Hunt Institute for Botanical Documentation
5th Floor, Hunt Library
Carnegie Mellon University
4909 Frew Street
Pittsburgh, PA 15213-3890
Telephone: 412-268-2434
Email: huntinst@andrew.cmu.edu
Web site: www.huntbotanical.org

DOUBLEDAY & COMPANY, INC. *Publishers*

277 PARK AVENUE, NEW YORK, N. Y. 10017 TEL: 212 TA 6-2000

March 15, 1971

Dr. David Rogers
Armory 101
University of Colorado
Boulder, Colorado 80302

Dear Dr. Rogers:

This letter, when signed by you and countersigned by Doubleday & Company, Inc., will constitute formal cancellation of our agreement of June 14, 1963 for publication of PLANTS AND MEN in our Plant Science Series.

Under this agreement you received an advance of Seven Hundred Fifty Dollars ($750.00), which you may retain unless you enter into an agreement with another publisher for publication of this work, in which case the money is to be returned to us.

Please sign both copies of this letter below and return them to us for Doubleday's countersignature, together with your copy of our agreement of June 14, 1963. One copy will then be sent to you for your own records.

Sincerely yours,

DOUBLEDAY & COMPANY, INC.

____

ACCEPTED:

____

David Rogers

x498

DAVID J. ROGERS

TAXIMETRICS LABORATORY
DEPARTMENT OF BIOLOGY
ARMORY 101
UNIVERSITY OF COLORADO
BOULDER, COLORADO 80302

INTRODUCTION

Economic botany, the subject of this book, can be defined in broad terms as man's relation to plants in the past, present, and future. There is obviously a vast amount of knowledge that could be brought together on this subject, and we will have to use a broad brush to cover some of the more important aspects.

The word "economic" will be used to indicate much more than the trade value or dollar value of plant products. In fact, there will be very few times when the actual statistics of the volume of sales, tonnages shipped, or total income from crops will be given. In our economic considerations of botany, we intend to show how plants and man are related, how intricate historical developments are made with plants as the basis of the development, and how society in general is affected by plants and their products.

I intend to introduce some of the knowledge that scientists have ~~produced~~ discovered ~~in~~ about the prehistoric ~~study of the~~ development~~s~~ of cultivated plants, some of the ways in which we use plant materials today, and even suggest some ways that plants and their products may be used in the future. There is no one road to the study of economic botany, but many pathways, all having some bearing on our knowledge. ~~One~~ You may, therefore, read the chapters in any order that pleases ~~him~~ you without losing much. ~~although there is a tenuous order which may be useful to follow~~.

At the outset, it is well to restrict our meaning of the "usefulness" of plants. In the basic biology of all living things, all green plants carr~~ies~~y on photosynthesis, the function by which light energy is captured by chlorophyl, and converted into stored chemical energy. The raw materials of photosynthesis are water and carbon dioxide with the end products as carbon compounds with the basic construction of a sugar, and free oxygen released into the atmosphere. In addition to the green plants, we also have groups of nongreen plants, the fungi, that are or may be energy converters. Many of the simpler bacteria use completely inorganic substances as their energy sources using the energy from the oxidation or reduction of inorganic sources to convert carbon dioxide into carbohydrate substances. Along with their synthetic activities which are of fundamental importance to all living things, both green and nongreen plants participate in the destructive activities, converting dead organisms back to simpler materials, and release the compounds for recycling in living organisms. If there were space available, we could expand this paragraph to show how important the various kinds of synthesis and degradation mentioned above are to our daily lives, but this is not our major goal. Let us say that usefulness, with reference to this book, refers to those plants which produce some product having value for man. Use is employed in the ordinary dictionary definition of the world.

From the very beginning, man's curiosity about the surrounding world has played a role in the discovery and development of useful plants. Not only was man interested in the basic materials necessary for his survival, but we can find that from prehistoric times onward people wanted additional materials to make life more livable, more pleasant, and free from discomfort.

Though man must have begun his first trials of plant materials with those from which he could derive sustenance, we easily see that he would, by the nature of his own body construction, particularly of his hands, pick up sticks to use as clubs, or to aid in getting under stones where he might find succulent roots or animals. The children, not immediately involved in the food-gathering activities of the adults might use pieces of wood for toys, playthings, swings, and hundreds of other items that inventive minds could imagine. Thus, from the earliest days when the mind of man began to develop from the purely animal toward that which we identify as human, learning played a role in the selection of plant material that had some satisfying effect. A body of useful information began to accumulate--this succulent herb had a good taste and satisfied hunger; the branches of this woody shrub were pliable and could be used for weaving crude windbreaks; the sap of another had a pleasant, sweet taste; the gum from another was capable of being formed into a ball; the hairy plants of a certain kind produced painful stinging and must be avoided; and others had substances in their tissues that produced violent reactions when eaten.

The information about these plants in the immediate environment was valuable to the trive, and children grew up absorbing the knowledge from the adults, and in turn, passed the general body of knowledge on to the next generation. We have only vague ideas about when man began active husbandry of plants for his own needs, but we know that in terms of the total history of Homo sapiens, only a comparatively short time ago did he take a few promising plants under his active care. Why did man begin cultivation? We can propose many reasons, and perhaps all have had some part in pushing people into the rather difficult task of agriculture. Some reasons are: increased and regular food supply nearby, better taste, easier harvesting, relief from migration, feed for domesticated animals, etc. Whatever the reasons, almost all races of man, wherever they settled, began to cultivate plants. People who have never developed an agriculture have never produced a very complex civilization, although agriculture, or husbandry of plants does not assure that people will develop a complex civilization.

Whatever and wherever civilizations exist in any part of the world, they depend in large measure upon the utilization of plant materials. When the knowledge available to the early types of man became insufficient to cope with increased needs, new endeavors were made to satisfy those needs. For long periods of man's history, indeed, the largest percentage of time that man has been "civilized", there was no need for organized endeavors to improve crops. Today, with more and more mouths to feed and fewer and fewer people (percentage-wise) to work the farms, the need for intensive study of plant materials and agricultural methods has led to extremely complex organizations whose objective it is to derive more and better products from plants.

The important feature that we must focus on in such a book as this is the plant material itself. Were it not for the fact that many of our needs can be met from some plant, then we would not have the drugs we do, the shelter we live in, the cloth for protection, nor the food to feed us. The remarkable flexibility of plants, allowing the productinn of new and different foods, producing more and more drugs, yielding higher and higher quantities of useful substances, permits mankind to continue towards a civilization level completely unimagined even at the beginning of this century.

I have an optimistic view of the potentialities for humankind. This optimism is tempered by the facts of life, and for this reason, I want to say something about the difficulties in the way of continued improvement. An example of this is our need for paper. If one Sunday edition of the New York Times requires all of the timber resources from ~~400~~ 227 acres of Canadian or United States forests, how can we continue to expand our towns and cities into the forested areas and continue to produce such fantastic quantities of paper, a product that can only be produced by long-term agriculture? Somewhere a balance will have to be made, and that balance will be determined by the ingenuity of forestry scientists who are now engaged in complex studies of the present timber resources of the earth, the rates of growth of timber suitable for paper, the optimum areas for timber production, use of all parts of the cut trees and scrap lumber, and many other items associated with the paper industry. Many other examples of increased agricultural need and shrinking agricultural lands could be cited. Explosive population increases throughout the world have already cut our own agricultural surpluses to near zero, and though we can increase our present production of foods and other important plant products, soon other types of measures will have to be brought to bear (in our societies). Some indications of the agricultural problem will be mentioned in this book where appropriate.

A General Review of the Plants and Their Usefulness

Insert table of major plant groups + numbers in each group

There are roughly between 200,000 and 350,000 species of plants in the world, including those of the oceans, bodies of fresh water, the land, and near the land's surface. We have to be careful in the estimated total number because of certain qualifications. First, we do not know how many new species of plants may still be found by scientists; each year for a number of years, there has been an average of 6,000 to 8,000 new species proposed (identified, named, classified). At the same time, other scientists have discovered that some of the "new" species proposed are actually the same as some that had been named previously, and in this manner, there is a reduction in the number. Obviously, there is some upper limit to the number of species now present on earth, but there need be no finite limit, as evolution is still active, and new forms, or species, are in the making at the moment, as well as ~~those~~ becoming extinct. Let us say, however, that we have as many as 350,000 species.

The number of plants that man uses directly, deriving some benefit from them, is at the most 10,000 species or 0.03 ~~per cent~~ of the total

or 3%

AQ: 3% or .03%?

number of species. This statement, standing alone, looks as though we are certainly wasting a golden opportunity to broaden our horizons, and wasteful of potential value that might be derived from the total. If, however, we take a closer look, we may not be so impressed with the difference between those used and the "potentially" useful. By far the largest number of species are microscopic, or do not grow more than an inch or two in total length, or are not formed into root, stem and leaves. This group has little value for structural purposes, for fibers, for fuel, or for ornamentation. Many of the microscopic species live in the deep ocean or fresh-water lakes where we cannot harvest them (although they are important in food chains), or in soil where their cultural requirements are so complex that we cannot economically reproduce the required conditions for cultivating them. Although the same basic elements go into the formation of all plant structures as we have in our own bodies, we cannot successfully ingest any plant body and derive food benefit in sufficient quantity or form that makes it profitable to harvest plants indiscriminately. This obviously restricts the number that we can use as food. The alkaloids, a large number of which are the drugs derived from plants, are not evenly distributed in the species of the plant kingdom. Only certain families of plants produce economically-significant quantities of the right sorts of alkaloids.

Among the 10,000 species that have proven useful, we find representatives from nearly every major group of plants, from the bacteria to the flowering plants. Thus man has not overlooked the potential of any group. The preponderance of economic plants by number of species is derived from the group known as the seed plants, including the Angiosperms (flowering plants) whose seeds are developed in closed structures and Gymnsperms (seeds developed on surfaces of scales, not enclosed). Amongst the flowering plants, there are two major subdivisions, the Monocotyledons (grasses, palms, lilies, orchids, etc.), and the Dicotyledons (buttercups, roses, sunflowers and many others). The grasses, a group within the Monocotyledons, are the single most important ~~group~~ family of food plants on earth. The orchids, while hardly being necessary to any fundamental physiological needs, are without doubt important in making the world a nicer and more enjoyable place to live.

In the Dicotyledons there are many families of direct economic importance. Some examples are the rose family (including such fruits as apples, pears, peaches, etc.), the bean family, species of which are of fundamental food importance and for commercial oils, for tropical timber and many ornamentals; and the sunflower family, with a large number of economic plants.

There are fewer species of the lower, or non-seed bearing plants cultivated than of the higher plants. However, some of them are essential to our life. The most important groups are the algae (which have several economically important sub-groups, including the green algae, the red, and the brown algae), all of which are commonly lumped together as "seaweeds", and the fungi, including among others, the mushrooms. The bacteria are also fundamentally important in our economy both from the standpoint of food production and from industrial standpoints.

Thus, we find that man has not been as wasteful of potential value as one might think. Considering our modern civilizations, and the fact that almost every need has been or is being fulfilled, we are using the plant kingdom fairly well. This does not indicate, however, that we will not find new species which we may wish to incorporate into our agricultural economy, nor that we cannot find wild species that have some special product useful in modern civilization. Indeed, one section of the United States Department of Agriculture is devoted to the search for new crops. In the past few the New Crops Research Branch,

years, ~~this group~~ has discovered that many species of wild flowering plants produce seeds that have valuable ~~types of~~ oils useful in various industrial applications. Whether these discoveries will lead into a new agricultural crop or not depends on many factors, some of them related to the plants themselves, others related to the real needs of the economy. In addition to the search for new crops for our manufacturers, there is a constant search for new ornamentals, for new germ plasm in wild species to be hybridized with older crop species, for new foods, fibers and timbers. While our needs and desires may change, the marvelous thing is that the plant kingdom probably has somewhere the needed variability and capacity to produce substances to meet these needs. Thus, the study of plants is an exciting and never-ending quest of the unknown.

LITERATURE

I have drawn upon many books, magazines (scientific and popular), newspapers, and the personal knowledge of my teachers and friends in the preparation of this book. In many cases, I have said something about the men whose particular contributions make interesting parts of the text. But in many more cases, I have not mentioned the individuals whose contributions fill the pages.

Today, reports on the plants man uses are frequently found in many different popular communications media. For example, in the business sections of most daily newspapers, one may find the price of wheat, soybeans, cotton, and many other plant products, reported on the commodity market. Very frequently the larger dailies have feature articles on some particular plant, crop, or procedure for utilization of the crop. Two excellent sources of well-documented stories are The New York Times and the Wall Street Journal.

On the radio, in stations across the nation, prices of various farm products are reported on the "farm and home" program, either at noontime or very early in the morning. Commercial television stations, on the other hand, have not yet discovered how really interested their viewers are in the plants on which we depend.

Two very good general reference sources on economic botany are A. L. Hill's Economic Botany, published by McGraw-Hill, and Robert W. Schery's Plants for Man, published by Prentice Hall. The one most significant journal (scientific magazine) for plant utilization in the United States is Economic Botany, published by The New York Botanical Garden, Bronx, New York.

Two specialized dictionaries for economic plants are very useful. These are: Willis' Flowering Plants and Ferns, published by Cambridge University Press and Uphof's Dictionary of Economic Plants available from Hafner Publishing C ompany. While these two may not be found in small public libraries, nearly every college and university library in the country have them on their shelves. Other fine sources of information are various general language dictionaries, both abridged and unabridged. Most encyclopedias carry descriptions of useful plants. These sources should not be overlooked, for the articles are either written, or checked for accuracy, by some expert in the field.

Other encyclopedic works of great value are perhaps not so generally available, but certainly should be sought if one lives near a large university. Some of these are L. H. Bailey's _Cyclopedia of Agriculture_, _Manual of Cultivated Plants_, _Hortus Second_, and _Standard Cyclopedia of Horticulture_; I. H. Burkill's _A Dictionary of the Economic Products of the Malay Peninsula_. The last mentioned work, in two volumes, is one of the most amazing banks of plant knowledge I know of. Though the title may sound quite restrictive, there is hardly a plant from any of the world's tropics that isn't included. Another valuable source of information particularly for the tropics is H. F. MacMillan's _Tropical Planting and Gardening_, published by MacMillan and Company. Although the book has special reference to Ceylon, it is general enough to be useful in most tropical areas of the world. The title is no indication of the wealth of information contained. There are general chapters on methods of cultivation, methods of reproduction (both sexual and asexual), fertilization, and an interesting discussion of garden design. The following chapters include lists and descriptions of many sorts of useful plants, such as food crops, beverage plants, tropical fruits, oil-producing plants, etc.

For a very enjoyable evening of reading, I must recommend Edgar Anderson's _Plants, Man and Life_, published by Little, Brown, and Co. and by Andrew Melrose (London). Here, a great botanist talks in a most engaging style about some of the fundamental problems of economic botany. Other well-worth-while books addressed to the general problems of economic botany are: H. G. Baker, _Plants_ *and Civilizations*, Wadsworth Publishing Co., as a paperback; and H. E. Jaques, *How to Know the Economic Plants*, W. C. Brown Co., Dubuque, Iowa.

The most important entry to today's literature on useful plants is found in Biological Abstracts, the serial publication of all the world's literature on biological subjects.

At the end of each chapter, I have listed works that will carry you farther into the subject, should you be so inclined.

Publication dates of these references should be included ✓

Chapter I

THE HISTORY OF PLANT CULTIVATION

For a long time we have been curious about how, where and why our ancestors began active cultivation of plants. Perhaps the earliest ~~speculators~~ savants (or at least the earliest who ~~could~~ ~~write~~ wrote about their speculations) were the ancient Greeks. One outstanding philosopher who indulged in such speculations was Theophrastus, who lived from 372 to 287 B.C., and who was a student and successor of Aristotle at the Lyceum in Athens. Theophrastus and other ancient authorities from other civilizations ascribed the origin of cultivated plants to some god. To most early students it was inconceivable that the useful plants could have been developed by trial and error by countless generations of predecessors.

Beyond speculation, very little was done to establish the dates of earliest agriculture until the sciences began to be established in the renaissance period (1300-1500 AD). The renaissance had almost ~~to~~ run its course, moving men to inquiry about their surroundings and beginnings, before any steps were taken to make active studies of the earliest cultivation ~~and~~ of plants and husbandry of animals. ~~Only in~~ Not until the mid-19th century, however, do we find active students of the problems. Charles Darwin was the major impetus in these studies. It was he who thought that if we could study the history of domestication of plants and animals that we might shed more light on the history of all the living things of the earth. A Swiss contemporary of Darwin was Alphonse DeCandolle. In Chapter 4, we shall see what contributions he made, as well as those of one of the most outstanding students of this century, the Russian geneticist and plant breeder, Vavilov. These three men, Darwin, DeCandolle, and Vavilov, stand head and shoulders above all

did active studies begin during Renaissance? or in mid-19th century?

lc

others interested in the origins of cultivated plants. Many other students, far too numerous to include here, have examined in detail the origins of useful plants.

Summarizing and condensing some of the findings, we can put together a picture of the beginnings of agriculture along the following lines.

Plant husbandry or agriculture first appeared perhaps 15,000 to 20,000 years ago, if the proposals of the various students are correct. Carbon dating, and more recently potassium-argon decay dating techniques give us more accurate information about the earliest agricultural use of plants. New investigations of archeo-ethno-botanists are also contributing to more accurate knowledge of early agriculture. Before investigationing agriculture further, however, a look at the various inherent characteristics of plants which lend themselves to man's manipulation will be profitable.

If plant cultivation began only 15,000 to 20,000 years ago, then an essentially modern flora was present on the earth's surface, and, with few exceptions, all the plants present today were present then. As Professor Oakes Ames pointed out in his work "Economic Annuals and Human Cultures," there would be no history of man had there not arisen before him plants that had annual life cycles, and whose carry-over mechanism from year to year was a marvelously complex package: the seed. Seeds are extremely variable in construction, but basically they consist of an embryonic plant, a stored food supply, and a protective coat. They are efficient, concentrated stores of protein, carbohydrate and fat. Plants producing seeds usually produce them in great numbers, more than will ever have a chance to germinate and produce new plants in the next generation. Therefore, seed productivity is a fundamental characteristic of plants useful to man.

The most casual observation will indicate another important characteristic--plants of one kind generally prefer one type of habitat. City dwellers can check this by the simple observance of the numbers and kinds of weeds that occur in vacant lots, in the cracks in sidewalks, along railroad and highway right-of-ways, ~~etc.~~ There may be only a few types of plants that can survive the rigors of such localities, but usually when a plant of one species is found in such places, there will be hundreds of individuals of that species. Those familiar with temperate-zone river banks can easily see the large numbers of jewel-weeds, of alders, of willows, or poison ivy, and other such weedy species colonizing large areas.

Similarly, an area of forest that has been burned over is rather quickly covered by plants with vigorous reproductive methods. Indeed some plants seem to require an "open habitat" and may be found only in the disturbed areas. One good example of this type of plant is the common pokeberry (known to children who squeeze the dark purple clusters of fruits to make "ink") which will be found only in areas that have been opened up and the mature vegetation cover disturbed or removed.

In all the above cases, one seldom finds one plant--there may be thousands of an individual species in the area. The characteristic of importance here is obvious--plants of the same species usually occupy the same type of habitat, and usually occur in great numbers. Thus, it ~~becomes~~ more efficient ~~to~~ man to gather ~~useful~~ products from those plants that most demonstrate ~~the above sets of~~ characteristics. ~~Furthermore~~, some species will grow only where no competing species are already established, ~~thus requiring~~ some sort of preparation of the area.

As is rather common knowledge, plants have many more ways of reproduction than do the multicellular animals. Bacteria "multiply by dividing" whereby a single cell, invisible to the naked eye, can soon produce a sufficent number of individuals to be visible without magnification as a colony. Similarly, portions of multicellular plants, when separated from the parent plant can regenerate another whole individual. Thus the sexual reproductive cycle need not be complete in order for new individuals to be produced. Portions of roots, stems, or in some cases, leaves, will develop into whole new organisms. This vegetative reproduction has many advantages; if the reproductive cycle fails, the next year's planting is not destroyed. In the more modern application, vegetative reproduction permits the maintenance of a selected superior variety year after year without genetic alteration by rooted cuttings of the mature plant, by grafting onto other root stock, etc. Some plants send out long underground stems that sprout to form new colonies (certain grasses), others produce underground storage organs from which new plants may grow (potatoes, onions). Indeed some plants have so long employed vegetative reproductive techniques that in the regular application of these plants, the sexual reproductive cycle is almost completely by-passed. The characteristic of importance for primitive man and the development of agriculture is that we have an alternate method of continued existence of plants even though their main reproductive method fails to produce sufficient propagules for the next generation.

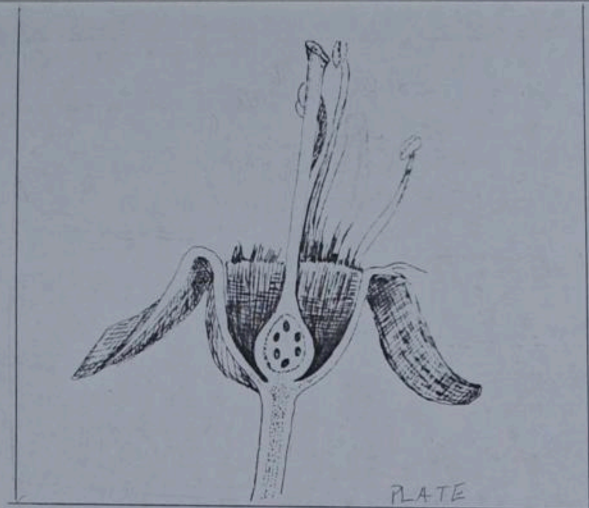
It is further obvious, given a bit of consideration, that plants have differing lengths of growing cycles. The shortest regeneration time we know of for economically-important plants is found in bacteria where, under optimum conditions, a division may occur every twenty minutes. Among the seed-bearing plants (Angiosperms and Gymnosperms), there are annuals, biennials, and perennials. In desert areas, some plants may germinate, grow to maturity, fruit, and seed in six weeks during the period of available moisture supply. In "normal" agricultural areas, longer cycling periods are permissible. In the tropics, where temperature variation is not the main consideration, water availability may determine the cycling time. Among the cereal grasses, the majority are annuals, but with longer or shorter growing periods. Corn (Zea mays) requires about three months to completely mature. Wheat is most frequently planted in the early fall, develops vegetatively in the fall, and produces its fruit the next summer. The characteristic of importance is that man may, by careful choice, have plants coming to fruition at different times of the year, or hold~~ing~~ onto their stored food products ~~into~~ for times of great need.

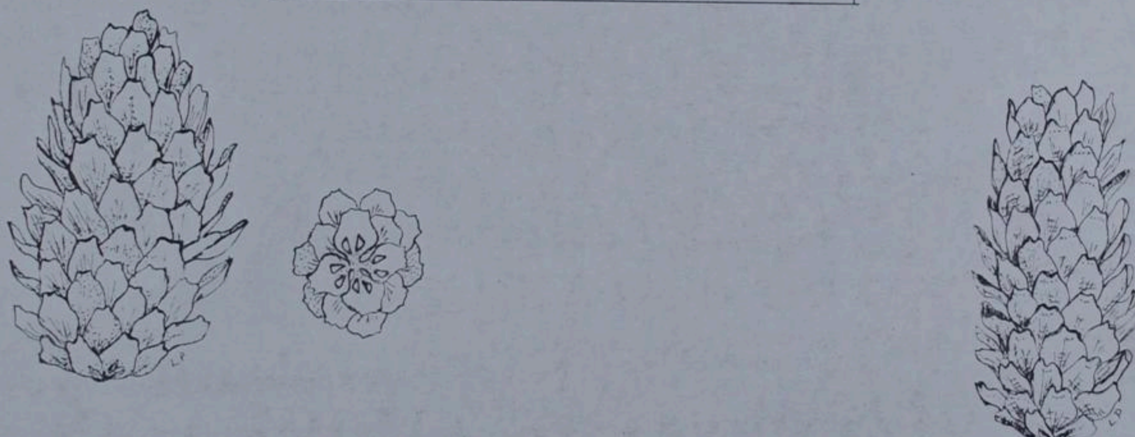
Now, having examined some of the characteristics of plants that would make certain ones ~~of them~~ fit subjects for man's earliest agriculture, it is well to look at some of man's characteristics to see how they may have contributed or directed man towards plant husbandry. There seems little doubt that from the earliest ~~of the Hominid types~~ times, there was a tendency for man (or man-like species) to live in groups. At first, the groups were probably casual, with shifting numbers in a group and shifting of individuals among the groups. When the groups began to settle down to live in one area for a season or more, the landscape surrounding them must have been modified, even though accidentally. There would certainly be accumulations of trash about, and it is doubtful that early man was any tidier than some of our great automobile apes today. We know that some of man's earliest abodes were caves, and these caves are more frequently found in limestone areas than in other geological types. In the trash piles near the cave, there would be all sorts of refuse--piles of bones, wood ashes, human excreta, etc. Here we have some of the prime requisites for plant cultivation--limestone, phosphates and potassium, nitrogen salts, and quite an array of trace elements.

Looking back on the first portions of this chapter, we see from the characteristics of certain plants, that they could and likely would populate such rich, open, disturbed areas. If this idea sounds as though it were pure hypothesis, one has only to make a visit to a tropical American Indian garden.. There will be weeds of all descriptions, mixed with tomatoes, peppers, squash (or some other cucurbit types, and perhaps a tree or two--some sort of fruit). If one scratches the surface, one will find the usual accumulation of junk ~~that gets thrown out~~ --sticks, pieces of pottery, bones, etc.

There was certainly no direct line from one type of activity to another in the development of agriculture. Certainly the natives did not connect the richness of the soil in their trash heaps to the junk they had thrown there, but sooner or later, one of the more perceptive members of the tribe would have seen that the desirable plants did thrive there. Such observations lead to attempts to duplicate the good conditions. It is likely that in discussing some of the reasons why certain plants did better in certain conditions, the village folk would try to associate a success with some naturally occurring, cyclic event such as the first day of the new moon, or perhaps "in the dark of the moon." ~~From such observations~~, it is likely that the tribe wanted some technique to know when to do the same agricultural task again, and from this desire, the development of calendars. Other civilized types activities are equally derived from agricultural endeavor--a system of land survey, and thence, a body of knowledge concerning geometry; agriculture would lead to specialization in work, and a ~~culture~~ would develop.

Ch 1





Ch. 1

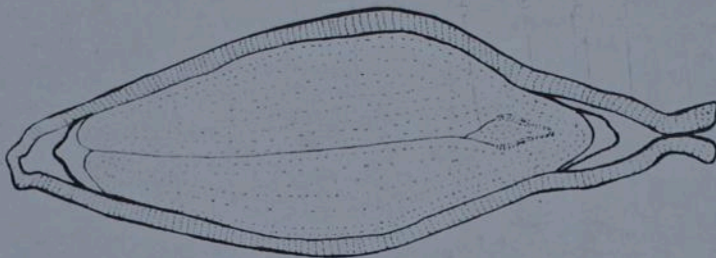
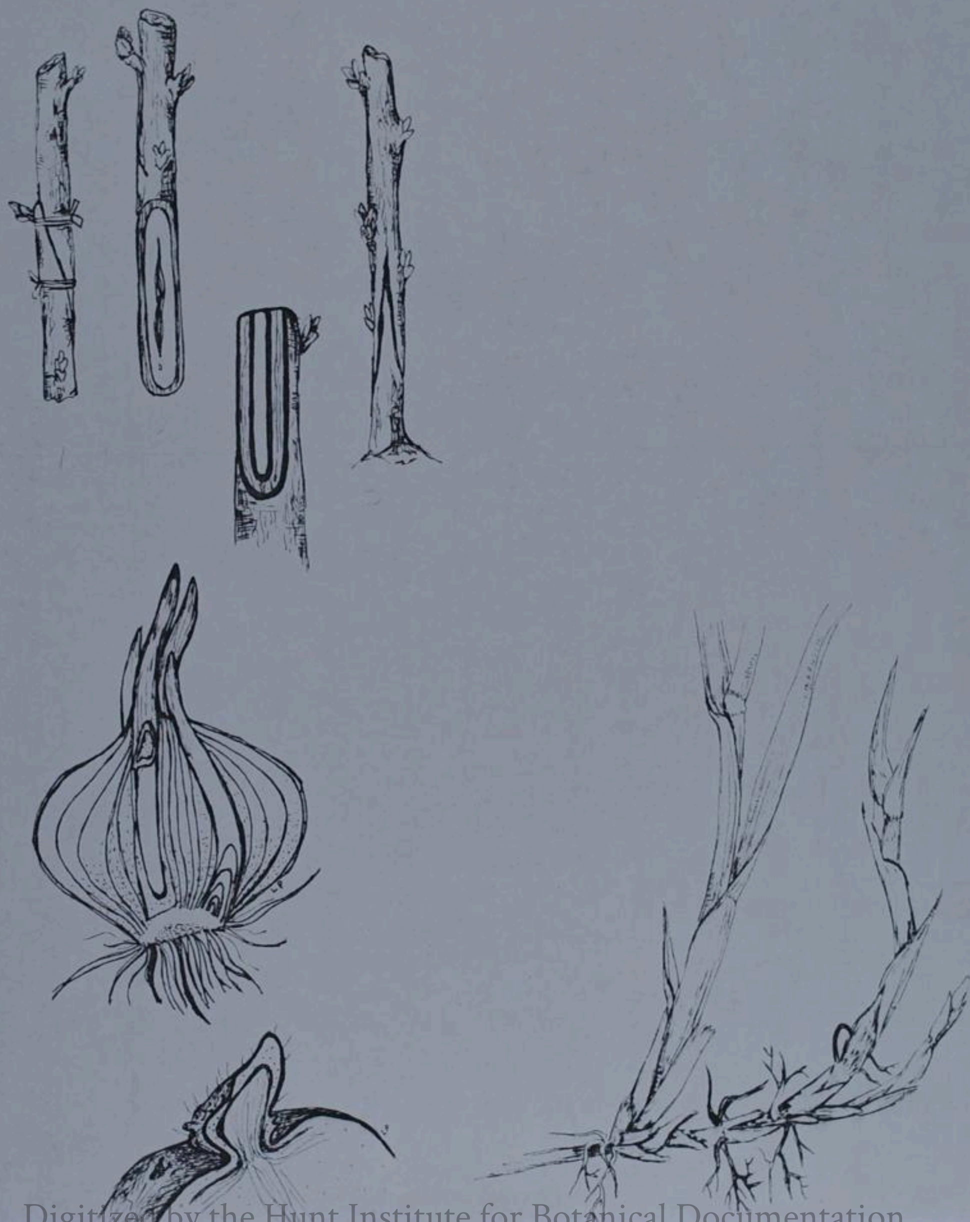


FIG.

