

**PLANT STUDIES SHOULD PRECEDE ANIMAL STUDIES IN
A HIGH SCHOOL COURSE IN GENERAL SCIENCE.¹**

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One of the most significant features of the modern teaching of science in the high school is the general unrest and dissatisfaction with the results obtained as measured by the interest of the pupils and by the effects as measured by the influence on their preparation for life work. This is a most hopeful condition for out of it may be expected to grow more rational methods, a more suitable selection of material and a more logical sequence of topics. This dissatisfaction does not mean that teachers are less efficient than formerly but it does mean that we appreciate our shortcomings more keenly than before.

Not only do we not get the results we desire but we are at a loss to know the exact cause of our failure. Science instruction is becoming less popular year by year according to carefully compiled statistics while the discoveries and important applications of science to everyday affairs is rapidly increasing. Evidently something is amiss that science fails to appeal to high school students as it should, especially students in the first two years, and hence an almost universal desire for reform in that part of high school science.

As an explanation of one of our difficulties, I venture to give as a cause the constantly increasing specialization that has come about in recent years. The body of scientific knowledge has grown to such proportions in our higher institutions of learning that a small host of professors is required to administer the various divisions and subdivisions of the science instruction.

This is just as it should be in the university but the spirit of specialization has worked its way down to the high school through teachers trained in these highly specialized schools without the necessary training in methods of reducing this material to the level of comprehension of the average high school student. Science instruction in the home and the elementary school has not been able to keep pace with the advances in the university and so there has developed a great chasm which must be bridged by the high school instructor in the first two years as best he can.

From the condition just mentioned there has developed much

¹ Read before the Biology Section, Central Association Science and Mathematics Teachers, Des Moines, Iowa, November 28, 1913.

discussion as to the place which each subject should have in the high school course with a very decided preference by every one for the third or fourth year. My contention is that there is no inherent quality in any division of science which requires its subject matter to be so abstruse that it shall absolutely demand the mature development of a third or fourth year high school student to master it. Much of what is taught to high school seniors or university freshmen may be assimilated by new juniors if it is properly presented.

This specialization has forced the minds of high school freshmen into specialized molds while they were still in an undifferentiated state and before they had had an opportunity to take a brief survey of the general field. Hence the dissatisfaction with science study.

One of the important questions at present is, what is the best order in which to present the various branches of science? If we wish to take a selfish view, we may consult our own desires and decide that the pupil should take the subjects which we wish him to take and at such a time in his course as we think he would be best qualified to comprehend our subject as we wish to teach it to him. Or we can make the needs of the pupil our governing factor and so shape our course as to secure the greatest good to the greatest number regardless of the violence it may do to our preconceived notions.

That the pupil's needs require a more gradual transition from his state of general information, more or less accurate in character, to that of formal science study is evident to all who have had extensive, thoughtful experience with high school freshmen. In advocating today the precedence of plant studies to animal studies I may say that my theories are based on eight years of almost exclusive teaching of high school science in the first year so that I am reasonably sure that the things proposed can be taught with pleasure and profit to beginning ninth grade pupils if need be.

Precedence as used in this paper should be understood to mean precedence of emphasis on plant topics, but not to the exclusion of related topics. Let it be understood that I believe for certain reasons it is better to introduce the learner to living things through the medium of plants, chiefly, rather than through animals.

First let us inquire what are the purposes of these earlier studies in biological science? To my mind, they are for the purpose of bringing the pupil into more intimate touch with his immediate

environment, to answer the questions that rise in his mind about living things that he finds there, to help him to methods of solving his own problems with a better chance of arriving at a logical conclusion, and to arouse in him a greater curiosity which may act as a spur to further investigation. With the exception of a few domesticated animals, plants come more prominently into the environment and form an overwhelming majority of the whole number of individuals.

Plants are more suitable for early experimenting for one reason because it may be carried on and keep unspoiled the natural reverence for living things which is inherent in the mind of every normal child. He shrinks from wounding, causing pain or taking the life of any animal. So also he does not like to handle its dead body. Plants may be badly treated, starved, mutilated or killed without that shock and revulsion which children feel toward a similar treatment accorded to animals. The bloom of poetic feeling is rubbed off all too soon from the child mind in its contact with the realities of the human struggle for existence.

In the second place, to put plants first is in accordance with genetic history. Plants were without doubt the earliest inhabitants of the world and they thus prepared the way for the more complex animal life which was to follow. The food supply of the world is of first interest to its living inhabitants so that after the air, earth, and sky with its life-giving sun, plants must have seemed of supreme importance to primeval man.

