PLANTS CONSUMED BY MAN

B. Brouk

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The aim of this book is to provide a comprehensive survey of plants for human consumption, including all primary food plants, those which yield non-nutritive ingredients such as flavours, colours, thickening agents and the bacteria and fungi which produce edible materials or which are themselves consumed. Also included is a special section on plants used for smoking and chewing as well as a chapter dealing with plants used for alcoholic and alkaloid drinks.

The plants are defined here botanically, though for the convenience of the reader, they are grouped according to common usage, (i.e. according to whether they are 'cereals', 'vegetables', 'fruits' or 'nuts', etc.). To help the reader who is unfamiliar with botanical terminology, an illustrated glossary of terms is provided and there is also, at the end of each chapter, a morphological survey which classifies the plants according to the botanical nature of the parts used for consumption. A brief history of each plant is included as is a note of the important factors relating to cultivation, suitable varieties for processing and other special features of interest.

The book is extremely comprehensive, well illustrated, and provides a concise coverage of the field of plants for human consumption. It will he welcomed by agriculturalists, food scientists, botanists, and in particular, by students of these disciplines. Its value, moreover, will extend to all who wish to acquire a knowledge of food plants.

Front cover illustration shows a *Castanea sativa* fruit. Photo: courtesy of Professor Dr. H.C.D. de Wit.

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PREFACE

My main reason for writing this book was the lack of a sufficiently large compendium of the plants of greater or lesser importance consumed by man, dealing with these plants from a variety of points of view. Although, in the 1960s, many books about food plants appeared, few of them enlarged significantly the number of such plants that were described, and few dealt with such important aspects as etymology, history, geography, chemistry, morphology, physiology and other points of interest.

The present book quotes over three hundred plants used in various ways for human consumption, but is far from exhausting them all. However, it is hoped that it will prove to be sufficiently comprehensive.

The main part of the book is arranged according to the broad categories of plant products, and their common names are used to arrange them alphabetically within these categories. A continuous list of plants, in the order in which they appear, is given among the appendices. I have also classified the plants according to their useful parts; a morphological survey of all the plants discussed appears in the appendices, in addition to the individual morphological surveys that are given at the end of each chapter. The terminology used for morphological classification must be clearly distinguished from the commercial nomenclature because the terms in everyday usage, although they may be the same words as those used in morphology, are often taken in an entirely different sense.

Finally, I wish to express my thanks to Mrs Barbara Renvoize for extensive linguistic and editorial help, and for retyping the manuscript; also to the Art Department of Academic Press for the expertly redrawn illustrations.

January, 1975

B. BROUK

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Although a few minerals (e.g. common salt) and synthetic chemicals (e.g. saccharin) are used in the preparation of foodstuffs, our food is otherwise completely derived either from plant sources or from animals which themselves are ultimately dependent on plants for their survival. However, the scope of this book is to survey not only food plants: apart from the plants that supply us with nutrients (carbohydrates, fats, proteins, vitamins and minerals), man consumes many plant materials for other reasons. For example, he uses various herbs and spices to impart flavour and odour to food, he produces alcoholic beverages from grain, fruits and roots and he uses various plants for smoking and chewing. These flavourings, beverage plants, fumitories and masticatories are not consumed for their nutritive value, though some of them contain nutrients in greater or lesser quantities. All these categories contribute to the plants consumed by man.

BOTANICAL CLASSIFICATION OF PLANTS

The true plant kingdom is represented only by the higher plants, i.e. Metaphyta (sometimes called Cormophyta or Embryophyta). The most advanced Metaphyta are the flowering plants, which produce seeds in a seedbox and are therefore called Angiospermae. The angiosperms, to which the great majority of the plants consumed by man belong, are further subdivided into Dicotyledoneae (plants with two seed-leaves or cotyledons) and Monocotyledoneae (plants with a single seed-leaf, e.g. palms and grasses). The less advanced Metaphyta are the Gymnospermae (plants with naked seeds, e.g. conifers), followed by Pteridophyta (e.g. club-mosses, horsetails and ferns), and the most primitive Metaphyta are the Bryophyta (mosses and liverworts).

However, the lower Metaphyta are negligible so far as consumption by man is concerned; none of the Bryophyta is used and only a single case occurs within the Pteridophyta—the developing fronds of ferns, so-called fiddlehead ferns. And the gymnosperms contribute no more than about eight or nine materials used for human consumption: *Zamia floridana*, a cycad, is used for the production of a type of arrowroot from its rhizome, and a

similar material is derived from the erect stems of palm-like cycads (*Cycas* spp.). Cycads also yield seeds from which flour is produced (e.g. the Mexican species, *Dioon edule*), and in Africa young leaves of cycads are eaten by natives as a vegetable. The wood of a conifer (*Larix occidentalis*) is the source of a gum and another gum is produced mainly from the pulp of coniferous wood. The arils of juniper seeds, pine nuts (the seeds of some pine species) and pine resin are further commodities derived from the gymnosperms.

Apart from the Metaphyta (the true plants characterized by division into organs—roots, stems and leaves), there are many other organisms that until recently have been classified as plants. However, modern classification sets them apart from plants as the Monera and Protista. Monera consist of Bacteria and Cyanophyta (blue-green algae), while Protista include Algae and Fungi, as well as Protozoa which were previously considered as animals. Older systems of classification assumed that these organisms, except for Protozoa, were lower plants in which the body was not divided into organs, and for this reason they were called Thallophyta, or plants consisting of an undifferentiated body. The lowest of these, the Monera, do not have nuclei and are the only akaryotes (organisms without nuclei) among living things. These, the smallest "plants", are consumed by man, but only exceptionally: bacteria are eaten in fermented dairy products, and *Nostoc*, a blue-green alga, is cultivated as a food in mainland China. In contrast, the more highly developed Thallophyta, the Algae and Fungi, belonging to the Protista, supply us with many useful species. Various kinds of algae are eaten in the Far East, and up to the last century many algae were commonly eaten in northern Europe. In the case of fungi it is mainly the fructification that is consumed, and in almost all countries some fungal fructifications are collected or even cultivated. Sometimes the whole thallus is eaten, for example in cheeses penetrated by *Penicillium* spp.

In this book the "plant-like" Monera and Protista are grouped together with the Metaphyta or true plants, and thus the term plant is employed in the sense used in more old-fashioned systematics, embracing true plants as well as plant-like organisms within the plant kingdom. Algae and Fungi will therefore be discussed, in addition to the true plants, and in special cases we shall deal with Monera, Bacteria and Cyanophyta. Only Protozoa, of the group Protista, will be excluded from discussion, since they do not supply man with any useful materials, and in any case, according to obsolete systematics they belong to the animal kingdom, not to the plants.

CLASSIFICATION OF PLANTS OF ECONOMIC IMPORTANCE

Plants consumed by man are not the only plants of economic importance. Other plants that should be considered are those used for shelter, decoration, industry, for animal fodder, in medicine and those that have acquired a special religious, superstitious or national significance.

Shelter plants include living plants in the form of hedges or other screens around gardens, yards, playgrounds, swimming pools, etc., as well as windbreaks and shading devices protecting plantations. Trees are planted along roads, country lanes, or in the open countryside to provide shade and shelter during outdoor recreation.

Ornamental plants include living whole plants or cut flowers and branches used to decorate gardens, parks, streets, houses and for all kinds of interior decoration.

Industrial plants. These yield materials for industrial use, such as timber for building, furniture making, construction of vehicles, boats, etc. Timber is also used for the extraction of cellulose, chiefly for paper making. Other important industrial plants provide fibres for fabrics, ropes, cords and nets; and straw, bast and other similar materials for hats, mats, baskets, brushes, etc. Others yield cork for stoppers, floor coverings and insulation; volatile oils used in perfumery; tannins for tanning of hides; and many other plants provide dyes, resins, inedible starches, oils and waxes.

Animal fodder plants. The economic value of such plants is in providing food for domesticated animals, e.g. herbage eaten by cattle and sheep, oats fed to horses, or grain consumed by the domestic fowl.

Medicinal plants are used in the treatment of human and animal diseases. Those used by man himself, although they form a large part of the plants he consumes, will not be discussed here in view of their enormous number and specialized uses.

Semantic plants are those that acquire economic importance as a result of some special significance. Thus the daffodil has become the national symbol of the Welsh people, and red carnations are the symbol of workers' movements in most continental European countries. Other plants have magical or superstitious meaning, such as the four-leafed clover which is supposed to bring good luck; and the Christmas tree reputedly had a magical function,

being installed in farmhouses and cowsheds to protect the inhabitants from evil power. Today the Christmas tree has become a religious symbol, and only by non-Christians is it regarded as a merely ornamental plant. Cut flowers are used to express our feelings towards the person to whom they are given—with a single flower you may say more than with a thousand words, according to the florists' posters!

Multiple Use of Plants. Plants used in some of the ways described above may also be used for other economic purposes. For example, the poppy, of which the seed is a culinary item, is also a source of latex containing morphine which is an important medicinal drug. Plants such as turnip and swede may be used as animal fodder as well as human food, and many plants used for human consumption are also used in industry for various purposes such as lubrication of machinery, as diesel fuel, for soap making, in varnishes and paints, etc. Liquorice, normally used as a flavouring agent in confectionery, is also sometimes used as a dying material for production of shoe polish. Other food plants are often used as ornamentals, e.g. beans, peas, sunflowers, kumquats.

In some cases a plant for human consumption may become an almost entirely ornamental plant. Various fruits and seeds are often used more for decoration of food than for their nutritive or flavouring value, usually being merely applied to the surface of, for example, cakes and pastries. Some plants may even be applied purely ornamentally, as in the case of a large piece of parsley leaf placed on a prepared dish entirely as an adornment and not intended for eating at all.

Larger trees yielding an edible crop may also function as shelter plants. Thus a pear tree provides not only fruit but also shelter. Other crop-producing trees may have many kinds of economic value; e.g. the walnut tree contributes an edible nut, a valuable wood, and is also a source of oil extracted from the kernel of the nut and used in printing, painting and perfumery. Furthermore, the walnut is also a highly ornamental tree found in gardens as a decorative plant.

Plants may have multiple uses within the sphere of human consumption itself. For example, maize can be used in the form of flour for *tortilla* pancakes; in flakes as a breakfast food; in whole cobs as a vegetable; as a beverage plant by fermentation of the germinating grain; or as an oil plant, when oil is extracted from the embryo. Similarly, the apricot may be consumed as a fruit, or as a beverage plant in the production of apricot brandy, or it may be utilized for colouring other food materials by the distilled extract of its juice. Coffee, now a widely distributed beverage plant, was originally used in Abyssinia as a masticatory, and roasted coffee beans are still served in many places all over the world for such a purpose. Coffee is used also as a flavouring for cakes, pastries, ice cream, chocolate, liqueurs, etc.

Perhaps the plant with the largest variety of multiple uses is the date palm, which is practically the only available plant in the Arabian desert. It is said that the Arabs use the date palm in about 800 different ways, and its fruit is sometimes even used as money.

THE CATEGORIES OF PLANTS FOR HUMAN CONSUMPTION

Different types of usage have led to the division of plants for human consumption into commonly accepted groups. The food plants are subdivided in colloquial and commercial language into cereals, vegetables, fruits and nuts. However, these subdivisions do not necessarily follow botanical principles. Grains yielded by cereals are fruits, but so are tomatoes which are included in the vegetables. A true nut is also botanically a fruit, but most of the nuts in the commercial meaning of the word are in fact the stones of drupes—for example walnut, coconut and almond. The commercial classification is useful in spite of the fact that it misuses botanical terms, since it does not claim to be a botanical system, but more a method of division according to the kind of use of the food plants. However, it is necessary to identify properly the commercial groups of food plants, and to complete them by considering the plants yielding as extracts starch, oil and sugar. These plants, whose products are grouped together under the title plant extracts, include in addition to food plants the non-nutritive plants from which are extracted gums and substances for dying and smoking foods. Further, the non-nutritive plants include beverage plants, fumitories and masticatories, and fermentative micro-organisms used in the processing of animal and vegetable materials for human consumption.

The main broad divisions of plants will now be introduced.

1. Cereals and Pseudo-cereals

This is the most important group of food plants. Cereal grains are formed by the dry fruits of cultivated grasses (the caryopses), chiefly used for the production of flour required for bread, cakes, pastas and dumplings; they are also commonly used as breakfast foods in the form of flakes or porridge. Cereals form the only group of plants consumed by man that is botanically uniform, and all cereals are used in roughly similar ways. Botanically different plants used in ways similar to cereals are distinguished as pseudo-cereals. They are mainly the seeds of various kinds of dicotyledonous plants, for example the seed of buckwheat borne in an achene.

2. Vegetables

These form the second and largest group. They defy botanical description since the group is drawn from various plant structures (roots, stems, leaves, flowers and fruits) and not merely from a fruit or seed as is the case with the cereals and pseudo-cereals. The vegetables contain members of most families of Angiospermae, and also the bulk of algae and fungi used by man. In general, vegetables provide a source of micronutrients (certain vitamins and minerals) and of roughage (cellulose and chitin), but some vegetables are also rich in macronutrients (e.g. the potato contains abundant starch, beans contain carbohydrates and proteins). The fruits included among vegetables are not sweet, e.g. cucumber and tomato, in conformity with the general non-sweetness of the vegetables.

3. Fruit

All fleshy fruits containing sugar and micronutrients are called in commerce fruit. Edible dry fruits appear in other groups, e.g. cereals and nuts, and fleshy fruits with a very low sugar content are referred to as vegetables.

4. Nuts

Commercially, nuts are edible seeds with a hard or brittle covering. This shell may be a hard testa (seedcoat), the pericarp of a true nut (e.g. hazel nut), or an achenial fruit (e.g. sunflower), but most often it is the stone of a drupe developed from the endocarp. All these types of nut are used in similar ways and contain a high proportion of macronutrients.

5. Plants Providing Extracts

These plants yield both foods and non-nutritive materials. The nutritive materials include starch, oil and sugar, while the non-nutritive substances extracted or exuded from plants include gums, dyes and smoke. Gums (mucilages) derived from plants are used in the preparation of foods, e.g. carageenan from Irish moss (Algae), and tragacanth from *Astragalus gummifer* (Leguminosae). Food-dye plants are scarce, but an example is the lichen *Rocella tinctoria*, formed by the symbiotic association of an alga and a fungus. It yields, when treated with ammonia, a blue or purple dye used for colouring sauces and bitters, and formerly used in wines. Smoke, usually derived from

timber, is used for preservation of many food products or for enhancing their flavour.

6. Flavourings

This group is devoid of food plants. Flavouring plants have practically no nutritive value, or at least they are not consumed for it. Sometimes the flavourings are eaten alone as appetizers, e.g. chillis.

7. Beverage Plants

These plants provide materials for preparation of alkaloid drinks such as tea or coffee, or materials for alcoholic fermentation, and both types of drink act as a stimulant. Although the alcoholic drinks are not consumed for their food value, they are derived from plant materials containing large amounts of macronutrients converted into alcohol which has a high calorific value. On the other hand, alkaloid drinks are derived from plant materials without any nutritive value (with the exception of chocolate taken as a drink), but often contain nutritive additives, e.g. sugar, milk.

8. Fumitories and Masticatories

These plants, having no nutritive value, are smoked or chewed, mainly for their alkaloid content which stimulates the nervous system. They include tobacco, poppy and peyote. There are some exceptions that do not contain alkaloids, such as chicle, a gum derived from the latex of the Sapotilla tree and used in the production of chewing gum; also the various dried vegetable materials smoked as substitutes for tobacco.

9. Fermentative Micro-organisms

These are bacteria and fungi used in processing foods, beverages and plant materials such as tea and tobacco. Although they are added to the plants consumed by man these lower plants are not always consumed themselves, but their products are highly important; in cases where they are ingested with their products they contribute to taste and/or texture. It should be mentioned at this point that fermented dairy products are the result of fermentation of

animal products by fermentative microbes ("lower plants"), while honey is produced from plant material (nectar) which is converted by animals (honey bees), by fermentation and other chemical processes. Thus dairy products will be dealt with in the section on fermentative micro-organisms, but honey will be considered in association with nectar, a higher plant product.

USEFUL STRUCTURES OF PLANTS

As we deal with the various ways in which plants are used for human consumption, it becomes apparent that normally only a part of the plant is required. A particular plant structure is very often exploited only in a single way, e.g. the root of horseradish as a flavouring, the swollen taproot of sugar beet for sugar extraction, the shoots of asparagus as a vegetable, the leaves of sweet bay as a spice, the petiole of seakale as a vegetable, the drupes of oil palm for vegetable oil, the achene of sunflower as a nut, the aril of litchi as a fruit, etc. On the other hand, structures of certain plants can be used in many ways, e.g. potato tubers may be consumed in the form of chips, baked potato, potato crisps, as a fermentation base for alcoholic drinks, as a source of the flour known as farina, or in many other ways. However, with some plants different structures have different uses, e.g. the blanched leaves of chicory are used as a vegetable, while a coffee substitute is produced from its root.

The entire plant is very rarely used for consumption, except for seedlings of some higher plants (soya, black gram, wheat, etc.) and a few lower plants—bacteria (e.g. *Lactobacillus* in fermented milk products), blue-green algae (e.g. *Nostoc* eaten by Chinese) and fungi (e.g. *Penicillium* spp. growing through cheeses).

The useful parts of plants can be described and defined according to the conventions of plant morphology. The main structures of angiosperms—roots, stems, leaves, flowers, fruits and seeds—can all be subdivided according to their modifications. Thus swollen taproots, swollen adventitious roots, root tubers and root bark are all subdivisions of roots, and achenes, caryopses, nuts, legumes, follicles, capsules, lomenta, carceruli, cremocarps, berries, hesperidia, pepos, pomes, drupes, etc. are all fruits. These botanical structures are consumed by man either entire or in part. The grape, for example, a typical berry, is normally eaten in its entirety without waste, and bilberries and currants are used similarly, while other berries may have their seeds removed before consumption, especially if the seed is large, as in avocado and date. Other types of fruit, such as the drupes, may only be consumed in part: in apricots only the soft part derived from the epicarp and mesocarp is eaten, and the stone, formed from the endocarp, is rejected. Pomes (e.g. apples, pears) are normally peeled and the cartilaginous core cut

out so that only the swollen receptacle without epidermis is consumed, and a negligible part of the true fruit. However, even the smallest part of a structure is significant and should be considered and classified.

In general, the botanical structures themselves provide a means of classification, except for seeds. These are not divided into groups and must be classified according to their origin, so that we must specify the seed of an achene, of a caryopsis, of a berry, of a drupe, and so on. The seed itself is morphologically subdivided, and its substructures such as embryo and aril are important items for human consumption. Other important substructures of plant parts include root bark, pith and bark of the stem, calyx and stigma of the flower. One may also include materials exuded by plants and used for consumption, e.g. sap obtained from the stem or inflorescence, latex and gums exuded at the site of an injury or incision, and nectar secreted by nectaries in flowers.

All these structures, substructures and materials are found in the Angiospermae, while only a few structures are recognizable among the lower Metaphyta and among the Protista. Systematic arrangement of various parts of plants will be found in the list at the end of the book introducing the morphological survey of all the plants described. In addition, at the end of each chapter is a morphological survey of all the commodities derived from the plant group that has just been considered (cereals and pseudo-cereals, vegetables, fruits, etc.).

It should be easy to identify the plants consumed by man according to the botanical structure used, but normally the morphological terminology is incorrectly applied. The main confusion started by mixing botanical terms with commercial terminology and was deepened by the botanical ignorance of the technologists. Unfortunately many botanists are themselves guilty of causing some of the confusion, by not using the botanical terms in their proper sense and often taking refuge in the broadest categories in the identification of botanical structures. Thus various fruits are merely called fruit despite the fact that more than twenty kinds of fruit can be distinguished (achene, legume, berry, drupe, etc.), and seeds are represented without identification of the fruit from which they originated. Also some commercial terms are often used by botanists, e.g. a pod of cocoa which is actually a berry. And the terminology of plant structures used for human consumption is in complete chaos: bakers speak of berries instead of caryopses; a food expert calls the date, which is a berry, a drupe; a respected English encyclopedia describes the Chinese artichoke as a root. In view of this confusion, it is of paramount importance to produce a careful morphological survey of all the plants consumed by man.

THE CHOICE OF PLANTS CONSUMED BY MAN

These plants cannot be defined from the biological point of view simply as plants containing nutrients, as flavourings or as stimulants. Many plants have such properties but not all of them are used. Whether or not a plant is used depends ultimately on our choice and not simply on its availability.

In a given population one often finds that only a proportion of the readily available plants is utilized or cultivated. In some parts of the world plants are consumed that are rejected elsewhere, even in the regions where they grow naturally. Many of the fungal fructifications that are so greatly appreciated in continental Europe also grow wild in Britain, but here they are suspected of being inedible, or even poisonous, and in general only the cultivated mushroom is consumed. Similarly, kohl-rabi, a vegetable widely used in central Europe, is unpopular in the English-speaking countries. The flat, umbel-like inflorescence of the elder (*Sambucus* spp.) is often eaten fried like a slice of meat in Central Europe (southern Germany, Czechoslovakia and Austria), while elsewhere this use of elder is unknown in spite of the fact that it grows plentifully. In France young leaves of the dandelion are used habitually like lettuce, but when dandelion salad was recommended during Hitler's regime in Germany to save money for guns, their eastern neighbours were quite horrified to observe what sacrifices were demanded of the Germans.

Selective consumption of plants has also reflected class distinctions. In Great Britain the turnip and swede are commonly used as human food, but in many continental countries they are regarded only as animal fodder or as food for the poorer classes. Another vegetable, the potato, was introduced on a large scale into Europe in the eighteenth century to save the poorer people from famine, but the aristocracy and upper bourgoisie refused to eat them. The acceptance of potatoes by the upper classes of France can be attributed to the French agronomist Antoine August Parmentier (1737–1813) who, after much effort, succeeded in including this vegetable among the commodities consumed by the French Court.