FIG.

Ch 1



REFERENCES

Darwin, Charles. 1859. The Origin of Species by Means of Natural Selection.

DeCandolle, A. 1856. Origin of Cultivated Plants. 2nd Ed. reprinted by Hafner Publishing Co., 1959.

Sauer, C. O. 1952. Agricultural Origins and Dispersals. The American Geographical Society.

Schwanitz, F. 1966. The Origin of Cultivated Plants. Harvard Univ. Press.

Vavilov, N. J. 1951. The Origin, Variation, Immunity, and Breeding of Cultivated Plants. Chronica Botanica.

Chapter 2

FOOD PLANTS

It is unlikely that man first cultivated certain plants for food because he thought of them as balancing his diet, or for spicing (flavoring) of his meal. His immediate interests were probably those of volume ~~of a hunger-reducing substance~~, abundance, ease of use, and absence of unpleasant taste. There would not be too great a number of potential food plants in the immediate environment of one tribe, and it is probably true that members of the tribe made many trials before they finally sorted out those that could meet their needs. The diet of any one group of early peoples was undoubtedly monotonous, and this is borne out by some investigators who have listed the plants gathered by primitive Indian tribes of ~~our own~~ West. Wherever ~~such~~ lists have been compiled, it is interesting to note that ~~those~~ plants gathered have come predominantly from the same families of plants. Nearly all cultures will have some sort of cereal (grass family), a legume (bean family), vegetable (cabbage family), fruit (rose family) and nut (hickory family). These same families have plants that have been used for man and herbivorous animals.

In addition to the major food-producing families, there are a number of other families that produce only one significant food plant. For example, the spurge family contains only one important food: cassava or manioc; the laurel family has only the avocado. The emphasis must be placed on the word "significant" for it may be that in some isolated areas, the same family of plants may produce a minor source of food.

Our modern diet is much more varied than that of a primitive society, not because we have invented new crops, but because we have much better marketing and distributional methods. A modern food market is a remarkable collection of animal and plant products from the world's agricultural areas. It is difficult, even for a trained botanist, to identify all the plant products found on sale at any season of the year in any one market.

If, however, one begins to break down our varied materials into the basic components needed to maintain life, we find that we may depend upon a very few basic plant species. To provide a well-balanced and continued growth and living potential, our diet must contain carbohydrates, proteins, fats, and accessory growth substances (vitamins). This may be provided entirely from vegetables, or from a judicious mixture of plant and animal products. Several cultures, for religious or other reasons, are entirely vegetarian. The prehistoric peoples of the New World domesticated but few animals, and most of their food was derived from vegetables. This diet evidently was quite adequate to permit the development of a complex civilization.

Most food plants contain more than one of the basic food requirements, and the most important food crops have fairly well-balanced percentages of carbohydrate, protein and fat. Perhaps the best of all is the coconut, whose meat and "milk" contain good percentages of edible carbohydrate, protein and fats, with an excellent source of accessory growth factors and mineral substances in the liquid portion. The coconut is the predominant food plant in many of the Pacific Islands and other tropical areas with extensive coastal lowlands. Because of the rather restricted areas in which it can grow, the coconut has not become the primary plant food crop for most of the world.

In the three main areas of the world's agricultural development--the Middle East, southeastern Asia, and tropical America,--no single group of plants dominated as much as did members of the grass family. These were wheat in the Middle East (see chapter on Wheat), rice in southeast Asia, millet and sorghum in Africa, and maize (corn) in the New World. But in these areas other food crops were also developed that provided some of the nutrients not well supplied by the members of the grass family. Most of the cereal grasses are predominantly carbohydrate (60-80%), although they also have protein (5-20%), and a smaller amount of fat (1-5%).

Because higher protein content in the diet was generally desirable, many people raised various herbivorous animals; those near bodies of water obtained protein from fish. In some early cultures (the American Indian, for example) the major source of protein was derived from members of the legume family, especially the peas and beans. (We cannot assume that the first people actually knew that the need was for a specific substance, protein, but as with all others, trial and error methods produced a reduction in some felt need.)

In the areas of influence of Chinese cultures, the soybean (an important protein source) was developed, and while it is one of the most ancient crops in those areas, it was not carried out of the Asiatic cultures until within the last 150 years. Soybeans (*Glycine soja*) represents one of the most versatile of plants, as far as mankind is concerned. A partial listing of its uses include the following: green vegetable, salads; source of a meal, made into breakfast foods, infant food, crackers, bread, cakes, muffins; biscuits, and macaroni; in ice creams and chocolate bars; substitute for coffee; source of casein, cheese; soy sauce (by fermentation); source of an oil, made into glycerine; in enamels, varnishes, paints, waterproof goods, linoleum, hard soaps, liquid shampoo, paste soap for hospital use; used in metal molding, foundry cores; used with rubber for manufacturing hose, rubber substitutes, lubricant and in printing inks; when refined, the oil is used for cooking, salad dressing, margarine, shortening; also used for illumination; as forage, hay silage and pasture for livestock, and as a green manure. (From J. C. Th. Uphof, Dictionary of Economic Plants, 1959.)

The cereals provide the major carbohydrate sources, the legumes the protein, and the fats are mainly derived from animal sources, or from certain seeds. An excellent ancient source of seed fats is sesame, or sesame seed (Sesamum indicum), which was known to the oldest cultures of the Middle East, is frequently mentioned in the Bible, and is the base for the old magic saying "open sesame!"

It was seldom that the ancient cultures put all their faith in one type of crop for each of the main nutrient requirements; frequently, others were developed as well. For carbohydrates, there was little problem for, ~~as will be recalled from the introduction,~~ the first metabolic product of photosynthesis which has any degree of stability is a simple carbohydrate-sugar. Starchy foods likewise are easy to produce, and are found in roots, stems, leaves and fruits. Many root crops are largely sources of starch, and prime examples are manioc or cassava, and sweet potatoes. Irish potatoes, taros, and yams are also classed as root crops, though botanically these are underground stems. Bananas, which we normally do not consider as a vegetable, but as a pleasant desert fruit was probably first cultivated because it contains large quantities of starch. A near relative of the banana, the plantain, is very commonly used in much of the world's tropics.

The best known source of ~~starch~~ other than the cereal grains is the Irish potato (Solanum tuberosum) whose underground tubers (modified stems) originally came from the higher Andean areas of South America. This remarkably well-adapted crop is now grown in areas ranging from the cool temperate to the tropical areas of the world. No other food source has had as an important a role in the history of a particular country as has the potato in Ireland. Over a period of perhaps two-hundred years, ~~the~~ social and economic factors in Ireland forced the farmers and peasant classes to become almost totally dependent on this tuberous crop, to the extent that failure of the crop to produce in one year meant famine for larger or smaller groups of people almost immediately (see Wellman, Plants have Diseases, in this series). In 1845, and again in 1846, two years ~~when~~ cool and moist weather occurred during the growing season, ~~combined with the introduction of~~ the potato blight disease (Phytophthora infestans, a fungus parasite), which attacked the whole country's potato crop. It is estimated that well over a million people died of starvation and the illnesses concomitant with undernourishment. In addition to those who died, Ireland lost hundreds of thousands more through migration. This great tragedy in Ireland is vividly documented in a book that should be "must" reading for any economic botanist, and for all conscionable people, The History and Social Influence of the Potato, by R. N. Salaman, Cambridge University Press, 1949.

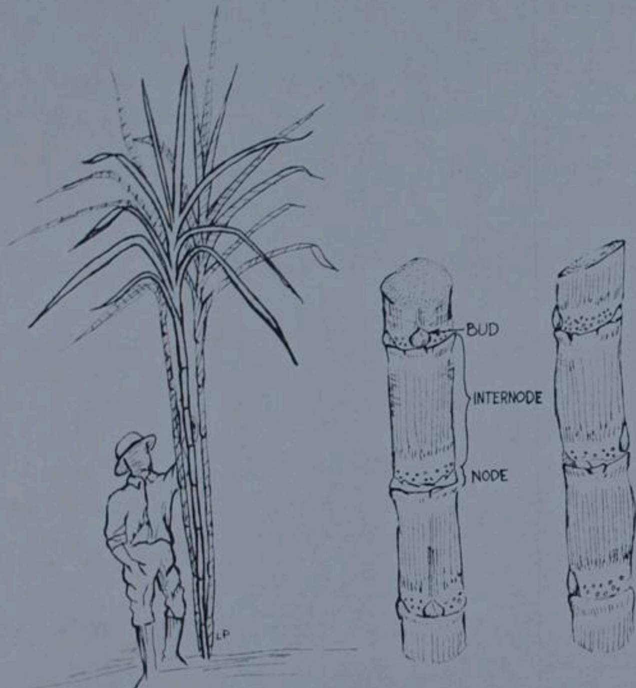
Sugar, one of the most important carbohydrates in our diet, is mainly derived from two crops, the major supply coming from a grass genus, Saccharum, while a second great source is the sugar beet (Beta vulgaris ~~var.~~). The sugar cane is a tropical or subtropical crop that originated in the Indo-Malaysian tropical areas, perhaps on the island of Borneo. The enlarged stems of this grass accumulate large quantities of a sugary juice which is extracted by pressure between heavy rollers. Sugar is derived by condensation and centrifugation, and is refined from a crude, brown product by filtration. The sugar beet is a temperate zone crop, originating in northern Europe or eastward in Asia. In the United States, the major center of sugar beet culture is in the northern prairie states. The principles of the extraction procedure for the sugar is similar, except in detail, to that developed for sugar cane.

Fruits and Vegetables

For the basic food supplies, the harvesting of certain adjunct-type foods is an important one for man-kind. Fruits have been taken into cultivation in much the same way that the other crops have--first by wild gathering, then by more and more complicated agricultural methods. The terms fruit and vegetable are hardly distinguishable botanically, and the terms are rather arbitrarily applied. The best example is, of course, the tomato, which is used as a salad vegetable, but is a true fruit, and botanically speaking, a berry. Similarly, the squashes are true fruits (a pepo), but most frequently are considered vegetables.

The major sources of food material today are raised on the land surface. However, many attempts are being made to cultivate the oceans. Algae are potential sources of the same food materials as derived from land agriculture, but the problems are much more complicated where there is no method of controlling the kind of plant that grows in a particular spot over all the others there, where cultivation and harvesting techniques are entirely different from those on land, where problems of fertilization are such that no one has even proposed a method for such activity. The closest attempt at fertilization is the application of sewage to beds or ponds growing certain types of fresh water algae, but no suitable salt-water forms, similar in productivity to the fresh-water forms have been found. In Japan, there is an industrial, or regularized cultivation of one type of seaweed, but this is still a rather uncertain one, not making full use of the area.

Ch. 2



REFERENCES

There is no doubt that man would not exist unless there had evolved in the plant kingdom that structure known as the seed. The role of the seed as food for man and animal is documented in one of the really great publications of our time by Oakes Ames in Economic Annuals and Human Cultures, published in 1939 at the Botanical Museum, Harvard University.

The publications of the United States Department of Agriculture, lists of which are available from the Government Printing Office, Washington, D.C. are very extensive, and cover most of the plants raised for food and other purposes. Two entre's to this wealth of plant literature is through other publications of the USDA, entitled the Bibliography of Agriculture, and the Agricultural Index. Both of these are serial publications, found in all libraries that are depositories for government documents. These two have the additional advantage of listing not only governmental publications, but most of the literature on plants and animals, wherever published.

A series of publications from the National Academy of Sciences--National Research Council, published over several years, and all entitled Races of Maize in (Mexico, Peru, Brazil, Colombia, etc.), provide a very interesting study of the most famous of all American food crops, corn (*Zea mays*). The introduction of each of these publications gives the history of cultivation of maize in the areas, documented with known archeological evidence, genetic and morphologic studies. The main portion of each work is the listing and description of the many corn varieties found in each of the countries.

Chapter 3

SPICES, MAN, AND HISTORY

We have said that man's first domesticated plants probably were those that fed, clothed, and protected him. Another group of plants that may not have been actively cultivated at the beginning, but were found to be useful adjuncts to the basic food-producing plants, were those that we now consider together as spices--plants with aromatic properties that add zest to foods. As far back as there have been records, men have written of various products which he considered of great value as drugs, spices, and perfumes. It is difficult to separate each of these three categories--the drug, if used in small quantities, adds a different flavor to food. Or the spice that had a delicious aroma could as well be extracted with boiling water, and the oily substance then spread on the body for perfumes. Oil of cloves is one such spicy material that frequently goes into men's after-shaving lotions. The whole clove is, ~~as is~~ well known, ~~a frequent adjunct~~ in the culinary arts.

It is curious that these plant products which today are far less income-producing than are cotton, wheat, or corn, should have had such a fundamental influence on great movements in history. ~~Men have fought wars,~~ ~~whole countries~~ Nations developed into great influence in the world, and waned into obscurity upon their control or loss of control of the spice trade. Certainly ancient men put more value on these relatively minor plant products than we do. What young ~~debutant~~ bride today would be satisfied with her lot if her father gave her a pound of pepper when she married? This was apparently not at all ridiculous to the daughters of the 15th century merchant princes in Venice, ~~in the 15th century~~ whose wealth came from the spice trade between Europe and Asia.

illustrate pepper plant

Then the young man considered himself extremely fortunate when his prospective father-in-law gave away his daughter with a plant product worth far more than its equivalent weight in gold. There is some evidence that we today are not entirely free of the desires for spices. For example, during World War II, when our trade routes to the Eastern Tropics were cut off, the price of black pepper, largely produced in the islands and bordering mainlands of southeast Asia, soared to $1 to $2 per ounce.

Some of the greatest achievements in our recorded history are the great sea voyages made in the latter half of the 15th and early part of the 16th centuries. These voyages were considered merely for the want of free routes to the sources of the fabulous spice countries of the East. The courage to face the hazards of unknown and uncharted seas, particularly when the earth was not really thought to be round, is certainly equivalent to ~~those of~~ that our probing into space. Perhaps our goals are somewhat different, but the goals of the Portuguese and Spanish sailors was well-established--plant products. We can almost hear Queen Isabella saying to herself, "OK, Chris, go ahead and prove the earth is round, but I'm giving you ~~support~~ the money to bring back those spices."

If you take this sentence out - you will make me very unhappy!

Some of the spices were already available to and cultivated by the Europeans, but these, such as mustard seed, coriander, dill, and garlic, did not have the same romantic and economic value as those from the countries of the Far East. There was much mystery surrounding the areas from which the spices came, largely fostered by the Arab merchants who wished to keep the Europeans from discovering the sources. The tales told were calculated to frighten away the bravest sailor--fire-breathing dragons guarding the entrances to harbors, deadly enshrouding mists that could be passed only by secret routes, the human sacrifices to evil gods, etc., etc. But, as in most cases, the lure of wealth and the desire for fame overcame the fears.

Shortly after Vasco da Gama's voyage around the Cape of Good Hope to India, ~~and safe return in 1499~~, Portuguese vessels were making regular trips to the coasts of India, and to the islands to the south and east. The Portuguese established trade centers, and in many cases began cultivation of the spices they encountered. These were cinnamon from India and Ceylon and cloves and nutmegs from the Spice Islands (today known as the Molucas). Not only did the Portuguese establish trade centers, but also they began colonization in India and the surrounding islands. Some of these colonies in southern India remained under Portuguese control until quite recently. However, the main holdings of the Portuguese were wrested from them by the Dutch after about one-hundred years of control. The development of the fabled Dutch East India Company was primarily based upon the desire to control the spice trade. The value put upon these plant products is still indicated in Dutch when one wishes to ~~indicate~~ that something is extremely valuable in the expression "peper-duur", as dear (expensive) as pepper. The organizational capabilities of the Dutch probably put the spice-growing onto a paying basis, and the systematic cultivation of the various spices in regular plantations had an eventual effect upon the prices--regular production and efficiency of operation brought the prices down, and with more intimate knowledge of the spices in various European countries, their romance began to fade, but not to the point of extinction. At least, the spices became more items of culinary need and a basic economic product and exchange medium than a romantic, beckoning lure.

As the Dutch were quick to recognize, other plant products were as valuable, if not more so than the spices. They turned their attention to coffee, to tea, and to rubber, the most fabulous product produced in all the former Dutch colonies known as the East Indies.

Though the Spanish attempts to discover trade routes ended in a far different direction from those originally intended, their discovery of the West Indies was not completely without profit to the spice trade, for they found two spices indigenous to the New World that have become standard items in the diets of people the world over. These are the various products of the Capsicum peppers, and allspice (not a mixture, as the name might indicate, but the dried, unripe fruit of Pimenta officinalis) which has flavors resembling a mixture of cloves, cinnamon and nutmegs. The Capsicum, or chili peppers, were valued by the natives of the New World and were cultivated by nearly all indigenous peoples before Columbus' arrival. Their origins, though definitely of the New World tropics have not been precisely established. Allspice was not transported far from its native habitat of the West Indies and parts of Central America, and was not as much appreciated by the natives as was Capsicum. Jamaica has a virtual monopoly on the trade in allspice, and even today there is little real cultivation of the small trees that produce the spice, for the plants seem to thrive without cultivation, and produce sufficient quantities of spice to satisfy the trade requirements.

I indicated at the beginning of the chapter that there is some confusion between drug, spice and perfume. Here I should indicate that the value of any particular spice is due to its content of essential oils. The essential oils derived from the well-known spice plants such as cinnamon, ginger, cloves, or nutmegs, may have drug (or at least antibiotic) qualities if used in sufficiently high concentration. It has been shown, for example, that clove oil, in sufficiently high concentration, will kill bacteria. This would imply then, that the oil would have merit as a food preservative and were so used for some time. Certainly the food might be preserved if sufficient quantities of the clove oil be added, but unfortunately, the flavor of the food so treated would be completely masked by the added oil, and would hardly be palatable. As is well known, spices must be added to foods only in sufficient quantities to add subtle qualities, and this concentration is far from sufficient to have preservative quality. Furthermore, the essential oils are not particularly selective for bacteria--concentrations sufficient to destroy the bacterial growth would likely also be destructive of human cells.

For these reasons, the drug value of the spices has constantly waned as we learn more about the nature of desirable medicines. We must not indicate, however, that there is no place for spices in drug use--there are benefits when appropriately used by qualified physicians. For example, many useful drugs are distasteful, and spices mask this unpalatability.

Even though much of the mystery surrounding the origins of some of the spices has been cleared away, we are still far from having precise knowledge of the beginnings of many of them. Recently, R. M. Newcomb, a geographer, reported on his search of many literature sources ~~the literature descriptions~~, and found that the far eastern spices were grouped from three areas, as indicated in the accompanying tables ~~on the map~~ (see figure). You will note in the tables that more than one center may be listed as the probable origin of certain of the spices, but ~~you will further note~~ for example, that "cinnamon" may be derived from several separate species, with slight differences between the products. Table I lists those spices found in two centers in India, Table II those of the Malaysian Center and Table III of the South China Center.

It is evident that our connection with spices is much more mundane than it was a few hundred years ago. Many people would laugh if one were to suggest that we should send out expeditions looking for spices. But the men of today's spice trade would take such proposals seriously, particularly if the proposal were framed in the language of the ethnobotanist who is still continuing to unravel the mysteries of the man's early homes through the studies of the plants that were first used. Among these we certainly would number the spices. The romance of search is still there, but the emphasis has shifted.

TABLE I 1/

Indian Center

Family	Scientific Name	Common Name
	A. Himalayan Foothills	
Zingiberaceae	Amomum aromaticum	Bengal cardamom
	Amomum subulatum	Greater, or Nepal cardamom
	Curcuma zedoaria	zeodary*
	Zingiber officinale	ginger
	Zingiber zerumbet	ginger
Piperaceae	Piper longum	long pepper
Lauraceae	Cinnamomum Tamala	Indian Cassia
Rutaceae	Murraya Koenigii	curry leaf tree*
	B. South India (Malabar Coast and Ceylon)	
Zingiberaceae	Curcuma longa	turmeric
	Curcuma edoaria	edoary
	Elettaria cardamomum	true cardamom*
	Zingiber officinale	ginger
	Zingiber zerumbet	ginger
Piperaceae	Piper Betle	betel pepper
	Piper cubeba	cubeb pepper
	Piper longum	long pepper*
	Piper nigrum	black pepper*
Lauraceae	Cinnamomum cassia	cassia
	Cinnamomum zeylanicum	true cinnamon*
Myristicaceae	Myristica fragrans	nutmeg, mace
	Myristica malabarica	nutmeg, mace

1/ Adapted from Newcomb, Botanical Source-Areas for Some Oriental Spices, Econ. Bot. 17(2): 127-132. 1963.

* Most certain place of origin.

TABLE II

Malaysian Center

Family	Scientific Name	Common Name
Zingiberaceae	*Amomum kepulaga*	false cardamom*
	Amomum xanthioides	false cardamom
	Curcuma longa	tumeric*
	Curcuma zedoaria	zedoary
	Elettaria cardamomum	true cardamom
	Zingiber officinale	ginger*
	Zingiber zerumbet	ginger
Piperaceae	*Piper cubeba*	cubeb pepper*
	Piper longum	long pepper
	Piper nigrum	black pepper
	Piper retrofractum	Javanese long pepper*
Lauraceae	*Cinnamomum cassia*	cassia
	Cinnamomum loureirii	Saigon cinnamon
	Cinnamomum zeylanicum	true cinnamon
Myristicaceae	*Myristica fragrans*	nutmeg and mace* (Moluccas)
Myrtaceae	*Syzygium apromaticum*	clove* (Moluccas)

* Most certain place of origin.

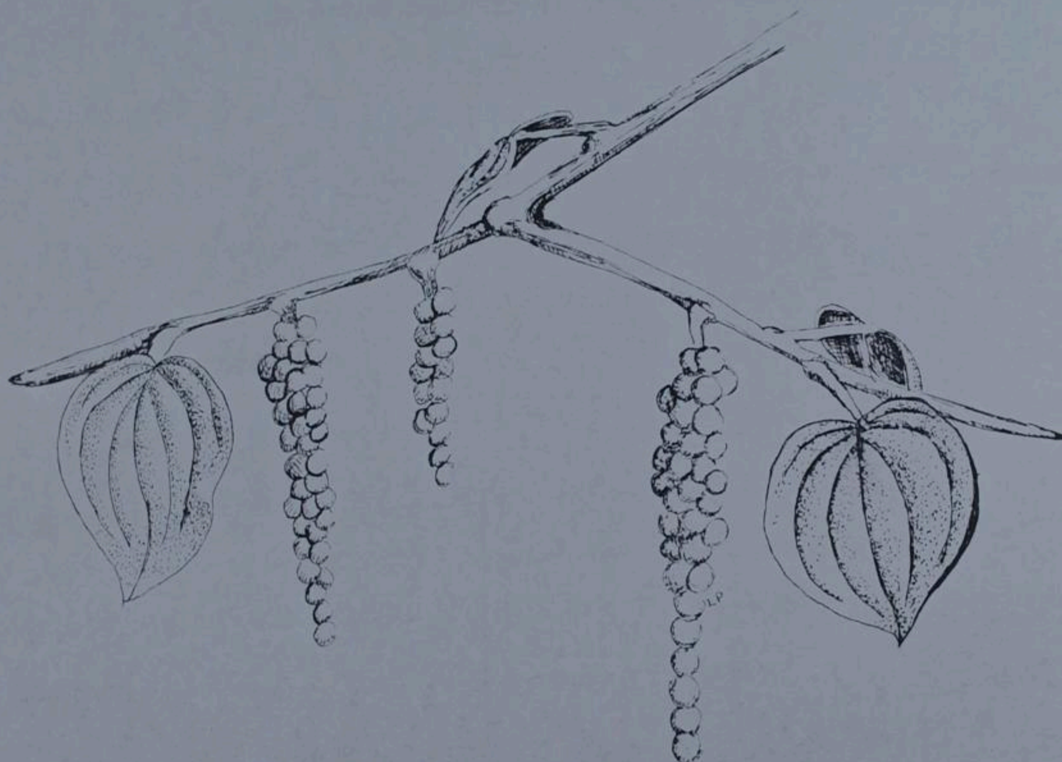
TABLE III

South China Center

Family	Scientific Name	Common Name
Zingiberaceae	*Amomum xanthioides*	false cardamom*
	Curcuma longa	turmeric
	Curcuma zedoaria	zedoary
	Curcuma zerumbet	zedoary
	Zingiber officinale	ginger
Magnoliaceae	*Illicium anisatum*	Chinese anise*
	Illicium verum	Star anise*
Lauraceae	*Cinnamomum cassia*	cassia*

* Most certain place of origin.

Ch3



Ch 3

REFERENCES

In addition to the general references listed in the introduction, the following may be read with pleasure:

Anon. A History of Spices. The American Spice Trade Assoc., 82 Wall Street, New York, N.Y. 10005.

Hayes, E. S. 1961. Spices and Herbs Around the World. Doubleday and Company.

Parry, J. W. The Story of Spices. Chemical Publ. Co., New York.

There are, in addition, many good cookbooks that not only give recipes using spices, but frequently add interesting anecdotes and history of this or that spice. One such book, for example, is: Day, A. and L. Stuckey. 1964. The Spice Cookbook. D. White Co., N.Y.

CHAPTER 4

Wheat

~~It is a truism to say that almost any subject, when investigated, is much deeper than when first considered, and yet this is a truism I must make that wheat is more complicated than we may think at the moment of first contact.~~ Say the word "wheat" to most tax-paying citizens in the United States today, and the immediate thought is "surplus", or "government subsidy." For the first time in history, agricultural output is ~~far~~ ahead of local need, at least in the United States and Canada. Although we cannot get too deep into the economic implications and the many factors at work causing the surplus itself, we can look into some of the basic agricultural and social phenomena that have caused the situation. We need to examine the history of the studies ~~of~~ wheat, what is known about its antiquity, the heritance mechanisms, the kinds of plants that fall into the category "wheat," and some of the phenomena that underlie the tremendous productivity. These latter facets deal with the land, with the government, and with the people. In this examination, ~~we will gain an insight into~~ just how complicated the subject of wheat is.

<u>What is wheat?</u>

I have found that most people think of a <u>single</u> thing when speaking of "wheat", or "corn", or "potatoes", ~~rather than to consider~~ that there are <u>many</u> things under each of these headings. ~~Without much difficulty we can see that~~ wheats have the fibrous root system, hollow, jointed stems, narrow leaves and chaffy flowers common to the grass family, or Gramineae. ~~With~~ closer examination, ~~we may discover~~ that there are at least fourteen species enough alike to be called wheats, in the one genus <u>Triticum</u>. ~~The common~~

Illustrate head of wheat

~~bread wheat, one of the fourteen species, is called~~ Triticum vulgare.
Furthermore, most of the fourteen species (see Table) have variations within the species, some species with more, some with less variation. One of these species Triticum vulgare, the common bread wheat, has literally thousands of varieties, more than any one individual person can readily know with any degree of familiarity.

Students of ~~wheat's origin~~ the Origin of Wheat

~~The present knowledge of~~ Our concerning the origins of wheat as a cultivated plant has been gathered from evidence that is sometimes fragmentary and sometimes very complete. Putting the story of the origin together is worthy of the best in criminal investigation or in "who-done-its", taking the evidence from disconnected sources and following several leads simultaneously, all the time watching carefully for false clues. what would these be?

~~We may say that~~ the first ~~stimulus for~~ studies of the origins of cultivated plants in general ~~was first given~~ were stimulated by Charles Darwin ~~in his~~ monumental work Origin of Species, first published in 1859 on the evolution of living organisms. ~~It was he who thought that we might learn more about the actual operations involved in the theory of evolution by the examination of the changes made in wild plants when they are brought into cultivation by man.~~ ~~He~~ Darwin saw that, in comparison to the total time of evolutinn, the evolution of our most important agricultural plants was indeed very short. He knew that the plants under cultivation in his day were greatly modified in many of their characteristics from the wild relatives of these crop plants, and he thought that we could learn much from investigations on the methods by which these plants had been so modified. ~~Remember that Darwin~~ Although he did not have at his disposal the tremendous body of genetic knowledge that we have today, but he did know of inheritance in a broad sense, ~~and could~~ realized that through better understanding of inheritance we could come closer to understanding the operations behind his ~~magnificent~~ theory.

