THE

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OF

BOTANY TO AGRICULTURE.

A LECTURE

DELIVERED BEFORE THE

MASSACHUSETTS BOARD OF AGRICULTURE,

AT BARRE, DEC. 9, 1872,

BY WILLIAM S. CLARK.

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Mr. Chairman and Ladies and Gentlemen:—There is much reason for gratitude and encouragement in the fact that the general subject of agricultural education need no longer be discussed at the meetings of this Board. That good mental training, some literary culture and familiarity with the laws and phenomena of nature are useful to the farmer, is no longer denied. That chemistry, by revealing the composition of air, water, soils and manures, as well as of plants and animals, has rendered a rational system of agriculture possible, is universally admitted. The chemical force, however, exerts its influence principally upon dead matter, and is subordinate to that other greater mystery which organizes mineral substances into those varied forms of vegetation which clothe the earth with beauty and furnish the indispensable food of animals.

Baron von Liebig has said: "The scientific basis of agriculture embraces a knowledge of all the conditions of vegetable life, of the origin of the elements of plants, and of the source from which they derive their nourishment." Professor Lindley also asserts that "good agriculture and horticulture are founded upon the laws of vegetable physiology;" and that "no man deserves the name of gardener who is not master of everything known as to the way in which plants feed, breathe, grow, digest, and have their being." How astonishing and humiliating then to every enlightened American must be the fact that while in Europe almost every university and every large city has its botanic garden for the instruction and entertainment of students and people, there is not in these United States a single general collection of living plants, systematically arranged and adapted to convey any adequate idea of the wonders of the vegetable kingdom. It seems, therefore, not

inappropriate to devote this hour to a consideration of the nature and objects of Botany, its relations to agriculture, and the position it should occupy in the education of farmers. The study of this science, with suitable facilities and a proper regard to its practical applications, cannot fail to add immensely to the material wealth, the intellectual and æsthetic culture, and thus to the happiness and general welfare of the community. Nevertheless many, even of our best-informed people, not only have no appreciation of its power to please or benefit, but actually regard it with prejudice, so vague and erroneous are their ideas concerning it.

Some suppose it treats merely of flowers, and consequently while well enough as a pastime for school-girls, is utterly unworthy the attention of a sensible and industrious man or woman. They have an idea that the sunflower, the poppy, the hollyhock, and such like blossoms, are the loftiest, most intricate and most profitable themes with which the botanist has to do,—which is just as correct as to suppose the science of anthropology to consist in the study of hats and bonnets. Flowers are, indeed, conspicuous and important parts of plants, where they occur, and well worthy our admiration and study. But a large portion of the species of the vegetable world are flowerless, yet they must be included in botanical science, and we shall find that the knowledge of some of them is of the utmost importance to agriculture.

Others, again, imagine the chief business of the botanist to be the gathering and pressing of specimens which, in their appearance, are calculated to awaken feelings of disgust rather than of pleasure in the breast of the unscientific observer. Dried plants are of much service for purposes of investigation and reference, but their acquisition is by no means the chief end of the science. Many a person has collected an admirable herbarium who was no botanist in any proper sense of the term.

As chemistry originated in alchemy, which was a search for the elixir of life, destined to cure all diseases, so the early botanists were incited to a critical examination of plants by a desire to procure new medicines, and ascribed remedial virtues to every species, even to the most inert. The first work on botany in the English language was entitled, in the antique style,

"The Great Herbal whiche giveth parfyct knowledge and understandyng of all manner of Herbes & their gracyous vertues whiche God hathe ordeyned for our prosperous welfare and helth, for they hele and cure all manner of dyseases & seknesses that fall or misfortune to all manner of creatoures of God created, practysed by many expert & wyse masters, as Avicenna, &c., &c., prented by me Peter Traveris, 1516." The title of one printed in London in 1551 is, "A new Herbal wherein the names of herbs in Greke, Latin, Englysh, Dutch, Frenche, and in the Potecaries and Herbaries Latin, with all the properties, degrees, and natural places of the same, gathered and made by William Turner, Physician unto the Duke of Somersettes Grace." Botanic gardens were formerly called physic gardens, and were designed especially for the instruction of physicians, the growth of drugs, and for testing the medicinal properties of new plants. The Roman emperors maintained such a garden on the island of Crete, and Montezuma had one at Mexico at the time of the Spanish conquest. Medical botany, at the present time, is merely an important branch of the applied science, and one very greatly neglected in this country. Botany, however, is something more than the science of roots and herbs.

Another common objection against this study is founded upon the fact that the botanical names of plants are in Latin, and the descriptive terms are largely derived from the ancient languages and must be learned by careful application. If the botanist had no other aim than to acquire the names of the one hundred thousand species of the vegetable kingdom it would be a forbidding and unremunerative task; though it should be remembered that a Latin word is quite as easily retained in memory as an English word that is new. Latin names are, also, much more easily spelled and pronounced than the popular names applied to plants in their native countries, when they have any, but the greater part have none whatever till Latin ones are given them. There are many obvious advantages in botanists of all nations having as they do this one universal language, and the precision of botanical descriptions resulting from an accurate terminology is, moreover, a source of very great pleasure to the student, and renders botany one of the most useful means of mental disci-

pline. Comparing botanical studies with the classics and mathematics, Professor Lindley says: "These subjects train the memory and the reasoning faculties, but they do not touch the habit of observation." This is of prime importance, and best acquired by the pursuits of the naturalist. Hence Professor Edward Forbes remarks: "The study of an animal or vegetable species is the perfection of observation as far as that species is concerned. The form, the substance, the qualities, the phenomena of existence, the influence of surrounding objects, are all observed with the greatest precision and defined so as to be capable of expression in words. No point affecting that species is left untouched. The study of a group or genus of animals or vegetables is in like manner the perfection of discrimination. All the members of the group are compared in all their parts with each other, the relations which they have in common are all summed up and their differences recorded in every possible point of view. The causes of those relations and differences are carefully inquired into and a survey is taken of the bearings of the whole group to its proximate allies, and, finally, to all equivalent assemblages in organized nature. Who can rise up from such a study and not feel mentally strengthened? The mind in such an exercise must gain in both its analytic and synthetic powers."