These examples of differing choice in the plants consumed by man show convincingly that the last word in this selection process is held by the society itself. We can make the general statement that the selection of plants is a social phenomenon, a relationship between the society and the available plants that have certain biological qualities, and this social phenomenon depends on customs and fashions.

In the past, plants had to be selected from the native flora, but nowadays, with the immense improvement in transportation and storage technology, this restriction is no longer significant. Tropical fruits, and sometimes even the whole plant, can be transported to countries with temperate climates and

vice versa. Thus, thanks to modern transport by air and sea, and modern storage devices, we can today buy fresh bananas in the streets of London, eat fresh litchis in an Alpine chalet, and enjoy a helping of cranberry sauce in Singapore! This transportation of fruit and other plant materials across the world has had a profound effect on our choice of foods. The appearance of new crops has caused some of the old commodities that were once so popular to disappear from the market in the face of such competition. Pomegranate, St. John's bread, tapioca and sago were once very popular in Europe, but they are now rarities. Similarly medlars and quinces are now almost unknown in Europe as more attractive products become available.

On the other hand, in emergencies such as wartime, revolutions, economic crises, etc., there may be a complete lack of the normal food plants and in this case people have to use whatever they can find as substitutes. During the Revolution, the Russians in Leningrad collected fallen leaves in the streets and boiled them in water rather than consume only hot salted water. Twenty years later Dutch people were compelled to eat bulbs and corms, when food supplies were withheld by the German occupying forces. The Germans themselves, during the Second World War, used an infusion of dried leaves as a substitute for tea, and used the dried leaves of the tea substitute for smoking instead of tobacco. Such emergencies can sometimes lead to the discovery of new plants for human consumption: a well known example is the sugar beet, which was first cultivated in Europe during the Napoleonic wars, when the continent was cut off from the supply of cane sugar by the British blockade.

The kinds of plants consumed in emergencies indicate that perhaps all plants could be utilized, and it appears as if there is no plant that has a chemical composition which prevents its being used in some way or other. In some countries even the fly agaric, a poisonous toadstool, is consumed, being chewed by certain Asiatic tribes as an intoxicant.

THE FUTURE OF PLANTS CONSUMED BY MAN

The enormous technological progress of the last decade has freed the consumption of plants not only from its geographical, but also from its seasonal barriers. Previously it was only possible to obtain fresh fruits in Europe in the summer, but now most of them can be obtained the whole year round. Many fruits are supplied fresh from South Africa and other parts of the southern hemisphere during our winter. Even the most perishable products may be successfully transported from the most remote countries by air: for example, strawberries are flown to Europe from New Zealand. Another way to remove seasonal limitation is the cultivation of plants in greenhouses, and this method has become highly developed for growing e.g. cucumbers,

tomatoes and grapes. The main disadvantage, at present, of imported exotic fruit is its unripeness. The fruit has to be picked early to withstand transport and storage, and it arrives under-ripe on our markets. Either people will become accustomed to it, or, hopefully, a method of preservation will be found that does not spoil the natural qualities of ripe fruits.

However, there are also some more important problems in modern food production. The rapidly increasing world population has made the production of food in the future a pressing problem. Among the numerous solutions that have been put forward and that are being pursued at the present time, the recommendation of cultivating algae seems the least promising. Algae are poor in macronutrients and in Japan, where they have been cultivated for centuries, they are used more for flavouring purposes than for food. It seems, therefore, that the answer will not be to extend agriculture from the land to the bottom of the sea. The greatest need is to find a supply of proteins from vegetable sources, and our main aim is to find a plant that will substitute for meat. Of all plants, soya beans can be used for this purpose most satisfactorily. They are already used as a common substitute for meat in sausages and salami, and in Japan a "synthetic" steak has even been produced from soya beans. This "artificial" steak only has to be flavoured with a meat extract.

Soya beans used as a meat substitute start a new epoch in the consumption of plants. It is the beginning of the scientific selection of plants for human consumption, and the outcome of these trials is hard to predict. Will such a scientifically selected diet prove to be agreeable, or will it be as dull and miserable as the worst wartime diet of fallen leaves, bulbs and corms? While one might feel revulsion at such a thought, there is some encouragement to be had from the autobiography of Princess Sofia Dolgoruka, who as a girl was stranded in the Crimea during the revolution:

> "We clambered over the rocks catching crabs, and as we grew hungrier, ate anything edible (crocus bulbs in spring were quite a delicacy) and made strange brews with wild sorrel and small fish."

The plants discussed in this book obviously do not cover the full range of plants consumed by man. Only the most important and the most interesting have been selected, altogether totalling some 300, which form only a fraction of all the plants used for human consumption.

II. CEREALS AND PSEUDO-CEREALS

The term cereal is derived from *cerealia munera*, the gifts of the goddess Ceres, and is commonly used to refer not only to the grain itself and many of the manufactured foods derived from it, including flour, meals, bread, flaked, shredded or puffed breakfast cereals, etc., but also to the cultivated grass plants themselves, namely wheat, oats, maize, rice, etc., which yield the grain. These cultivated grasses are cereals in the strictly botanical sense. However, there are various other plants which, because of the similarity of their use, must be grouped with the cereals, although botanically they are different. To avoid confusion, these will be called pseudo-cereals. At the same time, it must not be forgotten that certain uses of the true cereals may lead sometimes to their being classified more appropriately in other groups. For example, when sweet corn is served on the cob or in a salad, when germinating wheat forms a type of salad or when the green parts of sprouted wild rice are eaten (as happens in parts of China), they must be regarded as vegetables. Similarly, when barley is used to make beer, or rye to produce whisky, these must be classed as beverage plants.

Since most of the pseudo-cereals did not have to be cultivated, but were simply gathered, it seems probable that many of these were being used for food by man long before he succeeded in cultivating the grasses. Among such ancient sources of cereal-like foods were probably acorns, beechmast and sweet chestnuts, the nuts of the oak, beech and sweet chestnut trees, respectively, all of which have also served in more recent times to provide an emergency source of flour for breadmaking for the people of some parts of Europe. On the other hand, cultivated pseudo-cereals, e.g. buckwheat, were introduced into Europe from China at the end of the Middle Ages (1436) and some others are known to be cultivated by American Indians.

Today the pseudo-cereals are a relatively insignificant crop, but the true cereals, on the other hand, represent the world's most important source of food. It has been predicted that if any one of the other commodity groups became unavailable, man could still survive and remain tolerably healthy, but a failure of the cereal crops would bring starvation and malnutrition to most parts of the world.

CEREALS

Botanically, the term cereal includes all the cultivated grasses belonging to the large monocotyledonous family, Gramineae. The cultivation of these by man, together with the domestication of animals and the invention of pottery, marked the beginning of the Neolithic Age. All the cereals are native to the Old World except for maize, which originated in America.

The valuable part of the cereal is the grain which is the whole fruit, called a *caryopsis*, in which the pericarp and the testa are inseparable. This develops from small bisexual flowers borne in an inflorescence, either in a spike or in a panicle. The unit of inflorescence in grasses is not a single flower but a *spikelet* which may contain one or more flowers. This consists of a main axis bearing a number of scales. The basal scales do not bear flowers and are called *sterile glumes*. The other scales are bracts (modified leaves) with flowers and are variously called *lemmas, lower* or *outer palea,* or *flowering glumes*. Each lemma has, arising in its axil, a flower axis which bears another small bract or bracteole called a *palea* on the opposite side to the lemma and a further pair of scaly bracteoles called *lodicules*, just beneath the ovary. Maize is the only exception to this general pattern, in that its spikelets are unisexual, forming separate male and female inflorescences on the same individual. It is therefore monoecious, the staminate flowers forming the terminal panicle or so-called tassel and the pistillate flowers in spikelets, forming the spadix or cob from which the grain develops and which arises laterally in the axil of the foliage leaf in which it is ensheathed.

All cereals have endospermous seeds; the *endosperm* in the case of wheat, for example, represents about 80–85% of the caryopsis. The main part is the starchy endosperm consisting largely of starch with a little protein and fat, and the endosperm is separated from the testa by a richly proteinous layer from which starch is absent, called the *aleurone layer*. The very small embryo is situated beneath the husk at the base of the seed and represents only about 3% of the caryopsis. The epicotyl of the embryo is ensheathed in a membrane known as the *coleoptile* and the radicle in a similar membrane, the *coleorhiza*. The *scutellum* or single cotyledon lies next to the endosperm. When the seed of cereals germinates, the surface of the scutellum secretes enzymes which break down the endosperm, the digested material then being absorbed and transferred to the growing parts of the embryo. Thus the scutellum in the cereal fulfils the triple functions of digesting, absorbing and conducting food to the embryo.

The first use of cereals for food probably took the form of a cooked porridge made from ground meal, most of them being suitable for this type of preparation. Later, baked unleavened cakes were produced and before long, the great superiority of wheatmeal and wheat flour for baking became established. In ancient Egypt and then in Greece and Rome, white bread made from wheat flour was a luxury for the rich. The same situation existed in England until about the end of the seventeenth century, but after this, white wheaten bread gradually replaced the barley- and oat-cakes hitherto eaten by the poorer people. However, the occasional failure of the wheat crop owing to adverse weather conditions still made it necessary to fall back on the barley and oats from time to time. Today, wheat is the established bread cereal in most of the countries of the western world, Australia and South Africa, although in parts of Europe, notably Germany, Austria, Czechoslovakia, Poland and Russia, rye bread is preferred. Oatmeal, originally the main cereal in Scotland, is still an item of some importance there, being used for a number of purposes, including the making of porridge and oat-cakes. In warm countries of Europe and elsewhere, poorer people sometimes use maize flour to make a kind of bread, although this is not very palatable.

There are several reasons why wheat flour is used so extensively for baking. These include the tolerance of the wheat plant for many types of climatic conditions, its ability to yield a fine white flour when properly milled and processed and the superior bread-making properties of the flour so produced.

In the countries where wheat can be cultivated, white flour is usually preferred for bread making. To obtain this, almost pure endosperm must be separated and ground. Thus the milling process for wheat is a complex operation involving separation into three main fractions: bran or pericarp with the attached testa and aleurone layer (in all about 12–17%), the endosperm itself (about 80–85%) and the embryo or wheat germ (about 3%). The removal of the bran and germ may result in a loss of up to 98% of the total thiamine and about 90% of the niacin, pyridoxine and pantothenic acid. However, complete separation of the endosperm from other fractions of the wheat kernel is not achieved simply. The process of milling takes place in stages, the outer husk or bran being removed first and the exposed endosperm being ground successively from a coarse grist known as semolina to a fine flour, with some degree of separation occurring at each stage.

When the quantity of flour yielded by this process represents 70% of the original wheat grain, it is described as 70% extraction flour, which is about the highest quality of straight white flour commercially available. Flours of higher extraction rate in which there is less efficient separation are also milled, ranging up to 100% extraction which is known as whole wheat or Graham flour, whilst a few of lower extraction rate, so-called Patent flours derived from specially blended fractions of the endosperm, are also produced.

The amount of vitamins actually lost in the milling of a particular flour depends mainly upon the percentage extraction. However, since white flour is so widely used for bread making, statutory requirements for its enrichment with vitamins of the B group (notably thiamine and niacin) and with iron exist in both the U.S.A. and the U.K., and similar treatment is applied also, either compulsorily or voluntarily, in a number of other countries.

Even 70% extraction flour is not truly white owing to the presence of the natural carotenoid pigment lutein. This normally disappears as a result of oxidation if the flour is stored for a long period, but in practice, the process is usually hastened by the addition of oxidizing agents to the flour. Chemical additives are also used to accelerate the ageing of the flour proteins which results in considerable improvement of the baking properties. The accurate control of the colour and baking properties forms an important part of flour milling.

The earliest form of bread was unleavened and this survives even to the present day in the matzos eaten by orthodox Jews at the Passover. However, the process of leavening the dough by the addition of yeast, a fungus known as *Saccharomyces*, is very old and was well known in Biblical times. It causes anaerobic breakdown to alcohol of sugars derived from some of the starch in the dough, producing enough carbon dioxide gas to make the dough spongy and light. This use of yeast for leavening is an important example of the usefulness of this plant which also performs several other functions in food and beverage manufacture, as well as being a food material in itself.

Today, almost all bread is leavened, but fermentation by yeast is tending to be replaced in modern high-speed bread-making processes by the use of compressed air which is pumped straight into the dough and which produces the desired spongy texture much more rapidly when the pressure is released.

Cereals are not always used in the form of flour or meal. Sometimes the grain is used whole after removal of the husk, e.g. polished rice or pearl barley. In the case of maize, the unripe caryopsis is consumed after the whole cob has been boiled or roasted. Large quantities of decorticated grains are formed into flakes and dried or toasted to produce breakfast cereals such as rolled oats or cornflakes, while others such as rice or wheat are often cooked in high pressure steam which is released suddenly to cause them to expand into products such as puffed rice or puffed wheat. These breakfast cereals are produced in great profusion and are very popular, especially in the U.S.A. and U.K., as well as in most other English-speaking countries.

Thus it is true to say that cereals as food plants are cultivated grasses marketed in the form of grains (caryopses) and used for the production of starchy foods. If the grains are used in other ways, e.g. for brewing beer, they cease to be cereals and become, for example, beverage plants. However, in breweries cereals are used in the form of germinated grains, mainly of barley, whose endosperm is converted by germination into malt, a material containing mainly maltose. Malt for beer production is further broken down by *Saccharomyces* into alcohol and carbon dioxide, or it may sometimes be consumed as malt, either in confectionery or for the production of nutritive beverages. Barley used for production of malt is neither a cereal nor a beverage plant, but a plant for extraction (a sugar plant), and similarly maize (the embryo) is used for extraction of oil. Germinating grains, i.e.

young seedlings, together with the seeds (caryopses) may be used as a vegetable, and finally it should also be mentioned that flour is used as a thickening agent in sauces. Thus cereals in the botanical sense are used for human consumption not only as cereals but also as vegetables, beverage plants, sugar plants and for improving the texture of food.

Nutritionally, there is very little difference between the various cereals, and the most nutritive form in which they can be used is as the entire caryopsis. Unfortunately, the removal of the husk and the outer layers of the endosperm by modern milling processes results in the loss of important vitamins of the B group. The classic example of this is rice. When modern milling methods were introduced to the Far East, a hitherto almost unknown disease, beri-beri, spread rapidly through the rice-eating countries. The work in Indonesia of the Dutch doctor, C. Eijkman, in 1890 showed that the disease could be induced in the domestic fowl by feeding it on polished rice alone. This led ultimately to the discovery that the process of polishing which removed not only the husk but also the outer layer of the endosperm, resulted in the loss of most of the thiamine (vitamin B_1), the important nutrient whose absence produced the characteristic symptoms. Many of the poorer people of the Far East, living almost entirely on a diet of polished rice, quickly fell victims to the disease. As a result, artificial enrichment of rice with vitamins and minerals has been practised in the Philippines and elsewhere.

On the other hand, it had also been observed that the poorer people of northern Italy, whose diet consisted almost entirely of maize, sometimes developed a rather similar disease called pellagra, which in due course was shown also to be caused by a vitamin deficiency, that of another of the B group of vitamins, known as niacin or nicotinic acid. Pellagra is particularly liable to develop in people whose staple diet is maize, and it was discovered that although maize contains niacin, it is in a chemically bound form which is not nutritionally available, thus giving rise to the avitaminosis.

From Table I it can be seen that all the cereals contain a large amount of starch, a significant amount of protein and a relatively small amount of fat. They all contain appreciable quantities of the B vitamins thiamine, riboflavin and niacin, but no vitamin C, while vitamin A appears only in maize. In addition to the nutrients shown, cereals contain some other vitamins of the B group, namely biotin, folic acid and pantothenic acid, as well as tocopherols (vitamin E). They are rich in the valuable nutrient phosphorus and contain appreciable amounts of the essential trace elements manganese, molybdenum and also zinc, of which they form the richest vegetable source. On the other hand, cereals as a food are deficient in iron and particularly in copper, of which they are the poorest vegetable source.

The total world production of the various cereals is shown in Table II.

Table I

Comparative figures for the chemical composition of the various cereal grains. The data have been extracted from Agriculture Handbook, No. 8 "Composition of Food" published by the U.S. Department of Agriculture (Agricultural Research Center) 1963, except for the incomplete data relating to foxtail millet, Japanese barnyard millet and pearl millet. Dashes indicate the lack of reliable data, not absence of chemical compounds.

Name of cereal or pseudo-cereal	*Water* %	*Protein* %	*Fat* %	*Carbo-hydrate* %	*Vitamins A in international units, others in mg* *A*	*Thia-mine*	*Ribo-flavin*	*Niacin*	*C*
CEREALS									
1. Barley, Pearl, light	11·1	8·2	1·0	78·8	0	0·12	0·05	3·1	0
2. Maize (flour)	12·0	7·8	2·6	76·8	340	0·2	0·6	1·4	0
3. Millet, Finger	—	—	—	—	—	—	—	—	—
4. Millet, Foxtail (whole grain)	—	12·1	4·1	69·3	—	—	—	—	—
5. Millet, Japanese barnyard (whole grain)	—	10·6	4·9	69·3	—	—	—	—	—
6. Millet, Pearl (whole grain)	11·3	10·4	3·3	73·0	—	—	—	—	—
7. Millet, Proso (whole grain)	11·8	9·9	2·9	72·9	0	0·73	0·38	2·3	0
8. Oats, Rolled	8·3	14·2	7·4	68·2	0	0·6	0·14	1·0	0
9. Rice (whole grain)	12·0	7·5	1·9	77·4	0	0·34	0·5	4·7	0
10. Rye (whole grain)	11·0	12·1	1·7	73·4	0	0·43	0·22	0·16	0
11. Sorghum (grain of mixed varieties)	11·0	11·0	3·3	73·0	0	0·38	0·15	3·9	0
12. Wheat (whole grain)	12·5	12·3	1·8	71·4	0	0·52	0·12	4·3	0
PSEUDO-CEREALS									
14. Buckwheat (whole grain)	11·0	11·7	2·4	72·9	0	0·60	—	4·4	0

Table II

World production of cereals and buckwheat (a pseudo-cereal) for 1970 with the separate outputs of the principal producing countries. Where data refer to another year, this is given in parentheses after the producing country. The information is abstracted from "Production Yearbook" vol. 24, published by F.A.O., Rome, 1971. The amounts are quoted in millions of metric tons.

Name of cereal or pseudo-cereal	*Total world production*	*Largest producers*
CEREALS		
Barley	128·5	U.S.S.R. 28·0, U.S.A. 8·937, France 8·009, U.K. 7·494
Maize	266·8	U.S.A. 104·393
Millet	92·5	India 9·4, U.S.S.R. 3·0
Sorghum		U.S.A. 17·706, India 10·0
Unspecified sorts of millet and sorghum		China (Mainland, 1966) 17·120
Oats	52·6	China (Mainland, 1965) 16·9, U.S.A. 13·201, U.S.S.R. 11·0
Rice	306·8	China (Mainland) 100·0, India 62·5, Pakistan 22·2, Japan 16·479, Brazil 7·6
Rye	30·8	U.S.S.R. 15·0
Sorghum, *see* Millet and Sorghum		
Wheat	311·6	U.S.S.R. 94·0, U.S.A. 37·516, China (Mainland 1966) 30·0
PSEUDO-CEREALS		
Buckwheat	1·668	U.S.S.R. 1·5, Canada 0·062

1. Barley

Barley (*Hordeum vulgare* or *sativum*) is a cultivated grass and belongs to the tribe Triticeae; it has many varieties. It is an annual plant of temperate regions and, because of its hardiness and short growing season, it will grow at high altitudes and latitudes. For example, it may be grown as far north as latitude 70°N (Norway).

The height of barley depends on the variety and the environmental conditions, but it is usually about 1·2 m tall. The flowers form a spike in which

1. BARLEY (x0·5)
(*Hordeum distichum*)
Entire ear

single-flowered spikelets are arranged in groups of three on the main axis. In the commonest variety, *H. v.* var. *distichum*, two-rowed barley, only the central spikelet is fertile and awned. In *H. hexastichum*, six-rowed barley, all three spikelets are fertile and awned. Four-rowed barley, in which all three spikelets are fertile but are asymmetrically arranged, is also grown.

At one time it was considered that the cultivated varieties of barley were derived from the wild two-rowed barley, *H. spontaneum* of south-west Asia, but the more recent discovery of a wild six-rowed barley, *H. agriocrithon*, growing in Tibet, has led to a re-examination of the theories of the origin of cultivated barley. It appears likely that either *H. agriocrithon* gave rise to the cultivated variety *H. hexastichum* and that *H. spontaneum* was the parent of *H. distichum*, or that a cross between *H. agriocrithon* and *H. spontaneum* produced the ancestor of both cultivated varieties.

Neolithic excavations at Fayum in Egypt have revealed that barley was grown by the ancient Egyptians. It was also known to the Greeks and Romans and was cultivated in ancient China, from whence it was introduced to Japan about 100 B.C.

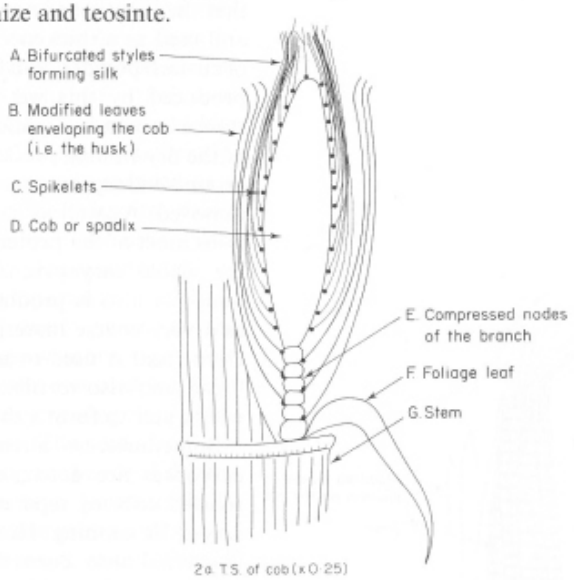
As a cereal, barley plays only a very small role at the present time and the bulk of the barley produced is used for brewing. The biggest producers are the U.S.S.R. and the U.S.A.