Is this the reference you mean?

In Geneva, Switzerland, Alphonse DeCandolle, a plant taxonomist with strong leanings toward the historical aspects of botany, and influenced by Darwin's work published "The Origin of Cultivated Plants" first in 1855, and greatly modified in the second edition of 1886. In this work he demonstrated that botanical evidence alone is insufficient to uncover needed data to fix the points of origin of cultivated plants, and that he would have to depend upon evidence from the study of man's early history itself in order to bring some part of the puzzle together. He was able to draw from the then young science of archeology, but he had no genetic studies available-- the science was born by then, but was still nascent, and had not yet become active.

DeCandolle made remarkably good suggestions as to the geographic origins of many crops, and today most of his suggested regions as the original points of cultivation still stand. He generally placed the origin of wheat in the Middle East, more specifically, Persia, and we agree today that this large region was centrally responsible for the beginning cultures of wheat.

The next major step in the study of origins of crops in general was done by N. I. Vavilov, a Russian geneticist with excellent training in both Russian and Western schools. He worked with numbers of geneticists and other botanists in England where his work was recognized as outstanding. His genetic studies were devoted to agricultural plants, and he became the director of one of the world's most outstanding experiment stations for genetic studies, at St. Petersburg, or as it is known today, Leningrad. His basic hypothesis was that by finding the areas in which the most genetic diversity of a particular species occurred, one would likely find here the center of origin of the plant. To explore this hypothesis, he sent numerous expeditions to various centers in Asia, the Near East, Africa, Europe, North and

South America. Botanists on these expeditions collected propagating materials from remote regions, and returned these to Russia where they were tried at secondary experiment stations in climates as close as possible to those of the original regions. Thousands of variations in hundreds of crops were returned, the largest among them, wheat.

Vavilov could be more specific about the origins of wheat than could DeCandolle if for no other reason than he had much more material at his disposal, but also because of his careful genetic analysis of his returned material. It was he who provided us with the basic classification used today for the different species of wheat, and upon his general findings we have been able to build a much more significant and definitive genetic knowledge of the crop.

These two men above with Charles Darwin and several others, provided the framework for our knowledge of wheat's origin and classification. Countless other men, in many fields, have done the actual specific work on wheat. Unfortunately, we do not have space to really tell the story of the men and their fascinating work. Let us pass on to some of the knowledge of early wheat cultivation.

Early cultivation of wheat

Generally speaking, the archeologist attempts to put together a history where none was written and he is very much aware that a large part of prehistory is tied up with man's agricultural endeavors. For example, in putting together man's early history, pottery remains can play an important role. The first pottery, presumably, was developed by early man as containers of food, and later pottery is often found decorated with designs of crops.

For many centuries, the origin of man himself was placed only a few centuries before Christ, and his use of crops was accordingly thought to be even more recent than that. But as the ~~science of~~ archeology ~~grew~~, man's origin was pushed further and further back, and along with it, his use of crops.

Of all the regions where wheat was used, the first to be explored by archeologists was probably Egypt, ~~where the pyramids were obvious beginning points for delving into the ancient past~~. Quite often grains of wheat were found in ~~these~~ tombs and some of these, when planted, germinated and produced modern types of wheat. These grains have become known as "mummy wheat" and have been shown to have been carried into the tombs by rats, or perhaps pranksters. No wheat will germinate beyond a maximum time of ten or twelve years' storage for beyond this time it loses its vitality. But other evidence such as pictographs and hieroglyphics writings describing the crop indicated that wheat was a very old crop in Egypt.

Other areas of the Middle East, as well as the Caucasas and various parts of Europe have yielded prehistoric wheats. In Swiss lake dwellings of the Stone Age, at least one kind of modern wheat has been found--Triticum dicoccum, or emmer wheat. The Chinese have documents dating to 2,700 B.C. describing wheat, ~~but~~ the oldest, well-documented actual remains of wheat are from Iraq, at ~~an~~ ancient village site, Jarmo. These remains, discovered by an archeological-botanical team headed by a University of Chicago archeologist, Braidwood, consisted of imprints of grains and spikelets in baked clay and adobe, as well as carbonized grains ~~and~~ seeds and spikelets. Both primitive and more advanced genetic types were found. Using the radio-carbon technique, these grains were dated at 7,000 B.C.

At many of these early sites remains of several different cereal grains are usually found, as well as certain wild grasses that are closely related to the species we now cultivate. Thus barley, rye, oats, sorghum and others have been found ~~nearly simultaneously~~ with the wheats indicating that the early agriculturalists recognized the potential of all these grains ~~had~~ as food. It is unlikely, however, that early man separated the various types of seeds and sowed them as unique crops. Indeed, early agricultural methods of harvesting were not well enough developed to accomplish a separation of the various kinds of grains. This is probably fortunate for us because, by keeping various related species together, early man gave the ~~related species~~ them better opportunity for hybridizing and gaining genetic diversity. This ~~genetic~~ diversity is one of the most important inheritances that we have from our ancestors. ~~because~~ It provides the opportunity to select, modify, and/or breed many new strains suitable to modern agricultural needs.

Recently, geneticists have been able to reconstruct some of the early hybrids by taking wild, related grass species still growing in the ancient cultivation areas, crossing them with various species of the wheat genus, and reconstituting earlier, less complex, cultivated types that have been found in ancient sites. Thus, crosses between wild species of the genus Aegilops (A. squarrosa) with Triticum dicoccoides, a wheat species called wild emmer found growing today in the Middle East, have much in common with modern spelt wheat, T. spelta. This remarkable bit of work was accomplished by two of our most famous modern plant geneticists, E.S. McFadden and E.R. Sears in 1946 ____________________.

Illustrate Aeg. + T. dicoc.

Though the early agriculturist might be called "sloppy" in his agronomic methods, he was not stupid. He would ~~be~~ have been able to see that certain chance hybrids ~~would be~~ were easier to separate from the chaff, ~~would hold~~ held on to the grains better and thus ~~make~~ making it easier to harvest, that certain grains were easier to grind into flour, etc., etc. He may not have picked up the various useful traits as soon as they occurred, but it is ~~very~~ obvious that at some point he ~~did sooner or later begin~~ began to separate the better types from those of less productive quality. We must be very humble before the early "savages", for what we use today is nothing more than refinements of the species and variations man had grown long before any science was developed.

The kinds of wheat and their variation

Following Vavilov's classification, there are fourteen species in the genus *Triticum*, only two of which are wild. The twelve others are cultivated. The fourteen species fall into three distinct groups, divided by their chromosome complement, as follows: diploid, with 7 pairs of chromosomes, 2 species; tetraploid, with 14 pairs of chromosomes, 7 species; and hexaploid, with 21 pairs of chromosomes, 5 species. The first knowledge that the various species could be so divided was provided by Sakamura in Japan in 1918. Shortly afterwards, and independently, Karl Sax of Harvard made the same chromosome counts, with similar conclusions.

Reference to the table will show the differentiation of the species, with the scientific and common names, geography and history of the species. The species are listed in the table to show their relationship, though you must recognize that a linear listing of the species cannot possibly show the relationships amongst species. One species is not derived directly from the one above it, and a multi-dimensional model would be needed to indicate the inter-relationships of these species, if we were certain how the various species were derived. Unfortunately, the origin of each of the species is obscure.

Although we have been able to make relationship models of the species, we cannot tell when, or exactly how, the species have arisen. Probably the earliest of the cultivated wheats is einkorn. Its chromosomes are diploid, and the chromosomes found in it are duplicated in all of the modern wheats. The higher the chromosome number, the more derived are the wheats, but again our interlaced inheritance, and the fact that the species are not straight-line descendants one from the other, makes it possible that some of the hexaploid species were formed before all the tetraploids were in existence.

There are many other characteristics that help to distinguish the species of wheat than just the differing chromosome complements. There are, for example, differing sizes to the grains, the number of grains, and the hulled, or naked condition of the grains. There are differing qualities of the flour produced by the species. Triticum durum produces a flour useful for making macaroni and similar materials, and the carbohydrate content of the grain is much higher than the protein content. Bread flour, from Triticum vulgare, has higher percentages of protein, an important character in the processing of kneeding of the dough.

It is possible to see from this short account that modern-day wheat is quite variable in the gene complements, and it is from this diversity that we derive the countless variations necessary to fit many different requirements, whether it be need for disease resistance, early maturation, differing requirements from the millers who wish to increase the protein content, etc.

Wheat improvement in this century

Wheat grows in almost pure stands. More and more farmers tended to grow one kind, or variety, because he will get a better price for his product, and the uniformity makes it easier to harvest. These facts have one serious drawback, the possibility of diseases of epidemic proportion attacking and destroying the entire planting. As long as the fields of wheat are sufficiently well separated, though one farm or a few neighboring ones be destroyed, there is better chance that all of the wheat will not be destroyed. As our population grew, and the demands of two world wars accelerated the requirements for greater food supplies, wheat fields were developed almost continually from Texas far to the north in Canada. This then forces upon the growers and the scientists involved in the study of the crop the need to be constantly alert, and ready for the potentials of vast destruction.

Let us see something of the breeding techniques, and some of the developments made by various methods. The direction of the breeding has changed considerably since the first scientific attempts were made to control genetic mechanisms some sixty years ago. The early efforts in wheat breeding were directed toward the selection of "pure lines" by growing the seeds of selected heads in separate rows, increasing the numbers of seeds from successive generations of individual plants that began the line. By taking the same seeds, keeping them well separated from other "lines", the breeders were able to observe which of the lines were best in a series of tests. The tests could be for hardiness, disease resistance, etc., but always mindful of the quality of the final product, and the needs of the farmers of a particular region. By the "pure line" technique, two basically important varieties of the common wheat were developed in this country, both in Kansas, and both demonstrating the international dependence of plant breeding. 'Kanred' variety of hard winter wheat (variety of _Triticum vulgare_) was developed by "pure line" techniques and first put on the market in 1917. It came from variety known as 'Crimean', introduced from Russia. The process of selection of the first seed for pure line testing began in 1906. The second variety, 'Blackhull', was also developed in Kansas from a variety that originated in Turkey. These two varieties were some of the most successful of the Midwest wheats, and were cultivated on millions of acres. Today, breeders still use these varieties in hybrid work because of their vigor, productivity and disease resistant qualities.

Today's methods of wheat breeding are more sophisticated than the "pure line" technique in that they attempt by hybridization to bring together the better qualities of two or more parent "lines" of known value. The qualities of the parents may be good milling quality and disease resistance, both needed in a top value wheat. The first generation hybrid is produced by carefully transferring pollen of one parent plant to the stigma of the other parent, and carefully growing the seeds of that plant to maturity. Its seeds are collected, then resown. The first generation, though combining the qualities of both parents, is not stable genetically, and the second generation will have many slight variations not seen in the first. It is in the second generation that the wheat breeder can show his skill in selection from the large number of variations. Here he must select a few variants, hoping to have in the selections the combinations of genes that will provide both of the qualities in the original cross. Then if he has been successful in his selections, he will attain a variety that will breed true for the qualities desired, thus achieving the goals, or objectives set at the beginning. This explanation may oversimplify the processes, and may further indicate that each attempt is successful. Such is far from the case, and from the large numbers tried, only a very few really good new varieties arise.

The question that is usually asked by those who must pay for the work of the hybridizer is "why bother with new varieties when we've already got more than we can use?" Several pertinent answers may be given. One is that if we were to have a repetition of the dry periods that came year after year in the 1930s, and were we not provided with varieties that could take more dry climates, our beautiful surplus might turn into a scarcity. Remember that our population is growing at a tremendous rate, and that it would not take long for the present population to eat up the surplus were we to fall behind in each year's production. A second, perhaps more compelling reason for continued search for better varieties, is the need to keep ahead of the always-present diseases ~~of~~ wheat. There are several serious diseases, some of which attack the stems and leaves, ~~some of which are most destructive~~ to the fruiting portions of the plant. One of the most destructive ~~of these~~ is ~~the~~ stem rust. "Rust" is a descriptive term for the appearance of one stage in the life cycle of a fungus parasite, Puccinia graminis, where pustules of red spore-bearing structures erupt on the stems of wheat. As the various species of wheats have evolved, so have the diseases that attack them. Like the wheat species, with their varied genetic complements, the rust is also quite variable. One noteworthy item is that a resistant variety of wheat does not maintain its resistance indefinitely, for shortly after the new variety is planted ~~out~~ we can predict that a new variety of ~~the~~ rust will soon be ~~found~~ capable of attacking the formerly resistant wheat.

To combat the various diseases ~~the~~ state and federal government have established an elaborate detecting system, manned by plant pathologists who have specialized in the study of cereal, or grain-crop diseases. These men, stationed in all the major grain-growing areas, gather data by various means from private individuals, from county agricultural agents, and by personal surveys of their region. They work in close contact with the weather bureau for the effects of weather are important in determining the severity of the diseases. A wet season may increase the damage to the crops tremendously. The local pathologists send in samples of possible diseases to central laboratories in several centers where the disease may be carefully cultured, and pathogenicity tested on the various types of wheat. The findings of the central labs are distributed by several means of communication, with possible measures for control or quarantine, or if early enough, with advice on what varieties may be planted that are known, or thought to be, resistant to the particular disease.

Other factors affecting today's abundance

Some other factors have contributed directly to our present-day abundance of harvested wheat in this country. ~~Our~~ first colonists in the temperate portions of the New World brought with them a wealth of inherited food types, agricultural methods, ~~and culture~~, and tried to apply these ~~to~~ the American continents. Because of essentially virgin soils of great fertility, they were able to succeed tolerably well in producing sufficient supplies of food for immediate needs. ~~Having some adaptive ability~~, the various colonial groups ~~took up the culture~~ of Indian corn and tobacco, as well as maintaining their ~~cultures of the~~ ~~old known~~ crops from Europe and Asia. The wheats they raised were varieties well-known in Europe with little innovation of newer varieties. Fortunately there was sufficient adaptability inherent in the various species and varieties to allow continued production even though the eastern coastal areas ~~are~~ different climatically from western Europe.

As the population grew and expanded westward, agriculture followed. Forests were cleared and the resulting bared earth tilled with tools little modified over several centuries in Europe. When the westward movement reached the vast prairie areas of the midwest on the North American continent, the settlers faced a new set of problems. The grasslands, without a tree cover, ~~would~~ seem to be ideally suited to agriculture and the cultivation of grain crops. With their weak tools, however, the settlers could not break the tough grass cover, ~~and~~ the interlocking root systems of the prairie plants defied their efforts at plowing and cultivation. Thus the whole area, from Ohio westward, wherever prairie existed, was ~~remarkably~~ given the appelation "the great American desert." This was not ~~present~~ area we know as desert, in the southwestern part of the United States. It applied to regions of deep soils with great fertility and sufficient water, but ~~it~~ which was a "desert" until the introduction of the mold-board plow with steel points that cut deeply and sharply.

~~But~~ we must not, however, discount the fact that the settlers did ~~utilize~~ use the land in the 19th century for cattle raising and sheep herding. This was country for grazing and the earliest use of the land by the white man in his agricultural endeavors was indeed in animal husbandry. Thus, when the agricultural techniques were developed for crop culture, there was inevitably a clash between those who wanted open range for cattle and those who wished to fence off areas for cultivation thus ~~and~~ preventing cattle grazing. That the ~~settled~~ agriculturist won out over the open range cattle rancher is, of course, a matter of history, as well as the subject of countless "western" movies.

The soil

When the real soil wealth of the vast prairie area was recognized, we were on our way to present agricultural abundance. Again, we are inheritors of potentialities that were developed, in this case, not thousands, ~~of years ago~~, but millions of years ago. The soils as we know them are the product of many interacting factors of wind, water, minerals, plant and animal life. In the prairie regions there are several types of soils but the ones of the major wheat zones are called "chernozems." This term indicates another debt to the Russians who were the first and ablest students of soils. Chernozems are not necessarily the deepest soils, but some do have depths that are remarkable. The word means, literally, black earth. Those of us who grew up on the coastal fringes of our continent are used to thinking of soil levels ~~available for cultivation~~ measured in inches, anywhere from 3 to 10. The midwesterner scoffs at such poverty, because he measures his soil depths in feet and yards.

One would be able to see that wheat would more likely be at home in grassland type soils than in forest regions. First, wheat is a grass, and second, the original regions of cultivation were grassland areas. Though the soils of the original home of wheat might not be so deep as those of our own midwest, they did have the same general type of origin and development, thus making it easy for our own settlers to develop an agriculture like that of the more ancient regions in the Middle East.

Government and social factors

Again, with a frustrating sense of barely looking through a door into an interesting scene inside, I jump you from the soils to another aspect that has helped our wheat industry. This portion may seem quite remote from the explanation of our tremendous productivity, but will be more understandable after some examination. The subject is the development of transportation and the increasing mechanization of agricultural methods.

Never before in history has a nation had such an equal development of the various sectors that make up modern-day civilization. Here was a land essentially open and unexploited by previous civilizations. Governmental organization, first European directed, then our own, was established. Such organization provided the basic protection needed, the channels for developing agriculture, industry and social life. Furthermore, there were funds to assist in the various aspects of development. One of the earliest industries that benefitted from government subsidy was public transporation, at the beginning, waterways, then over-land routes. Then the railroads came. They were given rights to public land, were given funds for building new lines, and were given tax relief, etc. As the people moved westward, so did the transportation lines to support them. Not only could the colonists receive goods and services from the more settled east, but also could send back the raw materials for the heavier populated eastern seaboard. From the south came cotton, tobacco and rice, and from the west came the grain crops, the furs, hides, the meat animals themselves. European patterns of central cities with satellite farming regions for each major population center, or city, were soon given up. Transportation also meant more rapid communication, first by letters, then by telegraph. Needed items could be brought in very rapidly from an order sent by rail or telegraph.

These developments were preceding apace as we began to shift from agriculture to industry as a major way of life. The various implements needed on the farm to assist in productivity were being produced at a remarkable rate, if we compare the endeavors in agriculture from the beginning of civilization to the amount of time from the beginning of our own midwestern activities to the present. First, the plow, progressing from a pointed stick pulled by oxen, or by man himself, to the sharp strong types that could rip through unturned sod and heavy soil, drawn by horses, then by mechanical power. Then the devices for harvesting larger and larger areas were developed. The land was flat and one could successfully pull large devices that cut a swath five to ten feet wide with a minimum of power.

Another advantage brought by transportation, by governmental assistance, and by rapid communications was the ability to market the produce from far-off areas in centers where the price was more attractive. Were it not for the fact that no practical limitation was set upon the individual farmer or producer as to where he would sell his output, we would certainly not have today the fantastic system of agricultural production we have. Were the individual to be in any other part of the globe, he would have come upon the wall of international boundaries almost within a day's travel from his farm. The tariffs imposed at an international boundary would, within short order, offset any possible profit to the farmer who tried to sell his goods across that boundary, even if the two countries were friendly one of the other.

Marketing of wheat

We know, of course, that today's farmer very seldom sells his produce directly to the consumer. In the marketing of wheat, the usual process today begins at the local mills or elevators, located along railroads in the grain-producing areas. Here the grain is conditioned (dried, cleaned), stored, and (sometimes) marketed, and then from the elevators, the wheat moves to a terminal market or mill, again largely by rail.

To understand in full detail how the price for wheat is derived is difficult because of the many factors involved. Basically, the farmer delivers his grain to a local elevator operator who pays the farmer a certain price per bushel. Obviously, the price flucuates according to the value of the product; if the grain is clean, free from much debris, has few or no diseased kernels in it, and is of a class most desirable, it will bring a better price than the adverse. The wheat is graded according to set standards of the Federal Government into seven main classes and these are further subdivided into 15 subclasses. The seven classes are: hard red spring, durum, red durum, hard red winter, soft red winter, white and mixed. These categories, and the 15 subcategories are based on color, texture, and size and shape of kernel. These standards are set in order to provide a uniform process wherever the grain is sold, and to prevent illegal or usurious methods. The elevator operator, after establishing the grain standard with the farmer, pays the farmer cash or may establish some credit-payment system. The elevator operator may be in the employ of a farmer's cooperative, to which the individual farmer may belong. At any rate, the operator must know how much to pay the farmer at any one time, and this is largely known because of the <u>futures</u>

market. Without explanation of the operations of the futures, let us merely say that this type of merchandizing permits a cushioning effect against the daily fluctuation of wheat prices. Both the buyer and the seller are theoretically best protected by such a method.

Many factors simultaneously effect the price of wheat. There are numbers of economic considerations more dependent upon psychological ~~phenomena~~ than on any physical phenomenon. It is interesting to watch the changing habits of eating and how these have influenced the sale of wheat and other grain crops. For example, there is a tremendous drive to prevent excess fat, or obesity and with it, people have learned to cut down upon their carbohydrate intake. This has a direct effect on the bread consumed, ~~for obvious reasons~~. In the United States the per capita consumption of wheat products has been reduced, but the wheat consumption has remained almost steady because of the increased population.

Summary

No one individual can ever hope to be completely conversant with all the facets of the knowledge of wheat. One man may spend his entire professional life on wheat breeding and not know the specific details about marketing problems. The reverse is just as true. I hope you will take away with you from this sketch ~~of wheat~~ that wheat's ~~place~~ in our lives is much more complex than you ~~had~~ previously thought; that there are many fascinating problems associated with its study, and that early man has left us a tremendous legacy by providing a very plastic group of plants without which we certainly would not be able to have the comfortable life we now have.

WHEAT SPECIES AND CHARACTERISTICS [1/]

Latin name	Common name	No. of Chromosomes	Growth	Geographic Distribution	Earliest Evidence
T. aegilopoides	wild einkorn	14	wild	Western Iran, Asia Minor, Southern Yugoslavia	Pre-agricultural
T. monococcum	einkorn	14	cultivated	Eastern Caucasus, Asia Minor, Greece, Central Europe	4750 B.C.
T. dicoccoides	wild emmer	28	wild	Western Iran, Syria, Northern Palestine, Northeastern Turkey, Armenia	Pre-agricultural
T. dicoccum	emmer	28	cultivated	India, Central Asia, Northern Iran, Georgia, Armenia, Europe, Mediterranean area, Abyssinia	4000 B.C.
T. durum	macaroni wheat	28	cultivated	Central Asia, Iran, Mesopotamia, Turkey, Abyssinia, Southeastern Europe, United States	100 B.C.
T. persicum	Persian wheat	28	cultivated	Dagestan, Georgia, Armenia, Northeastern Turkey	No prehistoric rema ins ?
T. turgidum	rivet wheat	28	cultivated	Abyssinia, Southern Europe	No prehistoric rema ins ?
T. polonicum	Polish wheat	28	cultivated	Abyssinia, Mediterranean area	17th century
T. timopheevi		28	cultivated	Western Georgia	20th century
T. vulgare (*T. aestivum*)	common wheat	42	cultivated	world wide	Neolithic period
T. sphaerococcum	shot wheat	42	cultivated	Central and Northwestern India	2500 B.C.
T. compactum	club wheat	42	cultivated	Southwestern Asia, southeastern Europe, U.S.	Neolithic
T. spelta	spelt	42	cultivated	Central Europe	Bronze Age
T. macha	macha wheat	42	cultivated	Western Georgia	20th century

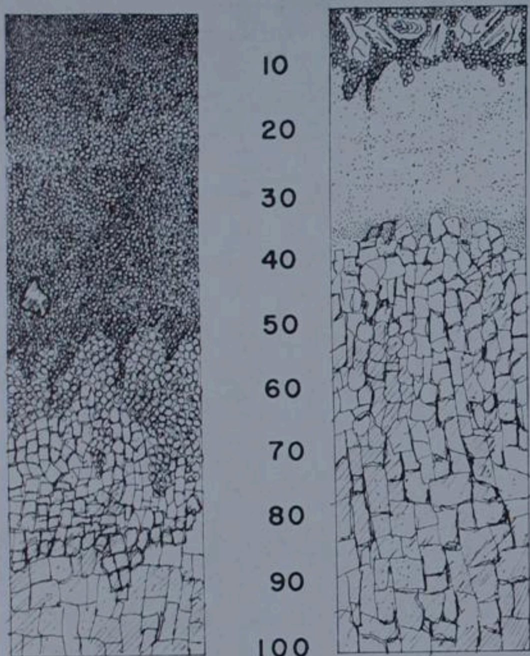
1/ Adapted from Mangelsdorf, P. C. Wheat. Scientific American 189(1): 50-59. 1953. Reproduced with permission.

Ch 4

pg. 183

Ch4

Ch 4



References

A listing of all references to wheat would be next to impossible to compile. The following however, will be useful in your more detailed examination.

1. MANGELSDORF, P. C. Wheat. Scientific American 189(1): 50-59. July, 1953. This is one of the best popular discussions on the genetics and origin of wheat to be found.
2. WILSIE, C.P. Crop Adaptation and Distribution. Chapters 5 and 6. W. H. Freeman & Co., 1962. Parts of the two chapters listed are specifically associated with wheat, though my advice to you is to read the book through for more fascinating reading and understanding of grain crops.
3. See also the books by Vavilov, DeCandolle and Darwin (references listed in Chapter 1, p. —)

CHAPTER 5

Cranberries

There are only three crop plants whose origins we can definitely ascribe to temperate North America, the cranberry, blueberry, and the sunflower. The cranberry and blueberry, on the other hand, have become successful crops in the regions where they are native. The sunflower, though raised sporadically in this country, is most successful as a crop plant in Russia. Our present-day celebration of Thanksgiving would be incomplete without cranberry sauce or jelly served with roast turkey, another American contribution to modern agriculture.

Illustrate plant & fruit.

Although the cranberry (Vaccinium macrocarpon) is not one of the major agricultural crops in the United States, it is interesting because it has passed through many of the same stages as have the basic crops, but in such a short time that we are able to document accurately what did happen. The North American Indians had long been harvesting the fruit from wild plants when the first European colonists arrived in Plymouth, Massachusetts. It is likely that cranberry mixed with dried meat (pemmican) was one of the earliest contacts for the Europeans with this rather acid fruit of the heath family.

We have one of the best histories of the beginning of agriculture with the cranberry, as it was not a cultivated crop until the early 19th century, and the way in which the crop came to be consistently cultivated is historical knowledge. This is in contrast to the preponderance of our cultivated plants, whose origins as cultigens (a generalized term for any cultivated plant) antedate history by several thousand years. Furthermore, the cranberry was first brought into cultivation by a fairly sophisticated society, contrasting the levels of cultures in the Massachusetts area with those of the Middle East at the time when our grain crops became the basis of agriculture.

NO! Leave alone!

A further reason for discussion of the cranberry is because of the role played in the distribution of the processed products of the cranberry by the Food and Drug Administration of the Federal Government's Department of Health, Education and Welfare. In October, 1959, the whole crop of cranberries from the Oregon and Washington areas was impounded because of the finding by the FDA of ~~certain~~ unacceptable concentrations of aminotriazole in the processed cranberry sauces. Aminotriazole is a compound developed as a weed killer, and had recently been introduced by the cranberry growers to prevent weed-growth in the cranberry bogs. Unfortunately, aminotriazole is potentially a carcinogenic agent (a substance which may induce cancerous growths), and therefore the FDA considered it necessary to remove the cranberries that had been subjected to this weed killer. The potentiality of ATZ as a carcinogen would hardly have been expressed in active cancers, however, since the residue left on the berries is of such minute amount that it would require considerable more of the weed killer than would be consumed in the lifetime of an individual cranberry consumer. It might, however, have activated latent tumors.

go out of place - should go in section beginning 5-6

The Crop

Illustrate plants in fruit

Cranberries are small, round to oblong, acid fruits about one-half to one inch long, growing on low, clambering, shrubby perennial evergreen plants. The plants grow in acid bogs from eastern southern Canada as far south as North Carolina in the east and as far west as Minnesota. For the first two hundred years after the coming of the white man, cranberries were harvested from the wild, without any organized efforts at cultivation. The first recorded cultivation activities with this small fruit were said to have been initiated on Cape Cod, by a citizen who observed that the plants growing on a bog just behind the sand dunes seemed to thrive better when the wind-blown sand covered the lower portions of the plants. Henry Hall, the observer of the sand phenomenon began cultivation by placing sand around the plants in his bog, and several of the people in the vicinity followed the technique and found that the plants produced a heavier crop than the plants left in the peat bogs alone. Apparently, the sand permitted the development of adventitious roots in the better aerated sandy levels, and thus to produce a greater root system, which is directly related to the overall vigor of the plants.

