of each kind are selected and placed in the oven of a stove in a dry vessel, and a thermometer is placed in the oven to ascertain, as nearly as may be with an ordinary glass, the temperature in which the seeds are now placed. Observations are now made every thirty minutes and new facts are obtained. A high temperature, in the course of an hour or more, will burn and destroy the seeds and render them lifeless and incapable of germination. The pupil now sees that a low temperature has no effect on dry seeds and that a high temperature burns and destroys them. Ten more seeds are selected and placed in saucers with water as before and put in the oven. Observations are made every thirty minutes and in an hour or two the seeds are cooked and lifeless. A high temperature is therefore fatal to the seeds whether they are wet or dry. Ten more seeds are again selected, placed in saucers with water and placed in a dark closet where the temperature is 70°. Observations are then made at 7 A. M., at 3 P. M., and at 9 P. M., and a record made of the condition of the seeds at each observation. A record is also made of the temperature to note any variations. Wholly new effects are now observed. The seeds swell and germinate, one group after the other, and at the end of ten days have (more or less of them) sent out tiny shoots and rootlets. Another fact is observed. The young seedlings are white and appear to be unhealthy. It is plain that the darkness has an influence on the germination of the seeds. Twenty-five seeds of each kind are now placed in water or on blotting paper that is kept constantly wet, and the whole is placed in a room at a temperature of 70°, and in a light place near a window. Observations are now made three times a day at 7, 3 and 9, to observe the time at which each variety of seed germinates and the proportions of those that live and those that fail to grow. A complete record is made of all these facts and from these records it is plain that much real knowledge can be obtained. This may serve to illustrate what is meant by a systematic course of observation as contrasted with the mere recording of observations made during an aimless ramble in the fields.

This example of a practical scientific study in the germination of seeds has proved of very great value in the training of habits of punctuality, exactitude in seeing and recording facts, in regularity and order in work and in giving opportunity to discover facts of interest directly from nature. The influence of temperature, moisture and light upon living seeds is discovered by the child himself as the result of his experiments and the knowledge gained of real value, because the result of personal research. The number of experiments and series of observations that can be thus planned out for young people is very great. The thing to be sought is some variable phenomena, like the different rates at which seeds germinate, and then to train the child to observe these variations accurately and to report them in such a way that they may use the records for after study.

We may take, for instance, such common phenomena as the variations in the temperature out of doors, the amount of clouds and the direction of the wind. On the changes in the temperature, the amount of clouds and the direction of the wind much of the child's personal comfort depends and thus the study of these things appears to him to be of immediate interest. As he comes to study plant and animal life he learns that all life, including his own, is dependent in large degree upon these same variations in natural phenomena. These make a good subject for observation and record, and even quite young children quickly learn to become regular observers and reporters. The best hour for such observations is seven o'clock in the morning, because at this hour the daily variation in temperature is usually at its lowest point. At precisely seven o'clock, local time, the young observer looks at the thermometer and notes the temperature, and at the same time observes the sky whether it be fair, clear, or cloudy. An observation is also made of the direction of the wind. The first two sets of observations should be recorded in the form of a diagram or by the so-called graphic method. With this is given a copy of a graphic record of the temperature and amount of clouds observed every day by Edith S. Higgins, aged fourteen, and a graduate in 1887 of the Chautauqua Town and Country Club, this being one of a number of such reports made by the child during her connection with the School.

The vertical lines stand for the days of the month, the horizontal lines for the degrees of temperature from 30° to 90° Fahr. At seven o'clock each morning a dot was put on the diagram at the junction of the vertical line for that day and the horizontal line for the temperature as observed by the thermometer. The diagram of these horizontal lines below serves to record the amount of clouds visible at that hour, dots on one of the lines indicating the observed fact in regard to the clouds. Beneath these two diagrams is a written record of the direction of the wind, the observation being made at the same hour.