Another argument of great moment in favor of botanical pursuits arises from the endless number and variety of objects for investigation everywhere presented to view whereby the attention is awakened and all the powers of the mind kept in a condition of activity. In mathematical and classical studies the lack of interest often entirely hinders progress and tends to beget dullness and inattention. In the training of young men to become intelligent and progressive farmers and gardeners, the value of this kind of mental culture and discipline can hardly be overestimated. The records of worthless experiments which fill our agricultural libraries attest the truth of this assertion, and show that more education is imperatively demanded in this profession.

It has been said that a person might be an excellent botanist without knowing the name of a single species. While this is not literally true, it expresses with great force the fact that the names of plants do not constitute the science of botany.

They bear about the same relation to it that a Webster's spelling-book does to English literature. The word botany means a plant, and every plant has once existed in a single cell. All plants are either single cells or aggregations of them, and differ from each other only in the number, form and mode of combination of these their constituent elements. The foundation of our science, therefore, is seen to lie in a knowledge of the vegetable cell and the changes of which it is susceptible. By the aid of the compound microscope we learn that a uni-cellular plant consists of a globule of protoplasm enveloped in a thin membrane of cellulose. This protoplasm is in an albuminous fluid, somewhat like the white of an egg, and usually containing one or more granules floating in it, which are apparently analogous to the yolk. Under the influence of the mysterious force which we call life, this gelatinous fluid exhibits a tendency, under favoring circumstances, to divide and increase in quantity, producing the phenomenon of growth. In the simplest plants this division occurs within the outer envelope, and each portion develops upon itself a new membrane and gradually increases to the usual size of the parent. By this process, the original cell is burst and destroyed, and the same operation continues during the growing period, producing in the aggregate countless numbers of individuals. Most plants, however, consist of a combination of cells, arranged in threads, or thin expansions, or masses of various but definite forms, each species assuming at length, on maturity, its own characteristic shape and substance.

Ordinary growth, as in the grasses, occurs by the subdivision of cells into two parts by the formation of a partition in the protoplasm, and then each of these parts enlarges to the normal size and becomes a perfect cell. The lower or inner one generally remains stationary, while the upper or outer one again subdivides, and so the process goes on until the plant attains its complete development. This growth may be well nigh imperceptible, as in some of the lichens, which stand for centuries almost unchanged, or it may be amazingly rapid, as in the giant puff-ball, which has been known to form sixty-six millions of cells per minute. Upon reaching a certain degree of maturity, every species is observed to produce and cast off seeds, bulblets, or spores, usually in large numbers, for the

continuation of its kind. This may be followed by immediate death and decay, as in the mushroom and century-plant, or, as in most perennials, growth and fruiting may go on together for many years, and the decline of the vital force be gradual. In the simpler forms of vegetation we find great uniformity of structure, even when the individual attains an enormous size, as in the gigantic kelp of Cape Horn, which reaches a length of several hundred feet, but shows no distinction of vegetative organs. If, however, we plant the seed of an apple, and watch its progress from germination to maturity, we notice at once several sets of organs with distinct forms and functions. The young tree has a root which avoids the light and penetrates the soil in all directions where the conditions are suitable. It has a stem of curious construction which rises from the ground, lifting its head high into the air. It is covered with leaves, which are evidently designed to expose the largest possible surface to the sunlight and the atmosphere. After a few years of growth, a portion of its annual crop of buds develop into blossoms, which in time become fruits with seeds.

Thus the chief end of all vegetable life, so far as the plant itself is concerned, seems to be the perpetuation of the species,—the multiplication of itself. But in the wise economy of nature no living thing exists for itself alone, and vegetation is the indispensable forerunner and companion of animal existence. The air we breathe, our food, our clothing, our timber, our fuel, our artificial light, and the mechanical power of our domestic animals, and our steam-engines, are all the more or less direct results of vegetable growth. Now, living beings grow only by the digestion and assimilation of food, and one of the first objects of inquiry for the botanist is, "Upon what, and how do plants feed?" They are seen to flourish as epiphytes without any connection with water or soil; they thrive most luxuriantly in the briny ocean, and they spring out of the earth as if that were the great storehouse of their existence. The careful investigations of modern science have explained these mysteries and taught us what it concerns every botanist and every farmer to know, and what, thanks to Professor Johnson, they may now readily learn, namely, "How Crops Grow," and "How Crops Feed." We are also promised a volume, by the same learned author,

upon "Tillage and Fertilizers," that we may understand how to apply our knowledge to the production of the most profitable crops, as well as how to improve and perpetuate the fertility of our soil.

We have thus alluded to a few facts of Structural and Physiological Botany, to show what an immense and important field of research is opened to the botanist without any regard to the names of plants. Descriptive and Systematic Botany are, however, by no means to be neglected. The human mind naturally associates together similar objects, and separates those which are unlike. The classification of plants is, therefore, a necessity, and greatly facilitates the study and comprehension of the vegetable kingdom. Various systems of classification have been suggested, most of them of a very artificial character and so quite unsatisfactory. Dioscorides, for example, in the first century of our era, names the six hundred species he describes under the following four divisions, viz.: Aromatic, Alimentary, Vinous and Medicinal Plants. Linnæus made twenty-four classes, based upon the organs of fructification. This system was remarkably simple and complete, and rendered it very easy for beginners to learn the names of plants, though often associating together those which were very unlike. In more recent times, the so-called natural system has been adopted, the plan of which is to bring together groups of plants which resemble each other, not merely in one particular, but in their general characteristics. Thus we have the *Rosaceæ*, furnishing the queen of flowers and nearly all the fruits of the temperate regions; the *Palmaceæ*, containing the most beautiful and useful trees of the tropics; and the *Graminaceæ*, producing fodder for cattle and most of the bread for the human race. As there are only about one hundred and fifty orders of flowering plants it is not a difficult matter for the student of botany, with proper means, to acquire a correct apprehension of the vegetation of the entire globe, so that wherever he may be he may feel in a certain sense acquainted with the scenery about him. The importance of botanical knowledge to the traveller, or even to the reader of a book of travels, is so obvious that it hardly needs illustration. Darwin says, "As in music the person who understands every note will, if he also possesses a proper taste,