2. Maize

Maize, CORN or *Zea mays*, a member of the tribe Maydeae, is the only one of the cereals which originated from the American continent. The discoverers of America found the plant already in a state of cultivation and there is ample evidence of its having been cultivated for at least 4000 years, since the time of the Mayas and Aztecs.

It is a native of tropical Central America, the wild plant nearest to it being teosinte or *Zea mexicana*. However, teosinte is not the true ancestor of

cultivated maize and it appears more likely that both plants had a common ancestor now extinct, which by hybridization with another grass, *Tripsacum*, produced both maize and teosinte.



2. MAIZE (*Zea mays*)

Maize attains a height of 90–450 cm and is a monoecious annual with flowers arranged in separate male and female inflorescences. The male flowers occur in a terminal inflorescence called the tassel, which is a panicle whose spikelets are two-flowered and occur in pairs, one of which is sessile and the other pedicellate. In the female inflorescence, only one of the flowers in each spikelet is fertile and the paired spikelets in this case are both sessile and appear on a spadix known as the cob, developing as the swollen tip of a branch with extremely short internodes. The overlapping modified leaves arise from the compressed nodes of the branch and form the husk which sheathes the spadix. The whole structure develops as a lateral branch in the axil of a foliage leaf with a smaller blade which sheathes it.

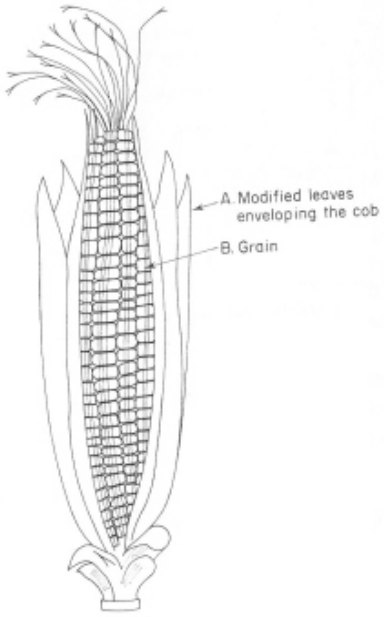
The corn produced in America may be either wet-milled or dry-milled. The products of wet-

milling include corn starch and its various derivatives such as corn syrup, dextrose, etc., also corn oil and animal feeding products. It is worth noting that the substance known as cornflour in the U.K. and used as a thickener for soups and as the basis of custard powder, is in fact almost pure corn starch produced by this wet-milling process. The substance known as cornflour in America is a product of the dry-milling process and consists of the finely ground endosperm with most of the germ and husk removed. As well as starch, therefore, it still contains most of the protein and some of the fat from the whole caryopsis. A coarser meal similar to semolina also is produced by dry-milling, as well as a very coarse material known as hominy grits. Corn meal is used to make a kind of unleavened bread and also tortilla cakes, or it may be boiled with water to form a thick porridge.

Sometimes, as already mentioned, the whole caryopses are eaten, either from the boiled or roasted cob, or separated from the cob and preserved by canning. However, much of the corn is converted into corn flakes by rolling and then roasting the suitably flavoured grits, forming a breakfast food which is popular in most of the English-speaking countries.

There are many varieties of maize. *Zea mays* var. *saccharata* is the common sweet corn, which is mostly used for eating as corn on the cob in the U.S.A. *Z.m.* var. *everta* is a special variety of maize from which popcorn is produced. The small, hard fruits of this variety have a hard and glossy outer endosperm. When the caryopses are exposed to a high temperature, they burst and the soft palatable inner endosperm is everted. Popcorn produced in this way was consumed first in the Southern States of America, but the soldiers of the Northern army during the civil war became acquainted with the commodity and later introduced it to the North.

The other varieties of maize normally cultivated include DENT maize, *Z. m.* var. *americana*, which is characterized by an indentation or depression on the top of the grain, caused by shrinkage of the soft

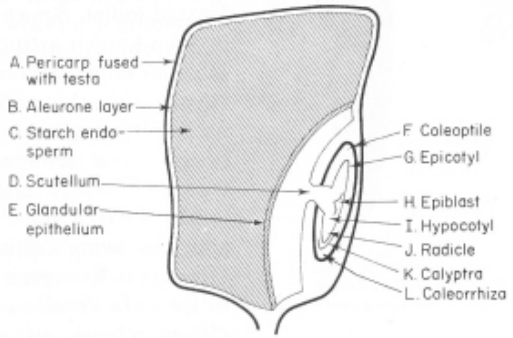


2b. *Ripe cob*
(Grain partly revealed) (x 0·35)

2. MAIZE (*Zea mays*)

endosperm, and which is the typical maize of the American Corn Belt. There is also FLINT maize, *Z. m.* var. *praecox*, with a hard endosperm but no indentation and normally cultivated in Europe. FLOUR or SOFT maize, *Z. m.* var. *amylacea*, is without the horny endosperm and is cultivated almost exclusively by the American Indians for their own use. POD CORN, *Z. m.* var. *tunicata*, has a pod-like covering to the grain and is of no use commercially. Lastly, WAXY maize, although not regarded as a distinct variety, is valuable because its starch consists entirely of amylopectin. In the other types of maize starch, there is approximately 28% of amylose mixed with the amylopectin.

Hybrid maizes are frequently grown in the U.S.A., as they generally grow more vigorously than the pure strains. However, the seed for these must be specially prepared by crossing the appropriate pure-breeding varieties. The seeds from the hybrids cannot be used owing to the rapid decline of the hybrid vigour in the later generations. In spite of its tropical origin, maize grows well also in the warmer parts of the temperate zones. Thus, it has become a typical cereal of southern Europe and also of South Africa, where it is known as the MEALIE. However, as can be seen from Table II, by far the greatest producer of maize is still the U.S.A., which itself is a country of the temperate zone.

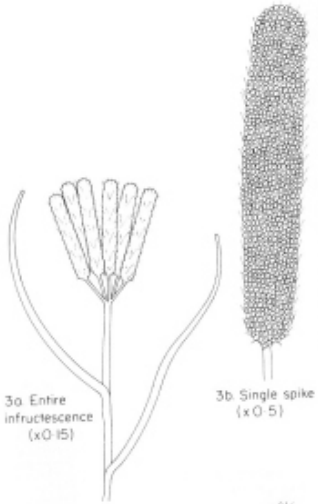


2c. *Caryopsis*
(Highly magnified)

2. MAIZE (*Zea mays*)

3. Millet, Finger

Finger millet, *Eleusine coracana*, is known also as RAGI, NAGLI, TELABUN, MARUA, KORAKAN, BIRDS-FOOT MILLET or AFRICAN MILLET. This is the only millet that belongs to the tribe Chlorideae, the others all belonging to the tribe Paniceae. Its spikes are about five in number and they arise from a common central point, thus resembling the fingers of the hand. They are from 10 to 12 cm long and the plant may reach a height of 120 cm. Finger millet is cultivated in India, Malaya and China, but it has also spread through the wetter parts of Central Africa. The plant probably came from India in the first place.



3. FINGER MILLET (*Eleusine coracana*)

4. FOXTAIL MILLET (*Setaria italica*), spike-like panicle (x0·5)

4. Millet, Foxtail

Foxtail millet, *Setaria italica* of the tribe Panicae, is often known as Italian, German, Hungarian or Siberian millet, according to its country of origin. At one time, this particular millet was commonly used for human food in Europe, but today, because of the higher economic standards in most countries, the millets are only ever cultivated for fodder. Foxtail millet is probably of Asiatic origin and was being cultivated in China in the year 2700 B.C. In Europe, it is known to have been grown by the Lake Dwellers. The plant is between 90 and 150 cm in height and its inflorescence, a contracted spike-like panicle, may be up to 30 cm in length. The caryopses vary greatly in colour and may be white, yellow, red, brown or even black.

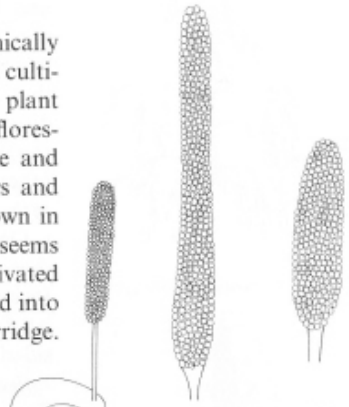
5. Millet, Japanese Barnyard

Japanese barnyard millet or *Echinochloa crus-galli* var. *frumentacea*, a member of the tribe Paniceae, also called SANWA MILLET, is used in Japan and Korea as human food, mostly prepared as a form of porridge. It is about 120 cm tall and the inflorescence, a panicle, reaches 15 cm in length. The spikelets consist of two flowers, one of which is sterile. This millet is cultivated as a forage plant in the U.S.A.

5. JAPANESE BARNYARD MILLET (*Echinochloa crusgalli* var. *frumentacea*)

6. Millet, Pearl

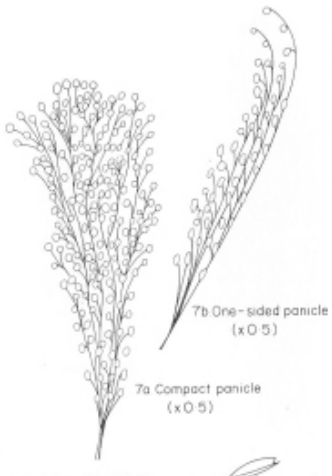
Pearl millet or BULRUSH MILLET, known botanically as *Pennisetum glaucum* or *P. typhoideum*, is a cultivated grass of the tribe Paniceae. It is a tall plant which may reach over 4 m in height. Its inflorescence is a spike-like panicle varying in size and colour. The spikelets occur usually in pairs and consist of two flowers. Pearl millet was known in Asia and Europe in prehistoric times, but it seems to have originated in tropical Africa. It is cultivated mainly in Africa and India, where it is ground into flour and made into bread or cooked as a porridge.



6. PEARL MILLET (*Pennisetum glaucum*)

7. Millet, Proso

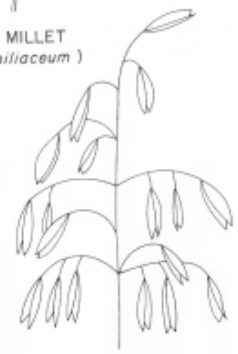
Proso millet, HOG MILLET or BROOM MILLET, a member of the tribe Paniceae and botanically *Panicum miliaceum*, is the true millet of the ancient Romans who called it *milium*. The name *proso* is the Russian word for millet. The plant is generally believed to have originated in Egypt or Arabia and to have spread to Russia, India, China and Japan,



7 PROSO MILLET (*Panicum miliaceum*)

where it is mainly cultivated. Some is grown also in the Mediterranean region. It may be as tall as wheat, about 90–120 cm, and its flowers are borne in two-flowered spikelets forming a panicle, either compact or one-sided.

8. Oat



8 OATS (*Avena sativa*)

The commonest cultivated species of oat (genus *Avena*, tribe Paniceae) is *A. sativa*. The origin of this cereal is uncertain, but it is believed to be native to Asia. It was widely accepted during the last 100 years that *A. sativa* was derived from the wild oats, *A. fatua*, while the cultivated red oat, *A. byzantina*, was believed to be descended from the wild red oat, *A. sterilis*. However, recent genetical, physiological and pathological studies have indicated that *A. sativa* is more likely to have been derived directly from *A. byzantina* and hence that *A. sterilis* is most probably the progenitor of all the other species of oat, including *A. byzantina*, *sativa*, *orientalis*, *fatua* and *nuda*.

Oat is one of the cultivated European cereals that may be grown as far north as latitude 70°N. Its height varies between 60 and 150 cm. The spikelets form a panicle which is either spreading or one-sided. The spreading type is characteristic of *A. sativa*, the one-sided type of *A. orientalis* (the Tartarian oat), now considered merely to be a variety of *A. sativa*. The lemmas of the two-flowered spikelets either have only short awns or are completely awnless. It is thought that oat may have come originally from south-west Europe or south-west Asia and also from north Africa. However, the ancient nations of the Mediterranean area were not acquainted with oat and no reference to it is to be found in the Bible nor in the works of Pliny or other authors of classical times.

Although the oat is a highly nutritive cereal, it is

cultivated mainly as an animal food plant, especially as fodder for horses in the colder parts of the temperate zone. The best known dish is porridge, popular in Scotland and rather similar to the oat pudding consumed in Russia.

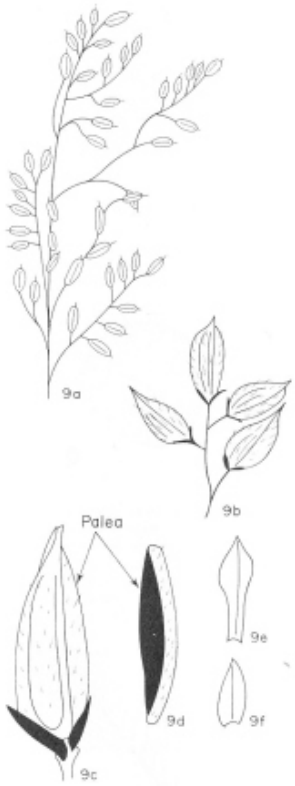
9. Rice

The rice (*Oryza*) species and their varieties (members of the tribe Oryzeae) are certainly the main, and often the only cereal used by nations of the Far East. According to the records, rice has been cultivated in China for 5000 years and Theophrastus mentions its cultivation in India.

Rice was first brought to Europe by Alexander the Great but its cultivation started no earlier than the eighth century A.D. In A.D. 711 the Moors began to grow rice in Spain. However, today the only European country producing rice in large quantities is Italy, where the plantations are situated in the north along the River Po.

The commonest species of rice is *Oryza sativa*. Its varieties belong to two groups, the 'japonica' and 'indica' types. The japonica types are short grained while the indica types are long grained. It is said that there are altogether 2400 varieties of cultivated rice and that in India alone about 1100 of them are cultivated. In general, rice is up to 120 cm tall but some rice cultivated in India and Iran may reach up to 450 cm. It has a hollow, erect stem and the leaves are long, ensheathing the stem. The inflorescence is a terminal panicle which grows at first erect and later, when the grains ripen, becomes arched.

Rice is the only cereal that is cultivated in flooded fields which remain flooded for the major part of the growing season and are normally drained some weeks before harvest. Drainage of the fields creates favourable conditions for the grain to complete its development. There are, however, also varieties of rice that grow like other cereals in soil that is not flooded; such rice is called dry, upland or hill rice



9 RICE (*Oryza* spp.)

9a Entire panicle (x 0·5)
9b Detail of the panicle (x 2)
9c Spikelet (lemma, palea and glume) (highly magnified)
9d Palea (highly magnified)
9e Lower glume (highly magnified)
9f Upper glume (highly magnified)

and is the oldest cultivated form but today is without economic importance. The bulk of the rice consumed is produced from flooded fields and is called wet, aquatic or lowland rice. The seedlings planted in the flooded fields are produced in nurseries which are also either wet or dry; in some countries rice is sown directly in the flooded fields but this method of cultivation is wasteful.

India, China, Vietnam and Japan are the largest producers of rice, and the crop probably originated in south-east Asia.

The so-called wild rice growing in Africa, south-east Asia and North America is in fact a plant of another genus, *Zizania*, but it belongs to the same tribe (Oryzeae). *Z. aquatica* was an important cereal for the American Indians, although it is strictly not a cultivated grass. It reaches 360 cm in height. Wild rice is also used in China, but more as a vegetable than as a cereal, the green parts and not the grain being eaten.

The inflorescence of rice is a panicle and its fine branches terminate in a single fertile flower which develops into a single grain with a brown husk. This readily detachable whole grain is known as "paddy". As a food, rice is generally boiled, as the lack of gluten prevents it from being used to make bread. However, a proportion is milled into meal and flour which is used for various purposes in bakery and confectionery.

10. Rye

Rye, or *Secale cereale* of the tribe Triticeae, is one of the most recently domesticated cereals, being known to the Ancient Greeks and Romans, but not to the Ancient Egyptians. It is believed to have originated in Afghanistan and Turkestan, where the wild species, *S. montanum*, is still found. It is the tallest cereal of northern Europe, growing to a height of 180 cm. The spike consists of two-flowered spikelets with long-awned lemmas. There are only a few varieties and 90% of the world crop

10. RYE (*Secale cereale*)
Entire ear (x0·5)

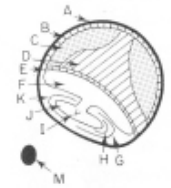
is produced in Europe where rye bread is preferred in countries such as Germany, Austria, Czechoslovakia, Poland and Russia. Russia is the chief producer, because rye can be grown well in colder climates with short summers.

11. Sorghum

This plant, belonging to the tribe Andropogoneae, was known as a cereal in Ancient Egypt at least 2200 years B.C. It is a native of Africa and Asia, the commonest species, which is also often erroneously called millet, being *Sorghum* (or *Sorgum*) *vulgare*. The many varieties which have been developed include *S. v.* var. *durra* (or DURHA), *S. v.* var. *caffrorum* (or KAFFIR), a variety cultivated in Africa, *S. v.* var. *rexburgii*, which is the Indian sorghum, known as SHALLU, and *S. v.* var. *nervosum* which is the Chinese sorghum, KAOLIANG. The plant varies in height, according to species, from 90 cm to 4·5 m and is very similar to maize. However, it has only one type of inflorescence, which is a panicle consisting of spikelets with bisexual flowers. It is a tropical plant and grows only in warmer countries including those of the Mediterranean region and the Southern States of the U.S.A.

Sorghum is an important human food in China, India and Africa, being used to make porridge and bread, very often being blended with wheat flour for the latter purpose. In other countries, the plant and grain are mainly used for fodder, some care being necessary since the young green parts of the plant are liable to contain appreciable quantities of cyanide.

11a. Compact panicle (x0·25)



A. Pericarp fused with testa
B. Aleurone layer
C. Hard endosperm
D. Soft endosperm
E. Glandular epithelium
F. Cotyledon
G. Coleorhiza
H. Calyptra
I. Epiblast
J. Epicotyl
K. Coleoptile
M. Caryopsis (x0·5)

11b. Cross-section of the grain (caryopsis)-(highly magnified)

11. SORGHUM (*Sorghum vulgare*)

12. Wheat

Wheat, *Triticum* spp., a member of the tribe Triticeae, has been known since prehistoric times, the oldest grains which date from 6750 B.C. being

found in excavations of the Jarmo site in the upland of eastern Iraq. In ancient times, it rapidly became the most important cereal, a position which it still occupies in almost all countries of the Western World. However, the main producers of wheat are in fact the U.S.S.R., the U.S.A. and China.

The species can be grouped according to the genomes or sets of chromosomes which their somatic cells contain. The so-called EINKORN group contains diploid wheat, *T. monococcum*, with seven pairs of chromosomes. EMMER wheats, with 14 pairs of chromosomes, belong to another group which includes: *T. dicoccum* or EMMER wheat; *T. durum*, commonly called DURUM wheat; *T. persicum* or PERSIAN wheat; *T. turgidum*, called POULARD or RIVET wheat; and *T. polonicum* or POLISH wheat. The hexaploid or *vulgare* group, with 21 pairs of chromosomes, includes *T. vulgare* (*aestivum*) or COMMON wheat, *T. compactum* or CLUB wheat, *T. spelta* or SPELT wheat, *T. sphaerococcum* or SHOT wheat, *T. macha* or MACHA wheat and *T. vavilovi* or VAVILOV wheat, the last two species being named after the Russian breeders.

12a Beardless variety (x0·5)

12b Bearded variety (x0·5)

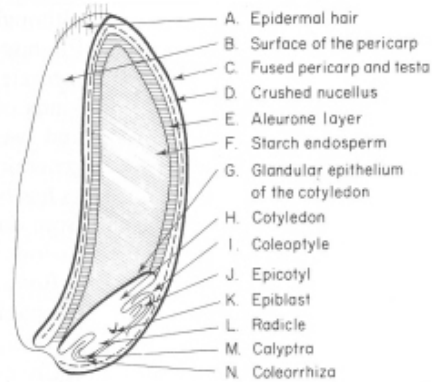
12. WHEAT (*Triticum* spp.)

Einkorn wheat has been known since the Stone Age and was developed from the wild wheat, *T. boeoticum*, which still grows wild in Asia Minor and south-east Europe. It carries two A-genomes. Tetraploid wheat was derived from wild emmer, *T. dicoccum*, still to be found in Syria and Palestine. It contains the two A-genomes of the einkorn parent, plus two B-genomes derived from a wild grass, *Aegilops speltoides*, so that its genotype is AABB. Hexaploid wheat was then developed from a further crossing which occurred when the cultivated tetraploid wheat came into contact with the weed *Aegilops squarrosa*, probably growing on the borders of the fields of the mid-European Lake Dwellers of the Neolithic Age. It contains two D-genomes contributed by the weed and its genotype is therefore AABBDD.

Einkorn wheat is no longer of any importance and is grown only rarely, mainly in the mountainous parts of Spain, where it is sown chiefly as a

fodder plant. The name einkorn (German: "one-seeded") refers to the fact that the spikelets contain only one caryopsis. The cultivation of emmer wheat also is limited, being now mainly restricted to Russia and some mountainous parts of Germany. On the other hand a very important source of tetraploid wheat is *T. durum* which grows best in warmer regions; this has become important as the source of semolina flour, most suitable for making pastas or paste products, such as spaghetti, macaroni, etc. The Italians claim that the best wheat for this purpose is the *T. durum* grown in Latium, the region around Rome. However, the most widespread type of wheat throughout the world is hexaploid wheat, mainly *T. vulgare*, which is used for bread-making.