The next diagram was made by Lucy C. Stone, aged 9, Chart of Temperature at 8 a.m., & Clouds & Wind at 7 a.m., for April, 1887 at Brooklyn, N.Y.



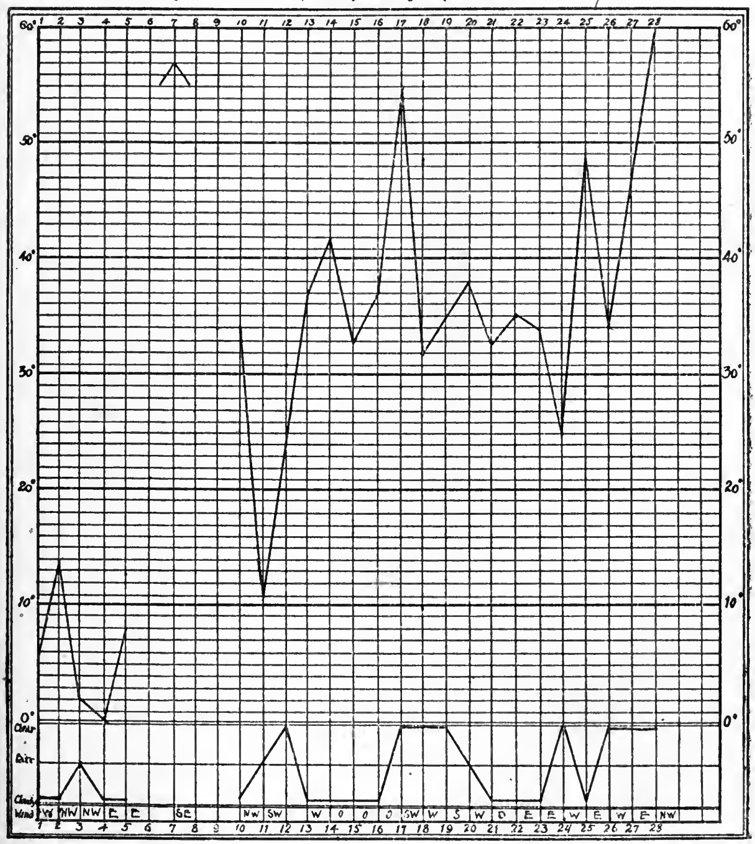
Edith Secor Higgins

at Kansas City, Mo. Two failures, caused by illness, appear in her diagrams, and in this sense the work is imperfect. This child made other and better reports and was a graduate of the Class of 1887. For certain reasons she was permitted to make her reports at 12 M. instead of 7 o'clock, but for such studies the morning hour is far better.

Of what value to the child is such work? In the first place, the making of the diagram (printed forms should never be used) is something in the way of mechanical drawing that is a good training for the hand and eye. Secondly, the diagram being fastened up on the wall in some convenient place becomes a reminder of stated work to be done at a fixed hour—a capital training in punctuality, promptness and precision. The use of a thermometer is helpful, as it is in the nature of a tool, and a tool is the one thing every child instinctively seeks. Toys are only tools of sport. Next it may be noticed that the observations must be made precisely at 7 o'clock, a first rate discipline in exactness and the happy virtue of early rising. The study of the wind and clouds calls him out of doors, for the whole sky must be observed to decide whether it is really clear or only fair or completely cloudy. Every day these variable phenomena must be noted and recorded, and pride is always taken by earnest students in seeing the curious course of the temperature grow from day to day through a whole month.

The record having been, in the course of the month, plotted on the diagram, then comes the development of the curve of the temperature or the irregular line that graphically describes the changes as well as the progress of the temperature. This work is also instructive and a useful exercise in neatness and accuracy. The work done, the child has two graphic statements of real phenomena in nature observed by himself and so recorded that, at the end, the entire work of the month is plainly seen. The curiously

Chart of Temperature, Clouds & Wind, at 12 o'clock, noon, for February 1887, at Kansas City, Mo. Lucy C Stone



eccentric line seems to possess an absorbing interest to both young and old and it was often found more difficult to prevent the Club members from making too many diagrams than to induce them to make one. Many members sent in reports month after month, though one only was required each year, and several members made reports every month for over two years, so greatly interested were they in the work.