more thoroughly enjoy the whole, so he who examines every part of a fine view may also thoroughly comprehend the full and combined effect. Hence a traveller should be a botanist for in all views plants form the chief embellishment." Humboldt often expresses his admiration of the plant world. In his Cosmos he remarks that, " Although the character of different portions of the earth depends on the combination of external phenomena, as the outlines of mountains, the physiognomy of plants and animals, the azure of the sky, the forms of the clouds and the transparency of the atmosphere, it must still be admitted that the vegetable mantle with which the earth is decked constitutes the main feature of the picture."

The ability of a person to enjoy and improve the constantly changing scenes of travel will be readily seen to depend upon his previous preparation by contrasting the experience of an Agassiz with that of a common sailor upon the same journey. The one is continually under the influence of interesting thoughts and pleasurable emotions, during every waking hour of health, whether on the land or on the sea. New facts rush in upon his already crowded mind incessantly and are forthwith arranged in their appropriate places to serve his great purposes in the various departments of science. The ignorant, unthinking sailor, on the other hand, goes whistling round the world, acquiring but little information and utterly unable to use that. The mental habits and capacities of educated and uneducated men are just as different in every-day life,—on the farm, or at a meeting of the Board of Agriculture. Other things being equal, he who has the best-trained intellect and the most knowledge will everywhere learn the most and accomplish the most.

The general character of the vegetation in every country depends chiefly upon the nature of the soil and the climate,—that is, upon the amount of heat and cold, moisture and drought, sunshine and cloudiness, and the force of the winds. The least-observant traveller can hardly fail to notice the peculiarities of plant growth in different portions of the world. Even in our own country, we have regions with singular and remarkable vegetation, such as the giant cactus of Arizona, the sagebrush of Nevada, the red-woods of California, the herbaceous carpet of the prairies, and the long-leaved pines of the

Carolinas. Whoever has ascended Mount Washington must have been struck by the gradual dwarfing of the forest firs and birches, until at last they rise only a foot or two above the ground, and, before he reaches the summit, disappear altogether. The distribution of plants with relation to latitude, elevation and climate constitutes a department of our science called Geographical Botany, which is both exceedingly interesting and of much practical importance in agriculture and horticulture. Multitudes of exotic plants are now cultivated under glass in an artificial climate, and the highest success in this branch of culture can only be expected when the natural conditions of each species in its own habitat are thoroughly known and imitated. This knowledge is also invaluable to those who desire to introduce from abroad hardy trees and shrubs, as is well illustrated in the attempt to grow the Patagonian beech in England. Notwithstanding its evident ability to endure the temperature, it was observed everywhere to perish, except in a single locality on the sea-coast, where the air was very moist, as in its native land. Every intelligent cultivator of fruit understands that he must adapt the varieties he would raise to the soil and climate of his locality. Hence the American Pomological Society has prepared with great care catalogues of all kinds of fruit which are specially adapted to the different sections of our extended country. Even in Massachusetts there is a marked difference in the adaptation of varieties to localities. The bouquet of wines and the flavor and perfection of fruits is effected often by very obscure causes, and there is abundant need of well-educated and shrewd observers everywhere in the domain of horticulture. The best wines and the best fruits are always in demand at the highest prices, and only those who can produce such can hope for distinguished success. Even the age of the vine influences in a noticeable manner the quality of the wine,—so that in Burgundy, where there are productive vineyards two hundred years old, it is said the worth of a vineyard, as determined by the value of its product, cannot be known before the end of thirty years from its planting. In the Azores, young orange-trees bear fruit with a thick skin and many seeds, while trees one hundred years old and more, produce a much more valuable fruit with a very thin skin and no seeds. Around

London are twelve thousand acres of land devoted to the raising of vegetables, and six thousand acres to the production of fruit; and even in this limited area the quick-witted market gardeners have learned that each locality has its peculiar adaptations, and the principal crop of each is regulated accordingly, so that the main supply of each variety is grown in one particular section. In like manner, the finest damsons in England are said to ripen in Cheshire; and near Paris, one town in a favored site, Montreuil, sends to market remarkably fine peaches, to the exclusion almost of those from other localities. Doubtless many similar instances of special adaptations in raising fruits or vegetables occur in this country. The importance of attending to this subject will not be questioned.

The necessity for the application of botanical knowledge to agriculture is again clearly shown by the recent investigations concerning those microscopic fungi, which are among the most destructive enemies of cultivated plants, and often suddenly blast the hopes of the farmer and gardener. The Report of the Commissioner of Agriculture, for 1871, contains an interesting article on the fungi found on the fruit of the pear, tomato and grape, and the foliage and bark of the peach, the vine and the lilac, with excellent illustrations and many useful suggestions respecting their nature and treatment. The disease called the yellows, which—though unknown in Europe, where more shelter is given to fruit-trees—has almost entirely deprived Massachusetts and the whole of New England of the most delicious of our fruits, appears to be only the result of the growth of a fungus, which our peculiar climate fosters. That careful observation and experiment will devise some means for its suppression, there can be no reasonable doubt. Can we afford to neglect longer the means which are necessary to accomplish this most desirable result, as well as to aid us in preserving from similar destruction, the foliage and beauty of our phloxes, our loniceras and many other ornamental plants?