Other developments came from chance observation, but each development has some basis in what we know today to be the most appropriate treatments for plant growth. One of the most interesting is the method of using water in the cultivated bogs. Water is flowed over the bogs in the winter, and ideally, the plants are totally submerged. When the water freezes, the transpiration rate of the plants, and thus water loss, is cut down, and in periods when the root system cannot absorb sufficient water from the frozen ground to balance that lost from the evergreen leaves, this water economy is important. The water is permitted to remain over the plants until early spring. As growth resumes, there is need for greater oxygen supplies than can be met under water, and it is necessary to remove the covering water. Actually, water may be flowed over the bogs again later in the spring to prevent frost damage to the developing plants, but must be removed in a short time or oxygen deficiency will destroy the plants. In young plantings of cranberry, water may be again used to kill insect pests, and to help in weed destruction. But flooding is not generally practised during the summer months because of the adverse effects on the fully active plants. A recent development in the harvesting of the fruits in some of the growing areas (principally in Wisconsin) has again depended on the flooded fields. At time of harvest, the fields are flooded, and a device that agitates the water, sometimes called an "egg beater," causes the mature fruits to break from the vines and float to the surface where they are more easily scooped up with less injury to the plants than by previous dry-harvesting methods.

During the first years of cultivation, the growers were satisfied to use the native plants found in the particular vicinity. However, as cultivation increased, and greater demand for the fruits ~~were calling~~ called for higher yields, the need for more uniform types developed. In the 1850's, Lettice Cahoon, wife of a sailing ship captain, observed one particular variety that ripened earlier than other plants and had a very dark red color at maturity. Mrs. Cahoon gave ~~the variety~~ it the name 'early black', and her husband began cultivation of the variety in 1857. It is today ~~the variety~~ grown on most acreage in North America. Three other leading varieties were discovered between 1843 and 1893, and the four have become the standards wherever cranberries are grown. There are many other named varieties, however, each with some particular desirable quality. Today, experimental work is being carried out to develop hybrids which combine qualities of the standard selections. As with other fruits, however, the introduction of new varieties is a very difficult task. There is a tendency for farmers to stick with those varieties that have been consistently good, rather than risk the chance that a new variety will not have the same appeal as those more familiar to the consumers. Furthermore, there is apparently no limit to the length of time that a good bog will continue to produce marketable fruit, and the change to another variety is a very costly venture.

Harvesting and Processing Procedures

If a cranberry bog is in good condition, the fruit set will be remarkable, and 50 barrels of fruit may be produced per acre. Unfortunately, the fruits mature rather late in the season (September-October) at times of variable weather, with cold spells that can destroy or wet spells that are equally damaging. The fruits ripen rapidly and must be harvested in a rather short time. These sets of circumstances required that some type of mechanical device be employed to assist in gathering the fruits. Labor shortages also have forced the development of mechanical devices, but the technical problem did not permit the immediate invention of the automated pickers.

The frist harvesting device was a shallow box, varying in dimensions from one about 12 inches wide to one about 18 to 24 inches in width, open on one side or end, and with smooth wooden teeth along the open edge to act as a rake to scoop the cranberries from the vines. The operator can make several passes through the vines before discharging the collected fruits into a larger container. Thus, a line of pickers, working together, can rapidly harvest the individual bogs.

The mechanized pickers essentially follow the same basic pattern as the hand-operated scoop, but with the added features of an endless belt take-off, and sufficient power to move the picker and operate the moving parts. There are several types of mechanical pickers, and the designs are constantly being improved for greater efficiency.

Because both the hand-operated scoops and the mechanical pickers are not selective, much culling has to be done to remove undesirable fruits, either over-ripe or otherwise. Today, separation of the over-ripe fruit from the good fruit is accomplished by a rather ingenious device which carries the fruit by conveyor to a bin at the top. The cranberries drop to inclined, resilient boards below, and either bounce over a barrier (if the fruits are good) or fail to bounce over. The good fruits are carried by conveyors to the final inspection area where workers make a final selection of the suitable products.

Cultivation Problems

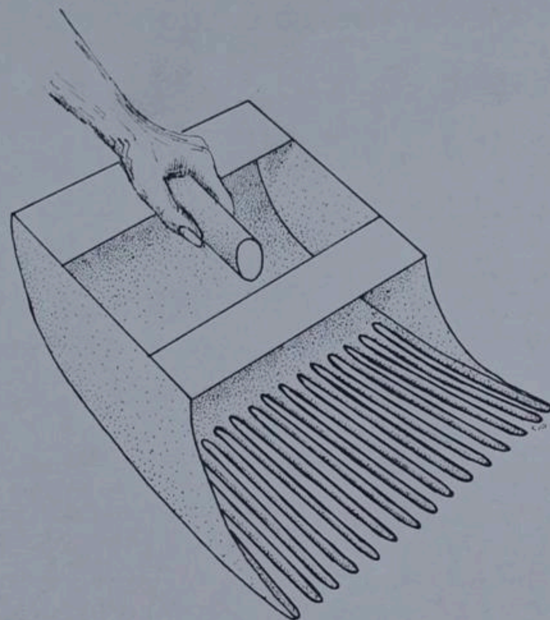
One of the problems in cranberry cultivation is that of weeds. Harvesting is also made more difficult if there is much trashy material or weedy vines mixed with the plants. Either of the harvesting techniques mentioned earlier is hampered by tenacious weeds. Many types of plants find the bog habitat especially desirable, and both woody and herbaceous weeds grow vigorously. Many reproduce by vegetative means, by runners, by root sprouts, by corms, etc. One of the worst of these for the cranberry grower is poison ivy (Rhus toxicodendron), not only because of its rash-producing qualities, but also because of its vigor and tenacity.

Because of the difficulty of weeding a mature bog, the cranberry growers welcomed the advent of selective chemical weed killers when they were introduced in quantity. The chemical weed killers vary from dusts to oily sprays and may be applied by hand-held sprayers, under pressure from tanks along the edge of the bogs, by helicopters or by light planes from above. No one weed killer is effective against all types of weeds, nor is one spray sufficient for the whole season.

Any material which combined broad-spectrum kill with long-lasting qualities would be welcomed. One weed killer, aminotriazole, was thought to combine many qualities, and after considerable testing by several agencies, private and public, was released and recommended to the cranberry growers. Aminotriazole had been recommended for use in the bogs up to mid-season, and its use was not to continue after this time. Almost all growers followed the precautions recommended, if they used the material at all. In one or two instances, mostly in the western areas of cultivation, the weed killer was applied later than recommended, and these crops were found to have testable quantities of the weed killer on the harvested fruit. Because of the potential danger of the aminotriazole as a cancer-inducing agent, the FDA recommended that the whole crop, irrespective of its source, be removed from the market. The growers immediately complied with this regulation, and millions of dollars (the crop for the country is estimated to be valued at about twenty million dollars per year) were lost. The United States Department of Agriculture came to the aid of the cranberry industry with assistance of about ten million dollars, but this amount was hardly sufficient to tide the growers over. The psychological effects of the scare caused by the aminotriazole, which was publicized and made front-page headlines all over the country, caused a serious setback to the market for the fruit, not for one season only, but for several years thereafter. Because of the Food and Drug Administration ruling, the industry has banned the use of this substance, and will probably continue to do so.

Such problems as these indicate the complexity of modern-day agriculture. ~~Our~~ Attempts at betterment of our food supply are beset with many more problems than those concerned with the breeding of better varieties, better cultivation and harvesting techniques. Marketing of the product is as important a feature as is any of the processes up to that point. Marketing is controlled in many subtle ways besides that of demand. Local, state and federal governmental agencies have effects that have been added as our society becomes more complex. The farmer is no longer the type pictured as a fellow in faded overalls and straw hat, with a straw in the corner of his mouth--he is highly trained and skilled in many things, or he does not long remain a farmer.

Ch 5



REFERENCES

The most extensive publications on cranberries are those of the various state agricultural experiment stations in the regions where the plants are grown commercially. Experiment Station Bulletins number 157, 447, and 513 from the Cranberry Experiment Station, East Wareham, Massachusetts, discuss the history, cultivation, and varieties of cranberries, with particular reference to Massachusetts.

CHAPTER 6

Man and Microbes--Fermentation

The fungi are of vital importance in the basic, fundamental processes of destruction of dead organic materials and the algae in the basic processes of photosynthesis. Man has rather recently learned to use the destructive forces of the fungi for his own benefit in the process of sewage disposal. Were it not for the activities of many fungi, bacteria and more complex types of non-green plants, a great number of our cities and towns would be faced with a much more difficult task of disposing of the waste products. Almost all sewage disposal systems employ a combined filtering and fermentation process to get rid of inorganic and organic solids. Microorganisms (largely bacteria) help in both the filtering and fermentation process.

I should point out that I have used the term fermentation rather loosely here, for there should be an implication in the term fermentation of anaerobic utilization of organic substances to release CO_2 and to produce energy for the microorganism. Actually, many fermentation-like activities proceed in the presence of oxygen (aerobic), all under a broad heading of catabolism, which is the reduction of complex organic substances to simpler substances.

In addition to the utilization of bacteria and fungi for processes of destroying unwanted by-products, many other methods of employing microorganisms are at work in our modern society. These methods cover such important activities as food production (cheese, mushroom-growing, and certain delicacies like the miso fermentation products of soy beans and rice enjoyed by the Japanese), beverage production (wines, beers, and liquors), medicine production (the antibiotics), industrial utilization (citric acid production,

~~etc~~. Retting ~~is~~ a process by which useful fibers (linen) are separated from nonfibrous cells in stems by bacterial degradation of the nonfibrous tissues. Most frequently, utilization of the microbes requires the application or employment of a single strain of one species of organism ~~in the process~~. For example, in the production of beer, one of the most closely guarded secrets of the ~~manufacturer~~ is the particular culture of yeast used by him. Large sums have been spent to screen and select the yeast cultures and to maintain the selected strains. The selected strain is as important to the brewer's art as is the quality of water used in the production of the beer. Many strains of ~~other~~ microorganisms are closely guarded company secrets in the pharmaceutical industry. In the case of the pharmaceuticals the strains may be protected by patent rights, but the difficulties to maintain the strain as a secret are extreme.

Actually, fermentation processes in food production are very old--older than recorded history. Inasmuch as primitive man (and men up to the time of Pasteur) had no idea what brought about the subtle and desired changes in grape juice or milk, we cannot attribute to him the actual development of a "fermentation industry" even in wine production. The earliest uses of microbes by man were probably intended as much for food preservation as for the rather pleasant effects caused by consumption of the wine. Grapes are generally ripe and ready for eating for only short periods. Unless collected in large numbers as they ripen, there would be much competition between man and animal for the fresh fruits. If large numbers were collected in containers, it would not be long before the naturally occurring yeasts on the skins of the grape would cause fermentation. The fermented juice could be kept for a longer period than the ripened fruit. The same sort of reasoning may be applied to fermented milk, in which the liquid portion of the milk, the whey, is separated from the milk solids, the curd. The curd may be kept long after fresh milk has passed any stage of usefulness. (Butter extraction may also have been an early way of preserving some of the milk fats, but even after the butter is extracted there remain other useful milk solids--the proteins and carbohydrates.)

It would seem from the discussion above that the first type of microbes utilized were yeasts, of which a large number of kinds exist. Yeasts most frequently found in the wine industry are members of the genus Saccharomyces (which may be translated as sugar-fungus), and these in turn are members of the large class of fungi known as Ascomycetes.

In addition to the yeasts, other types of organisms are found naturally in and with the grape juice. These are bacteria of a type that can actually use as their carbohydrate source the ethyl alcohol which is generated when the yeast ferments the grape juice. The untreated wines will not last very long unless some process for killing the bacteria be employed. Early wine makers could not prevent further fermentation in the wines. First of all, the yeast cannot tolerate or live in the presence of the alcohol produced as a result of their own action upon the grape sugars. At about 12% alcohol, they cease their action, but the bacteria present in the wine can work on the alcohol and other remaining constituents in the wine. The by-product of their metabolism may be vinegar, a liquid which, though very useful with other foods, is not a beverage (to be drunk) as is the wine.

The Wine, Liquor and Vinegar Industry

Wine-making is, by far, the largest and most stable of the fermentation industries. Wine is produced in most countries of the world although it is inevitable that France be thought of as the major center. There is little doubt that, as far as the art of wine drinking and making is concerned, France leads all other countries and ~~that~~ the most delectable and expensive wines come from that country. Champagne was first developed in France at a Benedictine Abbey in Epernay in the district ~~in France~~ of the same name. Pasteur's fundamental biological studies were prompted and supported by the wine industry, and the great process of pasteurization, now thought of being mostly for milk, was developed to save the wine industry in France. a paragraph above indicated that unpasteurized wines spoil easily.

Most people today assume that wine is produced only from grape juice, but, in fact, almost any fruit may be used to produce a fermented product of similar qualities--a beverage with 6 to 10% ethyl alcohol content. Other factors than the fermentable raw materials have been at work in making grape wine "the" wine. Grape juice ~~does, however,~~ contains many substances favoring fermentation by yeast--(pp. 133-ff., Rose, Indus. Microbiology) 15-20% sugar, chiefly fructose and glucose, small quantities of nitrogenous substances, chiefly amino acids, minerals, vitamins and other microbial nutrients. Also, the acid content of the juice is favorable for the growth of the wine yeast, Saccharomyces cerevisiae var. ellipsoideus.

Out of place put in References

There are many classifications of wines: dry or sweet wines, depending upon the amount of sugar left after the fermentation is complete; table wines (usually dry) or dessert and/or aperitif wines (usually sweet); white wines (fermented without the skin of the grape), or red (fermented with the skins left in); still wines (without additional CO_2) or sparkling wines (with additional CO_2); natural (alcohol content from 6 to 12%) or fortified (with additional alcohol added to bring the content to about 20% alcohol). Wines are also classified geographically, by country and by district within the country.

Basically, however, the grape wines are derived from only two species of grape, either Vitis vinifera (European) or Vitis labrusca (American).

Many varieties of these species ~~occur~~ are, either ~~as a~~ the result of naturally occurring variations being raised or perhaps by conscious hybridization. Both "black" and "white" varieties are used in wine-making. The final color of the wine (red or white) depends upon whether anthocyanin pigments = ? produced in the skin are left in the "must" (the crushed grape, including juice, seed, and sometimes the skin) or are removed before fermentation.

Many of the table wines, or vin ordinaire, are fermented by yeasts that occur spontaneously on the surface of the grapes. This, of course, depends upon the presence of yeasts in the environment surrounding the grape-growing district. If wine ~~were~~ was produced from grapes or other fruit in areas where no previous wine-growing occurred, other microorganisms would attack the sugars and produce fermentation, but not of the most desirable type. Even in areas where spontaneous wine yeast occurs, it is frequently desirable to control the type of yeast that causes the fermentation, and, as a result, efforts are made to produce particular strains, and to use these to the exclusion of all other strains.

To some extent, most wine-making processes do control the microorganisms which carry out the fermentation by passing sulfur dioxide through the "must" and thus killing off many undesirable organisms but leaving the S. cerevisiae, which is not killed by the SO_2. Where selected strains of yeast are used, these are applied to produce a specific type of wine, with either a different flavor or a different alcoholic content (but never more than 12% in the natural wines). For example, the sparkling wine, champagne, is ~~produced~~ made by ~~first~~ ~~regular production of~~ producing an artificially sweetened ~~the~~ white wine, ~~then to the artificially sweetened wine,~~ to which a special champagne variety of yeast is added. This causes a second fermentation with an excessive amount of carbon dioxide, which is kept in ~~when kept under pressure, remains as a liquid~~ solution by tightly corking the bottle. When the pressure cork is removed (with the famous or typical "pop"), the ~~CO_2~~ escapes as bubbles.

As derivatives from wine, there are a number of other beverages produced, including liquors and brandies. While these are very interesting in their history and production, no further microbial reaction is involved. Rather, distillation processes, ~~increasing the concentration of alcohol, reducing the water content~~, ~~and~~ the addition of flavoring agents and aging are employed to achieve the desired product.

For the production of vinegar, however, additional bacterial activity, using the alcohol produced in the wine fermentation, is involved. As with wine, other fermentable substances may be used to start the vinegar-making process, and many suitable carbohydrate sources are available which, when fermented, produce ethyl alcohol (ethanol), the starting point. Vinegar, which contains appreciable quantities of acetic acid, is the result of an alcoholic fermentation, followed by an acetification of the fermented liquor. The process of conversion of the ethanol to acetic acid is carried out by certain species of the bacterial genus Acetobacter. While wine is one of the starting sources of alcohol for vinegar production, very acceptable vinegar is produced from malt (popular in England), from apple cider (in the United States), and from a variety of other sources.

The word vinegar is derived from two French words, vin (wine) and aigre (sour). The traditional method of vinegar-making simply allowed the alcoholic liquor to stand in vats where liquid soon became covered with a film of acetic acid bacteria which then oxidized the alcohol to acetic acid. A continuous-flow process evolved from this slow and inefficient procedure, where new batches of the alcohol base were inoculated with previous batches of vinegar-producing bacteria, but this, too, is a slow and inefficient process.

In the early 19th century, another method of acetification--vinegar-making-- was developed. In this, the tower process, the alcoholic liquor is allowed to run over and through loosely packed wood chips on which acetic acid bacteria are growing. The speed of this process soon caused its wide adoption and is the method used in the western cultures most frequently today.

diagram

Whiskey and Other Alcoholic Beverages

Somewhere distillation process should be explained.

While there is no clear-cut geographic distinction that can be drawn, it is true that some peoples and cultures prefer their distilled alcoholic beverages derived from fermentation products other than wine (in the form of brandy). Whiskey is distilled from the fermented "mash" made from various starchy grains, such as wheat, rye, oats, or corn (maize), or from potatoes. Anglo-Saxon and Teuton types seem to prefer grain-mash-derived hard liquors. In the process, a number of different steps require various plant products. One of the materials, charcoal, is usually derived from various hardwood trees, maple being preferred by some. The charcoal helps to absorb some of the undesirable materials that are distilled from the mash. The raw, or freshly distilled, product (white lightning?) is usually unpalatable and requires aging, during which time various chemical transformations occur. Many whiskies are aged in wooden barrels, and for some types, it is essential that white oak be used in making the barrels. It is not known with certainty just what chemical processes occur as a result of the interaction between the wooden barrel and the whiskey, but at least some of the higher alcohols (with higher molecular weights than ethanol) are converted to lower molecular weight alcohols which are more palatable.

The list of materials entering into fermented drinks is long and ~~is~~ only limited by the imagination of the people who would use them.

Obviously, the prime requirement for fermentation is some form of carbohydrate (sugar), but other plant materials may be added to the fermented products as flavoring agents. For example, English gin is a fermented and distilled beverage flavored with extracts of the unripened fleshy "cones" of various cedar (*Juniperus*) species. In tropical South America, a type of beer called "chicha" is made either from corn or from cassava. Here, the starchy material is broken down to glucose by a rather repugnant process carried on by the Indian women, namely, by masticating the corn or the cassava. (This is an efficient way to break down starch to sugar: amylase (diastase) in the saliva is the enzyme responsible.) In Mexico, a popular low-alcoholic beer known as "pulque" is made from the juice of certain species of *Agave*.

Industrial Microbiology

Although much of this discussion has been related to the use of microorganisms in the production of alcoholic beverages, it much be emphasized that other applications of microorganisms in many industries are important in our modern economy. One industrial product of considerable importance is citric acid, an organic acid originally derived from citrus fruits (oranges, grapefruits, lemons, limes, etc.). Thousands of tons of citric acid are used in medicine, food technology and industry. Most of the citric acid is used in medicinal applications, chiefly as calcium citrate, which is of value as an alkalizing agent and as an easily assimilable sourse of calcium for human nutrition. A good portion of citric acid is used in the food and beverage industry, as artificial flavoring and soft drinks. In industrial applications, citric acid is used as a silvering agent, as an ingredient of engraving inks, in plastic and synthetic resins, etc. Investigations begining in the last half of the 19th century indicated that by microbial fermentation citric acid could be produced economically in quantity starting from a molasses base and using a fungus named <u>Aspergillus</u>. By the early years of the 20th century, the technology of microbial citric acid manufacturing had developed sufficiently to make the extraction of citric acid from citrus fruits almost passé.

The largest stimulus to the production of important chemical substances from microorganisms was given by the techniques invented for the mass production of the antibiotic drug penicillin during and shortly after World War II. ~~The story of~~ this development is one of the most dramatic success stories of combining ~~applying~~ American know-how in mass-production techniques with European scientific knowledge. In 1928, Alexander Fleming, an English microbiologist,had noted that one species of the genus Penicillium, a genus of filamentous fungi belonging to the Ascomycetes, inhibited the growth of certain bacterial organisms causing infectious diseases. He extracted some of the Penicillium product, tested it against an infected wound, and found that it cleared the infection. Two other British scientists H. Florey and E. Chain hoping to find drugs affective against wound infections in the late 1930's, read Fleming's report on his earlier finding. They recognized the significance of this find and retested the exudate of the mold to determine whether it were toxic to humans as well. They found that the penicillin produced was remarkably specific and caused no harm to healthy human tissue. With this, they began to think of methods of inducing the organisms to produce the huge quantities of the purified antibiotic that would be needed to protect members of the armed forces. Since Great Britain was already at war, much of the technical skills there were employed in direct support of the war effort, and this suggested that perhaps the scientists in the United States, not yet at war, might help in overcoming the many difficult problems.

center plate photo of Penicillium colony

When the British scientists came to the United States for help, they were given aid by both government and industry. The laboratories of the U. S. Department of Agriculture at Peoria, Illinois, were given over to the intense studies required. Since Penicillium notatum had been used by Fleming in the original work, this was the organism used at the beginning of the Peoria studies. Unfortunately, this species did not lend itself well to growth in large culture conditions. By examining many different species of Penicillium (there are perhaps 700 different species belonging to the genus), one species, P. chrysogenum, quite by accident was found to produce the required substance at the rate of about 200 times that of P. notatum. Even at this rate, only 200 parts per million of drug were produced by the mold.

The accidental discovery of the high-yielding species occurred in Peoria, Illinois, where the war-time development work was centered. One of the bacteriologists in the project, while shopping in a local market, noticed an over-ripe fruit (some say a cantaloup, others a grapefruit) with a large, beautifully developed colony of Penicillium growing on it. Since he was aware of the problem, he carried the fruit back to the lab, and from his curiosity and observation, the whole project proved much more successful.

The culturing process used at first required that the mold be grown on the surface of nutrient media. The containers first used were about the size of a quart milk bottle; if enough bottles were to be employed to produce the required amount of drug, all the output of milk bottle manufacturers in the United States would have to be requisitioned. From any standpoint, this was completely unsatisfactory. At this point, by combining the knowledge and skills of biologists, chemists, and engineers, the process of growing the organisms in huge tanks was developed. To supply the required nutrient material for proper growth of the organisms, a medium composed mainly of water in which corn had been steeped was found to be excellent. Since tanks holding thousands of gallons of the medium were designed, it was necessary to develop techniques to supply sufficient inoculum of Penicillium to the tank to cause the production of the desired drug rapidly.

This is done in a step-wise manner, proceeding from the small bottle cultures up to large-scale bottles, thence to tanks. Since the microorganisms must be supplied with free oxygen even in the depths of the tanks, new types of aerating procedures were developed. All these activities must be accomplished under the strictest of sterile procedures to insure that only the one species of microorganisms developed in the tanks. The enormity of the problem is recognized when one considers that millions of spores of contanimating microorganisms can be found in any ordinary atmosphere, and that the culture medium for Penicillium chrysogenum is equally suitable for many other fungi. Therefore, not only must the containers for antibiotic production be sterile, but the introduced oxygen for submerged culture as well. It would be a lengthy discussion to describe in detail the various sterilization techniques.

While one of the by-products of the metabolism of Penicillium chrysogenum is the desired antibiotic, there are others produced by the organism, and it is necessary to control very carefully the growth of the cultures in order to produce the highest amount of the drug while keeping down the production of the other undesired products. Microbiologists whose specialization in research is physiology spend much of their time in trying to understand the pathways of the mold's metabolism, following the development of the various products from the inception of the process through the multitudes of steps to the end result. Since several types of activities are occurring simultaneously in the cells of the fungus, it must be recognized that control of one type of productivity also affects others, sometimes in more desirable ways, sometimes in ways that will detract from those expected. For example, if the culture medium is too acid, the mold may convert the corn extract to undesired organic acids and produce little of the antibiotic.

In spite of the many difficulties, we know of the success in production of the various antibiotics from various microorganisms--penicillin, streptomycin, the chloromycetins, etc., and the search for new ones continues. The reasons for continued search are obvious. First, there are other diseases resistant to present-day drugs, and second, some of the disease-producing microorganisms are becoming resistant to drugs that formerly controlled them. We must recognize that we are dealing with living structures and that one of the most important characteristics of any living organism is its ability to adapt to various environmental conditions. As in the case of the microorganisms, the wheat rusts, discussed in the chapter on problems of wheat production, the microorganisms attacking man also vary, and we must be constantly alert for new methods to control old diseases. There is no such thing as a permanent cure, nor will we ever be in a position to say that any one disease is "wiped out."

Other Industrial Products of Microbe Metabolism

There are several organic acids produced regularly in industrial microbiological processes. Citric acid production was mentioned earlier. In addition, gluconic acid, fumaric acid, itaconic and kojic acids are products that find a multitude of uses in our modern technology. Even as the fermentation industry is a 20th-century development, so many of the products that require the fermentation materials were unheard of, or were mere laboratory curiosities, before the turn of this century. Some of the organic acids enter into medicinal compounds and reactions, others are used in the production of plastics, printers inks, tanning of leather, detergents, and other common consumer products.

Because ~~of the fact~~ the production of certain substances by microbial fermentation techniques often requires a very highly skilled, highly paid group of workers, most manufacturers look for means of producing the same materials synthetically, without any microorganisms. Many products formerly produced by microbes are today produced by completely inorganic techniques, but in most cases, the microbes themselves pointed the way in which the synthetic process might be accomplished. By following the processing of raw materials by the microorganisms, the microbiologist and biochemist ~~has~~ have learned to mimic, or duplicate the techniques of the microorganism in pipes, bottles and tanks. Though ~~there is almost always a reduction in efficiency of production~~ The industrial technique may be clumsy and inefficient when compared with the beautifully integrated techniques ~~of~~ inside the fungus, the guaranteed production of a standardized product is achieved.

Microbes in the Food Industry

We cannot describe all the various products and procedures of food production utilizing various microorganisms, some should be mentioned. Cheese-making is one of the most important, in which various fungi (mostly sac fungi, the Ascomycetes) provide the unique flavor of such cheeses as Roquefort, Camembert, blue cheese, and many others. The microbes react with the milk solids with characteristic products that identify the cheese.

In the production of coffee, chocolate, and some teas, fermentation procedures are of fundamental importance. In coffee, for example, the ripe fruit of the coffee plant is a beautiful bright red berry. The flesh of the berry, while quite tasty, must be removed before the "coffee bean" which is really the seed, can be processed. The fruits are laid out on huge flat surfaces, and allowed to ferment. The fermentation rapidly destroys the fleshy coat, and leaves only the seed. Whether the fermentation contributes to the final flavor of the coffee is a moot question, but the bacterial and fungal organisms, in mixed cultures, have saved much manpower in an otherwise tedious job. Similar activity is needed in the production of chocolate and cocoa. In the production of vanilla, ~~production~~ from ~~the~~ orchid pods, some "sweating" (heating) is done to strengthen the

explain?

flavor. In the sweating, bacterial action takes place. Teas may be fermented, by bacterial action but some of the tea leaves are dried without the action of microbes. A marked difference in flavor of the finished product is noticeable.

Earlier mention was made of "miso" fermentation of soy bean products in Japan. This process produces a product (a high protein solid with a distinctive flavor) , used almost daily in Japanese diets and represents a remarkably intricate set of manipulations of both rice, on which the fungus organisms are started, and the soy bean proteins. The process was developed at least 1,000 years ago in Japan, long before any recognition of the microorganisms that produce the unique flavor and modification of the soy bean meal.

Summary

The ubiquitous nature of microorganisms makes it inevitable that they be involved in our most intimate activities. Their remarkable ability to utilize an enormous range of substances for their own food supply gives them a potential value for many of man's required transformations of raw materials into finished products. We have attempted to indicate a few of the methods by which man has either knowingly or unknowingly put specific organisms to work, and have indicated that mixed cultures may as well be employed for some beneficial purpose. There are other methods of utilization that have not been specifically mentioned--there are many in medicine (production of vitamins), in agriculture, in industry, in scientific investigations, and other human endeavors.