The inflorescence of wheat is a spike made up of spikelets containing from two to five flowers. The lemmas are either awnless in the beardless varieties or have short awns in those varieties which are bearded. The plant attains a height of 60–180 cm.



12c. L.S. passing through the furrow of the grain (highly magnified)

At the present time, wheat is the most important of the cereals. Only in the Eastern countries is it rivalled by rice, which, however, will not grow at temperatures below 25°C. Wheat can withstand much lower temperatures, but on the other hand it requires a summer sufficiently long to allow it to flower and produce grain. Since such summers do not occur in extreme northern regions, it was the

Russians who became particularly interested in trying to induce wheat sown in early spring to flower earlier, and this was achieved by Lysenko, a Russian biologist who exposed the germinating grain of wheat in which the radicle was just appearing, to a temperature of −5°C. When these germinated seeds were planted early in the spring, they developed flowers and grain at the correct time. This treatment, now known as vernalization, has enabled wheat to be grown in areas where this would not otherwise have been possible.

From the practical point of view, wheat is differentiated into two main classes, namely hard and soft wheats which yield respectively the strong and weak flours known to bakers. In classical Roman times, the hard wheat was referred to as *triticum* and the soft as *siligo* so the distinction is by no means of recent origin. Strong flour from hard wheat is of a coarse texture and is required for the satisfactory making of bread. Weak flour from soft wheat, however, is a fine powdery flour which although of little use for bread-making is very good for biscuit manufacture. There are various intermediate grades of flour obtained from different kinds of wheat, or sometimes by blending strong and weak flours together. Self-raising flour is generally of medium strength. On the other hand, as has been mentioned, a very strong flour derived from durum wheat is needed for semolina and the various pasta products made from it.

Botanically, there are no distinguishing features to enable a clear identification of the two types of wheat. Although it is true that hard grains generally exhibit a flinty, vitreous appearance of the endosperm, whilst the endosperm of soft wheat is mealy and white, this is not an infallible guide. The two types can be identified with certainty only at the milling stage by the types of flour that they produce. It appears that the difference between hard and soft wheat varieties lies in the protein fraction of the endosperm. Straightforward chemical analysis reveals quite clearly that there is a difference in the amounts of protein, as can be seen

from Table III. Thus the hard varieties contain larger amounts of protein than the soft varieties. However, this is not in itself sufficient to explain the very great difference in the baking properties of the two types of flour, which is attributed to differences in the nature of the proteins in the endosperm. There is evidence that in the soft wheat

Table III

Chemical composition of some hard and soft varieties of wheat. The figures are quoted from "Cereal Crops" by Warren H. Leonard and John H. Martin (Macmillan, N.Y., 1963) p. 367

Type of Wheat	*Protein (%)*	*Starch (%)*	*Sugar (%)*	*Fat (%)*	*Ash (%)*
Hard Red Spring	16·5	61·2	3·19	2·00	2·04
Durum (Extra Hard)	16·0	63·0	3·58	2·19	2·19
Red Durum	16·8	61·3	3·33	1·98	2·14
Hard Red Winter	15·3	63·5	2·84	1·67	1·92
Soft Red Winter	12·4	66·5	2·90	1·66	2·07
White	11·2	66·6	4·02	1·80	1·86

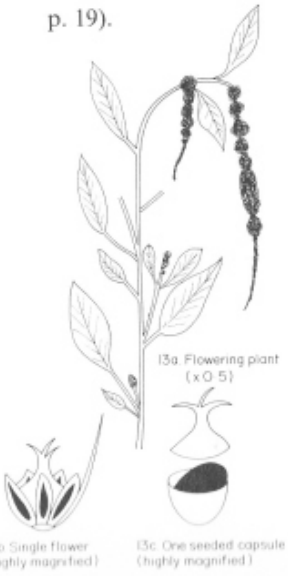
endosperm, there is a higher ratio of soluble proteins (albumins, globulins and proteoses) to insoluble proteins (glutenin and gliadin) than in the endosperm of hard wheat, which means that the latter contains very much more of the insoluble fraction or gluten, as it is called, than the former. However, the difference is still by no means fully understood.

Hard wheat is grown in the U.S.A. and Canada as well as in the warmer parts of Europe, while soft wheat is grown in the U.K. and in northern and central Europe. Those varieties described as "red" have a reddish-coloured grain owing to the presence of an anthocyanin in the bran.

PSEUDO-CEREALS

All plants outside the Gramineae with fruits and seeds that can be ground into flour for making bread and similar products might be called pseudo-cereals. This group also includes acorns, beechmast, sweet chestnuts, seeds of leguminous plants, etc. However, since these fruits and seeds have today lost their importance as pseudo-cereals and have mainly acquired another function for human consumption (e.g. as nuts or pulses), they will be dealt with under their more appropriate headings. Thus, the true pseudo-cereals are nowadays mainly plants with small seeds used in the same way as cereals and also cultivated like cereals in fields. They include: buckwheat, still sown in Asia and some parts of Europe and America; amaranth species, mainly of Central and South America, which were cultivated by the Aztecs; quinoa, the "cereal" of the ancient Incas, still growing in Equador, Bolivia and Peru; and the Mexican chia, another pseudo-cereal of the Aztecs. Otherwise, the only pseudo-cereal greatly dissimilar to cereals is the water chestnut, an annual aquatic plant bearing submerged large nuts. The water chestnut was cultivated in Neolithic times in Europe but today it is cultivated only in China and the Far East.

In chemical composition, the seeds of pseudo-cereals are all similar to the true cereals, but, unfortunately, figures are available only for buckwheat (see Table I, p. 18). Also only buckwheat, of all the pseudo-cereals, is mentioned in the world statistics of agricultural production (see Table II, p. 19).

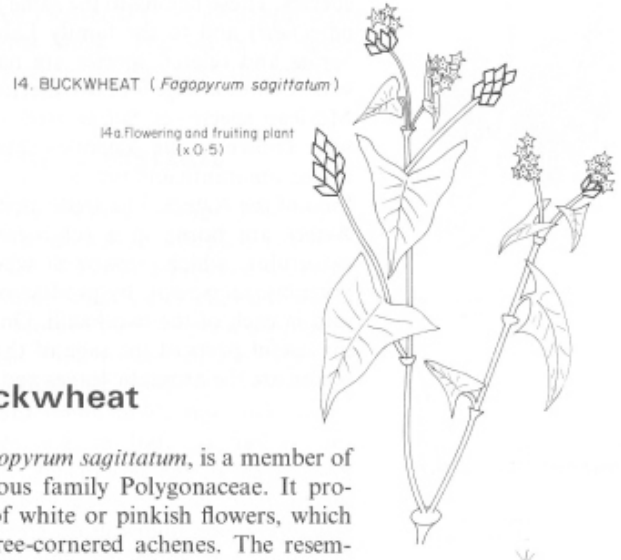


13. AMARANTH (*Amaranthus caudatus*)

13. Amaranth

The genus *Amaranthus* belongs to the family Amaranthaceae which is very closely related to the family Chenopodiaceae. All species of *Amaranthus* are herbaceous annuals yielding one-seeded capsules arranged in dense spikes and opening by means of a lid. *Amaranthus leucocarpus* grows in the New World and is native to Central America, being cultivated principally in Mexico and Guatemala. In Mexico, it has been an important crop since 5000–3000 B.C. and the Aztec Emperor Montezuma received annual tribute from his subjects in amaranth grain. *A. cruentus* also is cultivated as a pseudo-cereal in Guatemala and other parts of Central America, while *A. caudatus* is grown in the Andean region of Bolivia, Peru and northern Argentina. *A. paniculatus*, however, is a grain crop of south-east Asia.

Leaves from plants of this genus are used also as a vegetable, rather in the same manner as spinach.



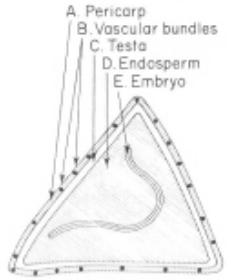
14. Buckwheat

Buckwheat, *Fagopyrum sagittatum*, is a member of the dicotyledonous family Polygonaceae. It produces racemes of white or pinkish flowers, which develop into three-cornered achenes. The resemblance of these achenes to beechmast led to the plant being called by the German name *Buchweizen* (beechwheat) corrupted in English to buckwheat. However, as its name also implies, it is cultivated in much the same way as wheat and its seeds are separated from the pericarp and ground into flour which is used for making porridge (Russian *kasha*) or pancakes. Sometimes the whole unmilled seed is consumed.

The plant is a native of Central Asia, where it still grows wild, but it has for many centuries been cultivated in China. It was introduced into Europe at the end of the Middle Ages and it is still an important crop for human consumption in Russia. Elsewhere, in the cooler western European countries, it is grown only as fodder.

Apart from *F. sagittatum*, another species is also cultivated; this is *F. tartaricum*, which is distinguished by rounded angles to the achenes.


14b. Achene (highly magnified)



14c. T.S. of the achene (highly magnified)

15. Chia

15a. Flowering plant (x 0·5)

15b. L.S. of the flower (highly magnified)

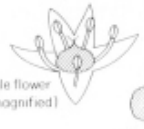
15c. Carcerulus (highly magnified)

15. CHIA (*Salvia columbariae*)

Another pseudo-cereal cultivated by the ancient Aztecs was *Salvia columbariae* and its related species. These belong to the same genus as sage (*S. officinalis*) and to the family Labiatae. *S. columbariae* and related species are native to Mexico, while common sage is of Mediterranean origin. The Mexican species of *Salvia* used as pseudo-cereals were known to the Aztecs as chia. Together with maize, amaranth and beans, chia formed the staple food of the Aztecs. The seeds used for grain by the Aztecs are borne in a schizocarpic four-seeded carcerulus which separates when ripe into 4 portions, mericarps, by production of a false septum in each of the two loculi. On the other hand, the useful parts of the sage of the Mediterranean region are the aromatic leaves and not the fruits.

16. Quinoa

16a. Infructescence (x 0·5)



16b. Single flower (highly magnified)

16c. Achene (highly magnified)

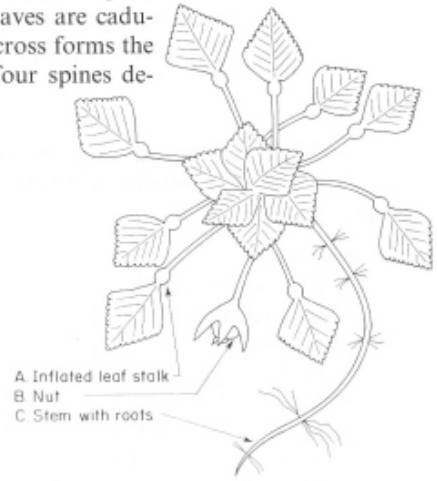
16d. Seed

16. QUINOA (*Chenopodium quinoa*)

Chenopodium quinoa is a member of the family Chenopodiaceae and a native of Peru, where it was used in large quantities by the ancient Incas. It is an annual herb, 1–2 m tall, and matures in 5–6 months. The seeds are achenes about 2 mm in diameter and are white, red or black. These may be ground into flour from which bread and cakes are prepared, or the entire grain may be eaten in soups. *C. quinoa* is still grown to a large extent in mountainous areas of Ecuador, Bolivia and Peru, where maize cannot be cultivated. Another species, *C. nuttalliae*, was grown in Mexico in pre-Columbian times, while in Iron Age Europe, man cultivated the species *C. album*, as seeds recovered from excavations of various settlements show. The leaves of some species of *Chenopodium* are also used like spinach.

17. Water Chestnut

Water chestnut, *Trapa natans*, belongs to the family Onagraceae and is an annual aquatic plant native to the territory marked by Persia, Egypt and southern Europe. In Neolithic times water chestnut was a common food of most of the European peoples; it also grew at that time in central and even in northern Europe. However, nowadays water chestnut is a rare plant found in Europe only in the warmer countries, e.g. in Italy. It has an unbranched stem 30–200 cm long and its leaves form a rosette. The floating leaves have an inflated stalk and measure 1·0–4·5 cm in length and width, and the petiole of the floating leaves reaches up to 17 cm in length. The submerged leaves are caducous. The blossom which is 2 cm across forms the fruit, a starchy nut. The nut has four spines de-



17a. CALTROP or JESUIT'S CHESTNUT (x 0·25) (*Trapa natans*)

veloped from the sepals and its horny appearance is responsible for the botanical name *Trapa*, a contraction of *calcitrapa*, the name of a four-spiked iron ball used as a weapon against cavalry horses by throwing it down to maim them. The English common name, CALTROP, is of the same origin, but it is also known in English as JESUIT'S NUT.

The use of the water chestnut as a pseudo-cereal grain in Neolithic times is proved by finds of these nuts in European prehistoric settlements. However, today Europeans seem to be interested more in the shell of water chestnuts than in their seeds; for example in Italy the fruits are sold as curios and souvenirs. Water chestnuts are still consumed as grain in China, Korea and Japan, but these nuts belong to another species of *Trapa*, *T. bicornuta*, which has only two horns and resembles the head of a bull, giving them the common name BULL'S HEAD. *T. bicornuta* is mainly used in the form of flour and in pre-Communist China it was one of the five most important "grains".

17b BULL'S HEAD (x 0·5)
(*Trapa bicornuta*)

17c BULL'S HEAD (x 0·5)
seed

The third edible species of *Trapa*, *T. bispinosa*, is a native of tropical Asia and is known as SINGHARA NUT (horny nut). Singhara nuts, which are sweet, are mainly the food of people living by lakes in Kashmir, and are usually consumed in the form of a porridge.

Morphological Survey of Cereals (CER) and Pseudo-cereals (PCER)

Seed

of an achene
14. Buckwheat (PCER)
16. Quinoa (PCER)

of a caryopsis
1. Barley (CER)
2. Maize (CER)
3. Millet, Finger (CER)
4. Millet, Foxtail (CER)
5. Millet, Japanese Barnyard (CER)
6. Millet, Pearl (CER)
7. Millet, Proso (CER)
8. Oat (CER)
9. Rice (CER)
10. Rye (CER)
11. Sorghum (CER)
12. Wheat (CER)

of a nut
Acorn (PCER), Introduction to CER and PCER
Beechmast (PCER), Introduction to CER and PCER
Chestnut, Sweet (PCER), Introduction to CER and PCER
17. Water Chestnut (PCER)

of a capsule
13. Amaranth (PCER)

of a carcerulus
15. Chia (PCER)

III. VEGETABLES

Vegetables form the largest group of plants consumed by man and this group is also the most heterogeneous. They are derived from most of the families of flowering plants and also from the algae and fungi. Furthermore, many different parts of plants are used as vegetables. So far as the Angiospermae are concerned, the vegetables may be the swollen taproots (e.g. carrot); the hypocotyl, the part below the cotyledons (e.g. radish); the stem (e.g. asparagus); the leaves (e.g. spinach); the flower bud (e.g. globe artichoke); the inflorescence (e.g. cauliflower); the fruit (e.g. tomato; or the pod of beans); seeds (e.g. pulses); and exceptionally the whole plants, as in the case of seedlings of some cereals and pulses. Thus vegetables can be delimited neither from a taxonomic nor from a phytomorphological point of view.

Vegetables also resist definition according to their chemical composition. Although vegetables are normally eaten as a source of micronutrients (vitamins and minerals) and roughage (indigestible carbohydrates—cellulose, or chitin, a nitrogen-containing polysaccharide constituting the cell walls in fungi), many of them provide macronutrients. For example, large amounts of digestible carbohydrates are present in potatoes, of fats in olives and of proteins in soya beans. Chemical composition forms the only basis on which to decide whether a fleshy fruit should be classed as a vegetable or as a fruit. The fruit is considered as a vegetable when it is not sweet (e.g. avocado, tomato and cucumber), while fleshy fruits containing considerable amounts of sugar and small amounts of starch, fats and proteins are included commercially among fruit. However, neither are sweetness and non-sweetness generally valid criteria for what is and what is not a vegetable, because there are also some sweet vegetables, e.g. sweet potatoes and garden peas.

Since it is impossible to define vegetables either botanically or chemically one might attempt to distinguish them according to the ways in which they are prepared and served; but this also seems unsatisfactory. Vegetables are usually eaten fresh or boiled, but the same can be said of fruits. Vegetables may be served as special dishes, e.g. asparagus with butter or cauliflower *au gratin*, or as supplements to meat dishes, but fruit may be consumed in the same way, as a separate dish, or it may be served together with meat like a vegetable, as in the case of apple sauce with pork or pineapple with ham.

The definition becomes still more difficult if we take into consideration the fact that many vegetables are also used as flavourings or merely as decorative materials. For example, the roots of carrot and parsnip may be eaten as a

vegetable, but if they are used as flavourings for soups and sauces they are usually discarded after boiling and only the tasty juice released from them is consumed. However, it is comparatively seldom that a plant is used in different ways when it is alternatively a vegetable or a flavouring. The carrot, for example, may be used in the same way for both purposes: boiled carrot may be considered as a vegetable if it is added in a large helping to a main dish, but it can be considered as a flavouring or even as a decorative material if only a few slices adorn the dish. Thus a plant may be considered as a vegetable or otherwise according to the quantity in which it is eaten. Unfortunately, there is not an objective method of determining the quantity that marks the transition between the use as a vegetable and as a condiment or decorative material.

Thus it seems possible to define vegetables only in a negative way as those plants consumed by man that are not included in another category. Yet we might more closely approach a satisfactory definition if we were to eliminate materials containing high amounts of macronutrients. In this case the potato would be included among starch plants, avocado among oil plants, etc., so that vegetables would be classified as the remaining plants that supply only micronutrients, vitamins and minerals, and roughage. Most vegetables certainly are of such a nature, and this is demonstrated by Table IV, which shows chemical composition of vegetables. The data are extracted from U.S.D.A. Agricultural Handbook No. 8 (p. 15), except the values for Chinese artichoke, bambara groundnut, adzuki bean, black gram, goa bean, horse gram, tepary bean, lotus, pigeon pea, scorzonera and seakale.

Table IV shows that the vegetables containing the most water are cucumber and lettuce, both of which contain 95·1% water; soya beans have the maximum protein content (37·1%); avocado contains the maximum fats (16·4%); and sweet potato achieves the maximum value for carbohydrates (26·3%). The young leaves of the dandelion contain the maximum of vitamin A (14,000 international units); the richest in thiamine (vitamin B_1) is soya bean (1·10 mg per 100 g); cultivated mushrooms have the greatest quantity of riboflavin (vitamin B_2) (0·46 mg per 100 g) as well as of nicotonic acid (4·2 mg per 100 g); and the fresh berry of capsicum contains the maximum of vitamin C (235 mg per 100 g). Other vitamins not mentioned in the table and generally present in most of the vegetables are pyridoxine (vitamin B_6), biotin, folic acid and tocopherols. Minerals required by man and present in vegetables vary in quantity according to the kind of vegetable as well as the type of soil in which the plant grows. On average the vegetables richest in iron are parsley leaves (8 mg per 100 g), leaves of spinach, turnip and lentil, and the dry seeds of beans and other pulses. Parsley and pulses are also the richest sources of cobalt, while the largest amount of iodine appears in algae; the iodine content of algae explains the fact that in Japan, where algae contribute a large part of the human diet, goitre is an almost unknown disease. Algae

are omitted from the table and fungi are represented only by a single fungal fructification (the cultivated mushroom) because of lack of reliable information. A special table dealing with some fungal fructifications will, however, be given in the section on Fungi (p. 56).