The "Monthly Report" for October, 1872, contains an illustrated article by Thomas Taylor, microscopist of the Agricultural Department, upon the onion blight and smut, which have proved exceedingly destructive in Essex County, in this State. The loss in a single season upon a four-acre field,

belonging to Benjamin P. Ware, Esq., of Swampscott, from which were obtained specimens for examination, was estimated at $2,000. Mr. Taylor regards it probable that the blight and smut are but different forms of the same species, which is very tenacious of life, and develops so fast as to ruin a promising field in three or four days. Mr. Ware states that the common custom of growing onions on the same land for several successive years cannot be safely continued after the appearance of this pest, as the spores will spring up the following year. The conservators of the agricultural interests of the Commonwealth certainly ought to encourage the study of microscopic botany at the State College, and ask for special investigations in regard to the habits and characteristics of so formidable a foe to one of our most profitable crops.

The mildew on the grape has been the cause of much annoyance in this country, while in Europe it has inflicted an annual loss of many millions of dollars in the wine districts, where it has raged for many years. In Madeira, where the vine is almost the only source of revenue, it has caused the greatest distress, reducing the people to actual starvation, so that contributions of food have been sent to keep them alive. Showering the infected foliage with dilute solutions of sulphide of calcium or sulphurous acid, and dusting it with flowers of sulphur, have proved tolerably effectual remedies; but doubtless improvements are to be sought in this direction, and M. Dumas recently proposed, in the French Academy of Sciences, that the government offer a prize of $100,000 for a means of entirely preventing the ravages of this destructive parasite.

In Europe, wheat is often attacked by a disease called pepper-brand, or bunt, which renders the grain disgusting in odor and unfit for food. It has been found by botanists to be caused by a fungus so minute that four million plants may occupy a single kernel of the grain. A similar disease, called smut and dust-brand, affects oats and barley, often doing great damage. It has been found very useful in preventing the attacks of these fungi to soak the seed-grain, just before sowing, in a solution of sulphate of soda; then to mix the moist grain with caustic lime, by which the plants or their spores are destroyed, if present.

Ergot is the distorted and diseased seed or grain of rye, and

sometimes of other grasses, caused by the attacks of a fungus, and is exceedingly poisonous to both men and animals. It is not so likely to occur on well-drained land as on that which is wet.

Rust is a disease attacking grains and grasses, and occasionally other plants, and is found to be caused by the development of minute fungi in the cellular tissue of the floral bracts, or chaff, and the leaves. It weakens the plant, and often renders the grain crop worthless. The growth of different fungi seems to depend largely upon the state of the weather,—whether dry, moist, or variable in temperature,—and is therefore difficult to control. Something in addition to what has been suggested may be done against these enemies by a judicious rotation of crops; by the selection of the most suitable varieties of seed; by improved methods of cultivation; or by removing from fields, ditches and hedgerows all those plants which support these injurious fungi, and so perpetuate them.

Another very destructive form of fungus develops in woody fibre, in close, damp places, producing "dry rot." This is so prevalent in some parts of London that wood-work in houses has to be renewed every ten or twelve years. This form of fungus may be checked in its ravages by saturating the wood with some metallic poison, as corrosive sublimate, or chloride of zinc. Fungi likewise often penetrate the wood of fruit and forest trees, beginning where wounds have been made, and gradually causing the death and decay of the entire mass of timber. In many cases, timber apparently sound, cut from dead trees, will be found on examination to be permeated by the mycelium of some fungus which on exposure to air and moisture will develop and destroy its durability. The growth of fungi on fruit which has been bruised or injured by insects, is one of the most common causes of decay. Experiment has shown that a sound apple, innoculated with fungus from a decaying one, may be destroyed in three days, and its tissue filled with the cells of the destroyer. The obvious remedy is extreme care in sorting, handling and storing the fruit.

Time would fail us to recount the damages inflicted upon the husbandman, and so upon the race, by these almost invisible, but innumerable and relentless, foes. It must answer our present purpose to state that every plant is subject to their attacks,

and that their presence even is often unsuspected, as in the case of the potato rot, the cause of which was everywhere sought in vain for many years, until at last Mr. Berkeley, the celebrated botanist of the Royal Horticultural Society in London, demonstrated that a microscopic fungus was the undoubted source of the terrible evil. "Where the carcass is, there the eagles are gathered together," and it has been discovered that the potato plant, weakened by the assault of its principal enemy, is subsequently attacked by no less than ten different fungi. More than thirty species are parasitic upon the grasses, which are infested by them, wherever cultivated, the sorghum and cane of the tropics, as well as the oats and barley of the North. The coffee-tree, the orange, the olive, and the mulberry suffer under the attacks of various blights, which, obstructing the cells and stomata of the foliage, induce disease and the failure of the looked-for crop. Even the silkworm has become the victim of a fungus, to eradicate which millions of dollars have been sent to Japan and China for the purchase of healthy eggs, which are annually imported into Southern Europe. Thus the knowledge of the origin of the disease has led to the finding of a remedy, without which one of the great industries of France and Italy must have perished. Still more impressive is the fact that epidemic and contagious diseases among men and animals are usually accompanied by the growth of microscopic fungi on or within the bodies diseased, which are often the cause of great discomfort, and sometimes of death.

The argument in favor of botanical studies might be still further strengthened by allusion to the useful qualities of some of the larger species of fungus. The chemical composition of these remarkable plants is very peculiar, and resembles that of animal fibre. Though the majority of them are exceedingly poisonous, yet more than one hundred species are used for food. The savages of Tierra del Fuego and New Zealand rely upon them as staple articles of diet, and in all parts of Europe they are regarded as delicious luxuries. In London, dried truffles are worth five dollars per pound, and other edible fungi are sold at high prices; and the demand generally exceeds the supply. In Paris, also, immense sums are expended for them, and, in 1867, there was one cultivator of common mushrooms who had twenty-one miles of beds, twenty inches in width,

devoted to this crop in the subterranean passages of the catacombs beneath the city. It is evident, therefore, that a large amount of excellent food is annually wasted in our fields and forests from the ignorance of our people, who are unable to distinguish the edible from the poisonous species, and consequently avoid them all. Many of these might be gathered and eaten, or sold in the city markets, and many more might be profitably raised by our gardeners. Even the microscopic fungi are sometimes useful. The mould, which epicures often plant in their cheeses to impart a desired flavor, the yeast-plant, which is inseparably associated with the important process of fermentation, and the vinegar plant, are examples of fungi which are beneficial in consequence of their power of producing chemical changes. Without their aid we should have only soda or unleavened bread, and neither alcohol nor acetic acid, except at great expense.