Ch 6

Ch 6

FLOW CHART OF VINEGAR MAKING

Apple Cider + Saccharomyces →

Ethyl Alcohol (C_2H_5OH, hard cider)

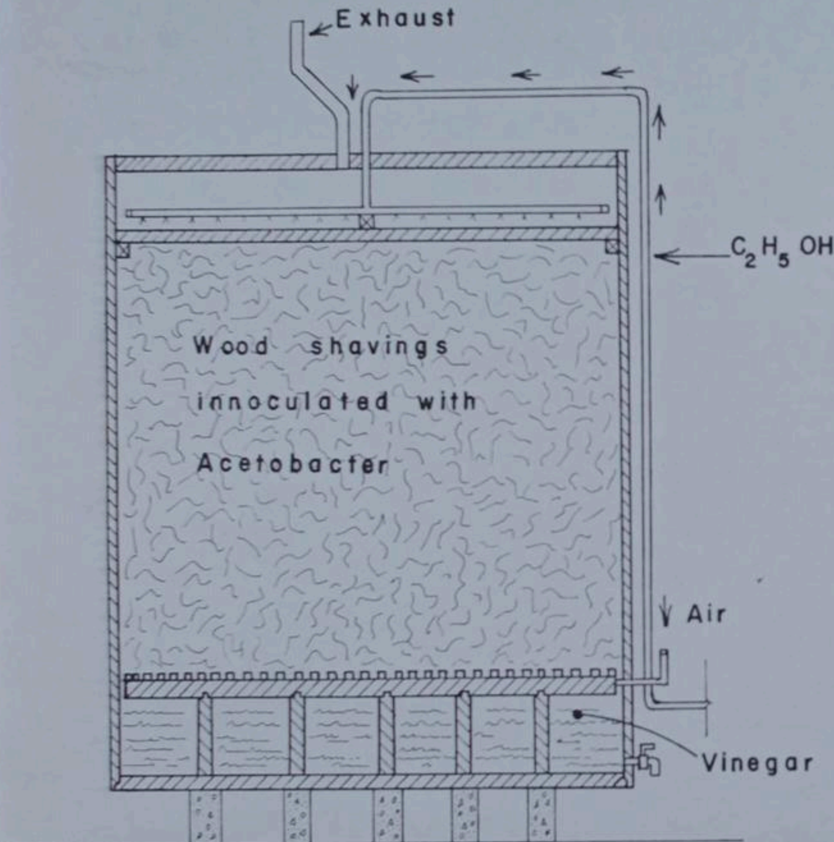
C_2H_5OH + Vinegar Bacteria + O_2 →

Acetaldehyde (CH_3CHO)

$CH_3CHO + O_2$ →

Acetic Acid (CH_3COOH)

Ch.6


Exhaust
C_2H_5OH
Wood shavings
innoculated with
Acetobacter
Air
Vinegar

REFERENCES

Anon. 1955. Our Smallest Servants. 32 pp. illus. Chas. Pfizer & Co., Inc., Brooklyn, N.Y.

DeKruif, P. 1926. Microbe Hunters. Harcourt, Brace and Co., New York

Gray, W. D. 1959. The Relation of Fungi to Human Affairs. 510 pp. illus. Henry Hold & Co., Publ., New York.

Lachine, A. Wines of France.

Large, E. L. Advance of the Fungi. Paperback edition by Dover Publications, New York.

Rose, A. H. 1961. Industrial Microbiology. 286 pp. illus. Butterworths, Washington, D.C.

Drugs and Medicinal Plants

The words, "drugs" and "medicines", have so many connotations that it is difficult to determine whether a difference exists between them, or whether they are the same. We will not enter this argument and will use the words as though they ~~are~~ were interchangeable. Obviously, not all materials that fall into these two headings are derived from plants. Mineral and animal substances are, or may be, used in the same way--to alleviate, change, or destroy some condition existing in the human or animal mind or body. We do not usually consider these substances used to cure plant diseases as medicines or drugs, but some might extend the name to such materials ~~as~~ that are effective in making for healthier plants. We speak of diseased plants, but the cure is seldom thought of as administering medicine or drugs. For an excellent discussion of plant diseases, see Wellman "Plants have Diseases" in this same series.

Medicines are, I suppose, more confined to curing disease than are drugs, which may be employed in quite different ways to bring pleasure, or perhaps escape from reality. Disease is another difficult concept, for in curing disease, we assume some ameliorating change in the patient. Disease may cover ills of the mind or body caused by all sorts of internal and external agents. Whatever definitions are, or have been, applied it is evident that the search for drugs and medicines has continued through the ages, and that many materials ~~that had~~ having real or fancied properties have been employed. Plants have provided a major source of materials, and still provide spectacular cures for various physical and mental ills.

~~The~~ whole plant kingdom, ~~or~~ Representative species from each of the major categories of these, provide some sort of remedy. ~~Today's relative health and~~ Our freedom from bacterial diseases is largely dependent upon the production of antibiotics from various types of fungi. The Actinomycetes, the Ascomycetes, the Basidiomycetes and the Fungi Imperfecti each have members producing one type of antibiotic ~~or other.~~ Penicillium, the antibiotic derived from <u>Penicillium</u> <u>chrysogenum</u> is a well known substance, and its history well documented. (See Chapter on fermentation.) However, discovery of the use of penicillin was made on a slightly different level than the discovery of most drugs that had been discovered earlier. Many valuable drugs were known to very primitive societies, and their application adapted by modern medicine after some time of skepticism on the part of physicians that they could learn or use anything from "ignorant" savages. One of the most striking examples of this folk use, and recent adaptation by modern medicine, is the tranquilizer serpifil, a tranquilizing agent used in treatment of mental irregularities, was known and used by Ayurvedic practitioners of India for countless centuries. To be sure, the modern drug is extracted and purified, whereas the older use was merely a water extract from ~~the boiled (or was the dried root ground up?)~~ roots of <u>Rauwolfia</u> <u>serpiphila</u>, a common weed in India. But sometimes when efforts are made to use a purified drug that was formerly employed as a crude extract, there seems to be little indication of success. This may be so because there are usually several substances extracted from the plant with simple boiling or steeping done by the medicine man or shaman, which may be effective in the drug or medicine. The "hocus-pocus" practiced by the tribal witch doctor along with the drug was probably strong psychological medicine itself.

Fig. of plant

As mentioned in the chapter on spices, it is sometimes difficult to draw the line between drugs, or medicines, and spices or condiments. Very frequently medicines given orally will have flavoring materials added to mask the taste of the effective drug materials. The common "sugar-coated pill" is another example of combined products to reduce the distaste of the medicine. Frequent use of the spices for their aromatic essential oils is practiced. Oil of wintergreen is very frequently used. Mint extracts also add something to make it easier to take the active drug material. However, one suspects strongly that many plant materials would not have been tried for medicinal value had they had an innocuous taste when the various parts were water-extracted. Certainly, if the plant product had a bitter taste, it must be good for something that ailed you! And many of the valuable substances from plants, such as the alkaloids, a poorly defined class of substances from which we derive such valuable drugs as quinine, atropine, cocaine, and morphine, are indeed bitter. Anyone who had been attacked by malaria before the days of the modern synthetics can attest to the extreme bitterness of quinine.

The drug materials from plants fall into several general types of substances; among them the alkaloids, mentioned above; a group of enzyme-inhibiting substances, such as the antibiotics, which either destroy the disease-producing bacterium by preventing normal bacterial enzymatic activity, or slow down the organisms output of some poisonous substance, thus allowing the white cells to engulf the invaders; astringent substances, frequently containing tannins, whose value is largely in superficial medicine (external); laxatives, from such sources as the castor oil seed, whose nature is a combination of oily substances with some alkaloids and some protein-like materials that interact to cause rather violent action internally; vermifuges, containing alkaloids primarily, used particularly in those societies where there is an acute lack of sanitation; and materials for anything from a toothache to ingrown toe nails. Many times substances have been employed as aphrodisiacs -- substances that supposedly heighten sexual desire, but infrequently have these materials proved in effective (fortunately for this over-populated globe). Again the psychological effects are the stronger medicine, and the plant substance is merely suggestive.

Some of the recent finds ~~among plants~~ that have been, or promise to be, dramatic break-throughs in medicines, ~~or promise to be~~, are drugs useful in the treatment of arthritis, and substances that have proved useful in one or two types of cancer. In the former case, substances known as sapogenins from the roots of a vine, Dioscorea, and other plants have been found to produce a precursor to ACTH which, when properly modified can be used, under proper conditions, to help reduce painful swelling in the joints. Unfortunately, this is not a universal remedy for arthritis, and in certain cases is not only ineffective, but also causes undesirable side effects.

The only known cure for any type of cancer (and there are many different sorts) that has as yet been clinically proven, is an extract from a plant common in tropical and warm-temperate gardens, the periwinkle, Vinca rosea (sometimes called Catharanthus roseus). This extract is effective against a type of leukemia. However, the chances that some material produced by plants may be effective in the treatment of other cancers is of sufficient potentiality to ~~cause~~ induce an enormous effort by the National Institutes of Health in collaboration with many other institutions. The thorough procedures employed in the screening tests, and the low percentage of materials that may be useful, indicate how much effort is required before a useful new drug becomes available for the treatment of the disease.

The Search for Cancer Cures

First, botanists from the United States Department of Agriculture collect plant samples in sufficient quantity and satisfactory condition to make it possible for further work. The samples are identified accurately so that if any one sample proves to contain interesting possibilities as a cancer cure, more of the same material may be collected. Other botanists may, and frequently do, submit plant material for testing by the National Institutes of Health. Second, the plant sample is extracted for potential cancer-reducing substances and tested with selected strains of cancer in mice. The samples are then evaluated to determine whether the crude extract has any potential value. Of the total collected samples, only a very few will give any indication of value for either curing or slowing down the growth of the cancer (there are at least nine types of cancer being tested simultaneously). For those that show some preliminary value, a great number of other tests must be applied before any real value may be obtained. After the preliminary testing has shown some positive action, the sample will be assessed for its toxic effects, because the preliminary positive may only be the result of some toxic substance that also kills healthy tissue. ~~Even though~~ this ~~be the~~ case, it may be determined that the toxic agent has two or more substances in the crude extract, closely linked chemically, but which, when separated, ~~may~~ have curative effects in one part which is not toxic to healthy tissue. If, after a series of tests, the original plant sample still shows value, the same species will be recollected, and then a new series of tests will be started. The botanist returns to the area where the original sample was collected and attempts to get enough material for continuing tests. This may be extremely difficult, because the original plants may be very small, occur in small numbers, may not be growing ~~in~~ the same vigor as ~~the~~ previous year's ~~(or several years' past) growth, etc.~~ There may, or may not, be any value in the second ~~year's~~ sample. This is a measure of the work to be done to find an agent (drug or medicine) which finally measures up to the requirements--a specific for certain cancers.

Great care must be taken to prevent premature announcement of a "cancer cure," because ~~the~~ numbers of times in the past when a substance seemed well on the way through all the testing procedures with positive results, ~~when~~ finally tested on human patients, did not have the desired effect. Yet the quest continues, for one type of cancer (mentioned earlier) has been checked by the extract from a very common plant.

I have described the procedures above in a very sketchy manner--(a very large number of detailed steps have been omitted)--only to indicate that any drug, no matter whether discovered in modern times or having a much longer history, has had to go through countless numbers of tests before its true use ~~can~~ could be identified. Even the oldest drugs went through a sort of testing procedure even though the practitioners and consumers may not have considered themselves as testers or guinea pigs. How long did it take for man to discover the benefit of quinine as an agent in the cure of malaria? We have no way ~~to~~ of knowing, but the period between first test and final application to the specific disease must have been very long. In a sense, we owe a tremendous debt to those early patients who willingly swallowed the medicine man's bitter concoction without any sure knowledge ~~that he wasn't going to his reward~~ of it's effects.

Today, although some of our most important drugs are synthetic--compounded from simpler starting materials in the laboratory or pharmaceutical industry tanks--by far the largest numbers are derived from plants, and it is rare that we find a drug ~~to be~~ administered that does not ~~have~~ contain materials derived from several plants. Perhaps the active substance is a single derivative, highly refined, but it is frequently carried in or dispersed in another plant product, ~~and~~ so that the taste, odor and sight are made more pleasing by the addition of extracts from spices, flavoring materials (i.e., vanilla, mint, et al.) and vegetable coloring (Bixa orellana, annatto, producing a red or yellow pigment, is one of the favorites). Other plant products are frequently employed in filtering or purifying the crude drug. Carefully prepared charcoal may be used to remove

TABLE

PHARMACEUTICAL APPLICATIONS OF CRUDE DRUGS AND THEIR PRODUCTS*

PHARMACEUTICAL USE	DRUGS		
Filtering medium	Purified cotton	Charcoal	Purified siliceous earth
Adsorbent (see 7-7 topline absorption ?)	Charcoal		
Decolorizing agent	Charcoal		
Suspending and emulsifying agents	Acacia Agar Sodium alginate	Chondrus Gelatin[1]	Sterculia gum Tragacanth Wool fat[1]
Vehicles			
Solvent oils	Expressed almond Castor Corn	Cottonseed Olive Peanut	Rapeseed Sesame Poppyseed
Ointments	Lard[1] Prepared suet[1]	Wool fat[1] Spermaceti[1]	Yellow wax[1]
Suppositories	Gelatin[1]	Theobroma oil	
Jellies	Agar Chondrus	Gelatin[1] Pectin	Tragacanth
Preservatives	Benzoin Guaiac	Storax Sucrose	Wheat germ oil
Diluents and fillers	Althea Cacao shell Glycyrrhiza	Lactose Rice hulls Starch	Sucrose
Binders and excipients	Acacia Gelatin	Honey[1] Starch	Sucrose Tragacanth
Sweeteners	Honey[1]	Sucrose	
Flavoring agents	Anise Cacao Caraway Cardamom Cinnamon Clove	Coriander Eriodictyon Fennel Glycyrrhiza Lemon Orange	Peppermint Sassafras Spearmint Thyme Vanilla
Coloring agents	Alkanet Chlorophyll	Cochineal[1] Cudbear	Red saunders[?] Annoto (added by author)
Perfuming agents	Lavender	Orris	Rose
Coatings	Acacia Cacao	Gelatin[1] Sucrose	Tolu balsam
Dusting agents	Glycyrrhiza	Lycopodium	Starch
Capsule material	Gelatin[1]		

* from Pharmacognosy by Pratt &Youngken, Lippincott, 1961. p. 168.

1 animal product

undesirable substances by absorption, or by filtration with cotton fiber. A glance at the following table will show the many products and methods of use of plants in medicine.

INSERT TABLE--Pharmaceutical applications of crude drugs.

Modern man is the benefactor of native medicines from all parts of the world. We have been able to sift from ~~among~~ the various remedies proposed in countless different groups of primitive peoples a very large number of agents ~~for their~~ with healing properties. But each primitive society developed a remarkable "materia medica" from locally occurring plants. Certain civilizations seem to have progressed further than others in deriving benefit from the plant materials around them. Among the most successful groups are the Chinese and certain South American Indian tribes. Certainly we have derived beneficial drugs from others, but today, the modern pharmacognocist is expending more effort to find primitive remedies among South American Indians than from any other group. There are still potential medicines to be found by imitating cures used by shamans and witch doctors, and we have overcome our disdain of cultures different from our own, at least to the point of copying some of their curative techniques.

It would be difficult to document the geographic origin of the many drugs presently listed in such compendia as the U.S. Pharmacopoeia, but it is profitable to examine one example. A standard drug in China, known and written about in a Chinese document as early as 2700 B.C., was derived from the genus Ephedra. Ephedra is a genus of unusual plants belonging to the Gymnospermae whose species are scattered in various parts of the world. Three or four species occur in China, and from one of these was derived a drug known today as ephedrine. The value of ephedrine was first detected by a Chinese pharmacologist, K. K. Chen, in 1923. He noted that the crude drug dispensed in Chinese pharmacies had effects similar to the hormone adrenalin (or called as a drug, epinephrine). Further examination and comparison of ephedrine and epinephrine showed that they are very similar in their structure, with the differences being that ephedrine lacks certain structures ~~which makes it~~ more stable and resistant to oxidation. ~~This similarity is a remarkable demonstration of the similarity of the chemistry of living plants and animals.~~

The drug epinephrine is used systematically for acute circulatory failure, shock, cardiac failure, hypersensitivities and serum sickness due to allergens and for many vasoconstrictor purposes. (~~Pratt & Youngken, p. 377~~).
Ephedrine has approximately the same effects as epinephrine and is commonly used for relief of nasal congestion and bronchial coughs; it also is applied in asthma.

Up to about 1940, ephedrine was extracted from species of Ephedra, but it was synthesized and produced in sufficient quantity by 1941 to reduce ~~the~~ extraction from ~~the~~ plants drastically. Still, some manufacturers prefer to use the natural product, and several species of Ephedra are found in this country which are, or have been, used to extract the ephedrine.

Patent Medicines

While the scientific search for new drugs goes on, there are still a very large number of medicines sold in drug stores that are described as "patent" medicines, which have been used by people in all walks of life for some real or fancied ailment, where no specific cure has been determined from scientific studies. It is an interesting passtime to examine the labels of the drugs sold over the counter without a doctor's prescription. Here one may find a wealth of plant materials, many of merit, many with none. Licorice is frequently one of the ingredients, derived from the roots and rhizomes of a plant grown extensively in the lands surrounding the Mediterranean basin. Pine tar and other extracts from the bark and wood of several species of pine trees ~~is~~ are found often in cough medicines. Sulfur and molasses ~~is~~ are a classic old "spring tonic."

The restriction on these drugs or medicines is that they contain no harmful substance and do not claim to cure a disease unless it's specifically demonstrated that they do. If it is determined by the Food and Drug Administration that harmful materials are included in the product or that the claims are untrue, it will be removed. Sometimes it is quite difficult to show the ill effects, and the burden of proof against the patent medicine is upon the investigators in the government laboratories. ~~Even after a medicine is touted, the struggle through the legal mazes which are available to the manufacturer is a very expensive and time-consuming effort.~~ It must be constantly in the mind of the scientist must be constantly aware that he may not be able to determine with finality the merit or demerit of one substance, for the body of man is an intricate structure, with many unknowns in its healthy state, and more intricate still when interacting with an agent of disease. In some cases, there is no doubt of the harmful effects of a drug, manifesting itself as a malformed baby, or blindness, but many effects are so subtle as to go undetected for many years.

1

Ch 7

REFERENCES

For a list of drugs and medicines derived from plant materials, and recognized today as having some merit, consult the latest edition of *The United States Pharmacopoeia*. The USP was first published in 1820, and has been revised on the average of every ten years since then. For an interesting comparison of plants considered as drugs in the first and last editions, read B. R. Hershenson's article in the journal Economic Botany, volume 18, page 343, 1964, entitled "A botanical comparison of the United States Pharmacopoeias of 1820 and 1960."

The *Merck Index*, frequently updated, is another dictionary-type listing of importance. Published by Merck, Inc., Rahway, N.J.

A college text, but one with valuable drug information, is R. Pratt and H. Youngken's textbook *Pharmacology*, Lippincott, 1961.

Norman Taylor has written a very valuable book on plants used as narcotics. This book was first published under the title *Flight from Reality*, and is now available as a paperback, entitled *Narcotics, Nature's Dangerous Gifts* published by Delta Books.

Chapter ~~XX~~ 8

VEGETABLE FIBERS

In keeping with the idea that this book should include discussions about the plants fundamental to our life, as well as some that we find pleasing and enjoyable, I have included this chapter on vegetable fibers. Certainly one basic requirement for mankind is protection from the elements, and since it is pretty certain that *Homo sapiens* has been essentially a hairless animal for many thousands of years, there has been a search for materials to provide bodily protection against extremes of cold or heat. It is also very likely that man's first efforts to clothe himself were with animal skins, ~~and that wool~~ [clothe] cloth~~ing~~[ing] ~~would~~ be a~~n~~ ~~early~~ [later] development. ~~in cooler climates.~~

The process of discovering useful fibers in sufficient quantity to make clothing, developing means to extract the fibers, and then weaving these into some kind of close-knit manufactured article required thousands of years for development. While fibers in plants are almost ubiquitous (at least in the higher plants), not all of them are easily extractable or particularly useful. We can [postulate] ~~hypothesize~~ that the evolution of fiber utilization began with the "bast" fibers ~~in~~ [of] many plants ([e.g.], members of the mulberry family) where the inner bark could be easily separated from the trunk and these used as strings. By twining several pieces of this stripped material, a stronger "string" could be produced. By simple, in-and-out plaiting, ~~some~~ basket-like structure could be produced [or by tieing knots at regular intervals, fish nets could be developed]. Then by gradual increase in invention, exploration, and just plain "fiddling around", plants which produced the most pliable, the strongest and the longest lasting fibers were discovered. These formed the basis for other inventions-- ~~in~~ the techniques of clothing manufacturing, rope and string

[Fig. illustrating bast fibers and location in the stem] making, basket weaving, matting construction, etc.

Vegetable fibers—plant structures upon which dependent

Some of the same materials and properties of plants which made it possible to develop a paper industry are responsible for the development of clothing, string and rope, baskets, and mats. These properties are cellulose in the cell wall, elongated cells, secondary thickening of the primary wall, and the relative stability and resistance of cellulose and lignin against attack by various fungi. Varying types and amounts of cell wall thickening make it possible to develop soft fibers for clothing, and harder fibers for ropes and string. As in the paper industry, it is frequently necessary to separate the useful fibers from their surrounding cells, and various techniques for this separation are required. Perhaps the earliest efforts were purely mechanical--beating with wooden or stone hammers; later men employed microorganisms to help in the separation of stem fibers from non-fibrous cells--retting. (See chapter on use of fungi.)

Useful vegetable fibers are developed in stems, leaves, and in fruits. In contrast to the paper industry where the preponderance of fibers are derived from woody plants, most of the fibers useful for clothing, ropes, etc., are from essentially herbaceous plants. The softest of the textile fibers are those developed on the seeds of the cotton plant. Next in softness are the fibers for linen (from the flax plant, *Linum usitatissimum*), developed in herbaceous stems. Less frequently used for clothing purposes today is hemp, from the tall, straight, herbaceous stems of *Cannabis sativa*. Frequently, a commercial classification of fibers is made on the basis of their hardness, and though hard to define the precise difference, we separate those fibers useful for clothing from those for other purposes as "soft" and "hard."

Almost all of the vegetable fibers in use today are developed in the Angiosperms, the flowering plants. (Paper fibers come very largely from the Gymnosperms.) Monocots and dicots both have important fiber-producing species. Among~~st~~ the monocots, perhaps the most significant ~~species~~ is <u>Musa textilis</u>, a species closely related to the edible banana, and one of the largest of all herbaceous plants. The hard fibers from the leaf stalks of <u>M. textilis</u> (whose common name is Manil~~la~~ hemp or abacá in Spanish) are employed in rope-making~~, and are, therefore, hard fibers~~. Other ~~importante~~ monocots producing hard fibers are members of the lily family, though frequently the most important fibers from these species are separated into another family (the agaves, or Agavaceae). Sisal (from the succulent leaves of <u>Agave sisalana</u>) is one of the most important, and the fibers are widely used for twine and cordage. ~~Members of~~ Leaves of the pineapple family, Bromeliaceae, ~~are~~ also ~~important~~ produce~~rs of~~ fibers ~~from leaves~~. The palm family ~~also~~ has a number of species used, mostly for basketry purposes, ~~and~~ where parts of the stem or leaf may be used. Coir is a fibrous material derived from the leaf-bases of the coconut palm and frequent use is made of the whole fibrous leaves of palms in thatch-roof construction. Other linear-leaved monocots from various families, including the grasses, are ~~also~~ used as shingling materials.

A whole host of confusing names is applied to a once-famous fiber product, the Panama hat. First of all, most people referred to it as the Panama hat palm, ~~but~~ although the moncotyledonous plant producing the fibrous material (<u>Carludovica palmata</u>) is not a palm at all, but a member of the family Cyclanthaceae. Secondly, the plants do not grow in Panama, but in lowland Equador, though the hats were frequently marketed through Panama. ~~and third~~ Finally, the fiber from these plants is known by the natives as "toquilla."

In the Dicotyledoneae, there are a small number of ~~about eight~~ families of plants producing the most important vegetable fibers. Three of these ~~most important~~ families were mentioned above: the Linaceae (linen), Malvaceae (cotton) and Moraceae (hemp). The other families produce such products as jute (Tiliaceae), ramie, (Urticaceae), Sunn hemp (Leguminosae), Kapok (Bombacaceae) and floss (Asclepiadaceae). Many other types of vegetable fibers with specialized uses come from other families of dicots, but their products are not included here.

One dicot, cotton (Malvaceae, Gossypium spp.), holds the first place in importance in the vegetable fibers. Biologically, this plant (or several related plants) is fascinating for a number of unsolved problems, for its unusual construction, and in various commercial ways. First, there are two major groups of cultivated cotton species: the Old World species with 13 chromosome pairs and the New World species with 26 chromosome pairs. However, the wild species of the New World also have 13 chromosome pairs. The New World cultivated species, with 26 pairs, therefore, arose by some doubling process, though no conscious effort was made by the early natives to accomplish this. The interesting fact is that, of the doubled pairs in the New World cultivated species, one of the sets was derived from an Old World species type. Since the doubling of the chromosomes apparently occurred long before there was any recorded contact between the Old and the New World, the question arises--how did the set of Old World chromosomes get across the ocean? No satisfactory answer has yet been provided.

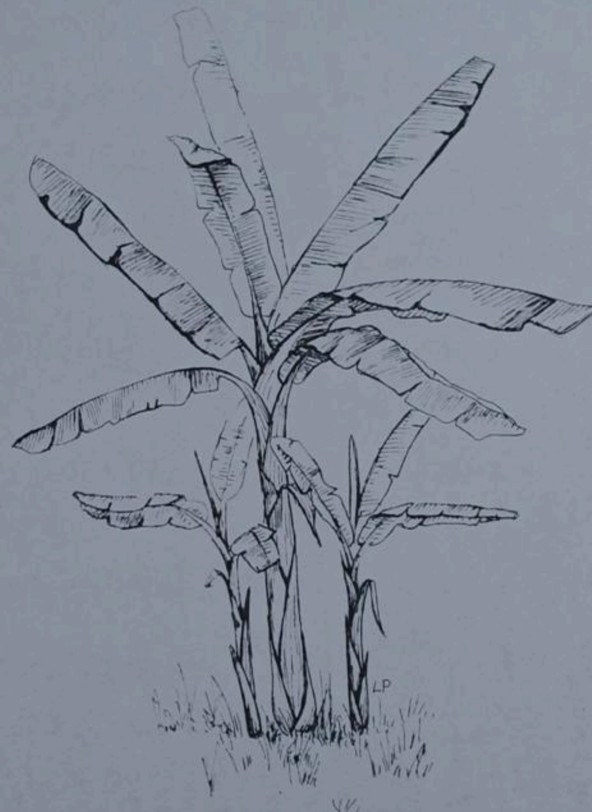
Another interesting biological problem is in the proper classification ~~and relationships~~ of the genus Gossypium. Traditionally, the genus has been considered a member of the family Malvaceae, and indeed the flowers of cotton very much resemble the other members of this family, ~~but~~ although in the fruits of the other plants in this family, there are practically no hairs on the seeds. A recent worker has proposed that cotton (and a few of its wild relatives) does not belong to Malvaceae, but to the Bombacaceae, a separate family. Many workers agree that this last relationship is more likely because there are other members of the Bombacaceae (the bombax family) with hairs on the seeds (such as kapok) and with flowers similar to cotton.

Illustrate

The hairs on the seeds are quite interesting in themselves. Each hair is a single cell, but the cell is not completely cylindrical or circular in outline. The cells are somewhat flattened along parts of their length, a feature which is attributed to the fact that the hairs develop on the seeds encased within the ovary and are therefore twisted and compacted. While the flattened areas along the cell walls of the hairs (which are practically pure cellulose with little or no lignin) make it possible to first make a strong thread, and then cloth, the uneveness tends to cause problems for the cloth manufacturer. One of the biggest problems is the fact that cotton fibers are quite hygroscopic--they take up water readily. On drying, they do so unevenly, ~~thus~~ hence the shrinking problem. Not only is ~~their~~ there variation in the length of fibers between different species and varieties of cotton, but there is also some variation in the length of fiber taken from the same plant. The fibers of the upper bolls (ripened fruits) are of a slightly different length than those from bolls lower down on the branches. This lack of uniformity is something of a problem for cloth manufacturers who would much prefer a completely uniform length to the fibers from all parts of the plant.

Another problem for the manufacturer of cotton textiles is the fact that the bolls do not all mature at the same time; the lower bolls ripen

Ch 8



Ch 8

and are ready for harvesting before the upper ones. The harvester ~~wants~~ needs to gather all the cotton from a field at one time, and must therefore let the lower, open bolls remain on the plant until the upper ones have matured and opened. As a result, the lower, older bolls may be wetted, covered with dust, subjected to mechanical and insect damage, stained, and therefore less useful for manufacturing of fine cotton goods. This problem is magnified by the use of mechanical pickers which indiscriminantly collect all bolls from each plant, without regard for such variations and impurities as those mentioned above.

Much has been done by research to improve the stability of cotton textiles. The fibers can be made less hygroscopic, and thus less liable how? to shrinkage. Much has been done to make the cloth more wrinkle-free. Frequently, admixtures with other synthetic, fibers makes a superior product. However, the textiles from purely synthetic materials still cannot be made as comfortable as cloth with high percentages of cotton in it, and for this reason, cotton will be used for a very long time to come.

REFERENCES

R. H. Kirby, 1963. Vegetable Fibres. World Crops Series, Leonard Hill, Ltd., London. This is a very comprehensive account of the vegetable fibers other than cotton.

H. B. Brown. Cotton. 3rd Ed. 1958. McGraw-Hill, N. Y.

Hutchinson, Silow and Stephens, 1947. The Evolution of Gossypium and the Differentiation of the Cultivated Cottons. Oxford Univ. Press. Much insight into the genetic history of cultivated plants in general, but with specific relation to cotton, may be gained by reading this book.

CHAPTER ~~XI~~ 9

Wood and Paper

In this chapter, we will consider the uses of the portions of certain plants developed from a growing layer in the stem known as the cambium. Primary growth of any plant develops from growing points at the apex of root and shoot. Secondary growth, the enlargement of the stem, comes largely from the addition of new layers of cells laterally by the cambium, a single layer of ever dividing cells between the bark and the wood. ~~The cambium in such plants as bamboos and palm trees is of a specialized, different type from that found in most woody trunks.~~

is this what we think of as wood?