Table IV

Chemical composition of per 100 g edible part of vegetables

Name of Vegetable	*Water*	*Proteins*	*Fats*	*Carbohydrates*	*Vitamins (Vitamin A in international units, others in mg)*				
					A	*Thiamine*	*Riboflavin*	*Niacin*	*C*
	%	%	%	%					
CYANOPHYTA									
18. *Nostoc*, raw	—	—	—	—	—	—	—	—	—
ALGAE and FUNGI (19.–37.)									
31. Mushroom, White, raw	90·4	2·7	0·3	4·4	tr	0·10	0·46	4·2	3
PTERIDOPHYTA									
38. Fiddlehead Fern, raw	—	—	—	—	—	—	—	—	—
ANGIOSPERMAE									
39. Artichoke, Chinese, raw	78·5	4·31	0·16	16·88	—	—	—	—	—
40. Artichoke, Globe, raw	85·5	2·9	0·2	10·6	160	0·8	0·05	1·0	12
41. Artichoke, Jerusalem, raw	79·8	2·3	0·1	16·7	20	0·2	0·06	1·3	4
42. Asparagus, spears, raw	91·7	2·5	0·2	5·0	900	0·18	0·2	1·5	33
43. Avocado, raw	74·0	2·1	16·4	6·3	290	0·11	0·2	1·6	14
44. Bambarra Groundnut, mature dry seeds	—	18·0	6·0	60·0	0	0·3	0·1	2·0	0
45. Bamboo Shoot, raw	91·0	2·6	0·3	5·2	20	0·15	0·07	0·6	4
124. Banana, Baking (Plantain), raw	66·4	1·1	0·4	31·2	—	0·06	0·04	0·6	14
46. Bean, Adzuki, ripe dry seeds	9·7	23·6	1·0	61·5	—	—	—	—	—

Name of Vegetable	*Water*	*Proteins*	*Fats*	*Carbohydrates*	*Vitamins (Vitamin A in international units, others in mg)*				
					A	*Thiamine*	*Riboflavin*	*Niacin*	*C*
	%	%	%	%					
47. Bean, Black Gram, immature pods, raw	—	—	—	—	—	—	—	—	—
ripe dry seeds	9·7	23·7	1·0	61·1	—	—	—	—	—
48. Bean, Broad, immature seeds, raw	72·3	8·4	0·4	17·8	220	0·28	0·17	1·6	30
ripe dry seeds	11·9	25·1	0·7	58·2	70	0·5	0·3	2·5	—
49. Bean, French, immature pods, raw	90·1	1·9	0·2	7·1	600	0·08	0·11	0·5	19
ripe dry seeds	10·9	22·3	1·6	61·3	0	0·65	0·22	2·4	—
50. Bean, Goa, immature pods, raw	91·8	1·9	0·2	5·7	—	—	—	—	—
ripe dry seeds	—	37·0	15·0	28·0	—	—	—	—	—
51. Bean, Horsegram, ripe dry seeds	—	26·4	2·32	67·8	—	—	—	—	—
52. Bean, Lablab, immature pods, raw	88·8	2·8	0·3	7·3	580	0·09	0·11	0·9	20
ripe dry seeds	11·8	22·2	1·5	61·0	—	0·62	0·18	2·1	—
53. Bean, Lima, immature seeds, raw	67·5	8·4	0·5	22·1	290	0·24	0·12	1·4	29
ripe dry seeds	10·3	20·4	1·6	64·0	tr	0·48	0·17	1·9	—
54. Bean, Moth, ripe dry seeds	9·3	23·0	0·7	63·0	—	—	—	—	—
55. Bean, Mung, immature pods	—	—	—	—	—	—	—	—	—
ripe dry seeds	10·7	24·2	1·3	60·3	80	0·38	0·21	2·6	—
sprouting seeds	88·8	3·8	0·2	6·6	20	0·13	0·13	0·8	19
56. Bean, Scarlet Runner, immature pods, raw	91·6	1·1	tr	5·9	in mg 0·3	0·05	0·10	0·9	—
57. Bean, Soya, immature pods, raw	69·2	10·9	5·1	13·2	690	0·44	0·16	1·4	29
ripe dry seeds	10·0	37·1	17·7	33·5	86	1·10	0·31	2·2	—
sprouting seeds	86·3	6·2	1·4	6·0	80	0·23	0·20	0·8	13

Name of Vegetable	Water	Proteins	Fats	Carbohydrates	Vitamins (Vitamin A in international units, others in mg)				
					A	Thiamine	Riboflavin	Niacin	C
	%	%	%	%					
58. Bean, Tepary ripe dry seeds	9·5	22·2	1·4	62·7	—	—	—	—	—
59. Bean, Yam, tubers, raw	85·1	1·04	0·2	12·8	tr	0·04	0·03	0·3	20
60. Beetroot, Red, raw	87·3	1·6	0·1	9·9	20	0·03	0·05	0·4	10
61. Breadfruit, raw	70·8	1·7	0·3	26·2	40	0·11	0·03	0·9	29
62. Broccoli, raw	89·1	3·6	0·3	5·9	2500	0·10	0·23	0·9	113
63. Brussels Sprout, raw	85·0	4·9	0·4	8·3	550	0·10	0·16	0·9	102
64. Cabbage, raw	92·4	1·3	0·2	5·4	130	0·05	0·05	0·3	47
65. Cabbage, Chinese, raw	95·0	1·2	0·1	3·0	150	0·05	0·04	0·6	25
66. *Capsicum*, immature green berry, raw	88·8	1·3	0·2	9·1	700	0·09	0·06	1·7	235
67. Cardoon, raw	—	—	—	—	—	—	—	—	—
68. Carrot, raw	88·2	1·1	0·2	9·7	11,000	0·06	0·05	0·6	8
69. Cassava, tubers, raw	62·0	0·7	0·2	37·0	—	0·07	0·03	0·7	30
70. Cauliflower, raw	91·0	2·7	0·2	5·2	60	0·11	0·10	0·7	78
71. Celeriac, raw	88·4	1·8	0·3	8·5	—	0·05	0·06	0·7	8
72. Celery, raw	94·1	0·9	0·1	3·9	240	0·03	0·03	0·3	9
73. Chard, Swiss raw	91·1	2·4	0·3	4·6	6500	0·06	0·17	0·5	32
74. Chayote, greens, raw	91·8	0·6	0·1	7·1	20	0·03	0·03	0·4	19
75. Chervil, Turnip-rooted, raw	—	—	—	—	—	—	—	—	—
76. Chicory, raw	95·1	1·0	0·1	3·2	4000	0·06	0·10	0·5	22
77. Cress, Garden, raw	89·4	2·6	0·7	5·5	9300	0·8	0·26	1·0	69
78. Cress, Water, raw	93·3	2·2	0·3	3·0	4900	0·08	0·16	0·9	79
79. Cucumber, raw	95·1	0·9	0·1	3·4	250	0·03	0·04	0·2	11
80. Dandelion, raw	85·6	2·7	0·7	9·2	14,000	0·19	0·26	—	35
81. Egg-Plant, raw	92·4	1·2	0·2	5·6	10	0·05	0·05	0·6	5

Name of Vegetable	Water	Proteins	Fats	Carbohydrates	Vitamins (Vitamin A in international units, others in mg)				
					A	Thiamine	Riboflavin	Niacin	C
	%	%	%	%					
82. Elder, inflorescence	—	—	—	—	—	—	—	—	—
83. Endive, raw	93·1	1·7	0·1	4·1	3300	0·07	0·14	0·5	10
84. Fennel, raw	90·0	2·8	0·4	5·1	3500	—	—	—	—
85. Jack-Fruit, raw	72·0	1·3	0·3	25·4		0·03	—	0·4	8
86. Kale, raw	82·7	6·0	0·8	9·0	10,000	0·16	0·26	2·1	186
87. Kohl-rabi, raw	90·3	2·0	0·1	6·6	20	0·06	0·04	0·3	66
88. Leek, raw	85·4	2·2	0·3	11·2	40	0·11	0·06	0·5	17
89. Lentil, raw ripe dry seeds	11·1	24·7	1·1	60·1	60	0·37	0·22	2·0	—
90. Lettuce, raw	95·1	1·2	0·2	2·5	970	0·06	0·06	0·3	8
91. Lotus, Sacred, rhizome, raw	84·26	1·57	0·19	12·46	—	—	—	—	—
92. Okra, raw	88·9	2·4	0·3	7·6	520	0·17	0·21	1·0	31
93. Olive, unripe pickled (green)	78·2	1·4	12·7	1·3	300	—	—	—	—
ripe pickled (black)	80·0	1·1	13·8	2·6	60	tr	tr	—	—
94. Onion, raw	89·1	1·5	0·1	8·7	40	0·03	0·04	0·2	10
95. Parsley, root, raw	—	—	—	—	—	—	—	—	—
96. Parsnip, raw	79·1	1·7	0·5	17·5	30	0·08	0·09	0·2	16
97. Pea, Garden and Field, immature seeds	78·0	6·0	0·4	14·4	640	0·35	0·14	2·9	27
ripe dry seeds	11·7	24·1	1·3	60·3	120	0·74	0·29	3·0	—
98. Pea, Chick, immature pods, raw	—	—	—	—	—	—	—	—	—
ripe dry seeds	10·7	20·5	4·8	61·0	50	0·36	0·15	2·0	—
99. Pea, Cow, young pods	86·0	3·3	0·3	9·5	1600	0·15	0·14	1·2	33
immature seeds, raw	66·8	9·0	0·8	21·8	370	0·43	0·13	1·6	29
ripe dry seeds	10·5	22·8	1·5	61·7	30	1·05	0·21	2·2	—
100. Pea, Grass, ripe dry seeds	10·0	28·8	0·6	58·2	—	—	—	—	—
101. Pea, Pigeon, immature seeds, raw	67·4	7·0	0·6	23·7	—	—	—	—	—
ripe dry seeds	10·1	19·2	1·5	65·4	—	—	—	—	—
102. Potato, raw	79·8	2·1	0·1	17·1	tr	0·10	0·04	1·5	20

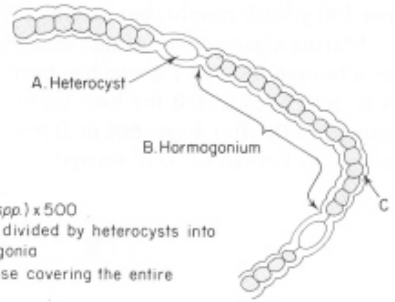
Name of Vegetable	Water	Proteins	Fats	Carbohydrates	Vitamins (Vitamin A in international units, others in mg)				
					A	Thiamine	Riboflavin	Niacin	C
	%	%	%	%					
103. Potato, Sweet, raw	70·6	1·7	0·4	26·3	8800	0·10	0·06	0·6	21
104. Pumpkins and Squashes									
Pumpkin, raw	91·6	1·0	0·1	6·5	1600	0·05	0·11	0·6	9
Squash (Zucchini), immature, raw	94·6	1·2	0·1	3·6	320	0·05	0·09	1·0	19
105. Radish, raw	94·5	1·0	0·1	3·6	10	0·03	0·03	0·3	26
106. Rhubarb, raw	94·8	0·6	0·1	3·7	100	0·03	0·07	0·3	9
107. Roselle, calyx, raw	86·5	2·1	0·3	10·3	—	—	—	—	—
108. Salsify, raw	77·6	2·9	0·6	18·0	10	0·04	0·04	0·3	11
109. Seakale, boiled for 20 minutes	95·6	1·4	tr	0·8	—	—	—	—	—
110. Scolymus	—	—	—	—	—	—	—	—	—
111. Scorzonera	80·39	1·04	0·5	14·8	—	—	—	—	—
112. Spinach, raw	90·7	3·2	0·3	4·3	8100	0·10	0·20	0·6	51
113. Swede, raw	87·0	1·1	0·1	11·0	580	0·07	0·07	1·1	43
114. Taro, corms, raw	73·0	1·9	0·2	23·7	20	0·13	0·04	1·1	4
115. Tomato, ripe and raw	93·5	1·1	0·2	4·7	900	0·06	0·04	0·7	23
116. Turnip, raw	91·5	1·0	0·2	6·6	tr	0·04	0·07	0·6	36
117. Water Chestnut, Chinese, raw	78·3	1·4	0·2	19·0	0	0·14	0·20	1·0	4
118. White Mustard (mustard and cress), raw	92·5	1·6	tr	4·6	—	—	—	—	—
119. Yam, raw	73·5	2·1	0·2	23·2	tr	0·10	0·04	0·5	9

CYANOPHYTA

The Cyanophyta, or blue-green algae, differ from true algae and all higher organisms in that their cells are anucleate (without a nucleus). For this reason they are grouped by modern taxonomists together with the other type of anucleate organisms, the bacteria, and classified as Monera, the most primitive cellular organisms. Cyanophyta may be roughly divided into two groups: unicellular organisms normally forming huge colonies, the Chroococcales; and filamentous organisms, the Hormogonales. *Nostoc*, the only blue-green alga consumed by man, belongs to the latter group.

18. *Nostoc*

Nostoc spp. occur in single rows of spherical cells resembling a string of beads embedded in a gelatinous cellulose sheath. These chains are actually colonies of more or less uniform cells interrupted at intervals by special thick-walled translucent cells, the so-called heterocysts. The row of cells between two successive heterocysts is called a hormogonium and the whole thread is able to break up into individual hormogonia from each of which a new plant can develop. *Nostoc* belongs to the family Nostocaceae, a member of the Hormogonales, and is consumed in the interior of China, where true marine algae are not available. The plant cultivated in China is a freshwater species, *N. commune* and its variety, *N. commune flagelliforme*, previously called *N. edule*. In central Asia another species, *N. ellipsosporum*, is cultivated and eaten. Although *Nostoc* is a microscopic organism it produces macroscopic structures, slimy spheres composed of many individuals adhering together by means of their gelatinous sheaths. In nature *Nostoc* occurs in fresh water and it also thrives in damp soil. In this form, *Nostoc* could be taken for the manna of Biblical times. (See Manna, Chapter VI, p. 244)



18. NOSTOC (*Nostoc spp.*) x 500
A.B. Filamentous alga divided by heterocysts into sections called hormogonia
C. Mucilaginous cellulose covering the entire thread of cells

ALGAE

The true algae, those with nucleate cells, supply many species that are consumed; these belong to the green algae (Chlorophyta), the brown algae (Phaeophyta) or the red algae (Rhodophyta).

The vegetative structure is a thallus, but in many cases the thallus has a leaf-like appearance. The thallus may then be differentiated into a blade(lamina)-like structure, often showing a "midrib" which may be continuous with a stalk(petiole)-like structure called a stipe, which ends in a holdfast, fixing the alga to the substrate. This anchorage device, the holdfast, is either discoid or root-like; if root-like, the holdfast consists of haptera, root-like outgrowths, and is called a hapteroid holdfast. Sometimes the algae also produce special sporogenous outgrowths, the "sporophylls".

Algae have great regenerative ability and new "leaves" can develop from the holdfast if the old ones die or are cut off. Almost all true algae are aquatic organisms and all those that are consumed by man are marine benthic plants.

Nowadays algae only have nutritional importance in the Far East. Their water content varies from 80 to 90% fresh weight, while in dried algae it is 11–24%. Proteins usually form about 10% of the dry weight, and only in *Porphyra tenera* is a value as high as 28% attained. Fats are present in very small quantities, while carbohydrates make up the bulk of the dry weight—generally over 50%. However, only a fraction of the algal carbohydrate is digestible, so that most of it is roughage as in other vegetables. Algae contain many vitamins apart from A and C, but this fact has received very little attention. It appears that ascorbic acid (vitamin C) in algae supplies half the human requirement in the diet of some Eskimo tribes. Minerals occurring in huge amounts are potassium, sodium and chlorine, and algae are the richest source of iodine.

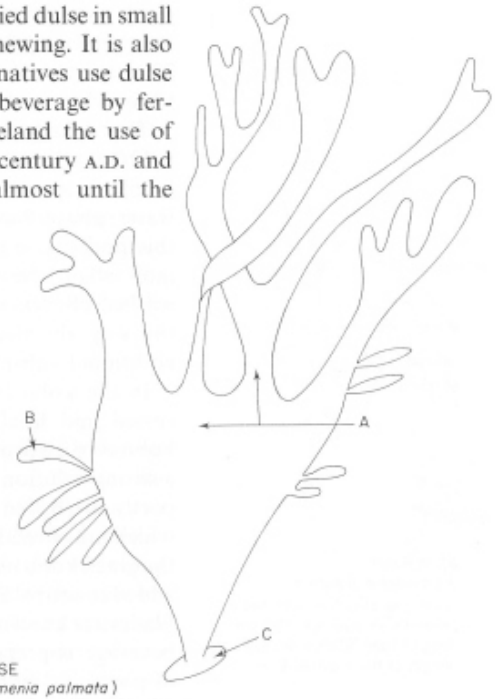
It must not be overlooked that the chemical constitution of algae varies very much according to the vicinity and the season. For example, vitamin C in *Laminaria saccharina* (sugar wrack) in February amounts to only 4 mg per 100 g fresh weight, but in May this quantity increases to 24 mg per 100 g.

Marine algae are consumed as a vegetable or as a flavouring, and their use as a human food in Europe has been recorded as early as the eighth century A.D. It is hard to tell for how many centuries marine algae have been consumed in the Far East, but in Japan at least, the cultivation of nori, for example, is known to have started about 300 years ago.

19. Dulse

Dulse is the common name given in Scotland to *Rhodymenia palmata*, a member of the family Rhodymeniaceae of the Rhodophyta (red algae). In Ireland this alga is known as DILLISC and in Iceland as SOL. It is a perennial alga of a dark red colour. Its "lamina" arises directly from a small discoid holdfast and is usually divided distally into

several segments, thus resembling a palm with fingers (hence the specific epithet). From the margin of the broad palmate part grow out leaflet-like structures, "sporophylls", which produce spores. The length of dulse varies from 25 to 30 cm. It grows along the Atlantic and Pacific shores of the northern hemisphere, and its leaf-like structures were eaten in Scotland, Ireland and Iceland as a vegetable with fish. In addition, dried dulse in small rolls was used like tobacco for chewing. It is also reported that in Kamchatka the natives use dulse for preparation of an alcoholic beverage by fermentation of the laminae. In Iceland the use of dulse was recorded in the eighth century A.D. and persisted there, as elsewhere, almost until the nineteenth century.

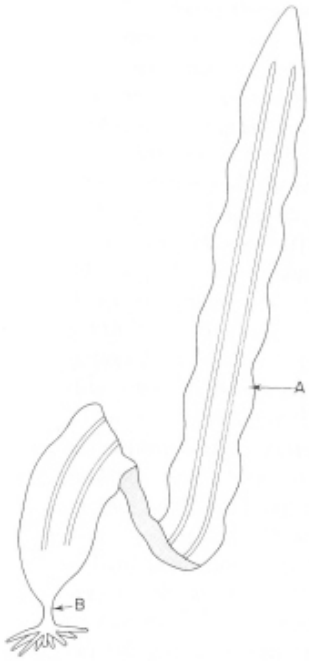


19. DULSE
(*Rhodymenia palmata*)
A. Palmate frond 25–30 cm long
B. "Sporophylls"
C. Discoid holdfast

20. Kombu

Kombu (or KOBU) is the Japanese name for food products prepared from various species of *Laminaria*, none of which is found in Europe. The most important of these are *L. japonica*, or MA-KOMBU, *L. religiosa* (HOSOME-KOMBU) and *L. cichorioides*

(CHIZI-KOMBU). *Laminaria* spp. are brown algae (Phaeophyta) belonging to the family Laminariaceae and consist of a "lamina" with a stipe fixed to the substrate by a hapteroid holdfast (see Sugar Wrack). The Japanese species are gathered by fishermen from their boats by means of a long stick with a hook on the end, and the algae twist round the hook and are torn off. *Laminaria* spp. grow as much as 10 fathoms deep but they are usually harvested only from a depth of 5 fathoms (*ca.* 9 m). They are dried on the shore and then sent to factories where kobu or kombu is manufactured.



20. KOMBU
(*Laminaria japonica*)
Leaf-like structure with two "midribs" on average 320 cm long (A) and 30 cm wide, average length of the stipe (B) 8 cm

The collected Japanese *Laminaria* spp. grow wild but often the crop is considerably augmented by planting stones in the sandy bottom of shallow water, about 9 m deep. Special stones are used for this purpose, e.g. basalt which has small cavities into which the spores can settle without being washed off, and new plants become established. In this way, the algae are not actually cultivated, but additional substrate is provided for their growth.

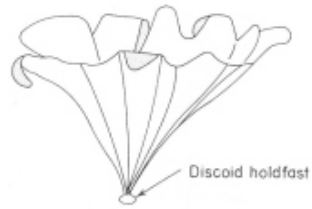
In the kobu factories, the dried algae are processed and finally shredded or ground. If green kobu is to be produced the blades are first boiled in a strong solution of deep green aniline dye and then partly dried and compressed together into blocks which are shredded by planing. The shavings form the green kobu used as a vegetable or as a flavouring added to soups. Smaller shavings of twice-shredded blades are known as CHA-KOMBU (tea-kombu) and a beverage is prepared from them. For preparation of powdered kobu the blades are specially treated and cut into pieces which are dried over a flame. The dried pieces are then ground and the powder is often formed into small cakes coated with sugar. Otherwise, powdered kobu is used as a spice for soups and sauces.

21. Laver

Porphyra umbilicalis, a red alga (Rhodophyta) belonging to the family Bangiaceae, was in common

use as a vegetable in Scotland, Ireland, Wales and Iceland. In Britain it is called laver, and in Ireland SLOKE. Sometimes it is called PINK LAVER, to distinguish it from the green laver, another common name for sea lettuce (*Ulva lactuca*), a green alga. Laver has an orbicular blade 15–20 cm in diameter, and is attached to the substrate by a small discoid holdfast. The blade is pink but its colour fades readily to an olive green. In Britain, laver was mainly eaten in Wales, Cornwall and Devon, and in 1944, E. R. Yargreen reported in "Country Life" that it was still available in shops in Cardiff. Laver was usually boiled or fried to make it tender and was frequently eaten with meat as a vegetable. Alternatively, it was mixed with oats and used for pancakes called laver bread. In Ireland, sloke was also converted into a jelly by stewing or boiling. Some authors describe laver as *P. laciniata*, but this is not a separate species, only a variety of *P. umbilicalis*.

21 a. Orbicular frond from above

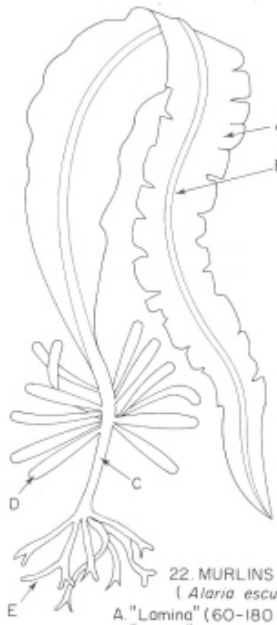


21 b. Orbicular frond from the side

21. LAVER (*Porphyra umbilicata*)
Orbicular frond 15-20 cm across

22. Murlins

This is the Irish name for *Alaria esculenta*, an edible brown alga (Phaeophyta) of the family Laminariaceae. In Scotland it is called BADDERLOCKS and in Iceland MARINJARIN. Its thallus consists of a stipe 5–15 cm long which is continuous with the midrib of the undivided blade: this may be up to 3 m long. Sporogenous structures occur as leaflet-like outgrowths of the lower part of the stipe. The stipe is anchored by means of haptera 5–8 cm long. *Alaria esculenta* was eaten as a vegetable in Scotland, Ireland and Iceland, while another species, *A. fistulosa* is still consumed by the North American Indians of the Pacific coast. *A. fistulosa* is a giant species reaching 12 m in length but its weight does not usually exceed 13 kg. The most palatable parts are the "sporophylls" which develop on the stipe in large numbers, as many as 200. The "sporophylls" of *A. esculenta* were also eaten, but there are reports that the midrib was selected, at least when the alga was young.