Turning now from the least among plants to the greatest, and gratifying thus our natural fondness for antithesis, let us for a moment consider the importance of botanical studies in their relations to forestry, or the care, cultivation and utilization of trees for shade, shelter, ornament or timber. Much discussion upon this subject has occurred of late with special reference to the preservation of forests on our public domain, and the planting of useful species on the treeless prairies and plains of the West. Many millions of valuable forest trees have been planted during the past few years, and enthusiasm on this subject has attained such force in Nebraska that the legislature has set apart a special day to be annually devoted to this business. While, from the nature of our government, it seems impossible to accomplish much toward the permanent preservation, or the renewal, of our forests by legislation, great good will result from the agitation of these topics by the enlightenment of the people. Very few are fully aware of the beneficial influence of growing woods upon the soil, the streams, the climate, the crops and the salubrity of the atmosphere. The planting, pruning and proper harvesting of a wood crop are not deemed matters of sufficient utility to be considered by our land-owners. Large areas of stony, bleak and barren soil exist in our own Commonwealth, which to-day would be covered with a luxuriant growth of wood, except for the per-

nicious habit of burning over recently cleared lands for the sake of one poor crop of rye or a few years of scanty pasturage. While the inventions of modern times have provided innumerable substitutes for the wood which two centuries ago seemed so indispensable for fuel, house and ship building, and a thousand uses in the arts, it is still an indisputable fact that every country, to be the comfortable abode of civilized man, must have no inconsiderable portion of its surface covered with living trees. Wherever wealth is amassed and luxuries are sought, the planting of trees for ornament and shade, as well as for fruit, will be largely practised. The millions recently expended upon the Central Park of New York and Prospect Park in Brooklyn, are indications of this tendency in the United States. But in Europe, and especially in England, where the law of entail exists, and untold revenues are hereditary from generation to generation, the royal palaces and the mansions of the nobility are environed by the most magnificent gardens, parks and forests which the art of man can create. Henry Ward Beecher is reported to have said that he never had any suitable appreciation of the power of the Almighty, as exhibited in creation, until he undertook to level a small hill. Those who have attempted grading for ornamental purposes will agree that landscape gardening is one of the most expensive luxuries, and where immediate effect is to be produced by planting large trees, the cost is enormous. This is clearly demonstrated in Paris, where one hundred thousand shade-trees are maintained by the government at an annual expenditure of three hundred thousand dollars. These trees have to be reset on an average every twelve years, and the expense of the larger ones is from twenty dollars to twenty-five dollars each.

In Europe, all the principal agricultural schools teach the whole art of forestry with great thoroughness, and the utmost care is everywhere bestowed upon the planting, keeping and cutting of timber. As a large proportion of the forests belong either to the government or to wealthy nobles, it is comparatively easy to apply there the most perfect system which science and experience have hitherto been able to devise. In Massachusetts, we can only hope, by the thorough education of our college graduates, by frequent discussions, with the

powerful aid of the agricultural press, and by the example of a few intelligent leaders, to introduce rational improvements in this department of our agriculture.

Here again botanical knowledge will prove of very great service. That no one is qualified to engage intelligently in tree culture without an acquaintance with Structural and Physiological Botany is self-evident; but familiarity with Descriptive and Geographical Botany is hardly less essential. This is admirably illustrated by the introduction of the Australian *Eucalyptus globulus*, or blue gum, into cultivation. It was first planted in France in 1856, and so rapid is its growth, that plantations of this species are estimated to produce five times as much valuable wood in the same period as an equal area of native timber. The forests of France are now valued at eight hundred million dollars. To increase the annual product fivefold is therefore a matter of some consequence. Hon. Marshall P. Wilder informs us that he saw specimens of blue gum in California which, at the age of six years from the seed, had attained the height of fifty feet. This tree has a surprising power of absorbing and exhaling moisture, and of destroying malarious exhalations from swampy and unhealthy regions. It also imparts to the air a salubrious, balsamic odor. It has been affirmed by good medical authority that the general planting of this species in the malarial districts of Southern Europe would be followed by the speedy restoration of the people to health, vigor and enterprise.

Nothing but experiments, continued for many years, can teach us what trees are best adapted for planting in New England. The ailanthus, which grows here more rapidly while young than any other hardy deciduous tree, and the European larch, which has been so successfully grown in Scotland by the Duke of Athol and others, are among the most promising of foreign species. It is, however, quite probable that Japan or China, whose vegetation seems peculiarly suited to our climate, may furnish some other more valuable kinds as yet undiscovered or untried. But we have one among our numerous native trees which ought to be planted abundantly wherever it will thrive and does not already exist in quantity. The sugar maple may be raised from seed and transplanted almost as readily as a Swedish turnip, and in a tolerable soil grows

with rapidity. Its timber is very highly prized in the arts, and the wood of its branches is most excellent fuel. No tree is more vigorous or symmetrical in form, and none suffers less from the attacks of insects. Its foliage is clean and beautiful in summer, and as the season advances it assumes the most gorgeous tints of yellow, orange and scarlet. The sap, which flows freely from incisions or borings in early spring, yields a large amount of sugar, identical in its chemical composition with that of the cane, the beet and the palm, while its peculiar flavor is far more agreeable. Trees thirty years old will furnish one pound of sugar per annum, and larger ones more, according to their size,—the greatest well-authenticated product from a single tree in one season being about thirty pounds. What more certain or sensible way of benefiting the public and improving an estate can there be than to plant a few hundred or thousand sugar maples?