Wood used in its natural form

Wood is made useful in many ways: as sawed or hewn pieces in lumber, as chemically and/or physically separated cells in paper, as whole trees for telephone poles or dock piling, or in crude building of huts, or cut and split pieces for fence railing, and fuel either as wood or charcoal. In the environment of the highly developed nations, wood for fuel is considered more as a luxury than as a necessity, and its use is declining, but millions of people in the less well endowed areas of the earth's surface directly depend upon this source of energy for all heating purposes. It is not an uncommon occurrence to see whole families cutting and stacking and carrying wood for great distances to or from their homes. Some prefer to cut and stack wood near the source, partially cover the stacked wood, and by partial combustion, prepare charcoal. In many ways charcoal is a more satisfactory fuel than is wood — it burns at a more even rate, and produces less smoke, and is lighter and more easily transported.

¶ There is such need for wood as fuel that scarcely any of the world's forests remain untouched, and the entire composition of ~~the~~ forest~~s~~ ~~may have~~ has been modified by repeated cuttings by nearby inhabitants. We ~~may~~ tend to think of the tropical forest, for example, as largely a virgin area, but such is usually far

Figure giving 90 of various uses of wood.

Figure, or perhaps a center plate, showing people + animals carrying fire wood.

from the truth. Though some types of wood are better for fuel than others, some people are so desperate for wood that anything that will burn is used.

I have no figures to prove my point, but I suspect that we use more charcoal in our suburban " patio cookery" in the United States (approximately 164,000 tons in 1961) than is used in any Latin American nation. Thus, though we use petroleum products or electricity to start our charcoal grills, we continue to be one of the world's greatest consumers of such products ~~of~~ wood.

~~Though one~~ walking down the main thoroughfares of cities would gain the impression that wood has dwindled to small porportions in the building industry and that concrete and steel have entirely replaced our needs for lumber, it must be remembered that concrete is poured wet, and that unless sturdy wooden frames are prepared, concrete sinks to a meaningless mass. A glance at Fig. ~~11-1~~ will indicate the great significance of wood in our modern economy. To further dispell the notion of wood's declining use in modern construction, one has but to walk into any building to find that much of the interiors are dressed with handsome panels, railings, furniture, carvings and other wooden fixtures. As a matter of fact, an inventory of the uses of wood in any one building (or its contents) would fill several pages of closely ~~packed~~ type. Many modern structures are using lumber in ways that were invented only recently. Laminated beams are providing structural lumber for large, clear spans, as in chruch auditoriums. One inch pieces are bent to fit a desired curve for an arch, and to each piece others are added, and glued together with modern bonding adhesives that provide strength greater than could be provided by a single, thick piece of lumber. Wood panels made from wood chips held together by ~~another type of~~ adhesive ~~substance~~ are modern uses of formerly waste products. Pressed hardboard (or paper board) is made by grinding up wood into very fine pulp, mixing in adhesive and then pressing out to ~~certain~~ thickness with great pressure and heat. This fine material has made it possible for the building industry to provide many new ways of construction that are light, strong, and durable. The most recent development in the American wood market is particleboard. As the name suggests, chipped pieces are formed with resinous adhesives into boards of varying thickness, and in any desirable dimension. This development is a great advance in that scrap lumber pieces and rejects can be used in a profitable way. Many uses have been found for particleboard, including core-stock for veneer panels, cabinets, floors, interior siding, floors, and several others.

~~If~~ Since wood ~~be~~ is so versatile in application, it is useful to look at the material itself to see what ~~basically~~ provides ~~the~~ its various qualities. First, lumber is rather arbitrarily classified by manufactures as either "soft-wood" or "hard-wood." Though there are some softwoods harder than some hardwoods, and vice versa, the classification at least allows one to know in general what type of lumber is being produced in certain mills. Furthermore, this classification generally separates lumber manufactured from the cone-bearing species of the Gymnosperms (pine, Douglas-fir, redwood, etc.) as softwoods, from the hardwood lumber manufactured from the woody members of the flowering plants or Angiosperms. In the northern and southern temperate zones, most construction lumber comes from the softwoods, whereas in the tropics, the hardwoods predominate. The reason for this switch is that there are phytogeographic differences--the conifers are mostly found in the cooler regions of the earth. Lumbering in general developed faster in the temperate zones than in the tropics again ~~because of~~ for botanical reasons. The temperate zones tend to have one or two dominant tree species in one region, and the lumbermen can produce from these ~~dominants~~ a much more uniform product with much less specialized equipment; in the tropics no one dominant species occurs ~~as~~ in pure stands. Mahogany is a good example--there may be only three mahogany trees of suitable size to cut in any one acre of land.

The softness or hardness of wood is determined by the anatomical details of its composition. Wood in general is secondary xylem, the technical term for that tissue derived from the cambium, and deposited on the inner side of the cambium. As the cambium manufactures new cells, they may at first appear identical, but very shortly afterwards, as the cells mature, they can be differentiated by microscopic examination. There will be certain numbers of very thick-walled cells, or fibers, as well as cells with slightly less thickening, or vascular tissue for conduction, and interspersed in greater or less degree will be thin-walled cells called parenchyma (see Fig. ~~11-2~~). Each species has its own characteristic development of each of these types of cells. If the species has a predominant number of the very heavy walled cells, with correspondingly fewer parenchyma cells, its wood will be heavier, denser, and harder, than the wood of a species that develops with few fibers and greater areas of parenchyma. To some extent the rate of growth of a tree will determine how hard the wood will be, but this statement must be applied with caution.

~~Not only~~ the proportion of the three types of cells, ~~but also~~ the arrangement of the three types within the cylindrical trunk has a bearing on the quality of the wood. Some woods have strength to withstand torque or twisting, others can withstand lateral pressures and others vertical. For example, a baseball bat is best made from wood of the American ash (*Fraxinus americanus*) because of its close-grained, diffuse porous wood. This same wood is excellent for handles on carpenter's tools, for plow-handles, etc. Oak wood does not make quite such good wood for this purpose, and is better for furniture, for barrel staves and other construction. The organization of the cells is the determining factor. Frontispiece

This may end up on the cover of the book!

illustration is a highly magnified photograph of a cross section of oak wood.

Various wood grains are desirable in surface of fine furniture. While it is possible to identify certain woods because of their common patterns, each piece of furniture wood has enough variability to make ~~each piece~~ it unique. Some of the factors that make for the variability are the position of the piece of wood in the tree, the speed or rapidity of growth of the tree (favorable or unfavorable growing conditions), the genetic variability from tree to tree, and others. The type of grain exhibited is also influenced by ~~the type of cutting of the log~~ how the log is cut. To get the maximum amount of lumber from a cylindrical trunk, the most frequent type of cut will be a series of tangential sections, and each tangential cut will exhibit a slightly different appearance. For most purposes, such tangential sections are perfectly satisfactory, particularly in construction lumber. However, in some woods, more beautiful grain patterns appear if each section made is a radial cut. Oak flooring of the most expensive type is "quarter-sawed", where each cut made is on some radius of the log (see Fig. 11-3). This type is expensive not only because the log must be positioned for each pass of the saw, thereby increasing the time of cutting, but also because there is much more waste left after radial cutting. To get the maximum amount of lumber, and at the same time, to derive the most desirable grain, experienced men must decide how each log will be cut.

For ease in cutting, most logs are cut "green" or while the trunk still has most of its moisture. Following the first cut, the lumber must be reduced in water content to an optimum concentration. ~~The optimum concentration~~ This varies, but should be an amount more or less in equilibrium with the average moisture content of the air. The removal of too much moisture would cause the wood to unevenly reabsorb moisture, resulting in checking and cracking. Drying the lumber may be done either with artificial heat in a kiln, or air-dried. The former method has the advantage of being more rapid, and better controlled, but is much more expensive than the latter. Air drying, the obviously longer process, is used most where dry, sunny days predominate. Once the lumber is dried, it is cut again to its finished size in planing mills. Some people are confused when they find that a piece of lumber labelled as a "two by four" is smaller than these dimensions. Perhaps they do not realize that they are paying for a piece of material that was originally two inches by four inches, but in the planing process has lost three-eighths of an inch in both dimensions.

Another set of factors of importance in determing the usefulness of ~~the~~ wood is ~~the~~ its chemical composition. Except for the youngest, outermost layers, the cells in the xylem (wood) tissue are dead. Though dead, they serve the plant as useful areas for storag~~e of~~ing the products of the plant's metabolism. We ~~can determine~~ know why the plant stores some of these substances, but in other cases, we can only imagine why certain products are stored in the cells of wood. One of the greatest quantities of stored substances in wood is lignin. This substance ~~is~~ forms by far the ~~greatest quantity~~ largest amount of material making up the thick-walled cells. Without lignin, wood would not be wood. It is quite inert chemically, and does not serve any known purpose in the plant's metabolic activity. Like bone in animals, it is the hard material for the plant's frame. Once deposited on the cellulose primary cell wall, it stays there for the life of the wood. Man's use of wood is certainly furthered by ~~its~~ the presence of lignin, not only because of the strength it provides, but also because it helps the wood withstand many destructive environmental actions. Wood also is the storage place of many different types of resin (such as turpentine), of waxy substances and other secondary materials that prevent decay and destruction by either molds or by insects. Bald cypress (Taxodium distichum) from the southeastern United States is very good for boat building and for underwater pilings because it contains natural fungistatic ~~(fungus resistant)~~ (agents which stop, but not necessarily kills, the fungus) agents. There are countless other agents accumulated in the wood, and man has learned to use many of them. Another substance, rather recently put into use, is a by-product of the paper manufacturing process. "Tall oil", a word derived from the Swedish term meaning "pine oil," is now finding its way into industry for paints, ~~for~~ soap, ~~for~~ as a carrying substance for printer's ink, and many other purposes. = Tall oil

Man has learned to overcome many of the imperfections found in wood for lumber. For example, a few generations ago, lumber was graded according to the freeness from knots--the places where branches arise in the trunk. Because of the orientation of the cells making up the branch, they made for a weak area in the board. If there were too many knots, the wood was unsuitable for structural purposes. To overcome this difficulty, and for a number of other reasons, the manufacturers turned to making plywood. This is the same idea essentially as laminating, mentioned earlier, but in this case, the preparation is different. Instead of sawing the log into boards, then putting the pieces together, the whole trunk is "peeled" by turning it against a very large, sharp blade. This is an over-simplification of the whole process, but serves to describe the main operation. In this way, layers of even thickness are removed as sheets. The sheets are flattened, dried, cut to size and then laid one piece on another with strong adhesive. One sheet is placed with the grain in one direction, and the next sheet above is oriented at right angles to it. This gives added strength, and provides many other desirable characteristics that would

Illustrate →

not be found in a single board sawed to the same thickness from the trunk. The making of plywood has other advantages. There is no waste from the cut--no sawdust. The manufacturer can use imperfect pieces in the interior parts of the plywood, and place on the outside those pieces with the least imperfections, such as knots, or pieces stained with various undesirable agents. Thus, we have gained both a better building material, and at the same time saved wood that would otherwise be wasted.

Veneer panel is in many ways the same as plywood. However, in most veneer panels used for furniture, the center part is not a laminated piece, but a single solid core. In the United States, one of the favorite core stocks is from the yellow poplar, also known as the tulip tree (<u>Liriodendron tulipifera</u>). This wood, when properly prepared, makes an excellent base for thin layers of selected hardwoods ~~that will be used~~ in furniture manufacture. As mentioned earlier, particleboard is now much used as core stock. Many people feel that it is "cheap" to buy veneer furniture--it isn't ~~so~~ desirable as solid wood. Perhaps the earliest use of veneer gave some reason for such decisions because the adhesive used wasn't strong enough to prevent separation from the core stock, making a "cheap" piece, ~~but~~ today the bond is such that two parts will not separate under the most adverse conditions. In fact, use of veneer today gives many more people an opportunity to share the beauty of the wood grains than would have been possible if only solid stock were available. Even so, the supply of high quality hardwoods is far below the demand. For this reason, many substitutes for wood are being used. Plastics and metal are being increasingly employed. Such is the desire for the patterns of wood, however, that designers and manufacturers are imitating the grain of various quality furniture woods.

Wood used in altered form

Some ~~indication~~ mention has already been ~~given~~ made of the importance of wood in the manufacture of paper, but we hardly stop to think of the fantastic drain on our forests and woodlands ~~when we think of paper~~ it causes. ~~Some~~ One indication of the magnitude of our dependence may be gained by the statistic that one Sunday edition of the New York Times requires the wood from ~~[illegible]~~ 227 acres of northern coniferous forest.

Paper from timber is one of the few truly modern inventions in the area of plant utilization. Only within the past 100 years have tree trunks been ground to pulp, processed by chemical treatments and then made into paper.

Historically, paper is a very ancient material. The name itself is derived from papyrus, the early Egyptian writing material made from a member of the sedge family (*Cyperus papyrus*). These plants contain no wood, and very few cells (percentage-wise) of secondarily thickened cell walls. To prepare a writing surface, layers of cells were stripped from the stems, flattened and laid out side-by-side. Then a second layer of strips was placed across the first. The whole was then moistened and pressed. The papyrus held together as a sheet because cellular substances composed largely of carbohydrates--sugars and starches--acted as an adhesive when the sheet dried. This hardly qualifies as paper, and one would be frustrated if one attempted to write with a ball-point pen on it. Egyptians used fine brushes (probably the first camel's hair types) dipped in inks derived from various plant pigments to inscribe their hieroglyphs. It is interesting to speculate whether or not the development of Egyptian hieroglyphic writing ~~wasn't~~ was dictated by the papyrus base on which they "hieroglyphed." (wrote?)

Paper as we know it was first developed by the Chinese about 2,000 years ago, and the invention is ascribed to a chap known as Ts'ai-lun.

Supposedly, the Chinese produced their first paper from the inner bark of mulberry plants and from bamboo shoots by pounding these tissues until the cells separated, suspending the macerated material in water, and passing the pulp through screens. Then the sieved pulp had the water drained away, and the fibrous material rolled and dried. This process was kept secret, and thus did not spread rapidly from the area where it originated. However, the Chinese developed paper-making to a skilled art, and produced papers that have lasted for hundreds of years. Eventually, the art of paper making did spread to the countries of the Middle East, and thence to Europe. In the Middle East, before the arrival of the art of paper-making, writing surfaces were first clay tablets, and, perhaps simultaneously, ~~the development of~~ parchment, or the specially tanned inner epidermal layers of sheep skin. The scrolls of the peoples surrounding the Dead Sea (the Essenes), now famous for the religious writings (the Dead Sea Scrolls) were made of parchment.

Somewhere along the development of paper-making, the raw material became cotton and/or linen rags, replacing the earlier dependence on the inner bark fibers. This development made the process much simpler, for the separation of the "bast" fibers of bark by mechanical means was more laborious than separating the fibers from cotton (a product of the seeds) or from linen, (internal stem fibers of an herbaceous plant). The paper quality improved with the employment of these two fiber sources, and perhaps had an influence on the development of printing, which required much tougher paper than would be needed for handwritten documents. Even today, many quality writing papers are high rag content papers, but the demand for paper ~~in~~ for ~~so many~~ different applications ~~makes it~~ is so high that it would be impossible to meet ~~the demand,~~ if only rags were used ~~for paper:~~.

Not long ago, a derogatory term for a shaky economy was ~~to dub it as~~ a "paper economy" particularly ~~so~~ when money was thought to be valuable only if it were some metal--silver or gold. The favorite Chinese derogatory term for a coward is a "paper tiger." The obvious connotation is the weakness of the earlier products, certainly a derogatory epithet that cannot be used for many types of paper today. Modern-day methods of manufacture have improved the quality and quantity of paper to keep pace with our ever-increasing demands for writing, wrapping, cleaning, protecting, and a host of other essential activities.

Paper manufacturing today results from a combination of various endeavors, in engineering, chemistry, and forestry. Certainly one of the most important early developments occurred in the early 1800's, when a suggestion by Mathias Koops (a German) was made for using wood pulp to manufacture paper. The processes for practical production of paper from wood developed within the next sixty years, when the major processes employed today were first invented. One process, is a purely mechanical one--ground wood, which was invented about 1840 in Germany, but did not come into commercial use for another thirty years. Two combined mechanical and chemical processes for separating wood into useful cellulose fibers for paper were also brought into commercial practicality in the middle to later 1800's. These two are the sulfate and sulfite processes.

Going along with the developments necessary to reduce wood to fibers were the developments of paper bleaching, filling between the fibers to give a better writing quality (sizing), and coating ~~of~~ papers to give various qualities ~~from those~~ for printing half-tones, ~~to~~ making paper less water-soluble, continuous process machinery (the Fourdrinier type paper machines), and general efficiency in the process.

A major ~~development~~ advance occurred when it was discovered how to remove some of the sticky resinous substances in various coniferous trees, allowing the production of kraft (German word for strong) paper from very inexpensive and voluminous quantities of trees in the temperate zones. Grocery bags and wrapping paper are Kraft paper.

The groundwood pulp process produces paper used most frequently in the manufacture of newsprint. Some sulfite pulp is now being added to groundwood pulp (20%) to improve the printing qualities of newsprint. Other types of paper require a much tougher product, and more refining is necessary. These are the products of the mechanical-chemical combination type manufacturing methods.

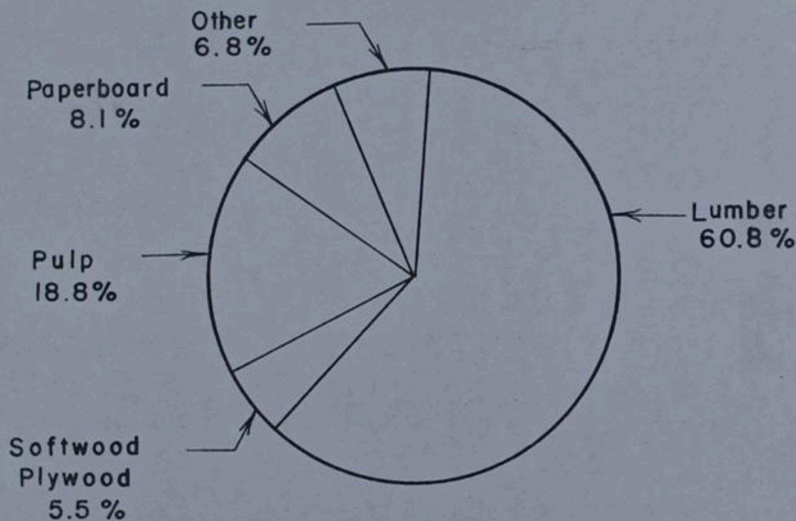
The chemical composition of wood is complex (an average softwood contains 50% cellulose, 30% lignin, and 20% carbohydrates, proteins, fats, resins, and minerals), and for this reason, to reduce the hard substances of wood as we know it to a soft, pliable, nearly chemically pure material for paper requires a number of steps. The desirable cellulose fibers in the wood are produced in the cell walls, but with the cellulose is associated the chemically-complex lignin, a substance which, unless removed from the cellulose fibers, produces a lower quality of paper. The two processes named above, the sulfate and sulfite, act ~~as much on~~ the lignin to remove ~~it as they do on~~ as well as the adhesive substances (carbohydrates and proteins) produced between the individual cells. The sulfate process produces the kraft paper, and is today the process by which the largest quantity of paper is produced. The sulfite process, on the other hand, produces a type of paper that cannot be produced by the sulfate method. Such specialty papers as glycine, and the more refined products cellophane and rayon are produced from sulfite pulp.

One of the major problems of the paper manufacturer is the biological variability of the trees upon which the whole process is based. Not only is there variability in the types of trees and their fibers, but also in the number of various species that can be economically produced. Such variability inevitably leads the manufacturer to seek more reliable, uniform starting materials. (The same point was made in the chapter on vegetable fibers) Recently synthetic fibers have been introduced into the paper-making process, with some remarkably strong papers resulting. However, there is not much prospect that synthetic materials will completely replace naturally-produced raw materials. Wood, in any form, has managed to more than survive in our modern economy--its usefulness grows as our imagination and ability to think of more efficient and satisfying products. Just look around you--there is wood.

One more word: wood is a <u>renewable resource</u>. Through proper husbandry of our forests, we will be able to continuously supply mankind's needs.

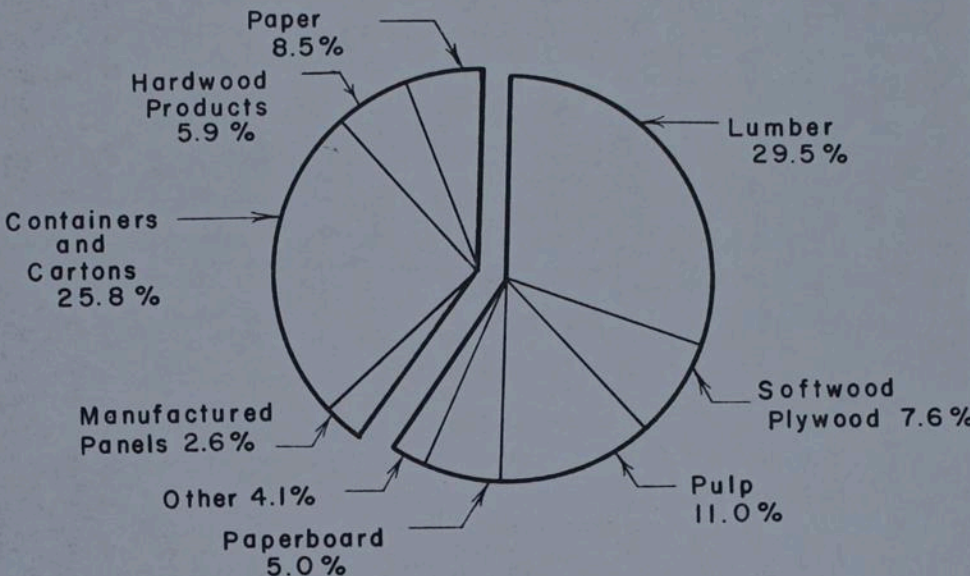
Ch 9

A DECADE AGO



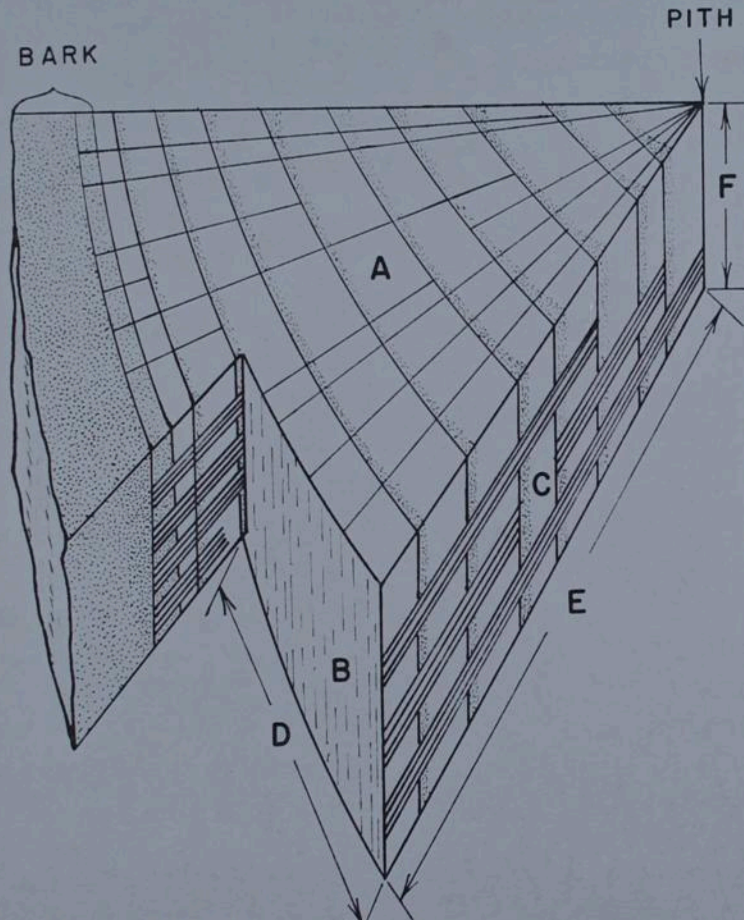
Ch 9

TODAY



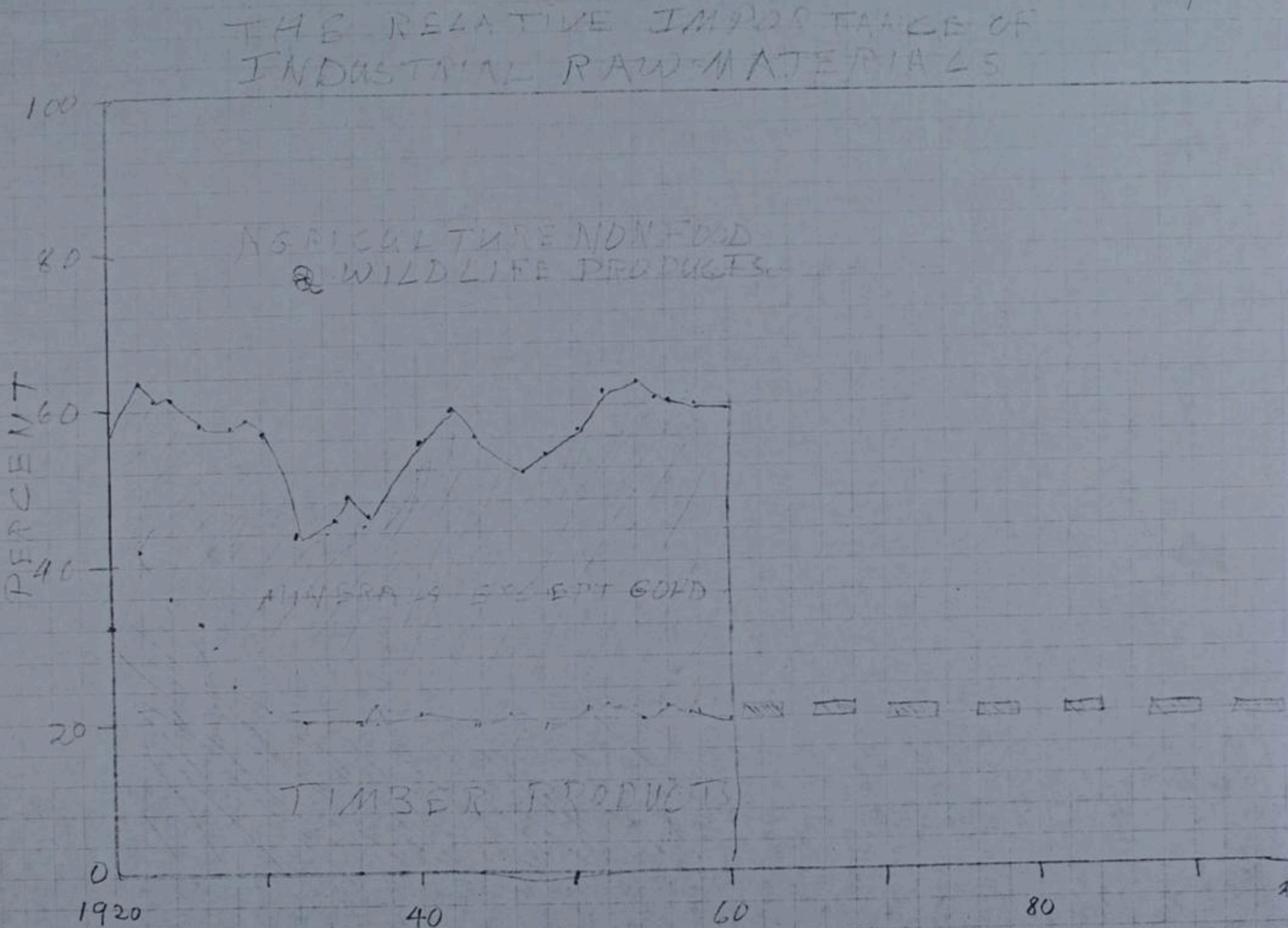
Paper
8.5%
Hardwood
Products
5.9 %
Lumber
29.5%
Containers
and
Cartons
25.8 %
Softwood
Plywood 7.6%
Manufactured
Panels 2.6%
Pulp
11.0%
Other 4.1%
Paperboard
5.0%

Ch 9



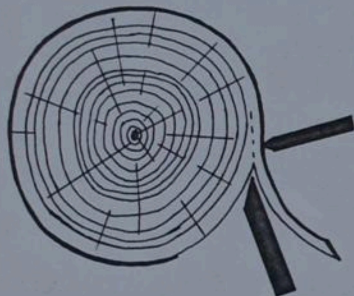
A-- CROSS SECTION
B-- TANGENTIAL SECTION
C-- RADIAL SECTION
D-- TANGENTIAL DIRECTION
E-- RADIAL DIRECTION
F-- LONGITUDINAL DIRECTION

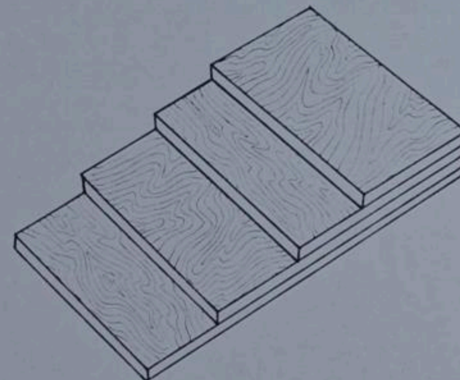
Ch 9



THE RELATIVE IMPORTANCE OF
INDUSTRIAL RAW MATERIALS
AGRICULTURE NONFOOD
& WILDLIFE PRODUCTS
MINERALS EXCEPT GOLD
TIMBER PRODUCTS
PERCENT
100
80
60
40
20
0
1920
40
60
80

Ch9





REFERENCES

1. General

For details of the structure of plants and their internal anatomy, see Crockett,__________________, in this same series.

