

his own preference in keeping the lines of study distinct or in combining them to reach his ideal biological study.

So far as work in human physiology is concerned, I feel that better results will be obtained by placing this alone in the last year of the secondary school course. In the first place there has been a rest from the legal grind and from the uninteresting and often deadening repetition of the required instruction in grammar grades, and there is also the possibility of discussing the subject from the advanced standpoint which a study of chemical, physical, and biological science has made possible.

PLANT ECONOMICS.

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One of the criticisms more commonly made on our courses in high school botany is that they are "too scientific." The principals tell us that we are trying to imitate the college too much; those parents who try to be particularly practical often elect book-keeping or stenography for their children instead of botany, and some of the pupils themselves, if they do not openly express their idea of a less utility of plant study, manifest it otherwise by occasional fits of indifference. Thus the parent and the child, although they may not be able to formulate their criticism as well as the principal, are often in agreement with him in their objection that the botanical courses lack sufficient contact with ordinary life.

The old idea of spending most of the time in the study of leaves, flowers, fruits, seeds and so forth and in making herbaria may not have been a well balanced or a scientific one, but it at least resulted in the acquaintance of the pupil with the plants that surround his daily walk in life and that is wherein many of our present courses are weak. This does not mean that our present efforts in physiology and ecology should be lessened. Plant physiology and its applications, as far as they may be brought out in secondary work, make such courses more valuable in this respect than the corresponding zoological studies. And although the late enthusiasm for ecology seems to have declined somewhat, ecological studies have come to stay, as is proper. But as a result of these tendencies and a much fuller treatment of the lower

forms, while the subject matter is beyond question much more complete than that of a generation ago, it has become too much isolated from the common life of the ordinary child. Not being able to realize its great philosophic value, and not seeing any broad areas of contact with his own life, he avoids it or takes it "for credit."

To counteract this, special emphasis must be placed on plant economics. We may thus demonstrate that very much that comes to us in life comes from plants and that problems of their products are life problems for both ourselves and the plant. Some of our best text books deal with occasional topics along this line. But the method of developing the real economic plant values may be open to question. It may be by mere discussion of such values in connection with the groups to which they belong. The discussions in lecture or recitation make both the laboratory work and text more vital through contact with human life. For instance, after studying lichens, to know that they may furnish food for reindeer in Norway increases the interest. To know that they may furnish the basis of an indicator valuable to chemists at home, with a simple demonstration of litmus, ought to increase it more, and the fact that they are important agents in corrosion of rocks in our door yards, most of all, because it deals with action in the child's own world. The phenomenon of symbiosis which would appeal to the botanist as of paramount importance may appeal to the pupil least of all. He does not feel that it really concerns him.

If this be the case the remedy appears plain. A sense of the practical importance of botany must be more generally developed in our courses and it may be most easily done by bringing in more work relating to our food, shelter and other of the endless economic phases found in our relations with plants. To do this, without overdoing it, will require certain concessions on the part of the demands for morphology, taxonomy and some other topics as usually treated. The economic phases will be often of a lesser importance from a scientific and philosophic view point. But if it makes the pupil think more about what he eats and wears and sees around him it will be of much more value than a broader biological metaphysics about which he does not think.

In order to do this, mere discussion is insufficient. These relations must be developed more fully as part of the laboratory

experience. And evidently since they are found in so many phases of plant study they must be correlated with them and any attempt to confine them to any special interval would be futile. Thus if we look for some of the broader points of contact, such topics as food, textiles, building materials, ornaments, relation to disease and health naturally suggest themselves. Evidently such a grouping of topics would cause confusion from a botanical standpoint and it would be better to take them individually under roots, stems, fruits, bacteria and so forth, as they occur naturally in the course.

Suppose we begin with "seeds." The above plan would suggest something like the following: Development of the economic importance of the seeds or grains of the bean, pea, corn, wheat, oat, barley, rye, broomcorn, cotton, coffee, cacao, nutmeg. These or their products alternate at breakfast, lunch and dinner throughout our lives. Does botany as usually presented develop an intelligent interest in them?