When we compare the cultivated fields and gardens of Massachusetts with our native flora, we can hardly fail to be impressed with the fact that her natural productions are chiefly rocks, ice and timber. Not a plant grows wild within her limits which is capable, even if cultivated, of furnishing any considerable amount of food, so that only a few wandering savages could subsist within her borders, except for the plants which have been introduced from other regions. Our cereals, vegetables, fruits and flowers, and our principal fodder crops, are almost every one exotics, while the great mass of our staple productions remains the same from year to year; yet every intelligent person knows that new species and varieties of useful and ornamental plants are being constantly brought into notice and cultivation. With the exception of a few varieties, like the Concord grape, originated here, this work has hitherto been done for us mainly by botanists and horticulturists under the patronage of European governments and societies, many of whom maintain constantly both experimental gardeners at home and intelligent collectors searching for desirable rarities in various parts of the world. There are also a few enterprising dealers in plants who now employ travelling botanists, whose discoveries enable them to bring out novelties to attract the attention of the public to their establishments and to keep up the interest in floricultural pursuits

among their amateur customers. Extraordinary facilities for this work have been enjoyed in England, in consequence of the great number of her colonies in all quarters of the globe, and the general attention given to such matters in a country so abounding in persons of wealth and culture. David Douglas, a botanist in the service of the Royal Horticultural Society, sent to England more than fifty new hardy trees and shrubs, and one hundred and fifty new herbaceous plants, from our Pacific coast. He was finally killed by a wild bull while collecting at the Sandwich Islands, being then only thirty-six years of age. It is worthy of mention that more than half the botanical collectors who have been sent abroad during the present century have fallen in the field through sickness, accident or violence. The amount of valuable labor performed by some of the gentlemen who have gone from Europe to act as superintendents of botanic gardens in India and elsewhere is almost incredible. Dr. Wallich, at Calcutta, forwarded to two thousand one hundred applicants, in different parts of the world, one hundred and ninety thousand living plants in the short period of five years. Baron von Müller, at the present time director of the botanic garden at Melbourne, Australia, has also been indefatigable in discovering and distributing new plants, as well as in introducing foreign species which seemed likely to prove of service to the agricultural and horticultural interests of that peculiar country. Among other things, he has recommended the planting there of the cranberry, the blueberry and the huckleberry in swamps and wilds which now produce no useful fruit or root. He has also begun the culture of the tea shrub, and has lately announced the invention of a machine for curing the leaves by steam, with which two men can do the work now requiring the aid of twenty-five Chinamen. Is it not time for Americans to begin to do their share in the great work of introducing new and valuable plants into cultivation?

If, now, we have attained to any just apprehension of the nature and utility of botanical studies, we are prepared to consider what provision ought to be made for this department in the Massachusetts Agricultural College. The Board of Agriculture, as overseers of the institution and guardians of those public interests which are by law intrusted to them,

may surely be expected to regard with favor any reasonable plan for its advancement; and the people of Barre, with five of their young men now members of the College, will be eager to have the best means provided for their education in so important a branch of science, as well as in all its useful applications, especially to agriculture, forestry and horticulture. The trustees have from the first treated this department with extraordinary consideration, and done all in their power to promote its welfare. They have appropriated the most suitable portion of the College estate to its objects, and erected a tasteful building for a lecture-room, library and museum. Valuable gifts of books and plants have been made by Hon. Marshall P. Wilder, Hon. Albert Fearing, and many other liberal benefactors. William Knowlton, Esq., has given two thousand dollars for the purchase of an extensive herbarium, and the erection of glass cases for its accommodation. Dr. Nathan Durfee, himself a large cultivator of fruits and flowers, both under glass and in the open air, has built the beautiful and commodious plant-house which bears his name, at a cost of ten thousand dollars. The foundation of this department was laid, however, by Messrs. L. M. and H. F. Hills, who contributed ten thousand dollars as a fund, the income of which should be applied to the purchase of such books, drawings, apparatus and specimens as might be deemed most desirable by the director of the botanic garden.

The most pressing wants at the present time are suitable glass structures for propagating plants, for forcing vegetables and flowers, and for raising peaches, apricots, grapes and pine-apples. Till these are provided, it will be impossible to qualify students to act as intelligent and skilful gardeners. This profession, which should be most attractive from its associations and honorable from the intelligence it requires,—now filled almost exclusively by foreigners,—ought to receive large accessions from the ranks of our young men, and would, if they enjoyed the opportunity of suitable education. At least twenty-five thousand dollars are imperatively needed to complete the original design of the Durfee plant-house, and erect the additional buildings wanted. Sales to the amount of three thousand dollars per annum might then be made, which would do much toward rendering the department self-sustaining. The

proposed enlargement of the plant-house would also furnish room for the exhibition of all the most important tender exotic plantsin cultivation, and give more ample opportunity for experiments in regard to the production and improvement of varieties by the growth of seedlings, by hybridization, by modifications of heat, light, soil and plant-food in the liquid or gaseous state. Valuable results might also be obtained by the trial of various methods for the prevention of injury to plants, cultivated under glass as well as out of doors, from both the vegetable and animal enemies which cause so much loss and annoyance to the gardener.