2. Wood

Many libraries have copies of a unique series of "publications" originally produced by R. B. Hough, entitled American Woods. A later edition, by E. S. Harrar, entitled Hough's Encyclopedia of American Woods, was published by R. Speller, New York, in 1952. Actually, the several volumes in this series contain a number of very thin sections of wood of various American tree species. For each species, there is a cross, longitudinal and radial section mounted, and with each species the identification and description of the species are given.

From one of the most famous commercial concerns in the United States dealing in specialty woods comes a book by the owner, Albert Constantine, Know Your Woods, etc., published in 1959 by Home Craftsman Publ. Corp., New York. For an international view of wood and its uses, a good popular account is given by B. Latham, Wood, from Forest to Man, published in London by G. G. Harrap in 1964.

3. Paper

A fine, popular account of the many aspects of paper is given by J. H. Ainsworth in Paper. The Fifth Wonder, published in 1958 by Thomas Publ. Co., Kaukauna, Wisconsin. For a good technical account on paper, consult K. W. Britt, Handbook of Pulp and Paper Technology, Reinhold Publ. Co., New York, 1964.

CHAPTER ~~12~~ 10

Elastic Materials

Gums

To most Americans, the word gum means primarily a substance with some flavoring that does not dissolve when chewed, but stays about its original size no matter how long it is chewed. This substance is sometimes called chicle, and is produced by *Achras sapota* trees growing predominantly in Mexico and Central America. But if considered longer, the word gum is found to include many differing substances, some elastic, some sticky, some water-soluble, and some soluble only in organic solvents such as alcohol, or acetic acid. About the only thing these various substances have in common is that they are all largely plant-produced, and most are exuded through slashes in the stem, or root. A few are produced by grinding up the various parts, particularly seeds and leaves. Rather than give a lengthy discussion to various classifications, let us merely divide the gums on the basis of one of their chemical properties. Rubber, and the other non-water soluble gums are hydrocarbons in some combination with resins, and the water soluble gums are usually complex carbohydrates.

Illustrate

?

The complex carbohydrate, water soluble, gums are not truly water-soluble, in that they are colloidal substances, but the particular colloidal form they have is such that ~~these gums~~ they disperse to a liquid phase in water. These gums, of which the most important are gum tragacanth (from *Astragalus* species) and gum acacia (mostly from *Acacia* species), are very important in pharmaceutical and food industry. Others make useful adhesives (i.e., the adhesive on stamps and envelopes).

~~Rubber~~

The hydrocarbon, non-water soluble, gums are a diverse group within themselves, and have many different uses in commerce. The most prominent of these are rubber and gutta gums, and the reason for their prominence is their high content of a complex molecule called a polyisoprene. The rubber gum contains a cis-polyisoprene, and the gutta gums contain the isomer, trans-polyisoprene. The former molecule is responsible for the elasticity of the rubber, and while the second is less elastic, the gutta gums also have some "give" to them, and are useful in ways related to ~~the~~ rubber. Gutta gums have the property of being nearly solid when at normal temperatures, but become plastic when heated. They are, or have been in the past, used as insulation on electrical wiring, and particularly on underwater transmission cables. They are also used as the core substance in golf balls, around which long strands of rubber are wound.

Figure - a diagram of the main structure of the polyisoprene.

The gutta gums have been largely replaced today by synthetic materials made either from coal or petroleum products. This is true also for natural rubber, but to a lesser extent. Because of the importance of rubber in our present society and the role of rubber in history, the major discussion in this chapter will be devoted to this substance.

Rubber

At many points where the early Spanish and Portuguese explorers touched the tropical American shores, they found the natives using substances never before seen by Western European cultures. In Mexico, the Mayans and Aztecs used an elastic substance to make balls used in a game similar to basketball. Pizarro's men, who conquered Peru, noted the native use of a cape which shed water readily, and slippers to keep feet dry. But these were rather casual uses of certain plant materials, and did not impress the newcomers greatly. Perhaps one reason for lack of great interest in these particular substances was the rapid deterioration, and sticky nature of the materials. Another reason might be that the substances were not harvested from cultivated plants, but collected from wild stands. At various points where the European explorers noted the native use, the products were probably produced from a variety of different plant species. Along the eastern shores of South America, the elastic products could have been manufactured from the latex of *Hevea guianensis*, *Hevea brasiliensis* or from *Manihot* species; the capes and slippers found by Pizarro's men in Peru probably came from species of the genus *Castilla*, and the balls used by natives in Mexico might have been derived from *Cnidosculus* species.

Fig illustrating rubber tapping.

There is no record of the early transport of the trees that produced these substances back to the Old World. This ~~would come~~ came much later, after colonization of the New World was almost completed, in the 19th century. That particular story is dramatic, and, in its own way, had a tremendous influence on the world's commerce. One country's economy was ruined, and ~~that of~~ another~~ area of the world~~'s, greatly improved.

The origin of the "rubber" name ~~of the materials~~ is rather odd. The almost universally accepted English name for these substances with the interesting properties of elasticity and rain-resistance did not come from the native name, but was supplied by a chemist, Edward Nairne (1726-1806) who noted still another useful property of the products. This property is the ability of the substance to erase carbon pencil marks. Soon, the material used for rubbing was given the name of its action, and became rubber! The native name may have had something to do with the substituted one--it ~~doesn't~~ does not fit European tongues well--"caoutchouc" (Ku'-chuk).

Rubber is mostly derived from one tropical American tree, *Hevea brasiliensis*, but there are other species of the same genus from which the

center photo of rubber tree

material may be derived, as well as from other, unrelated species. In Brazil, Ceara' rubber is derived from Manihot glaziovii, a small tree species in the same family (Euphorbiaceae) as Hevea. Small quantities of rubber may be derived from quayule Parthenium argentatum in the sunflower family. This particular source was greatly pushed during World War II, when the western powers were cut off from the major source of Hevea rubber, the East Indies (Indonesia), but it never became economically feasible. Still the number-one producer of rubber is the Brazilian rubber tree, but not in its native habitat. These rather handsome trees, growing to stately forest giants in the native Amazonian jungles, occur only sporadically, never as concentrated in numbers per acre as we would find pines, oaks, or maples in temperate zone forests. If man attempts to make plantations of these natives in their own habitat, he is thwarted by the fact that a virulent disease (a leaf-spot, caused by the fungus, Dothidella ulei spreads rapidly through the plantation. As a result, there are very few plantations of rubber in productive stands in the Americas in spite of intensive research by a number of governments and private business organizations.

Sir Henry Wickham was commissioned by the British government in the latter half of the 1800's to study Brazilian rubber in its native habitat and to transport seeds from Brazil to England for transplanting to the British-held island of Ceylon. In spite of the difficulty of transporting viable seeds, Wickham was successful, and a few plants were raised in green-houses in England, and then transported to Ceylon. The plants were very successful in the new habitat, half way around the globe, free from the destructive disease of the Americas. Fortunately, Wickham was successful in getting disease-free trees, and to this day the fungus has not been found anywhere in the eastern tropics where rubber is most successfully raised. There is a constant danger that the disease will be accidentally transferred, and then the serious problems of developing disease-resistant strains will have to be faced. Whether there is some reason why the disease will or will not succeed in the eastern tropics is an open question. There may be environmental factors at work which discourage the disease while at the same time favoring the vigorous growth of the rubber trees.

Brazil's economy was drastically affected very shortly after Wickham made his transport of the rubber seeds. Brazil had attempted to corner the rubber market, and fixed prices that almost guaranteed that some way would be found to circumvent the restrictions. But before the plantations of the East came into bearing, and were of sufficient numbers to meet the market, the Brazilian economy boomed. Huge fortunes were made and large cities erected in areas where the rubber collecting centered. Manaus, at the confluence of the Rio Negro and the Solimoes (main branch of the Amazon), was the most spectacular development about 1000 miles upstream from the mouth of the Amazon. Here was built an enormous opera house that has been maintained, and large public buildings copying the grand European style of architecture, with every piece of building material transported by ship from Europe. Belém, at the mouth of the Amazon (actually on one of the branches near the mouth, the Guama) also shared in the sudden wealth. Its streets were paved with cobblestones brought from Europe, and some of the buildings from this era are fine examples of the best European architecture. About 1905, the Eastern plantations became fully productive, and the Brazilian rubber monopoly was broken. The wild-collected rubber was not only of lower quality, but it could not be harvested as economically as the lined-out plantation trees. The number of laborers available in the eastern tropics far exceed the under-populated Amazonian basin. The imported labor in Brazil found great difficulty adapting to the life required in rubber-growing areas along the Amazon River and its tributaries. The laborers that did survive were horribly exploited, in an almost slave-like state, and there was little sharing of the great wealth derived from their efforts.

Interest in the development of plantation-grown rubber in the Western tropics was stimulated during two world wars, when the regular supply was cut off. The United States Government subsidized research and carried out large programs to help Brazilian rubber specialists to overcome the disease problem. However, at the end of each of the wars, in an economy-mood, and with pressure from the synthetic manufacturers, all the efforts stopped, without any great advances toward the solution of the difficulties. The solution of the disease problem takes long-term support because determination of disease resistance and high yield require long periods of time. The research required cannot be performed in the length of time that the wars have lasted, and to build up competence in the work, research specialists require time, much more than that allotted. Many approaches to develop plantations of disease-resistant, high-yielding trees have been tried, but the most promising one yet developed is the breeding of the disease-resistant varieties. While the disease can be controlled by spraying with fungicides, the expense of such an operation is prohibitive in lands where high rain-fall is a constant condition. The breeding of resistant types is also a very discouraging, slow procedure, and very expensive.

In general, and without all the details, the methods of developing new resistance is as follows: first, seeds from native plants are germinated in seed beds, and when the young plants have sufficiently developed, are set out in nursery beds. When the plants are about two feet tall, cuttings of high-yielding varieties developed in the eastern tropics are grafted onto the seedling root stocks. These grafted plants are again transferred and

Illustrate

planted sufficiently far apart to allow even growth all around. When the trunk of the plant has grown to about eight feet tall, a second graft is made. The plant material for the second graft is selected from varieties thought to be disease-resistant to the leaf spot. These trees, after the second graft has had time to grow a good set of leaves, are then set out in plantations sufficiently well-spaced to permit the trees to grow to producing size. Thus, each plant is composed of three different sets of Hevea brasiliensis germ plasm: the rootstock, the high-yielding "panel", and a disease-resistant top. These plants are then carefully watched to determine their ability to withstand disease onslaught and rubber yield.

ok
note preceding page root stocks (apres)

The difficulties in this technique, which has been in operation for a number of years, are multitudinous. First, the various grafted portions may not be "compatible"--the panel may be more vigorous and grow more rapidly than the rootstock; or the reverse may be true, producing odd-shaped plants at the point of grafting. The same incompatability may also occur between the panel and the top. Until the second graft has been made, the trees must be sprayed frequently to keep the susceptible portions free of the leaf spot. Even after a successful second graft is made, there are many chances that disappointment awaits the researchers. As a matter of fact, only a very few varieties have been successful out of a very large number ~~millions~~ attempted, and few of these are good yielders for the length of time required to recover the costs.

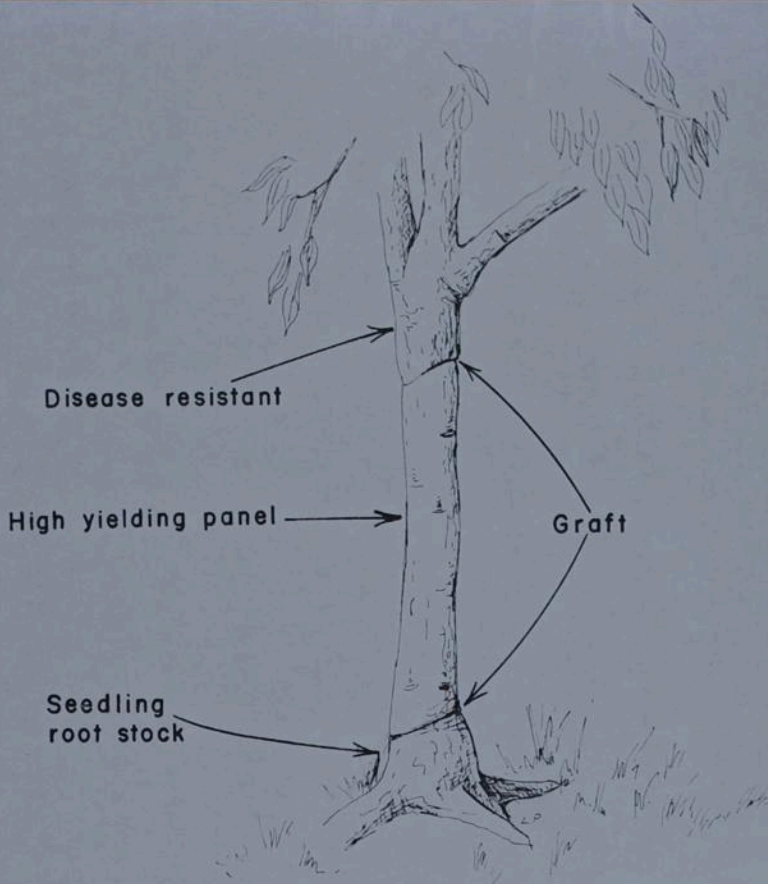
With this uncertainty, and with the costly effort required for such skimpy positive results, the question can be raised "why bother to continue?" There are many valid reasons, reasons which apply not only in the case of rubber, but for almost all of our use of plants for man. Though we do have synthetic rubber, there are still many interesting and valuable properties found in the native plant products not found in the synthetic substances.

There are many variations in the plant-produced substances, some of which may be found useful in ways yet undiscovered. Another valid reason is that for many countries, the price of the synthetics are still too high, and the plant-produced elastics are ~~still~~ more economical. The various South American countries still derive benefit and products from their native rubber stands, and to supplant these with imported synthetics has an adverse effect on their economies. There are scientific results of fundamental importance to be gained by the continued activities to overcome the dreaded leaf spot of Hevea in the American tropics. If we can overcome this virulent disease in these plants, perhaps other tree crops can be better protected, or the same skills and knowledge applied in different ways.

The impetus for cultivation of the trees in the eastern tropics came from the increased use of rubber products. At first, the products had serious limitations--rapid deterioration, lack of good qualities when warmer than a certain temperature or when colder than certain limits. The rather accidental discovery by Charles Goodyear in 1839 that the raw material, when heated with sulfur, not only lasted longer but became more elastic, and was not adversely affected by great temperature variations, opened the door to many uses.

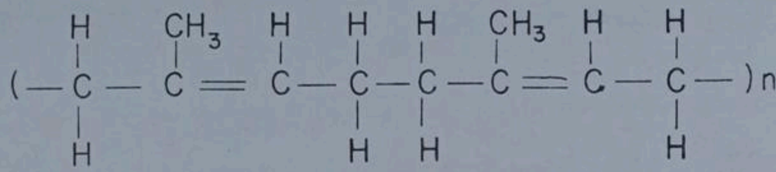
The raw substance produced in the various species is an interesting material. First, there is no known physiological value to the plants that produce the large molecular structures known as polymers and the method of production of the polymers in the plants is poorly understood. In the plant, the latex is liquid, and only on exposure to the air does ~~is~~ it coagulate~~d~~. In most species, the rubber-carrying tissue is in the phloem (roughly the bark), and because of this, it is easy to extract the latex from the living trees. The bark of Hevea brasiliensis has remarkable capacity for recovery from wounds, and knowing just the correct procedure, collectors can keep trees in production for as long as a quarter of a century. Various techniques for collecting the exuded latex are employed, and the end product is a much added-to material. With a little consideration one may make a long list of important applications of rubber. No means of transportation could exist without rubber in numerous forms, from the tires and shock-absorbing bumpers to insulation and weather-proofing. The typewriter would hardly be successful without the soft rubber roller that absorbs the shock of the striking key. Certainly walking would be less comfortable without the rubber used in shoe soles and heels. An interesting application of the latex is for surfacing roads, in place of asphalt. Endless belts of fiber impregnated with rubber carry tons of materials for processing, or drive motors, fans, crushers, etc.

Although natural rubber is being replaced in many applications by synthetic substitutes, none of the substitutes have all the qualities that Hevea rubber has, and it is not likely that there will be a time when the plant-produced material is completely dispensed with.

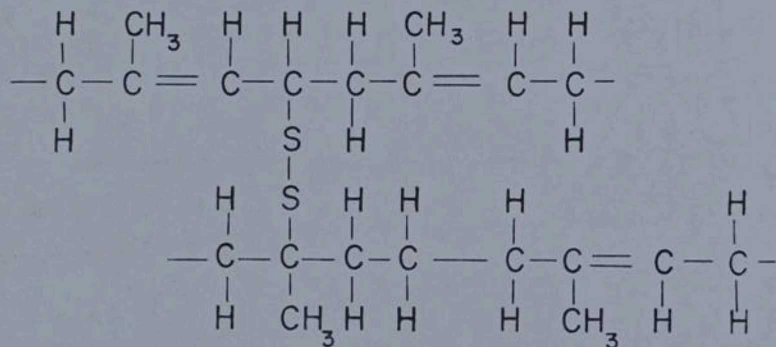

Disease resistant
High yielding panel
Graft
Seedling
root stock

Ch 10

Ch 10



Unvulcanized natural rubber



Hypothetical chemical structure of vulcanized natural rubber showing one sulphur cross-link.

REFERENCES

A series of articles in the journal ECONOMIC BOTANY, written by Llewellyn Williams, and all entitled "Laticiferous Plants of Economic Importance", discuss many, if not most, of the kinds of plants from which various elastic products are derived. The first three papers in this series were published in volume 16, 1963 of ECONOMIC BOTANY, and the remainder appeared in the 17th volume, 1964.

Chapter ~~13~~ 11. Ornamental Plants

We are surrounded by the beauty and satisfaction of plants, both in their wild native setting and in our own man-made habitats. Inddors and out, in all seasons, not by utility, but purely for their beauty, plants have ~~some of their most~~ fundamental values to mankind. Man is certainly inspired by the tall, magnificent spires of evergreen trees and under whose canopy he may have the closest feeling of oneness with a bigger, more encompassing world than in almost any other setting. Through the ages he has attempted to bring these feelings closer to his daily life by cultivating herbs, shrubs and trees of a fantastic array of variations in color and form.

The fundamental attribute of plants which makes them valuable to us as far as providing free oxygen, also provides us with a very satisfying color, green. Photosynthesis occurs in chemical structures within the plant, because the processing of light energy to chemical energy does not require and/the green portion of the spectrum, we have a color that softens and enlivens our visual senses. Were the green but of one hue and intensity, this could be dull and uninteresting. Fortunately, plants have a marvelous mix of light, medium and dark green; bluish-green, reddish-green and just plain green, glossy or dull. Other plant pigments that make plants satisfying are the reds, blues and yellows found in stem, leaf, and flower. Basically, these pigments are anthocyanins, carotenoids and flavones. Their varying concentrations, their placement in the various organs of the plants, and different concentrations of plant acids produce all the color variations we see. The ~~factor,~~ placement, (location of pigments) is a morphological feature of the individual species. In some plants the pigments are deep below the epidermis, making the color darker, or less intense. Other plants, such as dusty miller (*Artemesia stelleriana*), have hairy coverings which mask the green pigments, giving a slivery aspect. The pigments may also be modified by the presence

Question for Dr. Klein: Can you suggest a figure giving a spectrum of colors, where would you relate the various pigments to this spectrum? Not in Black + White RK of varying layers of a waxy coating, the cuticle, exuded from the epidermis. Usually the "bloom" on fruits, and the bluish-green cast of various leaves, is produced by the cuticle.

Figure: leaf vein pattern of the giant water lily Victoria amazonica and of some typical monocots.

The varying patterns of leaf veins (vascular bundles which are the conducting and supporting elements of the leaf) also have modifying effects on the pigment expression. In leaves there are two basic vein patterns--parallel, as in grasses, orchids and lilies, and netted, as in maples, oaks, poinsettias, etc., but the variations on these two basic patterns are many and interesting. Frequently the veins have a different pigmentation from the tissues between the veins. The color variations of many house plants are due to these differences.

In addition to the color variations of plants useful in ornamental plantings, the multitudinous forms of plants lend themselves to almost any desired effect. Forms of trees may be generally classified as conical-shaped, as many conifers, fan-shaped, as the American elm, or globose, as the sugar maple. There are many intermediates between these three categories and all have some pleasing effect. Shrubs may also be classified in the same categories of form. The overall form of the individual plant is controlled by genetic mechanisms and is generally the same for the whole species, though variations between and among species of the same genus occur. For example, in the elm genus (Ulmus), the American elm has a fan shape, but the Chinese (Siberian) elm is more globose to conical.

Fig. illustrating these forms

Where pruning of trees and shrubs is done for more desirable effect, one must consider the particular form and growth habit of the species, attempting to maintain the general form rather than to change the form to something quite different from that which is genetically controlled. Many bizaar effects may be achieved by pruning, and some special categories of ornamental gardening frequently have interesting colors or unusual patterns which, either in nature on in gardens, give us pleasure. In the respect, perhaps the most outstanding tree of the northeastern woodlands is the paper, or white birch. In late fall, the white bark is striking contrast to an otherwise dull drey or brown landscape. Combine these trees with a background of evergreen hemlock or pine or spruce and very pleasing effects are produced. A shrub with unusual bark patterns in *Euonymus alata*, the burning bush. Corky extensions of the bark form wings on each side of all the branches, and when snow falls, the lacy patterns of snow caught on the wings is very handsome. Other bark patterns are interesting for deep fissures in the bark, giving contrasting light patterns; striped barks of such trees as moosewood (*Acer pennsylvanicum*) produce very desirable effects.

We mentioned earlier that the veins of leaves make interesting color pattern variations. Leaves have other characteristics, particularly in form, which make them valuable as ornamentals. Indeed, florists take advantage of this in construction of bouquets and corsages. Seldom are these made with flowers alone, and even the lovely orchid corsage has some sort of green foliage background. The foliage selected for these backgrounds has to provide a beautiful setting for the center-stage flower and also must last at least as long as the flowers. For this reason, leaves with a heavy cuticle, or thickened and succulent interior, are selected. Leaves, like flowers, vary in the length of time they will remain fresh and colorful after cutting.

Kinds of Plants Used as Ornamentals

From the foregoing discussion it should be evident that almost any plant can be used as an ornamental. Even mosses, without true stem and leaf, are employed in ornamental plantings, particularly in some Japanese gardens. Ferns are frequently used as decorative plants in shaded or moist areas. The coniferous plants (gymnosperms) are favorites used by nearly all peoples, from the coldest to the warmest parts of the earth. In the temperate zones, perhaps the commonest genus of gymnosperms used for ornamentation is Juniperus, in a multitude of species, varieties and forms. Closely following the junipers in popularity are the arbor-vitaes (Thuja species). Many pines, spruces and hemlocks are also choice garden plants. An interesting characteristic found in most of the conifers is the dwarfing habit, where, by some genetic modification (a mutant or sport), the distances between the branches is much shorteneed, and much more compact, dense-leaved effects are achieved. The dwarf conifers are some of the most expensive nursery plants in the world. This is true because it takes many years of growth before these dwarfs reach a sufficient size to be marketable, and thus represent a considerable investment by the nurseryman. ~~Kinds of plants used as ornamentals~~

Many of the 300-odd families of flowering plants and cone-bearing groups have ornamental representatives. It is hard to judge which family has the largest number of ~~useful~~ ornamentals, but I would hazard a guess that the sunflower family, the Compositae, has more different species cultivated for their beauty than any other. But the rose and bean families (Rosaceae and Leguminosae) must be close seconds in number of species so used. The grass family, as in many other instances throughout this book, contributes greatly to our gardening pleasure.

One man's ornamental is another man's weed. In the eastern United States, Campanula rotundifolia (bluebell or bellflower) is much sought and cared for in gardens, but people in the western plains states make considerable effort to eradicate it from their lawns. Tropical weeds frequently are found as ornamental house plants in the temperate zones. For example, Rhoeo discolor has to be chopped out of fields in Jamaica, but makes a very handsome planting in greenhouses and homes in the temperate zones. But the qualities which make for weediness are sometimes of advantage for ornamentals, to the are topiary and bonzai. In topiary work, the successful practicioner selects plants whose growth habit lends itself to what might be called plant sculpturing--forming "statuary" in the forms of horses and men or various architectural structures such as gates, interrupted columns, etc. In bonzai, where the plants (either conifers or broad-leaved deciduous species) are kept in a stunted condition, the practitioner attempts to produce bizaar shapes, but within the general growth pattern of the species he selects. For example, if a maple species is selected, the bonzai will be most successful when the generally globose, though stunted, shape of the plant is maintained.

We do not usually consider the process of grass mowing as pruning, but it should be in this category. We could not have our close-cropped, smooth surfaces unless the morphology of the grasses used in lawns permitted. In many grasses, the growing point of the stem is very close to the ground, surrounded and protected by encasing leaf-sheaths. Thus, clipping the leaf blades does not reach the point from which new growth is developed. Indeed, judicious mowing actually stimulates the production of more leaves. Incidentally, this characteristic of grasses makes them exceptionally well-suited as pasture plants. Animal cropping does not usually cut off the growing points unless the pasture is over-grazed.

Fig showing morphology of bluegrass and location of growing point.

Effective decorative forms may be achieved by plants whose growth-habit is a vine. Both herbaceous vines (i.e. Philodendrons) and woody vines (Virginia creeper, Parthenocissus quinquefolia and many others) are used indoors and out for decorations or effects backgrounds. Herbaceous plants in the temperate zone make pleasing masses of color, or outline other plants which we desire to highlight.

Plant form may be pleasing in other ways. The bark of shrubs and trees extent that the types of plants which have such hardiness are useful when plants are grown in our dry-heated homes.

Garden types

What constitutes a garden is largely a definition made by the individual. In some gardens, plants are strictly in the minority contrasted with cement, gravel, stone or rock. Some people can make an attractive ~~a~~ ornamental garden ~~for ornamental purposes~~ with vegetable crops ~~as the most esthetically minded individual can desire~~. The common cabbage can be used in its numerous variations to produce ~~a~~ satisfying color and forms ~~garden.~~ Espaliered (formed on a trellis) fruits, i.e. pears, apples, cherries or peaches, can provide a marvelous background for any garden. Recall that tomatoes were once considered as much or more an ornamental than a food plant.

Some of the most useful culinary herbs[1] are grown as hobbies by people as much interested in design and architecture as they are in the value of the produce from the garden. A favorite form for the herb garden is the "knot" garden where rows of dissimilar color forms are intertwined for the effect of a knot. But it is likely that the form and design aspect grew out of an earlier need, where the housewife either grew her own spices and herbs near the kitchen stoop, or did not have any of the useful food adjuncts--the earlier grocery stores ~~ies~~ did not stock them. Medicinal herbs once provided the druggest with his major source of curative materials, and indeed, one of the great stimuli for the study of plants was the interest developed from the need for medicine.

Fig. illustrating a knot garden

ftnote

1 (*) Definitions of herbs are as complex as any other aspect mentioned in this book. Many herbs are used as garnishes (parsely, Petroselinum crispum, and watercress, Nasturtium officinalis) or as fresh greens; others, such as sage (Salvia officinalis), thyme (Thymus vulgaris) and many more are used primarily in cooking; some are used for beverages (mint tea, etc.) and still others as pleasant odor-producing materials in nosegays or sachets. The primary characteristic of all these is that they contain some pleasant, aromatic, essential oils.

We commonly grow Digitalis purpurea (foxglove) in cool-temperate gardens, but the earliest growth of these plants was for the drug, digitalis, extracted from the leaves and used in the treatment of various heart diseases.

In this country we are the inheritors of many foreign contributions to our gardens. Indeed, since man has been interested in ornamental plants for a very large part of his civilized state, most of the species used are those that were developed in the older cultures of Europe and Asia. No doubt the earliest of men could not afford the luxury of ~~time to~~ spend his time on a thing so frivolous as decorative plants, but as civilizations grew (because of improved agriculture) then gardening and an interest in esthetic things became more widespread. One of the Seven Wonders of the Ancient World was the Hanging Gardens of Babylon. Though long since disappeared, the story is that King Nebuchadnezzar had the hanging gardens built for a favorite wife about the 6th century B.C.E. In this garden were grown tropical ornamentals (in baskets) palms and other exotic plants purely for the pleasure they ~~plants~~ provided. No other gardens achieved such fame for another thousand years. Certainly the Greeks and Romans had gardens, but none of them made such an impression on the public. The inhabitants of monasteries and other religous foundations in the Middle Ages kept gardens, but largely for utilitarian reasons. They were most likely kitchen gardens, or gardens of medicinal plants.