22. MURLINS
(*Alaria esculenta*)
A. "Lamina" (60–180 cm long)
B. "Midrib"
C. Stipe (5–15 cm long)
D. "Sporophylls"
E. Haptera

23. Nori

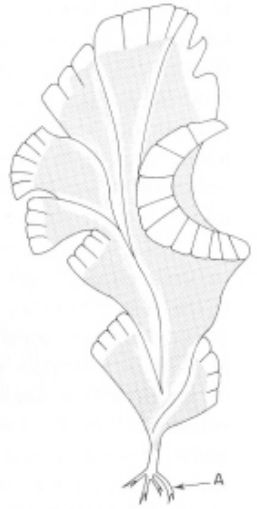
23. NORI (*Porphyra tenera*)
Cultivated form, life size

The Japanese name nori is given to certain species of the genus *Porphyra* (Rhodophyta, family Bangiaceae), mainly to the species *P. tenera*, one of the most highly appreciated algae in Japan, and also consumed in China and other Far Eastern countries. In Japan *P. tenera* is frequently cultivated. Bundles of twigs of a kind of bamboo are planted in September 3–5 m deep in sea water particularly rich in salt. Small algae (mainly diatoms) settle on the surface of the twigs, forming a slimy coating. Later, spores of the reproducing nori adhere to this slimy coating, and when the spores develop into young algae on the bamboo bundles, the bundles are taken out of the water and stored in the shade on the shore for five days. The bundles of twigs are then replanted, but if the spores have germinated and developed well in very salty water, their further growth requires only slightly salty water. For this reason the bundles are replanted in the sea near to river estuaries, where the sea water is mixed with fresh water, and the algae continue to grow until they are harvested, usually between January and May. More recently, however, a new technique for cultivation of nori has been introduced. Instead of bamboo bundles nets attached to poles are used. The algae develop on the nets and at harvest the nets are lifted over the surface and the young algae picked off from boats.

The harvested algal blades are washed, sorted and chopped and afterwards dried on uniform mats of bamboo splints. As it dries, the chopped nori unites on the mats into fine thin sheets of a uniform size. These sheets are mainly used for wrapping rice or fish into rolls and then cut into smaller pieces known as sushi. In Japan sushi are as common and as popular as bread rolls or sandwiches are in the West. Alternatively, the dried sheets of nori are baked or fried until they turn a green colour, and may then be broken and added to soups and sauces as a condiment. Sometimes, also, nori is used for bread-making.

24. Sea Lettuce

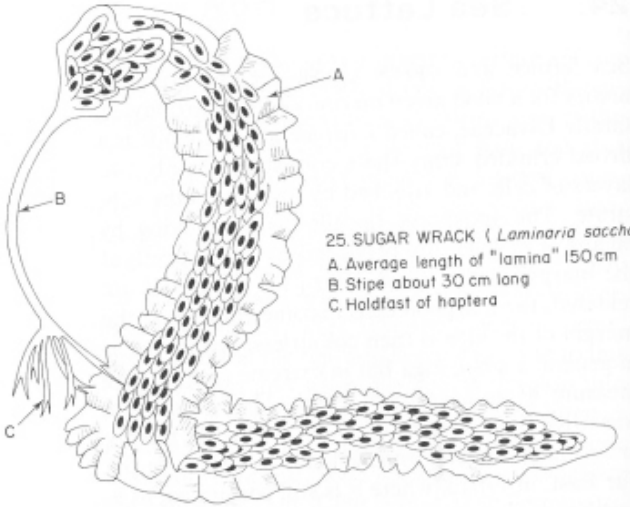
Sea lettuce and GREEN LAVER are the common names for a vivid green marine alga (Chlorophyta), family Ulvaceae, called *Ulva lactuca*. Its blade is a broad crinkled slimy sheet consisting of only two layers of cells and attached by haptera to the substrate. The zoospores (motile spores moving by means of flagella) are produced by normal cells at the margin of the frond. When the zoospores are released, the marginal cells become empty and the margin of the alga is then colourless. Sea lettuce is in general a small alga but in extreme cases it may measure 30 cm or more in length. The entire blade was eaten fresh or slightly boiled in Europe, mainly in Scotland, Ireland and Iceland, as well as in the Far East, in Japan, where it is still consumed, as is another species, *U. pertusa*. *Ulva* is used as a vegetable, mainly for salads, or for garnishing meat. In Scotland it was also added to soups.



24. SEA LETTUCE (*Ulva lactuca*)
Grows to 30 cm or more in length
A. Holdfast of haptera

25. Sugar Wrack

Sugar wrack, *Laminaria saccharina* (Phaeophyta, family Laminariaceae—see also Kombu) was, according to the records, a common food in Scotland until the middle of the nineteenth century. Sugar wrack has a ribbon-like blade with a frilly margin and an undulate central strip. The blade is on average 150 cm long and 12–15 cm wide. It arises from a stipe about 30 cm long anchored by means of haptera to the substrate. As in other species of *Laminaria*, *L. saccharina* has an intercalary meristem, i.e. a zone of dividing cells between the stipe and the blade and not at the apex. Thus the youngest part of the plant is at the base of the blade, while the apex of the blade is the oldest part. As the specific name (and also the common name) indicates, *L. saccharina* is a sweet brown alga. Its sweetness is due to mannitol (mannine) which is a sugar alcohol present in brown algae as a food storage material, and in sugar wrack mannitol



25. SUGAR WRACK (*Laminaria saccharina*)
A. Average length of "lamina" 150 cm
B. Stipe about 30 cm long
C. Holdfast of haptera

reaches up to 25% of the dry weight. In Scotland sugar wrack was used until the nineteenth century and its young stipes were sold in the streets of Edinburgh as a vegetable.

FUNGI (MACROFRUCTIFICATIONS)

The body (thallus) of fungi is usually a network of fine, anastomosing whitish threads or filaments, called hyphae, and the whole network is known as a mycelium. The mycelia of most of the higher fungi produce large sporogenous structures, fungal fructifications, so-called mushrooms and toadstools. These structures also consist of hyphae, but they are closely interwoven to form a massive fleshy, hard or even woody structure.

Mushrooms and toadstools belong either to Ascomycetes (subdivided into Protoascomycetes and Euascomycetes) or to Basidiomycetes (subdivided into Holobasidiomycetes and Phragmobasidiomycetes). Both these types of fungi have a septate mycelium, i.e. divided by incomplete septa into cells, and develop by conjugation into special hyphae with two nuclei in each cell. In the fructification these dikaryotic hyphae produce spores at their ends. In the Ascomycetes the spores are formed inside the terminal cell in a so-called ascus and each ascus yields eight endogenous ascospores. The Basidiomycetes produce exogenous spores developing in sterigmata, outgrowths of the terminal cells called basidia. Four sterigmata, and thus four basidiospores, develop from each basidium. Asci and basidia, together with the paraphyses (sterile terminal cells), form a lining to the fructifications called a hymenium.

The typical fructification of the Ascomycetes is cup-shaped and the inside of the cup is lined with the hymenium. The typical fructification of most of the Basidiomycetes, on the other hand, is characterized by an umbrella-shaped cap, the pileus, borne on a stalk known as the stipe. The hymenium lines special lamellae (gills) which are present on the lower surface of the pileus in the family Agaricaceae, or special tubules which, e.g. in the Boletaceae, open on the lower surface of the cap to the exterior. In the Gastromycetales, another group of fungi belonging to the Holobasidiomycetes, the hymenium appears inside the fructification which is usually a closed sphere.

Mushrooms, edible fungi, are consumed as a vegetable or as a condiment, boiled, fried or pickled but normally not raw. The most common method of preservation of mushrooms apart from pickling in brine or vinegar is to dry them. The fructifications are sliced vertically into thin sections and dried in the air. The flesh of some mushrooms, e.g. the white flesh of *Boletus edulis*, remains unchanged in colour but in others it turns black. According to this characteristic dried mushrooms are distinguished in commerce into white and black. Fresh and pickled mushrooms may be used as a vegetable while dried or salted ones are used only as a condiment, a flavouring for soups, sauces, etc. Young, small mushrooms are generally preferred to old, large ones, and the pileus is valued more than the stipe. In many cases the stipe is even discarded.

Until recently, the chemical constitution of mushrooms had not been properly studied, and even now only incomplete reliable information is available, as shown in Table V. In general, mushrooms contain 90% water; they are rich in proteins and poor in fats. Carbohydrates also form a large part of the solids, but mostly occur in the form of chitin which forms the fungal cell walls and which, like cellulose is not digestible. For a long time it was stated that vitamin C did not occur, but it has now been proved that at least some mushrooms, e.g. *Boletus edulis*, the cultivated mushroom, (*Psalliota bispora*), and chanterelles (*Cantharellus cibarius*), contain vitamin C. The steinpilz and chanterelle also contain vitamin D, which occurs in the cultivated mushroom (*Psalliota bispora*) only in negligible quantities. Vitamin K was detected in the cultivated mushroom and vitamin E in the steinpilz. The B vitamins, particularly niacin, may occur in appreciable quantities; also the precursor of vitamin A, carotene, which is present in the chanterelle. Among the reported minerals are fluorine, manganese, zinc, silver, bromine, titanium, rubidium, vanadium and lithium.

Only a very few fungal fructifications can be cultivated because most of them are produced by fungi of which the mycelium grows in symbiotic association with the roots of certain trees. Such fungi are called mycorrhiza and to promote their occurrence means to plant new forests. Thus the commercially cultivated mushrooms are all non-mycorrhizal fungi such as *Psalliota bispora*, the Japanese shiitake, the tropical padi straw mushroom

and the Jew's ear. However, there are also reports of cultivation of morels (*Morchella esculenta*) on apple pomace from cider presses and of wood blewits—*Tricholoma* (*Lepista*) *nudum*, a gill fungus—on composts of beech leaves prepared in greenhouses. However, the cultivation of these mushrooms has never been sufficiently successful to justify commercial exploitation.

All other mushrooms that are consumed must be gathered from the wild. People who gather them are fully acquainted with the association of the fungi with trees as well as with special places in woods or meadows where certain mushrooms are found each year. Most of the wild edible mushrooms grow in the late summer, in August and September, and they are particularly abundant if it is warm and wet. The fungal fructifications grow very rapidly, and in particular the species of *Boletus, Lactarius, Russula* and *Cantharellus* may appear within a few days under favourable conditions. The mushrooms described are only representative species of different families; many other mushrooms within these families are consumed.

The consumption of mushrooms is known to have started in prehistoric times, and Heer reported in 1886 that traces of puff balls were found in the dwellings of Stone Age man in Switzerland, Germany and Austria. Many mushrooms were considered as a delicacy by the ancient Greeks and Romans: Theophrastus, the favourite pupil of Aristotle, born about 370 B.C., mentioned fungi as a food, and the poet Horace, born in 65 B.C., praises especially mushrooms which he calls *pratenses* (meadow mushrooms) and which seem to be the fructifications of *Psalliota campestris*. Pliny the Elder, who died in 79 A.D., discussed truffles in detail, and called *Amanita caesarea* "a rare edible Amanita of excellent taste" and *Boletus edulis* "the most delicious mushrooms". From earliest times also there are records of fungal poisoning and Pliny himself mentions that the Emperor Claudius was poisoned by his wife Agrippina in A.D. 54 with a dish of mushrooms. Many later historical personages died of fungal poisoning, including the Pope Clement VII in 1534 and the Emperor Karl VII in 1740.

Table V

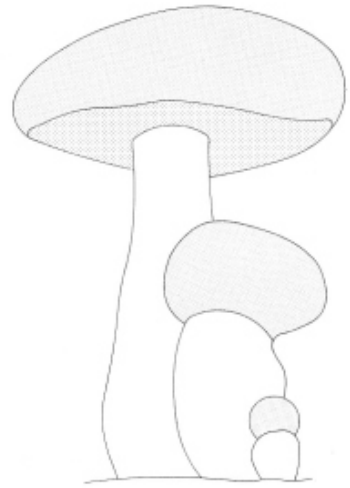
Chemical composition of some mushrooms

Name of fungus producing the fructification	*Water* %	*Proteins* %	*Fats* %	*Carbohydrates* %
26. *Boletus edulis*	90·0	3·1	0·79	—
26. *Boletus luteus*	92·6	1·48	0·27	5·17
27. Chanterelle	91·3	1·62	0·88	—
30. Morel	89·95	3·28	0·43	4·50
32. Orange agaric	88·77	3·08	0·76	3·09

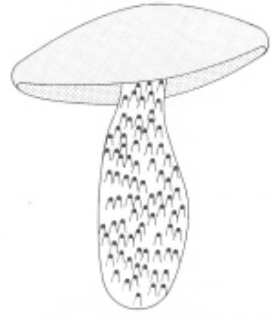
26. *Boletus* spp.

The most widely appreciated species of the common wild mushrooms are those of the genus *Boletus* (order Hymenomycetales (Holobasidiomycetes), family Boletaceae). The species *B. edulis* is considered as the most delicious all over Europe. It lacks a common name in English, but we often use the French name CEP, or the German STEINPILZ. The mycelium of the steinpilz grows as a mycorrhiza, associated with the roots of coniferous and some deciduous trees, e.g. beech. Its cap is at first spherical and shows only its upper surface. Later the cap becomes hemispherical and even flattened, and thus becomes detached from the surface of the stipe. As it develops the lower surface of the cap becomes visible and can be seen to consist of a spongy mass of tubules in which the basidiospores develop. In the older steinpilz the lower surface of the cap has the appearance of a velvet cushion and is yellow-green. The flattened pileus measures 6–20 cm across, while the stipe, enlarged at its base and pale brown in colour with raised white veins at the apex, may reach up to 25 cm in height.

Fresh *Boletus edulis* is often used as a vegetable, fried and added to scrambled eggs, or it may be pickled. Dried or salted *B. edulis* is generally used as a condiment for soups and sauces. Other species of *Boletus* are used similarly, as e.g. butterpilz; this is the German common name for *B. luteus* which is found under conifers. It has a brownish-yellow flattened cap, 5–10 cm in diameter. Its upper surface is slimy and its lower surface, when the fructification is still young, is covered with a white veil, a membrane joining the margin of the cap with the stipe. Later this partial veil, known as the velum, breaks and the remainder of the veil adheres to the stipe in the form of a ring called the annulus. The ring appears on the upper part of the stipe below the cap, and later becomes brownish or purple. The stipe is yellow above the ring and brownish below it. The flesh of the entire fructification is pale



26a. *Boletus edulis* pileus 3–18cm in diameter, stipe 5–15cm long



26b. *Boletus scaber*, pileus 3–18cm in diameter, Stipe 5–15cm long

26. *BOLETUS* SPP.

yellow and does not change its colour. The height of the rather short stipe varies between 4 and 7 cm.

Other well known species of *Boletus* consumed by man are *B. scaber* and *B. versipellis* or *testa-scaber*. Both occur mainly in birch woods. *B. scaber* has a brown cap 5–15 cm in diameter and a white stipe which may be 7–18 cm high with black fibrous scales. *B. versipellis*, which also occurs sometimes under coniferous trees, differs from *B. scaber* mainly in the colour of the cap which is reddish. Its flesh is white but if cut it becomes blackish within minutes. The flesh of *B. scaber* becomes blackish too, and both species are sold as black mushrooms when dried. The edible species of *Boletus* are less common than many other species of mushrooms, and *B. edulis* in particular is hard to find in forests if one is not familiar with the places where they grow. For many people in continental Europe the activity of gathering *Boletus* spp. takes place more as a sport than for the fungi gathered. However, many people do not gather them to consume, but to sell, and *Boletus* spp. are seen in European markets in quite large quantities.

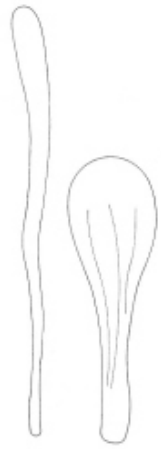
27 CHANTERELLE
(*Cantharellus cibarius*)
Pileus 2–8 cm in diameter
Stipe 2–6 cm long

27. Chanterelle

Chanterelle is the French common name for *Cantharellus cibarius* and this name is used also in the English language. Chanterelles belong to the family Cantharellaceae, another family of the Hymenomycetales (Holobasidiomycetes). They are small fructifications of a yellow colour. The cap is funnel-like, 2–8 cm in diameter, and ends in a stipe 2–6 cm long and of the same colour as the cap. Decurrent ridges are found on the outer side of the cap and these bear the hymenium. Chanterelles occur in coniferous forests, and in comparison to boleti are very common—dozens of them may be found in one place. Chanterelles are normally eaten fried and mixed with scrambled eggs.

28. Club and Coral Fungi

These are mushrooms belonging to the genera *Clavaria* and *Ramaria*, members of the family Clavariaceae, order Hymenomycetales (Holobasidiomycetes). Some of the edible *Clavaria* spp., e.g. *C. fistulosa*, are truly club-like; they occur singly or in twos or threes, especially on the branches or leaves of beech. *C. fistulosa* is unbranched and its swollen end is very elongated. The whole slender fructification measures 10–12 cm in height. It is yellowish and the whole surface is covered with a hymenium, which is missing only at the base. The fructification of *C. pistillaris*, another edible species, is stouter, usually 10–15 cm high and the swelling at its apex is much more pronounced so that it has the appearance of a pestle, giving it the specific epithet *pistillaris*. *Ramaria* spp., once also classified under *Clavaria*, differ from the true *Clavaria* spp. in being densely branched, and resembling corals. One species producing edible fructifications is *R. botrytis* in which dense branches arise from a stout stipe 3–4 cm high. The whole fructification is 5–10 cm high and its branches, reddish at their tips, form a structure up to about 15 cm in diameter. *R. botrytis* grows in deciduous woods.



28a. *Clavaria fistulosa*
10–12 cm tall

28b. *Clavaria pistillaris*
10–15 cm tall with a pronounced swelling at the apex

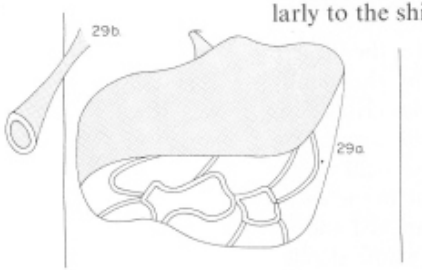
28c. *Ramaria botrytis* entire fructification
5–10 cm tall

28. CLUB and CORAL FUNGI (*Clavariaceae*)

29. Jew's Ear

The Jew's ear or *Auricularia auricula-judae* is the only well known edible fructification of the group Phragmobasidiomycetes. It belongs to the family Auriculariaceae and appears on dead wood, mainly on the dead branches of elder. Its name arises from the fact that it has a similar shape to the human external ear. It is a translucent, gelatinous structure 3–10 cm across, with a greyish velvety outer convex surface, while the inner concave surface, bearing the hymenium, is brownish. Jew's ear is occasionally eaten in Europe but it is more widely appreciated in China; here it is also culti-

vated in the open, on logs soaked in water similarly to the shiitake mushroom (p. 65).



29a. Mature fructification 3–10 cm broad
29b. Young, developing fructification

29. JEW'S EAR (*Auricularia auricula-judae*)
ear like gelatinous structure 3–10 cm broad

30. Morel

30a. Entire fructification stem and "cap" each 6–12cm tall

30b. L. S. showing the hollowness of the fructification

30. MOREL (*Morchella esculenta*)

This mushroom, botanically known as *Morchella esculenta*, is an edible member of the Euascomycetes, family Helvellaceae. The typical cup-shaped fructification of Ascomycetes occurs in the morel but is converted at a later stage into a convex structure on the surface of which the hymenium is thrown into folds forming ridges and pits. This unusual egg-shaped "cap" is borne on a stem which develops only rarely in the Ascomycetes. The "cap" is 6–12 cm high and its colour varies from deep ochre to deep brown. The stem is white or orange, thick and furrowed, and may also reach 6–12 cm in height, but it is normally shorter than the "cap". The entire fructification is hollow. The morel is a non-mycorrhizal fungus occurring in grass, below deciduous trees, in hedgerows, etc. Some mycologists have succeeded in cultivating morels in greenhouses, but marketed morels are still only wild fructifications, in spite of the fact that they are much appreciated as a vegetable and as a delicious condiment. Morels are in large demand in Europe and also in the U.S.A.

31. Mushroom (White)

31a. The earliest stage (button)

31b. Second stage – the annular cavity still hiding the gills

31c. Third stage – showing an annulus, a remnant of the velum

31d. Fourth stage – pileus flattened

31. MUSHROOM (WHITE) – (*Psalliota bispora*)
Cultivated – mature size, pileus 8cm across stipe 6cm long

The true mushroom (often specified as white mushroom) belongs to the genus *Psalliota*, family Agaricaceae, order Hymenomycetales (Holobasidiomycetes), known as gill fungi. The wild mushroom, occurring in meadows and pastures, is the species *P. campestris*, which has a white pileus and pink gills; the cultivated mushroom, which in Britain is almost the only fungal fructification eaten, is derived from another species, *P. bispora*. This species is never found in meadows but on manure heaps and along roads far from grass. *P. bispora*, as its name suggests, develops only 2 basidiospores on basidia in the hymenium lining the light pink gills of its fawn pileus, while other Agaricaceae yield 4 basidiospores per basidium. The 2-spored basidia are also typical of the cultivated mushroom of which the pileus is whitish and only sometimes slightly brownish towards its centre. The cultivated mushroom (sometimes specified as cultivated white mushroom) is usually classified as *P. bispora* var. *albida*. As in all species of *Psalliota*, the cultivated mushroom first appears in a button-like form in which the spherical pileus is joined to the pillar-like whitish stipe by a veil (velum). The pileus soon expands and the velum is broken, so that the pileus and the stipe become distinct, as do the gills which were earlier enclosed by the velum in the annular cavity. The remainder of the velum persists in the form of a ring, the annulus. The pileus, when it emerges from the button-like stage, is convex, but in older mushrooms it becomes flattened. The pileus measures 6–8 or even 10 cm in diameter while the stipe may be up to 7 cm long.