The making of such graphic records of nature has, besides these advantages by way of discipline, another and most important advantage. Such records as these are both descriptive and comparative. Miss Stone's record shows that in Kansas City in February the temperature advanced through the month. This accords with a well-known fact in nature that with the lengthening days the average temperature rises. In this way the record is interesting, as it accords with the result of many previous observations made by trained observers in the Signal Service. In fact, our young student is herself a scientific observer and in a certain way this work has inspired her with the scientific spirit. Miss Higgins' record is quite as interesting, as it shows a more even temperature, resulting, in part, from her nearness to the sea and in part from a relatively more equable month. In like manner the nearness to the sea and the more rainy month has made her diagram of the clouds more eccentric. These comparisons between the two diagrams could not of course be made by the pupils, as each saw only her own. There is, however, in each diagram something to be learned by the pupil by a comparison of the three records, and this feature of these graphic records was shown to the pupils by means of the required books of instruction.

Taking Miss Higgins' record let us see how the child may be taught to make comparative observations. On the fourth day she records a high temperature with a south, south-west wind. Again, on the 11th, there is a high temperature followed by a slow fall accompanied by low temperature for more than a week with westerly and northerly winds. On the 21st and 24th there are south-west winds, and the temperature rises with only a moderate drop for a westerly wind. Here are comparative statements concerning certain great facts in nature. The child learns that as the wind is, so is the temperature; that from the south comes warm air, from the north cold air. At once the child's horizon widens and she learns to look beyond the thermometer and the weather vane to the world, the climate of the continent, and from this to the sun and begins to get broader views of the universe. Unobserving, making no records, careless, except for comfort whether it be hot or cold, the child sees (or rather does not see) the grand procession of natural phenomena unheeding and with narrow vision and small interest. Taught to observe and to record in a graphic way so that observations extending over many days are seen at a glance, the child instinctively takes wider views, learns to see, to compare, and to reach results for himself and form his own conclusions. His horizon widens and his mental as well as physical vision becomes clearer and sharper. Every picture before the child's eye, like a sensitive plate in the developing bath, gains in definition. Things unheeded before become interesting. Unusual phenomena, a sudden fall in the temperature, a change in the wind become as entertaining as a story, because observed and recorded and because they lead to new facts and new aspects of the universe. The relation of the wind and the temperature to the clouds becomes, by means of comparative study, full of interest and the record increases in educational value. The diagram explains things. It answers questions and is therefore full of interest.

It may be asked how it can be known that any such results follow from the making of the records, if the pupils did the work at home and only a very few of the students were seen personally by the instructor. The answer is simple. Every member was free to write to headquarters at any time and it is the written testimony of parents, governesses, tutors and teachers in schools, and it was the testimony of many of the adult pupils that the making of these records proved to be of the greatest benefit in many ways to those who, like these two children, have made these simple graphic records. In one private school, where all the members of the school were for more than a year obliged once a week to present a record of observed phenomena in nature, the teacher reports that nothing ever introduced into her school has ever been of so great benefit to her young ladies. As she said, "My girls have learned to see."

This plan of recording the temperature, clouds and wind is not original with the writer, and it is only noted here because, during the time the school was open, many hundreds of such records passed under his observation and the school gave an opportunity to try an educational experiment of a somewhat novel character upon a very large scale and with the best results. The recording of these three phenomena is but the beginning of what might be done. The point that seems to be of most value is this: the study of any variable phenomena includes the element of time and this makes it possible to record the observations in the form of diagrams or in the graphic method and these very graphic records are in themselves useful both in training the student and in enabling him to make comparisons of records extending over a long time.

Any series of facts having relation to time, quantity, distance or variableness may be made the subject of graphic record. There is infinite variety in nature and even the commonest facts observed by young people from day to day may be made the subject of most interesting study.