It was probably through interest in medicinal plants that in the Renaissance, ~~that~~ the interest of royalty was attracted, and the beginning of modern type gardens emerged. In this period every European country established "royal" gardens, many of them as vigorous today as when they were begun. At first, these large royal gardens were but for the pleasure of their owners, but slowly they were transformed to allow all people to enjoy them. These gardens became regular institutions for the study of plants, and there the whole science of botany had its beginning ~~in them~~. Through the botanists on the staff many expeditions to various parts of the New and Old World were mounted. Almost every voyage had ~~a staff of~~ botanists along with the mission of discovering new and useful plants for the country sponsoring the expedition. These botanists expanded the knowledge ~~of~~ about plants by bringing back living and dried specimens for the botanical gardens. At these gardens, new types of endeavors were fostered--the science of classification was given stimulus and support; interest in better methods of growing the plants and caring for them gave impetus for the science of horticulture. The basic functional aspects of plant growth began with fertilizer experiments in botanic gardens, and in a small garden in Brno (formerly Brünn), Czechoslovakia, the science of genetics was born with the work of Gregor Mendel.

Slowly these gardens added other functions. The first efforts in education were probably in the development of apprentice gardeners. There was a need for a staff to maintain the plants in the individual gardens, and to train them, the older gardeners took in young men to learn the intricacies of plant care. From such beginnings, more formalized instruction grew and with this, came the first relations with the universities where all the sciences were, at various periods ~~over the last two hundred years,~~ becoming established. It is not uncommon today to find that graduate students in botany ~~in universities~~ do much of their research on plants at related (formally or informally) botanical gardens. This is more true in Europe than in the United States, though there are several universities with formal ties to large botanic gardens in this country.

In the United States, ~~without royalty,~~ a few wealthy private individuals established a small number of botanic gardens. These institutions, while extremely ~~productive~~ active in days before taxation took away their sources of income, have fallen on rocky times today. Most of the botanic gardens in this country are privately endowed, and without the recourse to public funds, cannot maintain the former excellence as ~~the~~ initiators in the study of plants. It is a pity that our political leaders have not had the foresight and encouragment from their constituents to find ~~accomodating~~ methods for the support of these private institutions whose goal is the common good and enrichment of mankind.

Ornamental Plants in Modern Economy

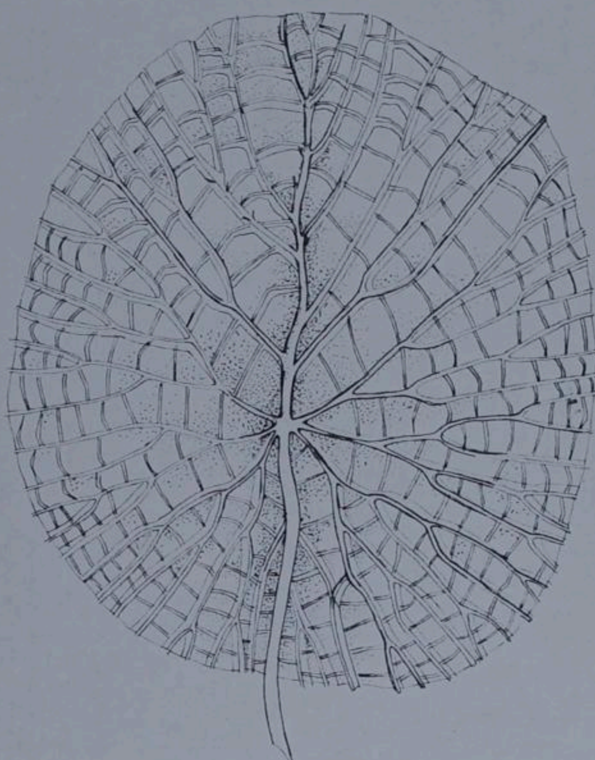
The business of providing ornamentals for the public has grown by leaps and bounds in the past few decades. This is particularly true in the United States, where several governmental decrees have greatly stimulated the nursery industry. In governmental underwriting of loans for housing through the Federal Housing Authority and the GI Bill of Rights, a clause is included which states that houses built with these guaranteed loans must be landscaped before the contract is considered complete. Landscaping of the new federal interstate highways is an integral part of the construction. The recent efforts of Mrs. Lyndon Johnson, the First Lady, to beautify America has had a profound effect on the whole area of raising ornamentals for profit. While there ~~has~~ have always been a number of ~~ordinary~~ citizens interested in gardening in the United States, these measures and stimuli have greatly increased the numbers of people working in these areas.

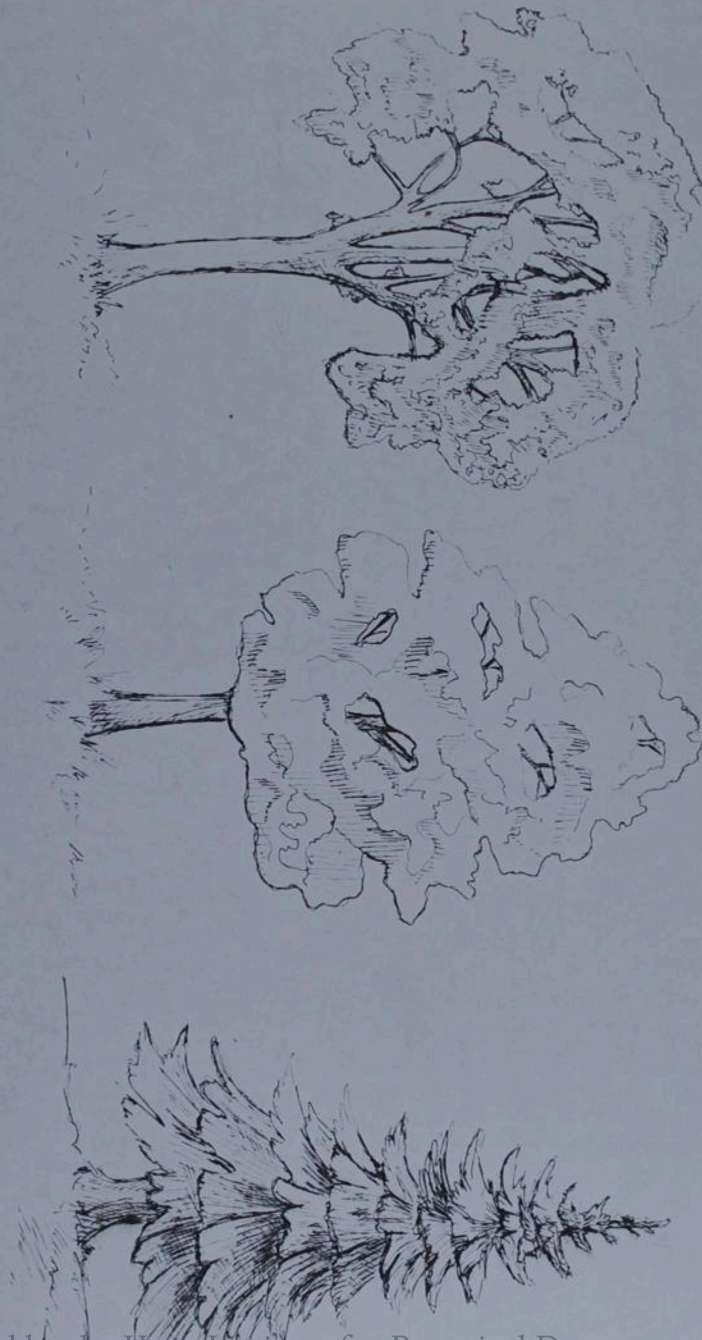
It is true that anyone can have ornamental plants, no matter how rich or poor, and that a "cutting" of a geranium, an African violet, or a rose bush can be propagated in the meanest hovel, free of charge. Yet the rose industry in the United States is a multi-million dollar industry. African violets are reported to bring more income than the total apple crop in the United States. Perhaps no ~~other~~ crop, ~~raised for~~ food, costs as much as lawn grasses. When one considers the number of weekend manhours spent mowing and cultivating lawns by suburban Americans alone, the cost of bluegrass (*Poa praetense*) becomes astronomical. When the cost of high-grade, ~~pure,~~ grass seed, fertilizers, soil conditioners, weedicides and pesticides, mowing and sweeping equipment is added to the labor costs, I am certain that my estimate of costs would be conservative.

In every state one may find nurseries that provide plants suitable to the climate and soil of that state. The nursery industry has the same structure as most other industrial complexes. That is, there are wholesale nurserymen usually concentrating their efforts on a few plant species, and retailers who buy from several wholesalers. The florist's trade is established in the same general way--the poinsettias for Christmas, carnations and chrysanthemums for bouquets, are raised in large, wholesale greenhouses or out-of-doors in subtropical areas of the United States and Puerto Rico. Orchids for corsages are now largely raised in Hawaii and flown to the continent in jet freighters. This pattern of wholesale and retail trade in ornamentals is followed for the same reasons: knowledge of the growth and development of each type of ornamental, and the necessary mechanics of growing these plants, makes it more economical for both personnel and equipment to concentrate on one or a few similar types, but the wholesaler would have trouble marketing his plants if he had to deal directly with the public. However, some of the largest nurseries and seedsmen carry through the whole process from production to retail trade under their own names. These large units are responsible for the various tempting colored catalogues of beautiful flowers and luscious fruits that come to our homes in the dead of winter.

These private companies depend heavily on government-supported research work in agricultural experiment stations where certain staff members concentrate their efforts on various aspects of the problem of producing attractive and healthy ornamentals. The same or similar diseases attack garden plants as any other crop; soil fertility is an important factor; new methods in plant breeding and hybridizing are essential for development; plant exploration for new types of ornamentals; and studies of the economics of marketing ornamentals, are all vital functions to support our desire for plants raised for pleasure.

Ch 11





Ch11

REFERENCES

The reader is faced with an extremely voluminous literature on ornamental plants. The only way to satisfy one's curiosity from reference sources is to define the area of interest in gardening precisely, establishing a number of key words describing this area, and then proceed to the catalogues of the nearest library. To give some help along these lines, I recommend, for encyclopedic works, L. H. Bailey's Cyclopedia of Horticulture. Another valuable, and more recently published encyclopedia is the New Illustrated Unabridged Encyclopedia of Gardening, editted by T. H. Everett. These two cover most of the subjects and plants which are likely to be found in the temperate and sub-tropical areas. For tropical areas, MacMillan's Tropical Planting and Gardening (mentioned in the Introduction) is a standard. Beyond these, we run into a matter of personal choice as to the best source of information. In temperate zones, the English are known to be the outstanding gardeners, and numerous publications from England on various types of gardens and plants for gardens may be consulted. I frequently refer to two excellent gardening books (though not too recently published), Woman's Home Companion Garden Book, edited by John C. Wister, and The Garden Encyclopedia, E. L. D. Seymour, editor. Mention of these two, however, does not indicate that they are necessarily recommended to the exclusion of many others not mentioned.

The references given in the Introduction will contain much useful gardening information. Again, recall that newspapers are an excellent source of information, particularly the Sunday editions where many gardening recommendations are made. Frequently these papers include jobs to be done in the garden at that particular time of year. Catalogues from the large nursery and seed companies are a wealth of information, and can be read with pleasure. Popular gardening magazines and journals of many types may be easily found, some on regular newstands, almost all on shelves of the local library.

Conservation and Economic Botany

Up to this point I have concerned myself more with individual plants, crops or agricultural systems than with areas in which the crops are grown, or with the allied problems which arise as a result of our agricultural industry. I should, before closing, make some comments on the economic implications and point out some uneconomic practices which have wide-ranging effects on our society. This chapter does not concern itself with the value of one plant or group of plants, but rather with the total biosphere (the area from just below the surface of the soil to the highest point in the atmosphere where living organisms usually live). In large measure, I am speaking of the maintenance of a suitable habitat for man and other organisms to live in their best possible balance. Conservation is the usual title given this area of interest, and today, conservation has come to take on absolutely vital significance. Today, we speak of the conservation of the soil and minerals, the water, the atmosphere, and all the organisms existing on this earth, whereas an earlier concept of conservation (at least in the eyes of laymen) dealt only with saving one species or wild region from man's destructive tendencies. Now we must consider conservation to include even the saving of <u>Homo sapiens</u> itself. himself

The problems involved in the modern definition of conservation are very broad. For example, how do we make the maximum <u>and</u> most beneficial use of land? How can we continue to build road systems, new dwellings, shopping centers, recreation facilities, factories, etc., and still have sufficient room for agriculture and recreation? How do we contol our waste products so that refuse, air and water pollution do not destroy us? It is no longer possible for individuals to ignore these problems. Manufacturers must consider their product's effects on the environment as well as the profit-making motives. It is no longer possible for communities to forget other communities around them. Much more of our productive efforts are going to be required to survive and function properly.

For many years there have been a small number of naturalists (men dedicated to the observation of plants and animals in their native habitats) who have warned that man is moving at a rapid pace towards the destruction of the habitat in which he lives. There have been many indications of the seriousness of the problems, but these have been passed over by our society as merely unimportant mouthings of people who were "nice, but harmless." If a naturalist suggested that, for example, the vicious habit of destroying "varmints" by ranchers, farmers, or hunters with a voracious appetite for killing, was causing a disruption in some important natural cycle, very few influential people listened until the cycle was so badly disrupted that some economic effect was felt.

We have known for a long time that all living things are intimately related to and delicately balanced with their environment. We have seen the significance of this through evolutionary cycles. Drastic changes in climate have wiped out certain kinds of organisms, both plant and animal. Indeed, natural selection is the central force involved in evolution. The changes in evolutionary scales are not visible to man, or to several generations of men, but are usually counted in millions of years, although we know that evolutionary processes are occurring all the time. The processes take long periods to be expressed, but sometimes the periods are shorter than others. In evolutionary changes, some living forms have more genetic capacity to modify and adapt to changed environments than others, for reasons that are not entirely known, but still there is (or has been in past ages) time for an adjustment to occur. Surely some forms do not survive, nor modify sufficiently so that the offspring of that particular species survives, but it usually true that the genetic materials which went to compose that group or species may be incorporated (hybridized) with closely-related species, thus assuring that genetic traits are not entirely lost. Certainly, change is a part of the history of the earth, but the beautiful relationship of living things to environment is balanced for long periods. The important thing for us to remember is that we have intruded more of a single kind of organism (man) than can safely be accommodated by the balanced environment. Remember that every living organism contributes something to the environment, though the contribution may be measurable only with very small scales. If we, because of some immediate need, wipe out some organism or other, we have lost some genetic material long before processes of evolution would have given time to allow incorporation of that genetic material in related forms.

So what? What significance if some weed is removed now - it didn't help out. But help out what? I find it hard to think that we can answer that question with any certainty. An example is useful to indicate my meaning. In the coastal plains of the southeastern U.S. one of the most difficult of all plants to eradicate from fields was Bermuda grass (Cynodon dactylon), a weed by almost any definition. This species is practically worthless for grazing cattle because the foliage contains little nutrition. Much effort was expended to rid the fields of Bermuda grass. But today one of the reasons why cattle are successfully raised in Florida and other coastal states is because one particular variety of Bermuda grass was found by agronomists in 1943. This variety, now known as "Coastal" Bermuda, is nutritious, makes an excellent cover for the soil, and grows only where it is desired because, by some mutation, it is sterile and never sets seeds. It cannot spread beyond where it has been planted, and thus is controllable. Here is an example of the extreme caution necessary in making a human decision about the value of any type of plant. Within the genetic mechanism of the species may be found some particular attribute vary much needed to support our agricultural endeavors. With today's powerful weed-killing chemicals, we may lose valuable germ plasm before we have time to discover what values might have existed in the plants killed by the weed killer. These facts alone indicate our need not to intrude in the cycles which have taken many millions of years to to develop.

An appreciation and understanding by all people is absolutely essential to maintenance of the biosphere in as near equilibrium as we can.

Intricacies of environmental balance and disruption may be illustrated by a recent man-made modification of the nitrogen cycle. For twenty years or more Popeye the Sailor amused children and adults alike in comic strips, animated cartoons, in the movies and on TV shows. The relationship between Popeye, a lovable though dumb sailor, and conservation may seem far-fetched, but remember that whenever Popeye became involved against enormous tough guys, or gorillas, or any other creature his creators imagined to be threatening types, all he needed to do to become superhuman was to pop a can of spinach in his mouth, whereupon he became a whirlwind of strength. Before Popeye became so popular, spinach was a minor vegetable, eaten only when parents threatened or cajoled their children, and it generally was disliked because its flavor was not pleasing to many palates. I was told, for example, that spinach "had iron in it" and was therefore good for me - though to this day I cannot face the vegetable because I grew up before Popeye got his message across. But after some years of Popeye-type of propaganda, nearly every kid thought he had to have his spinach, and sales rose enormously. According to most nutrition experts, and certainly many parents, this increased consumption of a leafy vegetable was a good thing.

Because of its extra content of nitrates, the spinach, much of which is pureed (chopped up fine) and fed to infants, may not be the unmixed blessing we thought it to be, for rather complicated reasons. Spinach (spinacia oleracea) is a vegetable whose foliage responds dramatically to nitrate fertilizers. Added nitrates produce dark green foliage, and causes rapid growth of plants. The plants take up the nitrate rapidly and much of it ends up in the leaves. Nitrates are not poisonous to human systems, and almost all foods contain some. However, there are conversions of the nitrates to nitrites in the intestinal tract, ~~caused~~ by bacterial action, apparently more in very small children than in adults. Nitrites, in contrast to nitrates, are poisonous, and their effects are deleterious to the growing child, causing "blue babies."

It may also be noted that much spinach is sold in cans. The inside walls of the cans are enamelled - not like many other cans whose interior and exterior surfaces are coated with tin (therefore the title, "tin cans"). The necessity for enamelling the interior surface of spinach cans arose because the high concentration of nitrates in the spinach reacted with the tin of ordinary tin cans, and some of the nitrates were converted to nitrites, again deleterious to young children.

Normally, soils do not contain a very high percentage of nitrates, and any that is present is rapidly taken up by plants growing in that soil. To produce higher nitrate levels, the soil must have artificial fertilizers added. Because leafy vegetables respond very rapidly to this particular type of fertilizer, fields where they are grown are given heavy applications of fertilizers with significant concentrations of the nitrates. The nitrates are easily soluble, and much of it is carried away from the field in run-off water. The run-off from the fields eventually ends up in streams and lakes where other types of plants - green algae - utilize the nitrates, growing at enormous rates and crowding out many other organisms, both plant and animal. Thus, a substance added with all good intentions to the fields of spinach, becomes a pollutant in another environment, the balance of nature is upset, and deleterious effects are caused in many young children.

Let us add another part to the complicated nitrogen cycle balance, of which this example is a part. It has become more and more apparent over the last half-century that man must do something to dispose of this own biological waste products - fecal matter, urine, waste food materials, and many other substances which contain nitrogenous compounds. We mentioned that man has learned to use bacterial degrading systems to aid in this disposal in chapter 6. Usually, a physical filtering system is also employed to separate solid from liquid wastes. After the sewage disposal system has been employed, the remaining substances have been reduced to much simpler, relatively odorless, organic substances, and the fluids have had all (or most of) the harmful bacteria removed. The liquids still contain numbers of dissolved, harmless, inorganic compounds, among them nitrogenous compounds which can be considered as liquid, low concentration, fertilizers. Usually at this point, the sewage system considers the job complete, and the harmless liquids are pumped into some nearby body of water - lake, ocean, or river. Here the liquids increase the normal concentrations of nitrogenous, inorganic compounds by considerable amounts. If the liquid discharge is not too great, organisms in the stream, and normal dilution factors in the body of water reestablish a balanced condition, but as more and more people crowd into our cities, the bodies of water near the city are not sufficiently large to return the balance of normalcy. Again the plants living in the water - algae - grow at abnormal rates, stimulated by the additional nitrogenous substances which support them.

Let us now consider the combined effects of the run-off water from fields containing nitrate fertilizers with the liquids discharged from our sewage disposal systems in the areas which surround one of our Great Lakes, Lake Erie. Around this lake are some of the best farm lands of the country. Also, one of the greatest concentrations of people is found here. There is an almost continuous urban area from Detroit at the western end to Buffalo at the eastern end. Lake Erie is relatively shallow when contrasted to the other lakes of the Great Lakes system. Its bottom today is nearly all covered with the accumulated, dead remains of the algae which grew at such rapid rates. Few fish, and none of the game fish, can survive in this water. There are no pleasant recreations areas left - it isn't very much fun to swim in the water where so much dead organic matter remains. Though some efforts are being made to attack the problem in a concerted manner, there are still few means by which the continued influx of fertilized water can be controlled. This problem can only grow worse, and as it grows, we destroy more of the value of one of our most precious resources - good clean water.

Surely we cannot blame the artist and writer who first thought up the lovable, dumb sailor, Popeye, for all these unwanted circumstances. We must all consider the consequences of our short-term desires for a better life. We must be willing to understand that we have a closed system on our earth, developed over countless eons of time, and that we must find a way to balance ourselves with the living things around us, or we shall surely do what no nations has yet been able to do in war - destroy a whole people. Basically, this is what conservation is all about - conserving resources that we cannot live without.

I have given but one example of our destruction of the world in which we live - there are many others. Grave dangers exist in those regions where man rips up the earth by strip-mining methods to extract more and more coal and other minerals. continuous removal of agricultural land for cities, streets and highways, parking lots, drive-in movies, etc., etc., now cause and will increasingly cause more difficulty in supporting expanding populations.

If one flies across the country from the east coast to the west coast in a jet airplane at 35,000 feet, he can see that nearly all the land below him has been put to some use. Very few areas remain untouched by some form of human endeavor. The mountainous areas in the west, seemingly too steep or rocky for agricultural purpose, are used for cattle or sheep range, and the inter-montane valleys are frequently dammed and used for water reservoirs. Many recreation areas exist in otherwise unreachable territory, now accessible by paved roads, made by man's powerful road-building machines. There are no more frontiers of fertile land or virgin forest. Cities expand into the surrounding farms; swamps are drained, filled, and covered with asphalt, or are used for certain types of agriculture. No wild area is beyond some modern form of transportation, and jeeps or motorcycles go where formerly one could go only on foot or horse-back. Or we have "swamp-buggies" or shallow-draft boats to navigate the remotest regions of swamps. The land is full of man's leavings - beer cans, plastic containers, and other unwanted waste products that are, at least, an ugly reminder of man's untidy ways.

In the cities and towns, there is still much unoccupied, or unused land, but these areas provide further monuments to man's thoughtless destruction of his landscape, providing disease-ridden dumps of garbage, old automobiles, etc., and eyesores which can only lead to a lessened humanity. Much of this comes from a lethargic, uneducated, selfish governmental arrangement in the town, but more is the fault of the indviduals in the town who would rather close their eyes than to take the necessary steps to clean it up.

All of this writing would be worthless if no ideas were included to point some directions towards alleviating these unhappy conditions. From the standpoint of economic botany, what help can be given, what new actions can be taken? Are there any ways in which plants can be made to play useful roles? Clearly the answer is yes. But let us be sure that we understand that economy deals more with values to all humans than dollar profits to some individual. The economy function is served when we produce more oxygen-releasing organisms to provide a healthy atmosphere, when we make an area pleasing to live in, when we find satisfactory ways to balance human and other animal life to prevent unneeded destruction of our planet.

Some pragmatic persons may disagree with my recommendations because the recommendations are not "efficient" for large-scale productivity of some product or other, but the recommendations contain "efficiency" when concerned with more than just a single profit-producing product. For example, let us consider the production of cork. We still use many corks, produced from the cork-oak, Quercus suber. This species is well-adapted to many regions in California, and some cork-oak forests are planted in that state. The cork-oak tree is a rather handsome, spreading tree with evergreen foliage, and it grows easily with little or no attention. Let us use this tree more frequently in street-side plantings, in vacant lots, and other areas where its product, the bark, could be removed at suitable intervals, and between times serve as shade, beauty, and even a good place for kids to climb and build tree houses in its branches. Clearly, imaginative methods would be required to provide a profit-making motive to some entrepreneur, where cooperation between the city government, individual property owners, and individual workers would be absolutely necessary. Another example of multiple-use type of street and vacant lot tree use could be the slash pine (Pinus caribaea) or the loblolly pine (Pinus taeda) grown either for timber or for paper-pulp in the southeastern United States. Ingenious, or new, land-use rights might have to be worked out so that such plantings could be made, and harvested, either by individuals or by the large paper-mill companies on city streets, vacant lots, filled land, etc. Certainly, the cost of this type of planting would exceed the present procedures but my recommendation requires that cost-accounting be made in a different way than we are accustomed to.

In the great plains areas of the United States, most of the railroad, highway and power-line right-of-ways could be used for shelter-belt trees, for wild-game cover of fruit-bearing shrubs, or for plantings of

In Norway, the road sides are planted to hay grasses and these areas are mowed, the hay collected, and used as winter forage.

walnut trees which yield beautiful furniture wood. In the dryer southwestern regions, useful plantings of jojoba (Simmondsia chinensis, a native species in spite of the species name) could provide a useful wax from its fruits. I recognize that much experimental work will be needed to make the types of uses I recommend actually work, but I do not think that any of these plants mentioned are that difficult to adapt to these types of utilization.

Returning to the spinach growing, and other crops requiring high nitrate fertilizers, a potential (though not proved) technique to trap more of the nitrates contained in the run-off water so that the nitrates are removed before they enter into streams and lakes would be to plant other nitrate requiring plants at the lower ends of the fields where the nitrates are applied. These plants, though they take up some ground area, and would not necessarily be considered as economic crops, would be barriers, or traps, to aid in the removal of the nitrates before the water runs into the lakes and streams. We have soil and water conservation laws already in practice over much of the agriculture land in the nation, and with these laws, provisions for barrier, or trap, plantings could be easily added. In most such circumstances, the farmer is given some sort of payment for any soil conservation he does, and since the farmer would be taking up some land which he would otherwise put into the profit-making crop, he would have to be paid for planting the non-profit-making barrier plants on this land.

Of course, we could consider the possibilities of harvesting the algae after they have multiplied in the streams and lakes, but I fear that the time before we can find suitable techniques for using the harvested algae is some distance away.

The suggestions made here for conservation of natural resources, for more reasonable use of the lands, and for developing of crops on waste land are only a few of those already available and known to many different scientists. Unfortunately, the many techniques will not be put into operation as soon as they are needed, for we still have much to do to educate our people to the urgency and necessity for doing them. Let us hope that we learn our lessons in time to make them pay off.

SUMMARY REMARKS

While the major objective of this book has been to indicate the fundamental role of plants in our lives, one may also see that there have been other objectives. One of these has been to teach, in a relatively painless manner, something about the science of botany itself. Many times in the past, I have been told by one adult or another, that the botany they were taught in school was dull, lifeless, and nothing but a recitation of useless "facts." I hope that I have shown in this book that the study of plants can be exciting, useful and enjoyable. It is true that the individual has to have some motivation of his own, but without some direction, this motivation can be diverted, dulled, and even destroyed. Perhaps this work shows that there is much more to be learned about the kinds, the function, the inheritance, and the structure of plants. Economic botany, as I have used the term, is not as much applied botany as an explanation about the plants themselves. One question I have tried to answer is "what is there about plants that mankind finds so useful?"

I said in the introduction that we might get a glimpse of what the future holds in the way of using plants, but as I read through the chapters, I find that I did not give the glimpses as clearly as I thought I could. That mankind will find new uses for well-known cultivated species, and bring new species to usefulness, is a certainty. But what these will be is left to the fertile imagination of the people who study them. It is clear that I have not covered all the areas of plant utilization and relation to mankind. Many will point out that I omitted this or that vital role of plants in our lives. So I have, but I did say something about those that I have found interesting, and hope that this leads to the investigation of the others intentionally or unintentionally omitted.

One of the most noticeable omissions from the book is in the area of plants that have deleterious effect on man. Plants cause diseases, allergies, and violent skin reactions. Much time, effort, and energy are expended to alleviate the discomfort caused by ~~certain~~ these plants. The diseases most frequently encountered are those caused by the lower organisms, the bacteria and fungi, and some of our most dramatic successes in medicine have been the overcoming of these diseases.

Another important category omitted is a discussion of weeds, and how these plants have influenced our agriculture and economy. There is no one satisfactory definition ~~of~~ for all weeds, though many people have attempted to provide one for plants whose effects are disturbing in some way. Different plants are weeds in different settings. Water hyacinth, now found clogging many southern waterways, is certainly a weed. In its native habitat in northern South America, no difficulties with it exist. Weeds in corn fields have cause much effort to be expended to eradicate them. Some members of the grass family are our most pernicious weeds. The related sedges (family Cyperaceae) are also troublesome for certain types of farming. Since the discovery that a chemical, 2-4D, (2,4 dichlorophenoxyacetic acid) killed weeds, a very large chemical industry has grown up, providing a bewildering group of trade-named weedicides. Though many of these chemical substances do kill the weeds they are intended to, their side effects are not fully known, and may be more troublesome to agriculture in the long run than the weeds they were intended to kill. One such problem was discussed in the chapter on cranberries. This example was intended to show that no activity is completely isolated in its effects, and problems arise in a manner least expected by those who had the best of intentions in their first applications.

In all situations, however, we should focus our attention on the plants themselves. Other books in this series indicate some of the fascinating, basic scientific botanical investigations now going on in this country. We find new ways to investigate old problems, and along the way discover problems in plants that were not even thought of in earlier times. With some curiousity, you can enter a fascinating world through these books. I hope you will.