The cultivation of mushrooms began in France in the seventeenth century and during the Napoleonic era it became a thriving industry, mainly occupying the abandoned tunnels of quarries in the neighbourhood of Paris. Horse manure mixed with soil is used as a substrate for growing mushrooms. Nowadays the cultivation of mushrooms has

spread all over the world, but *P. bispora* var. *albida* is the only mushroom cultivated within the sphere of Western civilization. Mushrooms are on the market the whole year round and both well developed fructifications and button-like young mushrooms are sold. Button mushrooms are generally preferred and this type only is canned. Pilei and stipes are often sold separately, the stipes being the inferior and cheaper part of the fructification. The flavour of the cultivated mushroom is not so good as that of wild *P. campestris*, but there is little chance of comparing the flavours since field mushrooms do not often reach the market nowadays.

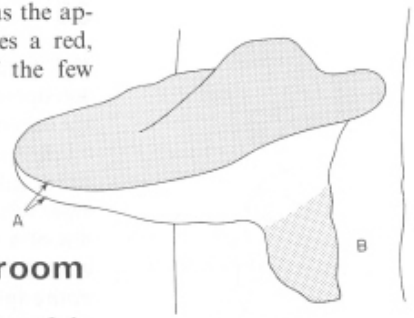
32. ORANGE AGARIC (*Lactarius deliciosus*)
Pileus 4–10cm in diameter, stipe 2–7cm long

32. Orange Agaric

Orange agaric or *Lactarius deliciosus* is a member of the family Agaricaceae, order Hymenomycetales (Holobasidiomycetes); it has orange fructifications containing a milk which rapidly turns orange when it is expressed. The convex pileus, when mature, is depressed in the centre and has pale green concentric rings. It is 4–10 cm in diameter and its decurrent gills reach the stipe which is 2–7 cm long. Orange agaric grows in coniferous forests and in clearings. Young fructifications are especially delicious if pickled in diluted vinegar.

33. Ox Tongue

Ox tongue, or LANGUE DE BOEUF, as it is known in France, is also known in Britain as the poor man's beefsteak. Its botanical name is *Fistulina hepatica* and it belongs to the family Polyporaceae, order Hymenomycetales (Holobasidiomycetes). *F. hepatica*, like most of the Polyporaceae, is a bracket fungus, forming stipeless or very short-stiped fructifications on the stems of oaks or other deciduous trees. The hoof-like fructification, up to 20 cm wide, has a rough reddish-brown top and on the creamy lower surface tubules lined with hymenium open to the exterior. Its flesh has the appearance of fresh meat and also releases a red, blood-like juice. *F. hepatica* is one of the few bracket fungi consumed by man.

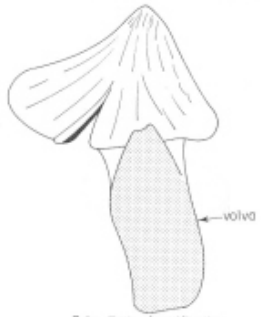


33. OX TONGUE (*Fistulina hepatica*)
A. Bracket fungus, 5cm up to 30cm broad
B. Stipe, eventually developed

34. Padi Straw Mushroom

Padi straw mushrooms are tropical forms of the genus *Volvariella*, cultivated outdoors in China, Indochina, Malaysia, the Philippines, Madagascar and Africa. *V. volvacea* var. *heimii* is the species cultivated in Madagascar, while *V. bresadolae* is cultivated in the Philippines. However, *V. bresadolae* may only be a variety of *V. volvacea*. *Volvariella* spp. are gill fungi and belong to the family Agaricaceae (Holobasidiomycetes). The pileus of both types of *Volvariella* is conical and in the case of *V. volvacea* var. *heimii* it measures 5–8 cm or even 14 cm in diameter. It is dark at the tip but lighter at the periphery. The stipe, which lacks an annulus, is slender, 8–12 cm long and 1·2–2·0 cm thick. It is whitish in colour with dull creamy streaks. The lamellae are white during development and pink when older. In the early stages of development the entire fructification is covered with a universal veil. This veil, called the volva, is ruptured by the growth of the mushroom and usually it is only at the base of the stipe that a remnant of it is left.

Padi straw means rice straw, on which these mushrooms are cultivated, but it has been demonstrated experimentally that other kinds of straw can also be used (e.g. wheat or sorghum straw). Rice straw used for cultivation is prepared in bundles weighing up to 2 kg and about 1·2 m in length. These bundles consist of leafless culms (stems of plants, especially of grasses) and are soaked in water for 24 h before they are used for preparation of outdoor beds. The straw beds have to be watered frequently.

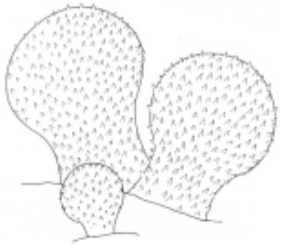


34a. Entire fructification

34b. L.S. of developing fructification

34. PADI STRAW MUSHROOM (*Volvariella* spp.)
Pileus 5–8cm in diameter, stipe 8–12cm long and 1·2–2cm thick

35. Puff Ball

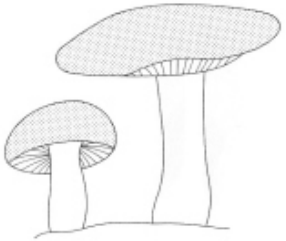


35. PUFF BALL, COMMON
(*Lycoperdon perlatum*)
3–8cm tall, 3–5cm across

Puff balls belong to the genus *Lycoperdon* (family Lycoperdiaceae) and the order Gastromycetales, the second order of the Holobasidiomycetes. *Lycoperdon* spp. produce closed, more or less spherical fructifications, which open only when ripe. When young, the puff balls are solid and consist of a skin called the peridium surrounding the central fleshy mass, the gleba. The gleba, filling the entire sphere, consists of sporogenous tissue and at maturity its spaces are filled with spores which emerge from the puff ball when ruptured as a cloud of dust. Thus only young puff balls with a solid gleba can be eaten. Those consumed also include the small, young form of the giant puff ball, *L. giganticum*. This species at maturity reaches 15–30 cm or more in diameter, and in common with other puff balls it is found in fields, meadows and pastures.

36. *Russula* spp.

36a. *Russula vesca*
Pileus 5–10cm across,
stipe 4–7cm long



36b. *Russula cyanoxantha*
Pileus 5–12cm across,
stipe 5–10cm long

36. *RUSSULA* SPP.

These are gill fungi (Agaricaceae; Holobasidiomycetes), which are the most common mushrooms of coniferous as well as deciduous forests, but they are not widely appreciated mainly because of the ignorance of collectors many of whom consider them as inedible. *Russula* spp. differ from each other mainly in their colour. They include *R. vesca* which has a red-brown pileus 4–8 cm in diameter. The pileus is slightly convex or flattened and depressed in the centre. The gills are at first white but later spotted with brown and the stipe is also white. *R. vesca* grows in deciduous woods, especially beech woods. Other edible species of *Russula* include the violet *R. cyanoxantha*, the lemon yellow *R. violeipes*, the green *R. virescens* and the rosy purple *R. xerampelina*.

37. Shiitake Mushroom

Shiitake is the Japanese name for *Lentinus edodes*, sometimes wrongly classified as a member of the genus *Armalaria* or of *Cortinellus*. It belongs to the family Agaricaceae (Holobasidiomycetes) and is a native of Japan and China, but it will not grow in cold or tropical parts of these countries. Shiitake develops on rotting wood and its brown pileus is furrowed by white fissures; it reaches 4–10 cm, and in extreme cases even 20 cm, in diameter. The stipe lacks an annulus and has a brownish tint. It is attached to the pileus eccentrically and measures 3–4 cm in length and 0·8–1·3 cm in width. The gills are pallid and colourless and continue as ribs at the apex of the stipe. The shiitake grows on trees and penetrates the stems with its mycelium. When the fungus is cultivated, logs soaked with water are used and holes are bored for inoculation. The holes are filled either with infected wood or with spawn produced in laboratories, and the logs kept outdoors in the yards. The cultivation of shiitake started at least 1000 years ago.

37a. Mushrooms growing on a log

37b. A single mushroom

37. SHIITAKE (*Lentinus edodes*)
Pileus 4–10cm in diameter,
stipe eccentrically inserted 3–4cm
long and 0·8–1·3 thick

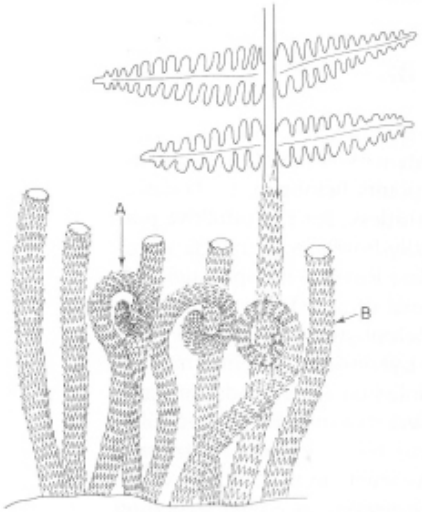
PTERIDOPHYTA

Pteridophyta form the first group of true plants with conductive tissue distinguished into xylem and phloem—the first plants belonging to Tracheophyta. They do not produce flowers and are fruitless; for reproductive purposes they form spores. The spores are normally borne in sporangia which develop on leaves or in the axils of leaves. The leaves with sporangia are called sporophylls and may be united in special groups known as strobili (cones). The Pteridophyta are divided into Psilophytinae (Psilopsida) represented by only two genera; Lycopiinae (Lycopsida) or club mosses; Equisitinae (Sphenopsida) or horsetails; and Filicinae (Pteropsida) or ferns. The ferns usually have large stalked leaves called megaphylls or fronds. The fronds arise from a rhizome and form a rosette above ground. In tropical countries the tree ferns develop a stem that may reach up to 15 m, but which has no secondary thickening. The fronds first appear as coiled structures which uncoil during development, this uncoiling process being caused by asymmetrical growth.

38. Fiddlehead Fern

The fern *Pteridium aquilinum*, known as common bracken and belonging to the family Polypodiaceae, is eaten in China and Japan. For this purpose young shoots are used, before the blades develop and while the rachis is still coiled and covered by ramenta—brown chaff-like scales. Its rhizome is also used for the starch it contains; after extraction this is called warabi starch. In the U.S.A. the eating of fiddlehead ferns is widespread among the white population. The finest young shoots come from the state of Maine and are derived from the species *Osmunda cinnamonum*, the cinnamon fern, a member of the family Osmundaceae. However, the custom of eating ferns was not introduced into America from the Far East but from Europe, where the habit was already common in France. In France not only were the young shoots of bracken used, but also those of other ferns such as the male fern, *Dryopteris filix-mas*. The shoots are used as a vegetable after boiling, and have a flavour that resembles a mixture of broccoli, asparagus and artichoke. In America it is possible to obtain the fiddlehead ferns in cans.

In Europe the rhizomes have only been used as an emergency measure in case of famine.



38. FERNS (*Filicinae*) (x0·5)
A. Fiddleheads, immature fronds
B. Ramenta

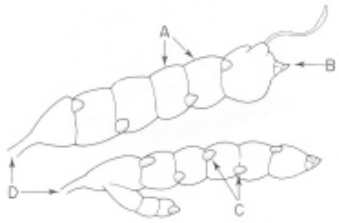
ANGIOSPERMAE

The angiosperms differ from the gymnosperms in bearing the ovule inside the seedbox cavity, formed by one or more carpels. Thus the pollen does not have direct access to the ovum which is present in the ovule, and it alights on a special organ of the pistil, the stigma. The pollen grain germinates on the stigma and grows by means of a pollen tube within the style until it reaches the ovule, where fertilization takes place. Fertilization, depending on two male gametes, is a double process in that, as well as the fertilization of the oosphere, the fusion nucleus is simultaneously fertilized and gives rise to the endosperm. After fertilization all parts of the flower except the seedbox usually wither and drop off, and the ovary wall undergoes development to become either dry or fleshy. In this way a fruit is produced, containing the seed(s). The fruit, as well as the true flower, only appears in the angiosperms.

The angiosperms are divided into Dicotyledoneae and Monocotyledoneae, plants with two seed-leaves or one respectively. Dicotyledones are the more numerous, with 200,000 species out of the total of 250,000 angiosperms. The Monocotyledoneae, with parallel venation and usually with linear leaves inserted on the axis by a broad sheath, number about 50,000 species, and are the second most numerous group of true plants.

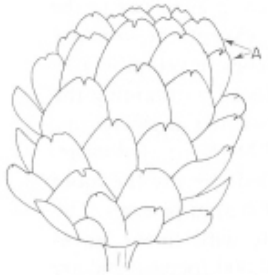
39. Artichoke, Chinese

Chinese artichoke or *Stachys tuberifera* is a herbaceous perennial of the family Labiatae and its underground stems are swollen at their tips into small elongated tubers resembling large grubs. The tubers incorporate several internodes (the part of the stem between two successive nodes, i.e. points at which the stem gives off leaves) marked by conspicuous constrictions which are responsible for the typical beaded appearance of Chinese artichokes. They do not store starch as their food reserve, but a tetrasaccharide called stachyose which consists of one residue of glucose, one of fructose and two of galactose per molecule, in contrast to starch which is a chain of glucose residues. The plant is native to the Far East and was first cultivated in Europe by two French botanists, Pailleux and Bois, at Crosnes in the department Seine et Oise. In France Chinese artichokes are called CROSNES



39. ARTICHOKE, CHINESE (*Stachys tuberifera*)
Stem tubers (x0·5)
A. Internodes
B. Terminal bud
C. Buds
D. Attachment to the stem

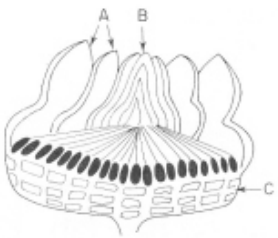
after their first place of cultivation, and because they were imported from Japan they are also known as CROSNES DU JAPON. Chinese artichoke is now distinguished taxonomically as *Stachys affinis* and Japanese artichoke as *S. sieboldi*. *Stachys* with edible tubers was introduced into Britain in 1827 but without much success. The tubers are eaten like potatoes, boiled, and often a "potato" salad is prepared from them.



40a. Bud (x0·35)
A. Bracts

40. Artichoke, Globe

The artichoke proper or globe artichoke is the floral bud of *Cynara scolymus*, a member of the family Compositae. It is native to the Mediterranean region, and perhaps to North Africa, and it is possible that it developed from *Cynara cardunculus* (see Cardoon). The globe artichoke was already known to the ancient Greeks and Romans, and Pliny scolds his contemporaries that they are willing to pay a lot of money for mere "thistles". However, the name artichoke is a corruption of its Arabic name AL'QARSHUF. The true artichoke is a perennial thistle-like plant 1–1·5 m tall and is propagated in cultivation either by suckers or by the division of the crown into pieces, each with a stem. The latter method is more advantageous because the part of the crown contains more reserve food than the slender sucker. The floral buds appear at the tip of the main and lateral stems and each plant yields several artichokes. The plants produce their best crop in their second and third year while after the fourth year the plants should be replaced by new ones.



40b. Inside of the bud (x0·5)
A. Bracts
B. Developing florets
C. Receptacle with the bract scars

40. ARTICHOKE, GLOBE (*Cynara scolymus*)

The actual artichoke is the bud of a special inflorescence typical of the Compositae and known as a capitulum in which many small sessile flowers (florets) are crowded on a disc, a receptacle produced by the flattening and lateral expansion of the axis. The capitulum of the artichoke in bud form is completely invested by bracts, green overlapping leaf-like structures which together form a calyx-like

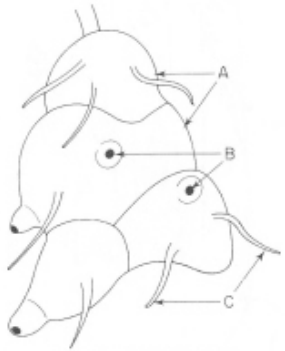
part of the bud. Thus the immature inflorescence (the floral bud) of the artichoke, measuring about 10 cm in diameter, forms a green sphere of overlapping scales from which arise a mass of blue-violet florets at maturity.

The edible parts of the artichoke are the fleshy bracts as well as the fleshy receptacle of the capitulum. They are usually boiled and served with a sauce or dressing: first the bracts are consumed; one by one they are removed from the bud, dipped into the sauce or dressing and then their fleshy base is sucked out. By the successive removal of bracts the head is reached and its fleshy receptacle is the most delicious part of the artichoke. The head is small, only about 3 cm across, and flattened. When artichokes are preserved only comparatively small heads with few bracts are used. They are also baked or fried and the very immature buds preserved in oil are used in Italy as an appetizer.

The artichoke plant can also be used for its summer shoots which are eaten after blanching.

41. Artichoke, Jerusalem

Jerusalem artichoke is the name given to the stem tubers of *Helianthus tuberosus*, a member of the Compositae very closely related to the sunflower (*H. annuus*). The plant is native to North America and its distribution extends from Nova Scotia to Minnesota and Kansas. It was already cultivated by American Indians before the first settlers arrived. The name "Jerusalem" may be a corruption of the Italian name for the sunflower, *girasole*. In spite of the fact that Jerusalem artichoke is a perennial plant it is usually treated under cultivation as an annual. It reaches about 2 m or more in height and produces underground stem tubers 10 cm long and 5–7 cm in diameter. Jerusalem artichokes were introduced into Europe at the beginning of the seventeenth century: to France between 1609 and 1617, while in England they were

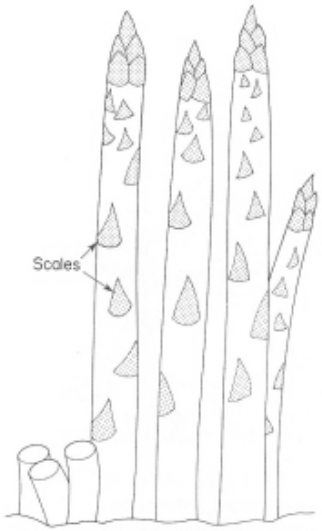


41. ARTICHOKE, JERUSALEM (*Helianthus tuberosus*) (x0·5)
Stem tuber of irregular form
A. Internodes
B. Buds on projections
C. Roots

first mentioned in 1622. In place of starch, they contain inulin, a polysaccharide consisting of residues of fructose and for this reason they are recommended to diabetics. They are consumed in the same ways as the potato—boiled, fried or in soups. They are also propagated like potatoes, whole tubers or large parts of them being used for planting. In Europe Jerusalem artichokes are planted mainly where the soil is dry and too poor for cultivation of potatoes. Apart from Europe the Jerusalem artichoke was also introduced into temperate regions of Asia and America but in the U.S.A. it is of almost no economic importance.

42. Asparagus

Asparagus, or botanically *Asparagus officinalis* var. *altilis*, is a monocotyledonous plant of the family Liliaceae and is native to temperate parts of Eurasia. The plant is a herbaceous perennial 1–3 m tall. It lacks leaves which are substituted by phylloclades, i.e. terminal needle-like stem branchlets. Asparagus is reproduced by means of crowns produced from seeds borne in red berries, normally in special nurseries which sell the crowns to farmers. The ancient Greeks and Romans thought highly of asparagus, and this, together with the artichoke, is still widely considered as one of the most delicious vegetables.



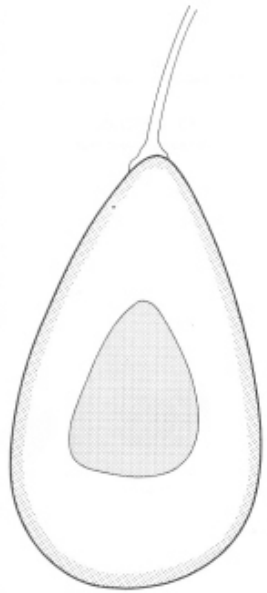
42. ASPARAGUS (*Asparagus officinalis*) Shoots (x0·5)

The part used as a vegetable is the young shoot; these leafless stem sprouts grow through the soil from the crown which is planted several centimetres deep and are harvested when they reach about 25 cm in height. If white (blanched) asparagus is required, the shoots must be earthed up by mounding the soil over the row of crowns before growth starts. The blanched asparagus is harvested when the tip of the shoot starts to protrude from the mound. In the U.S.A. and in Britain the green asparagus is preferred and the blanched kind is cultivated only for canning. But elsewhere in Europe blanched asparagus is preferred for eating fresh. It is boiled and eaten either plain, or with butter or sauces such as mayonnaise. The crowns normally yield crops for 15 years and then the new crowns have to be planted. It is a dioecious plant: some plants produce only female flowers while others bear only male ones. The female plants give a higher yield but it is not advantageous to discard the male plants: if the sex is to be identified the crowns have to be grown in nurseries for two years instead of one and the first year crop which is the best one would be lost.

The most renowned type is the Argenteuil asparagus which is cultivated in the Argenteuil region in the department Seine-et-Oise of France, near to Paris. Unfortunately, neither asparagus from Argenteuil nor that produced all over the world is sufficient to satisfy demands, and cheaper substitutes are therefore being sought. One possibility is leek, if it is used when it is thinner than that sold in Britain; but also some quite unusual plants are substituted, including etiolated stalks of seakale or midribs of cardoon. Another example is an aquatic plant with floating leaves, native to South Africa and introduced into Europe and the U.S.A. to supply a substitute for asparagus with its young shoots. It is called CAPE ASPARAGUS or *Aponogeton distachyum* (family Aponogetonaceae—Monocotyledoneae) and is naturalized in the temperate parts of the northern hemisphere. In addition, some very common plants are used as asparagus substitutes, e.g. the young shoots of blackberry.