In order to accomplish the proper work of the College in this department, whether for the instruction of its students, the improvement of agriculture in its various branches, or the advancement of botanical science, it is essential that orchards, vineyards and gardens be cultivated in the best manner, with every desirable variety of large and small fruits and esculent vegetables which are known to thrive in our own climate; besides which experiments should be undertaken with such as are new and untried in Massachusetts, but are found to be valuable in other localities. It is quite possible that varieties, originating in different regions of our own or other countries, might prove great acquisitions to us, even though decidedly modified by our soil and climate. Thus it is said the Roxbury Russet, so remarkable for its keeping qualities here, becomes in Mississippi a fine summer apple. Some French pears, like the Beurrè d'Anjou, introduced by Colonel Wilder, are found to thrive well here; while many others, apparently promising, for some unknown reason produce uncertain crops, worthless fruit or unhealthy wood. It is certainly reasonable to suppose that judicious experiments might demonstrate the fact that these modifications, desirable or otherwise, depend upon the nature of the soil in its proportion of water, clay, lime or organic matter; the aspect; the shelter or exposure to winds; the elevation above the sea level; the pruning; the thinning of the fruit; or the stock on which the variety is set. In Robinson's interesting work, "The Parks, Promenades and Gardens of Paris," are many suggestive facts relating to this matter. He informs us that even in that delightful, sunny climate, apples, pears, peaches and apricots are grown in

enormous quantities upon white walls ten to twelve feet high, with movable copings two feet wide. These walls or screens are built of brick, stone, or even of felt, parallel to each other in an east and west direction, and thirty feet apart, and only the south side is utilized. In this way the crop is certain and of the finest quality, as the prices obtained indicate. Apples of the Calville Blanc variety, raised on Paradise stocks, with shelter, are often sold at from fifty cents to seventy-five cents each, and are sent even to St. Petersburg, where they are sold for one dollar and fifty cents apiece. The finest winter pears, as Easter Beurrè, are produced in perfection only on walls; while many others, as Duchesse d'Angoulême, are grown admirably on trellises with a movable roof for protection from cold rains and frosts during spring. At Montreuil, are two hundred and fifty gardens devoted to the wall culture of the peach, the land between the walls being planted with strawberries, asparagus and other vegetables. As experimental culture must occupy a long period of years, it is of the utmost consequence to have it tried upon lands inalienably devoted to the object, lest they be sold for house-lots, which threatens the famous pear-orchard where our eminent pomologist, Colonel Wilder, has experimented with so great success in years past. The Royal Horticultural Society now cultivate in their fruit department, at Chiswick, near London, four hundred varieties of apples, three hundred and fifty of pears, three hundred of plums, four hundred and thirty of cherries, two hundred and twenty of grapes, and one hundred of figs. From this garden were distributed, in 1871, seventy thousand plants, sixty thousand packages of seeds, and four thousand five hundred packages of scions and cuttings. The possible benefit to be derived from such collections, properly managed, must be immense. The importance of having such standard plantations for the purpose of verifying names and comparing varieties, is shown in the fact that in England it has been discovered, at the exhibitions of the Horticultural Society, that the Black Hamburg grape is sold under thirty-six different names, the Black Cluster under forty-six, and the Grosse Mignonne peach under forty. If this can happen in the case of common kinds of fruit, what mistakes may not be looked for in those which are less known?

Another very useful branch of gardening which ought to receive thorough attention at the College is the raising of seeds of all kinds. The finest varieties of vegetables, grains, grasses and flowers, ornamental shrubs and forest trees, should be grown, and the seeds carefully saved for exchange or sale, so far as there might be found a demand for them. This practice would be a valuable means of education, and would benefit the public by furnishing clean seeds of reliable sorts, a most important matter to all cultivators of the soil, but especially to market gardeners, and yield an income for the benefit of the department.

Finally, liberal provision should be made as soon as possible for planting and supporting a botanic garden. This should consist of a tract of not less than thirty acres, tastefully laid out as ornamental grounds, and containing a large collection of such trees, shrubs and herbaceous plants from all quarters of the globe as will endure our climate in favorable situations with little or no protection. They should illustrate as far as possible the general characters of the various groups of the vegetable kingdom, and should be arranged with regard to the natural system of classification, and every species and variety should be correctly and conspicuously labelled for the benefit of students in botany. Besides these, there should be special collections of those plants used in agriculture, horticulture and medicine; and a Massachusetts collection, including every indigenous species of flowering plants, and all the larger and more durable cryptogams.

The proper maintenance and development of such collections as have been named necessitate extensive nursery-grounds, with suitable conveniences for propagation from seeds, bulbs, roots, green and woody cuttings, as well as by layers, grafting and budding. This, however, properly managed, would be a source of revenue, and an indispensable means for the thorough education of practical gardeners.

What then remains to be done? Why not go forward with the work and complete this magnificent design? With so many wealthy, influential and appreciating friends, nothing would be easier than to plant a few acres with interesting species, and call the collection a botanic garden. But the history of such enterprises, in this and other countries, shows

that it is not difficult to fail of permanent and satisfactory success, unless ample means are provided at the outset to defray the unavoidable expenses of such establishments.

In 1801, a botanic garden was started at Cambridge upon a small tract of unsuitable land, but it has never flourished nor been of much use, except to supply a few specimens for the illustration of botanical lectures. It certainly is not creditable to the alumni of Harvard, that, with all their munificent gifts to their *alma mater*, they have so neglected a department which has received such abundant honor in foreign universities. Quite recently it has been announced that the sum of one hundred thousand dollars has been given to establish an arboretum upon the Bussey estate at West Roxbury, in connection with the agricultural department of the University. This is a move in the right direction, and evidently made with an appreciation of the magnitude and importance of the undertaking. Within a few years, also, through the liberality of Nathaniel Thayer, Esq., excellent accommodations have been provided for the extensive herbarium principally collected by Professor Asa Gray, whose labors in this department of science have won for him a world-wide reputation. The marvellous achievements of the illustrious director of the Museum of Comparative Zoölogy at Cambridge, in procuring money for building and endowment, would seem to indicate that possibly the claims of the botanical department may not in former times have been presented to the solid men of Boston, or the state legislature, with sufficient clearness or urgency. With rare exceptions, wealthy men, burdened with the care of business, however distinguished for liberality, can hardly be expected to devote much of their valuable time to investigating the necessities of the scientific departments in our educational institutions. Hence the obvious propriety of full and specific explanations of their objects and wants, and of awakening a public interest in them, as the most rational means of obtaining the funds required for their proper support.