After studying the bean, castor-bean and pea seeds and the corn grain in the usual way, including germination and microscopic examination of typical starch grains and tests for sugar, proteids and oil, tables showing percentages of these substances present and the values of these should be discussed. For these, except the castor bean, see Leach, *Food Inspection and Analysis* (Jno. Wiley and Sons '04) p. 212 et seq.

Flax seeds, wheat, millet, oat, barley, and rice grains and buckwheat achenes should now be described, at least with regard to external characters and a microscopic examination of at least the oat starch made. It is convenient to study that of the potato here also. Tables may now be furnished showing the principal constituents present in most of these and their values. Samples of ordinary wheat flour, graham flour, corn meal, oat meal, bran and buckwheat flour may now be examined as to taste and appearance and tests made by alternate portions of the class for starch, sugar, oil, proteids and cellulose (Leach, p. 236, and *Farmers Bulletin*, Department of Agriculture, 142 p. 14 and 17). An exhibition set of corn products is useful here. A microscopic examination of material sold as corn starch (for cooking) and of laundry starch should be made and the origin of the two recorded. Discuss starch adulteration and its detection. Prepared breakfast foods naturally come next and a few typical ones should be examined at

least macroscopically, with a discussion of their origin and value. Quaker oats, puffed rice, Pettijohn's and corn flakes are suggested and a comparative microscopic examination of these is worth while. In addition to castor oil, mentioned before, linseed and cottonseed oils should be furnished and their values discussed and those of beans and peas as nitrogenous foods tabulated. Cotton seeds and cotton fibre may be exhibited and essay work on this textile assigned. Nutmeg seeds may be passed around and the flavors tested. A somewhat fuller treatment of coffee is of interest. The following has been used: State the differences observable between the samples furnished (Mocha, Java, Brazil, green and roasted, etc.) Describe and draw one seed. Boil a little ground coffee in water in a test tube. Extract a second portion with ether. Note the foreign matter present in adulterated samples furnished and the rapidity with which some samples color water. A positive starch reaction also shows adulteration. Note the artificial glaze on some samples. Obtain your material for an essay, from some reference work, on the following: description of the coffee plant and its fruit, areas of production, methods of curing; caffeine, its occurrence, properties and physiological effects; historical statements.

Further topics for study and references on cereals, their cultivation, breeding and relation to wild plants (illustrated by herbarium specimens or lantern slides), milling methods, bird food, cacao, Tonqua beans and so forth, relating to the foregoing may now be assigned for essay work and a tabulation made of the products concerned, which are used at home. Some of the well known medicinal values of seeds as exemplified in the mustard and flax seed plasters, castor oil and strychnia should be discussed. It may be more convenient to study types like the Brazil nut with fruits. The relation of the Department of Agriculture to seeds and seed distribution should be made clear and some bulletins examined. The testing of some different grades of commercial seeds and tabulation of the results showing percentages of germination is valuable.

Work of this kind which makes the pupil think for himself and leads him to observe and speak of his work at home cannot but vitalize the subject for the ninety and five who are not preparing to enter college. Does the average pupil really understand the connection between botany and his own breakfast? Has he any idea of the comparative values of seed products? Is

it of less utility to know the value of these products to man than to the plant?

In the study of stems the external characteristics and the internal structures of typical dicotyledon and monocotyledon stems and modifications due to special conditions of physiology and ecology are commonly studied. An attempt to bring this work into a broader contact with outside experience would naturally suggest something like the following topics: lumber, wood products, paper, resin, turpentine, gums, stem foods, ornamental stems medicinal values. In studying lumber, after median and tangential longitudinal, and cross sections have been studied it is well to begin with the top and sides of the laboratory table, book shelves, cases and floors. Samples of various woods polished on one side come next and a few specimens should be tested as to comparative hardness and weight. The assignment of tabulated reports on the character of furniture and its origin stimulates observation at home and the pupil often sees oak, pine or bird's eye maple in his own chair for the first time.