Since plants of some kind were the first inhabitants they might be expected to show primitive traits and exhibit the essential life-processes in a form more easily understood by the beginner. First among their exclusive characters is the power to manufacture food which process can be readily demonstrated in the green parts of plants. The storing of energy which takes place in this process is fundamental to the life-activity of all organisms and properly forms the starting point for the study of nutrition. Following this is the topic of digestion which can be most satisfactorily shown in a germinating seed.

Absorption and transfer of liquids through the agency of root hairs and the vascular system of plants is much more easily demonstrated and understood first in cells enclosed in cell walls. Growth and repair of living tissues is very readily studied from plant bodies. The germinating seedling is a most favorable object for the observation of growth and formation of new organs and the process of repair of wounds can be readily observed in almost

any tree, and if thought to be desirable, no violence is done to the finer feelings if wounds are made intentionally for the purpose of observing the method of repair.

The genesis of cells in the simpler plants is easily observed and the theory of cell lineage through mitosis is perhaps best taught through plants, which subject makes possible an explanation of heredity and the causes for the resemblances noticed in parents and offspring.

But it is in the explanation of the processes of reproduction, of the origin and meaning of sex, of race improvement through selection, the modification of form through the agency of environment, that plants lend themselves most readily and in a way which need not embarrass the most timid teacher who is fearful of the effects of sex instruction on the minds of the pupils. The pupils demand instruction in this direction either from properly constituted authority or from those who are always ready to give instruction.

This demand for enlightenment on sex phenomena is a normal one of the child mind and as necessary as instruction about any other function of the living organism. The basis for instruction in sex hygiene may well be laid in the study of green plants.

Special emphasis has thus far been laid on the adaptability of plants for explaining life phenomena, especially life processes, including those of reproduction. Plants have also certain advantages in the abundance of suitable material easily obtained; their comparative ease of handling in the laboratory; their ready response to changes of environment; and the ease with which they may be studied in their natural habitat recommends them to the teacher who may be handicapped by the lack of proper laboratory facilities.

There are also such a vast number of topics that are of intense human interest that appeal very strongly to children. Such simple exercises as planting seeds and watching for the plants to appear, the growth of mold on bread, the bacteria as agents of decay and in their relation to human disease, the fermentation of syrup by yeasts and the process of bread-making, the theory and practice of canning and preserving of fruits, the growth of mushrooms on wood and their relation to its decay, the proper way to plant seeds in the home garden or the ornamental flower bed are a few samples of topics that are of absorbing interest and because they touch on the life of the pupil they make a personal appeal and the science study seems to be really worth while.

You will doubtless say that what I have suggested is rather haphazard but it is meant only to show possibilities of selection of topics which will give at once valuable practical information, make a strong personal appeal to the interest of the child and also prepare the way to some extent for more special animal studies.

I do not intend to convey the impression that animal studies or rather the discussion of topics about animals should be excluded from this time when plant topics predominate. It will be found to be difficult, impossible in my own case, to exclude the discussion of related topics in other fields. Comparisons are inevitable and of the greatest advantage at times. When digestion is demonstrated in a sprouting seed the similar process may be explained in a brief and simple manner of digestion in the pupil's body. An easy parallel is drawn between the action of diastase and that of ptyalin, the respiration of sprouting seeds and that of human beings, the repair of a wound in a tree and the repair of a wound in flesh of an animal.

We must not forget that our divisions into botany, zoölogy, etc., are purely artificial and of use in pigeonholing our facts, and that such arbitrary divisions have not yet risen strongly in the consciousness of first or second year high school pupils. After once this unsystematic stage of thinking has passed over into that which seeks to arrange the facts of consciousness in accordance with great principles of classification, the priority of subjects in the course may then be decided by local circumstances or by personal preference.

LECTURE EXPERIMENT FOR MANUFACTURE OF WATER-GAS.

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Most laboratory manuals in chemistry do not suggest a lecture-table demonstration of the manufacture of water-gas, producer gas or oil-gas. The accompanying sketch shows a somewhat spectacular mode of accomplishing this aim. Although many teachers will not have gas furnaces, etc., a great number have the use of electric current supply.

As can be readily seen, the idea of the experiment is to produce a small electric arc in an atmosphere of steam. If the bottom of the Erlenmeyer flask be covered with a few cc. water, and the apparatus brought to a vigorous boil, the air will of course disap-