The only remaining item, then, to be mentioned as indispensable to the successful organization and working of the botanical department of the College, is a fund of fifty thousand dollars, the income of which may serve as the active capital of the establishment. This would be used principally

to pay for the labor of students in performing the various operations in the gardens and plant-houses, and so would do double service in the cause of education. The money thus expended would enable indigent students to earn something toward their support, would encourage habits of industry and self-reliance, and render it possible to keep the grounds and buildings in good condition without any draft upon the general treasury. Begun in the manner suggested, and carried forward wisely for a few years under an enthusiastic, intelligent and indefatigable director, the entire project would so commend itself to the public that abundant means would be furnished for needed improvements, while the annual income from sales would steadily increase with the increase of stock and reputation.

Many other subjects, which might legitimately be considered in this discussion, did time allow, must be entirely omitted, or receive but a passing notice. For instance, the great pecuniary value of even the slightest real advance in agriculture or horticulture, in consequence of the enormous aggregate value of their products, is worthy of notice. Thus an increase of only one per cent. in the wheat crop of the United States would amount to 2,877,456 bushels. There can be no question that in many ways this might be brought about. The use of the best variety of seed often does much more than this in all crops. Hence the importance of experimental grounds for testing varieties of plants and modes of culture.

Again, the introduction of new fruits or crops often results in untold good to a country. Thus the sugar-beet in France and Germany has wonderfully improved the whole system of farming, and vastly increased the wealth of these nations. In like manner the fig, the orange and the olive are valuable acquisitions to California. In 1839, a missionary transported from the splendid garden of the Duke of Devonshire to the Navigator's Islands a single banana plant, which increased rapidly, and now the people are abundantly supplied with this agreeable and most nutritious fruit. We might profitably consider the desirableness to the farmer of an acquaintance with the origin and characteristics of the weeds he would exterminate and the crops he would produce; the importance

of knowing what each cultivated plant takes from the soil and what it requires for its best development; and the necessity of understanding the relative value of the different grasses and other kinds of fodder for his special purposes.

The exceeding value of botanical knowledge to those who attempt the cultivation of ornamental plants, either indoors or out, both in enabling them to select the best species for their peculiar circumstances, and to obtain desired results, might easily be made evident. There is now an immense waste of money, labor and love in consequence of misdirected effort in floriculture. The pleasures and profits to be derived from the intelligent cultivation of good vegetables, fruits and flowers, for the farmer's family especially, and the consequent importance of educating the students at the College as thoroughly as possible in these matters, might be enlarged upon with great propriety.

Finally, a description of some of the famous gardens of Europe, such as those at London, Paris and Berlin, would be very entertaining, and show what may be accomplished in this direction with ample means and talent of the first order, while it would also demonstrate the the comparative moderation and economy of the plan now proposed for adoption.

Thus the council having in charge the *Jardin des Plantes* have recently recommended the erection of conservatories, to cost four hundred thousand dollars, to replace those destroyed in the late seige. The magnificent palm-house at Kew is built of iron and glass, and is three hundred and sixty-two feet long, and the main portion is one hundred feet wide and sixty-six feet high, with a gallery thirty feet in hight, from which the visitor may look down upon a most superb variety of tropical vegetation. These gardens now contain the largest and best arranged collection of living plants in the world, as well as the most complete herbarium and botanical museum. Nothing could show the utility of such institutions more conclusively than the history of Kew Gardens during the past thirty years. The estimation in which they are held by the public is shown by the fact that they were visited in 1871 by five hundred and seventy-seven thousand persons. While many expensive features of these large gardens near the great capitals of Europe are neither possible nor desirable

at Amherst, yet the facilities which have been enumerated for the study of Botany in its various departments and applications are absolutely essential, if the State College for farmers is to maintain a high position as a school of science and to be eminently efficient in the advancement of agriculture and horticulture. The appropriate work to be executed there is grand enough to satisfy the ambition of the most gifted botanist, or the most wealthy and liberal patron of learning. As the field is all ready for occupation, and trees grow while men sleep, it is fervently to be hoped the planting may speedily begin.

The possible and unforeseen advantages to be derived from cultivating together representative forms of vegetation from different countries, and so imparting to beholders some conception of the variety and magnificence of the flowers and foliage with which the Creator has adorned the earth, are beautifully shown by an incident in the life of the renowned author of "Cosmos." He informs us that "the sight of a colossal dragon tree and a fan palm in an old tower of the botanic garden at Berlin, implanted in his mind the seeds of an irresistible desire to undertake distant travels." The volumes containing the results of his journeys in Europe, Asia and America, are justly regarded as among the most learned and philosophical treatises which the world has ever seen. They have been translated into all the principal languages of civilized nations, and must in the ages to come be a perennial source of instruction and pleasure to every scientific lover of Nature. Who can say that some American youth might not be inspired by the scenes in a Massachusetts garden to enter, like Alexander von Humboldt, upon a glorious career of usefulness?

In conclusion, permit me to mention a circumstance in my own personal history in further illustration of the most important principle that all faithful and worthy study of pure science, without regard to its immediate application in the arts, will inevitably result sooner or later in some substantial good. More than twenty years ago I went to Europe to qualify myself to become a practical geologist, and spending a few weeks in London, I visited the Kew Gardens. Here I beheld, with wonder and delight, the first specimen ever culti-

vated of the Victoria regia, the grandest plant in both leaf and blossom ever seen in the temperate zone. In this imposing presence the resolution was formed to create, if possible, a botanic garden in the United States, and reproduce there this superb water-lily. The consequence was that my plan of operations were changed, so that instead of seeking my fortune in the mining regions of the far West, I became in due time a teacher at Amherst. My connection with the Agricultural College resulted directly from the opportunity there offered to begin the accomplishment of my botanical purposes; and already my heart's desire to look upon the flowers of the Victoria unfolding their beauty and exhaling their fragrance in my own country has been repeatedly gratified in the Durfee plant-house. Whatever has been or may be achieved at the College through my instrumentality, must therefore be credited to the Royal Botanic Gardens at Kew.