In connection with turpentine and resin, samples of gum arabic, gum tragacanth, cherry gum, Canada balsam, camphor, rubber, amber and varnish should be examined. Essay work on the resins, gums, gum resins and other extractives and their uses in daily life will necessarily vitalize the study. How many pupils realize that there is any vital connection between plant life and their chewing gum, erasers, rubbers, mucilage, pills and varnished table, or the contents of the camphor bottle? And mere words are insufficient. A minute spent in examining a gum itself will reinforce the idea more than a long discussion of something which they have never seen. In dealing with the topic of paper, various qualities may be examined, essays read on its manufacture and on the forestry problems related to it. The work of the Forestry Bureau should be emphasized. This may be done by assigning some of the bulletins for use on Arbor day. This suggests the identification, somewhere in the course, of a few common trees. Is the average pupil, after spending a year in botany, able to recognize twenty-five trees with certainty? Many of them do not know five, because it is easier for the teacher to bring algae into the laboratory than to take the class out to the trees.

The large part that stems play from an esthetic point of view will have been developed in studies of stem modifications.

Some of the more striking types like birch bark, twigs of the golden osier and red stemmed cornel should be brought in for this purpose. The values of stems as food for man and beast may be emphasized partly by mere mention. The potato and asparagus should be studied.

The use of corn stalks for fodder should be considered. An exhibition of corn products (partly stem) has been alluded to above. This will introduce the topic of textiles and specimens of flax plants should be furnished. Linen goods may be examined with and without magnification and several tests helpful in distinguishing linen from cotton demonstrated. Hemp, flax, Manila, jute and ramie fibers, bags and cordage exhibits and bamboo are useful in this connection. Cork, quinine, witch hazel and cinnamon should be taken up and such vegetable dyes as logwood, quercitron, Brazil wood, along with galls and their relation to ink.

In the study of the structure and modification of roots such forms as the sweet potato, beet, turnip, parsnip, carrot, radish and horse-radish will usually be included. Sassafras tea, ipecac, sarsaparilla and licorice extracts will be familiar to many. If the laboratory can afford it, a taste of ginseng root, similar to that formerly worth its weight in gold in Pekin, often excites a greater interest in roots of more real medicinal worth. Maddei root and its contained dye furnishes an example of other root uses.

The beauty of leaves and foliage masses will appeal to many. Lantern slides or park studies in landscape gardening and yard decoration offer a phase of much needed municipal improvement. Ferns, palms, evergreens, autumn leaves and decorative foliage plants such as Coleus and the rubber plant impress some children more than flowers. A more prosaic but first hand acquaintance with leaf uses comes out in discussing dandelion "greens," spinach, cabbage, onions, lettuce, parsley and tea. Since these products are matters of common experience discussion without special examination may be sufficient, if the time is limited. In connection with medicinal values boneset, wintergreen, horehound, peppermint, pennyroyal, bay rum and eucalyptus will furnish some examples of more or less familiar drugs extracted, at least in part, from leaves.

The use of clover, timothy hay and alfalfa should be discussed either here or under stems, and herbarium specimens shown.

The sugars, like some of the foregoing, illustrate the fact that many products may be taken up in either of several connections. It would seem logical to treat them under roots, stems, leaves, fruits or seeds. In spite of this manifold opportunity classes often emphasize only their relation to other carbohydrates. Many pupils finish botany without knowingly having seen and tasted glucose. It would seem that the origin, uses to plant and man, the food value and something concerning the refining industry ought to be included.

The study of flowers furnishes another example of the fact that many botanical courses conform too much to a philosophic standard rather than to values based on experience in life and the home. For usually the representative wild flowers of the important groups are studied to the exclusion of the carnation, the begonia and other cultivated house plants. The house geranium may be less interesting in itself than the orchid but the average pupil has to live with it. It would seem reasonable in this connection to tabulate the most familiar home grown plants, to indicate their relationships, peculiarities the best methods of caring for them and to have them around in the laboratory as a matter of course. A talk on floral perfumes and their extraction is well worth while and may be prefaced by having the class obtain a list of toilet waters, colognes and perfumes exhibited in the drug stores. An examination of cauliflower and cloves should be made in this connection to illustrate other than aesthetic uses.