The temperature, wind and clouds have, in the writer's experience, proved of great value as subjects for graphic records. The rainfall is also useful, and the rise and fall of the tide, the height of water in wells, cisterns, ponds and rivers, afford unending subjects for scientific observation. The thing to do is to take some one thing that varies from time to time and to urge the child to observe and record such facts on diagrams made by himself at a fixed hour every day for a fixed length of time. A week is little enough and a month is better. The cheaper and more simple the apparatus the better, and for this reason the thermometer is preferred to the barometer.

In all such records it is best to record two series of facts, as the temperature and clouds, at the same time, for the reason that the work becomes comparative as well as descriptive. The following subjects for observation will serve as hints for the teacher. Observe and record the temperature and rainfall, using a tomato can, free from dents and with the cover neatly cut off, for a rain gauge. Observe the temperature out of doors and in the house (in winter) and record in different colored inks on one diagram. This record will be instructive in more ways than one and in a school may serve as a moral restraint on the enthusiasm of the janitor. Record on one diagram temperatures at different hours. Record the temperature or the amount of clouds and the height of water in a well, cistern, pond or stream. Observe and record the phases of the moon and record on diagrams the highest point of the tide. Record temperatures on the ground, one thermometer being laid on bare ground and another in the grass. Record temperatures on the ground and at intervals of 6, 12 and 24 inches above the ground. Observe and record once a week the outside temperature at noon and the temperature of the water in a well, keeping the record for six months. These and many more of like nature can be done by any child of ten, and in either town or country.

Plant life affords a wide field for observation. Plant seeds of quick growing vines, like the Lima bean or morning-glory, either in pots or the garden, and record the growth of the plant every day on a diagram, and with it record the temperature and clouds. Record the growth of any plant, wild or cultivated, and the rain-fall or clouds or temperature. Report the temperature of a room and the growth of plants in it or the rate at which seeds germinate. Animals and poultry also afford subjects for daily study, the weight of a growing calf making a curious record in comparison with the temperature of the barn. The weight of growing chickens (the chicks weighed once a week) and the price of corn in the market makes also another most interesting and instructive diagram, as it teaches the child to see the commercial value of the feeding rations. Some of the Club members made most elaborate and extensive records of this character with both sheep, pigs, cattle and poultry and gained for themselves data of actual money value in their work and business. Nothing, in fact, is too small or too great to be the subject of observation and graphic record, whether it be the sun, the clouds, a growing chicken or the sprouting of a hundred seeds of water-cress.

In schools it will be found a good plan to trace the diagrams on a large scale on sheets of manila wrapping-paper. Trace the lines first in pencil and then go over them with a marking brush. When finished hang the diagram on the wall where it can be seen by all in the room. Let the observations be made at the opening hour, the pupils taking turns of not less than a week and making the record before the school so that all can see the final development of the curves. All diagrams should be hung up in some convenient place near the point of observation that they may be perpetually in sight as reminders of duty to be done. A good plan is always to begin a month's record on the first day of the month and, if no observations are made on Sundays, the record should be left blank to indicate an unknown quantity or value. In all the work let there be precision, promptitude, neatness and accuracy. Teach the child that scientific work is always exact, and that "I guess," "I think so," "may be," and "perhaps" have no place in the young observer's vocabulary.

In the experience of the writer these methods of graphic statement and record are of educational value in many other ways. Observing and recording facts in nature is itself educational—it brings out—and in a way that is, to nearly all children, entertaining as well as instructive. There is, moreover, a moral value to such work. The child taught to observe, to see everywhere and at all times something of interest, is safe against "wandering thoughts and low desires." He is perpetually entertained by the grand procession of the seasons, the great drama of the universe. He begins to comprehend the aim and work of the Creative Mind and has no longer the time for trivial things of self and narrow living. His horizon is too big for small affairs. Observation leads to the scientific spirit, and this is good for any man or woman, of whatever position in life and society.

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