Although the flower and leaf modifications may excite more interest than most others on account of their beauty, the topic of fruits is second to none in its breadth of contact with ordinary experience. In studying the important types of fruits many of the varieties found on the table will naturally be included. After such type study is finished, emphasis may well be placed on the remaining familiar forms like the winged maple "seeds," and table fruits. I believe that an attempt should be made to examine and discuss the following if they have not been already included in the preliminary examination of the typical forms: legumes, grains, acorns, chestnuts, citrus fruits, gooseberry, currant, grape, Capsicum, tomato, banana, apple, pear, cucumber, pumpkin, squash, peach, plum, prune, cherry, olive, walnut, cocoanut (the products of which should be clearly differentiated from cacao). Since there are so many fruits to be examined it may be necessary to have the pupil report on important types

only and to have a lecture and demonstration of structure of the remainder by the instructor. This saves both time and expense. Of course for material that comes into the market at an inopportune time preservative must be used or the structure illustrated by charts. Tables of the constituents and value of some important types should be furnished, (see Bulletin 142, cited above, page 18 and 28) and a comparison made with seeds.

The average class can give expert evidence as to the kinds of flavors used at the soda fountain and many of them come in here. Discrimination is necessary here, as for instance in the case of the orange where the pulp and juice are often used in ices, the oil obtained from the rind figures in various confections and orange water from the flower is used for other purposes. At this point lists indicating sources of perfumes, medicines, flavoring extracts, and other economic phases as indicated above should be made as complete as possible, by comparison of individual lists.

If we examine the thallophytes in the same way in an endeavor to find some pegs of experience on which to hang further knowledge, we discover that their relations to us are distinctly different. How many green or blue green algae will the pupil have used for food or clothing? Or how many brown or red algae has the average inland pupil ever even seen? And since these forms are not matters of common experience and conversation the phases of life relating to them are likely soon to be forgotten. Of course it is not difficult to compile a list of instances in which the lower forms play an important part in our lives. This is especially true of the fungi and some of these instances should be dealt with. But as compared with seed plants and excepting the bacteria, moulds, and yeasts, most of them are not so commonly experienced in home and business life and are therefore less valuable for our purpose. And while enough of the simpler types should be included to develop some of the fundamentals of physiology, ecology and evolution it would seem reasonable to emphasize these less and the spermatophytes more. In this connection botany needs perhaps to be saved from the hands of its friends who are trying to make our secondary schools into little universities.

We may summarize the foregoing as follows:

1. Our botany courses are often criticized as being "too scientific" and these criticisms come from sources deserving of consideration.

2. The remedy lies in developing as much of the practical side as possible.
3. Economic problems relating to seeds, stems, leaves, flowers, fruits and some of the lower forms are life problems for both ourselves and the plant and should be more fully developed than they usually are.
4. Many of the lower forms are not connected with our ordinary experience and they should be emphasized less.
5. In general the course should be based on the idea of utility to the pupil, rather than upon a broad philosophy of plant life.

VELOCITY OF SOUND IN SOLIDS.

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In answer to requests for explanation of the method used in our laboratory to determine the velocity of sound in solids, I give the following:

Materials required: Tuning fork. C," Small adjustable iron vice. Bench or board at least eight feet long, arranged for attaching the vice anywhere along the edge. About three metres each of wires of different materials.

The pitch of a tone produced by longitudinal vibrations does not depend upon the tension or the diameter of the wire, hence any common size and sufficient tension to hold the wire straight will answer the purpose.

Fasten a wire securely at one end of the bench or board and secure the other end of the wire with the vice in order to vary the length. Stroke the wire lengthwise with a small cloth well dusted with resin by pinching the wire lightly in the cloth with the fingers. This will cause the wire to give a loud tone from its longitudinal vibrations. By varying the length of the wire carefully determine the exact length necessary to give a tone having the same pitch (number of vibrations per second) that the tuning fork, C" has.

C" has 1024 vibrations per second. 342.5 m is the velocity of sound in air; therefore 332.5 divided by 1024 equals the length of each vibration, that is the distance between condensations in air, .3246 m. This bears the same ratio to the distance between the condensations in the material as velocity in air bears to velocity in the material. Double the length of the wire is the distance be-