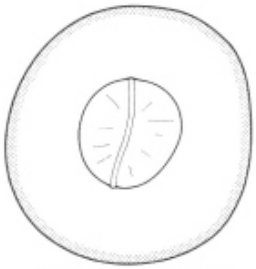
43. Avocado

Avocado or *Persea americana* yields edible one-seeded berries. The plant is a member of the family Lauraceae, a tropical evergreen tree up to 20 m tall, and a native of Central America. The fruits are normally pear-shaped and are therefore often called AVOCADO PEARS or ALLIGATOR PEARS. Some varieties, however, have round or oval berries, and the size of the berries also varies. *Persea americana* var.



43a. L. S. with the seed uncut

43. AVOCADO (*Persea americana*) (x0·5)



43b. T.S. of the fruit and seed

43c. Seed with testa removed

43. AVOCADO
(*Persea americana*)
(x0·5)

drymifolia, native to the mountainous parts of Mexico, has fruits the size of plums weighing up to 250 g, while some giant varieties yield fruits over 1 kg in weight. The fruit varies in colour from dark green (the most usual colour) to yellow or purplish. Avocado is prized for its high oil content and rich nutty taste. It is mainly eaten raw; the berry is split into halves and the large seed, consisting mostly of the two large cotyledons, is removed. The edible part is the pulp which is whitish and of a buttery consistency when ripe. Because of the high oil content (up to 25–30%) avocado has been given the name "poor man's butter", a name that is obviously only appropriate in tropical countries—in Europe as an imported vegetable it is very expensive because it is easily perishable and heavy losses occur during transportation. Avocado is usually served as half fruits sprinkled with lemon juice or vinaigrette dressing, and the cavity left after removal of the seed is often filled, for example, with prawn mayonnaise.

Avocado was first introduced into Jamaica about 1650, while in the Old World tropics it appeared much later, during the nineteenth century. Nowadays it is cultivated also in many subtropical countries and in all continents; most avocados come to Britain from Israel. It was cultivated in Florida from 1833 and in California from 1856, but in Europe it did not become fashionable until after the Second World War. The tree is easy to raise from seed but the cultivated varieties need vegetative propagation by means of grafting or budding.

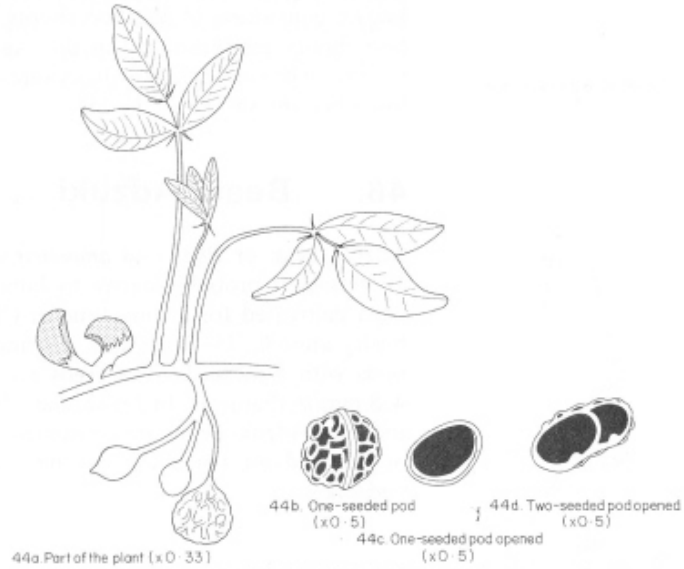
44. Bambarra Groundnut

Bambarra groundnut or *Voandzeia subterranea* is an annual herb, a member of the family Leguminosae, order Leguminales, and is a native of West Africa although it is now hardly ever found there in its truly wild form. It is an erect or trailing plant yielding subterranean pods like peanuts, which have largely replaced bambarra groundnuts in

Africa. Only in African regions with the poorest soil where other pulses and groundnuts (peanuts) cannot be grown are bambarra groundnuts still cultivated.

The underground pods are normally one-seeded and only occasionally two-seeded; the pods are rounded and when ripe are wrinkled. The seed itself is usually more or less round, smooth, and may be up to 1·5 cm broad. However, its size, shape and colour vary considerably according to the cultivar: there are whitish, red, black and mottled bambarra seeds. They are never used like peanuts for oil extraction, but are eaten like other pulses or are ground into flour from which various foods are prepared.

Bambarra groundnuts were introduced into Brazil in the seventeenth century and later to the Philippines and Indonesia.



44. BAMBARRA GROUNDNUT (*Voandzeia subterranea*)

Another West African plant closely related to *Voandzeia subterranea* is the KERSTLING'S GROUNDNUT or *Kerstlingiella geocarpa*. As its names suggest, this plant also produces underground pods,

and the seeds are used for human consumption in the same way as those of bambarra groundnut: either directly, as a pulse, or very often they are first produced into a flour, because they are extremely hard.

45. BAMBOO (*Bambusa* spp.) (x0·5)

45. Bamboo

Bamboos are tropical grasses belonging to the monocotyledonous family Gramineae, and the young shoots (stem sprouts) are a very common vegetable in South Asia, but in Europe they remain an exotic vegetable only available in cans. Edible shoots are yielded by *Bambusa vulgaris* and many other bamboos and bamboo-like species native to tropical Eastern Asia, e.g. *Phyllostachys pubescens* which is popular among the Chinese, the best known consumers of bamboo shoots. Most bamboo shoots are poisonous in the raw state, containing large amounts of hydrocyanic acid which is lost when the shoots are boiled.

46. Bean, Adzuki

Adzuki bean or *Phaseolus angularis* (family Leguminosae) is probably native to Japan but it has been cultivated for a long time in China. It is a bushy annual, 25–75 cm tall, bearing cylindrical pods with 5–12 seeds. The seeds are oblong and 4–8 mm in diameter. In Japan and China the ripe and dried adzuki beans are consumed either boiled or prepared into a meal which is then used for soups and cakes.

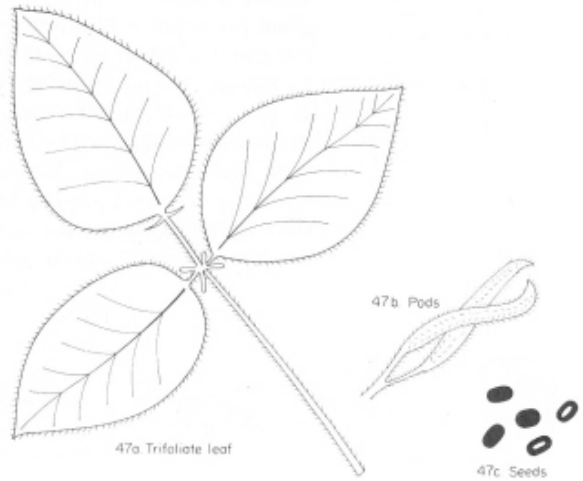
46a. Pod and leaf (x0·5)

46b. Seeds (x1)

46. ADZUKI BEAN (*Phaseolus angularis*)

47. Bean: Black Gram

The bean called black gram, URD or WOOLLY PYRUL is derived from the pod of the leguminous species *Phaseolus mungo*, known also as *Vigna mungo*. The plant is a member of the family Leguminosae, is native to India and is of economic importance only there, mainly in the region Mysore. It has been cultivated in India since ancient times but more recently it has also been introduced by Indian immigrants into other tropical countries, e.g. the West Indies. *Phaseolus mungo* is an erect or suberect annual, 20–80 cm tall and yielding erect or suberect pods measuring 4–7 cm by 0·6 cm. The pods contain 6–10 seeds which are eaten and appreciated chiefly by the high castes of Hindus. The seeds may be eaten boiled, either entire or split, but also a flour is produced from them. The flour is used for bread or mixed with spices and formed into balls that are eaten as porridge. The young green pods are also consumed as a vegetable.



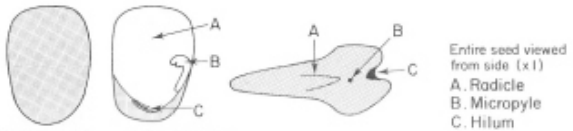
47. BLACK GRAM (*Phaseolus mungo*) (x0·5)

48. Bean, Broad

Broad bean or HORSE BEAN is the plant botanically known as *Vicia faba* (Leguminosae) and is confined mainly to the temperate regions of the world. Broad beans were the only beans known to Europeans before the discovery of America. They may be indigenous to the Mediterranean region or to south-western Asia and in the wild form they still occur in Algeria. Broad beans were cultivated by the ancient Egyptians, Greeks and Romans, and they have been found in the Swiss Lake Dwellings of the Bronze Age. It is claimed that they were introduced into China about 2822 B.C.

Vicia faba is an erect annual herb, without tendrils, 30–180 cm tall and yielding stout flattened pods, attaining up to 30 cm in length in cultivars. The pods have a pointed beak and are lined inside with a white velvety endocarp; they contain numerous large, flattened seeds about 2·5 cm long. *V. faba* is cultivated for its seeds (the beans), which are eaten either immature or mature. The immature greenish broad beans are marketed in their green pods, but it is only in certain countries (e.g. France) that the whole pods with the seeds are used for human consumption. The seeds of broad beans, as all other kinds of pulses, are exalbuminous, lacking endosperm and consisting mainly of two large cotyledons that can easily be split. Broad beans are now very popular in Europe, the Middle East, Egypt, India, Burma, as well as in Mexico and Brazil, where they are cultivated at higher altitudes.

48a. Entire pod (x0·5)

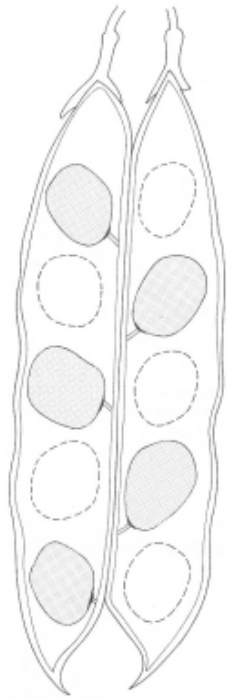


48b. Entire seed (x0·75) L.S. of the seed (x0·75)
A. Cotyledons
B. Epicotyl
C. Hilum

48. BEAN, BROAD (*Vicia faba*)

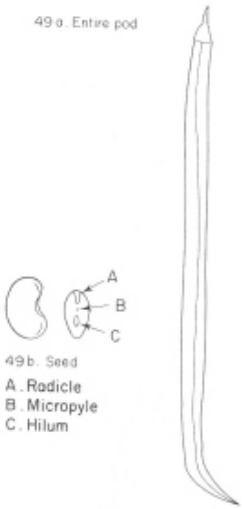
49. Bean, French

FRENCH, KIDNEY OR COMMON BEANS are the seeds of *Phaseolus vulgaris* (Leguminosae), a usually twining, annual herb 2–3 m tall and originating in America, probably Central America. The pods are slightly curved and prominently beaked; they measure 8–20 cm by 1–1·5 cm and contain 4–6 seeds (exceptionally 12 seeds). The seeds are often kidney-shaped, but are variable in shape and size and also in colour according to the cultivars which now number many hundreds. Among the cultivars are those that are not twining but bushy and dwarf, so that their erect stems do not need any support, being only 20–60 cm tall. Some cultivars yield yellow pods but normally they are green. Commercially the cultivars are classed into three groups according to their use. Cultivars from which the entire pods are used are called SNAP BEANS (I) and these are subdivided into bush varieties yielding either green or yellow pods, and climbing varieties with green pods only. The unripe pods of these varieties are boiled and eaten as a vegetable. However, the pods contain fibrovascular bundles (strings) along their dorsal and ventral sutures, and these have to be removed prior to boiling, making the preparation of this vegetable laborious. Fortunately, there are nowadays many stringless cultivars of French bean, or *haricots*, as the French call them. The second group (II) contains varieties of which the seeds are eaten immature and which are sold on the market in the green unripe pods. These varieties have the least economic importance. However, the third group (III) are of great importance; these are the varieties grown for their dry, mature seeds and are subdivided into four types: (1) MEDIUM FIELD BEANS of which the seeds are pinkish-buff with dark brown spots; (2) PEA or NAVY BEANS, resistant to mosaic virus disease; (3) MARROW RED KIDNEY BEANS, which are very important chiefly in Latin America; and (4) MARROW BEANS which are not widely grown. Dried French beans are known in Britain mainly as baked



48b. Pod opened along the ventral suture (x0·5)

48. BEAN, BROAD (*Vicia faba*)



beans, sold cooked with tomato sauce and canned.

French beans have been cultivated by American Indians since prehistoric times, and according to radiocarbon analysis remnants found at archaeological sites in the caves of the Tehuacan valley in Mexico are about 7000 years old. In the sixteenth century the Spanish and Portuguese brought them to Europe, and in 1594 the "French" bean reached England.

Phaseolus vulgaris is chiefly cultivated for its dry seeds in tropical America and in some parts of tropical Asia, but there native pulses are preferred. In temperate regions such as North America and Europe French beans are also cultivated on a large scale for the pods. In the U.S.A. fresh pods are obtainable throughout the year: in spring and summer from the northern States and in the autumn and winter from the southern parts.

49. BEAN, FRENCH (*Phaseolus vulgaris*) (x0·5)

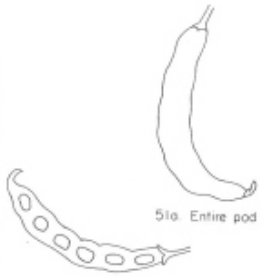
50. Bean, Goa

Goa bean or ASPARAGUS BEAN, known botanically as *Psophocarpus tetragonolobus* (Leguminosae) is probably native to tropical Asia but is considered by some authors as a native of the western part of Africa. It is a climbing perennial with pods 15–30 cm long and 2·5–3·5 cm wide. The pod has 8–17 seeds which vary in colour according to the variety and measure about 1 cm in diameter. Goa beans are grown chiefly for the immature pods which are eaten like French beans. Ripe seeds are also eaten and young shoots, leaves and flowers are also used as vegetables. Even the tuberous roots are often consumed raw or boiled.

50. BEAN, GOA (*Psophocarpus tetragonolobus*)

51. Bean: Horsegram

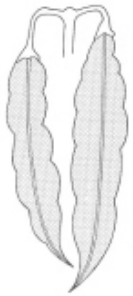
Horsegram or *Dolichos uniflorus* (syn. *D. biflorus*) is another member of the family Leguminosae and is native to south-east Asia—the Old World tropics. It is a slender, suberect plant with beaked downy pods containing 5–7 seeds. Horsegram is the poor man's pulse in southern India. The seeds are eaten after boiling or frying, whole or in the form of meal.



51. HORSEGRAM (*Dolichos uniflorus*) (x0·5)

52. Bean, Lablab

Lablab beans are the seeds from the pods of *Lablab niger* (syn. *Dolichos lablab*), a leguminous annual (family Leguminosae), usually a climber, native to India where lablab beans are eaten as much as broad beans or French beans in Europe. As well as being grown in India they are produced on a large scale in Malaysia, Egypt and the Sudan. The Arabic name for them is LUBIA beans, and in Europe they are also called HYACINTH beans, INDIAN or EGYPTIAN beans and BOMAVIST beans. The plant is a perennial herb but often handled under cultivation as an annual, reaching 1·5–6 m in height. Although it is a climber, bushy varieties also occur. The pods are variable in size (5–15 × 1–5 cm), 3–6 seeded, often curved and flattened, and with a strongly curved beak. The seeds vary in size and colour and have a prominent white hilum along one third of the edge. The immature pods are consumed as a green vegetable, while the ripe seeds are eaten in India as a split pulse. Lablab beans cannot be eaten raw because they contain a poisonous glycoside that must be destroyed by boiling.



52. BEAN, LABLAB (*Lablab niger* or *Dolichos lablab*) (x0·5)

53. Bean, Lima and Sieva

"Butter" beans sold in Britain are Lima beans, known botanically as *Phaseolus lunatus* (Leguminosae). The plant is a leguminous climbing perennial

2–4 m tall, which may be grown under cultivation as a bushy annual reaching only 30–90 cm in height and it is indigenous to tropical America. The pods are oblong, 2–4-seeded and covered with short hairs; they measure 5–12 cm in length and 1·5–2·5 cm in width. The seeds are mostly large, 1–3 cm in length and of variable shape and colour. The name *P. limensis* (of Lima, Peru) may be considered as a synonym for *P. lunatus* but some authors distinguish *P. limensis* as a separate species. However, it seems most likely that *P. limensis* is only a variety of *P. lunatus* and should be called *P. lunatus* var. *macrocarpus*. The variety *macrocarpus* (or the species, *P. limensis*) is mostly perennial and has large seeds that are usually white, while *P. lunatus* is usually bushy and yields smaller, often plump seeds of different colours. The name Lima bean should be reserved for the variety *macrocarpus* while the name SIEVA BEAN should be applied to *P. lunatus*.

53a. Pod (x0·33)

53b. Seed (x0·5)

53. BEAN, LIMA (*Phaseolus lunatus*)

It seems that *P. lunatus* originated in Central America (especially Guatemala) and spread to Mexico, the West Indies and South America. In Peru they have been found in excavations dated at 5000–6000 B.C. The Spaniards took Lima beans to the Philippines from where they were introduced into Asia, and they were taken from Brazil to Africa via the slave trade. Lima beans escape easily from cultivation and thus they are found growing apparently wild in many tropical parts of the whole world. They are now the main pulse crop of tropical Africa and are also grown on a large scale in Burma.

The seeds are eaten both mature and immature, and also the unripe pods are used as a vegetable. The mature beans contain a glycoside (phaseolunatin) which, when they are chewed, yields poisonous hydrocyanic acid. The white beans have a small, tolerable amount of HCN while larger amounts are yielded by coloured beans. For this reason the cultivation of large, white Lima beans is preferred.

54. Bean, Moth

Moth bean or MAT BEAN, known botanically as *Phaseolus aconitifolius* (Leguminosae) is a native of India and Burma. It is a slender trailing annual herb producing small pods (2·5–5 cm long and 0·5 cm wide) with stiff hairs, short curved beak and 4–9 seeds. In India its immature green pods are eaten as a vegetable, while the ripe seeds are eaten cooked either entire or split (*dahl*). Moth beans have been introduced into the U.S.A., but they have been cultivated there only for pasture, fodder or green manure.

a. Trifoliate leaf

b. Pods

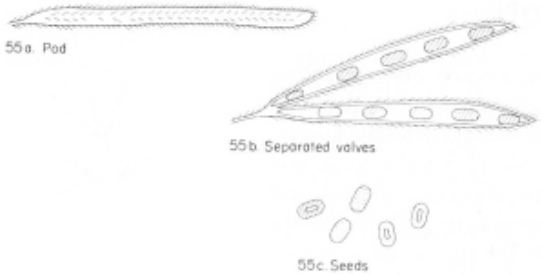
c. Seed

54. MOTH BEAN (*Phaseolus aconitifolius*) (x0·5)

55. Bean: Mung

Mung is the Indian name for *Phaseolus aureus* or *Vigna aureus* (Leguminosae), known also as GREEN or GOLDEN GRAM. It is a leguminous, erect or suberect, much-branched annual, native to India, and is 0·5–1·3 m tall. It has been cultivated in India since ancient times but is now also common in China and other Asiatic countries. The green or brownish pods bear short hairs, measure 5–10 cm by 0·5–0·6 cm and contain 10–15 small green or gold seeds. The dried mature seeds are eaten either whole or split, and also the unripe green pods are consumed as a vegetable. After the removal of the testa the mature seeds are often ground into flour. In China and nowadays also in the U.S.A. mung beans are also sprouted for consumption as seedlings. The sprouting beans are eaten either raw as a salad or boiled. The green-seeded varieties are more often used for human consumption (green mung), while the golden-seeded varieties are generally used for fodder, but there are also many cultivars of golden mung that yield a good crop for human consumption. Of the green cultivars, the ones preferred for sprouting are those that yield dark green, shiny, hard seeds.

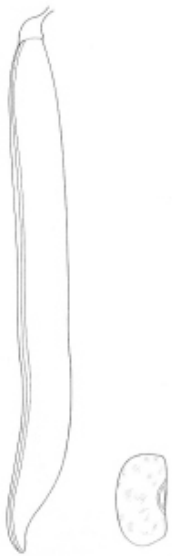
55. BEAN, MUNG (*Phaseolus aureus*) Seedling (x0·5)



55. MUNG BEAN (*Phaseolus aureus*) (x0·5)

56. Bean, Scarlet Runner

The botanical name of scarlet runner bean is *Phaseolus coccineus* or *P. multiflorus* (family Leguminosae), and the latter specific epithet gives it the common name used in the U.S.A. as an alternative: MULTIFLORA BEAN. It is a twining leguminous perennial up to 4 m or more in height. The pods, reaching 10–30 cm in length when ripe, vary in colour, as do the flowers; but most of the cultivars are red-flowered as indicated by the names "scarlet" and *coccineus*. Scarlet runner beans were cultivated for their attractive flowers, as an ornamental plant, and were introduced as such into Britain in 1683 from America; they are native to South America. In Europe their fruits were at first considered inedible and they did not become a food plant until the eighteenth century. Today they are used for their immature green pods or for their dry seeds according to the locality. In Britain the scarlet runner is most commonly used for eating in the form of entire pods, while in Continental Europe they are preferred for consumption in the same way as French beans. In the U.S.A. they are still cultivated only as ornamental plants.



56a. Pod (x0·33) 56b. Seed (x0·5)
56. BEAN, SCARLET RUNNER
(*Phaseolus coccineus* or *multiflorus*)

57. Bean, Soya

Soya bean or SOYBEAN is a leguminous erect annual with the botanical name *Glycine max* (Leguminosae). The plant is 20–180 cm tall and native to eastern Asia where the wild form still grows. The first record of its cultivation comes from China and is dated 2838 B.C., and it has also been cultivated from ancient times in Korea, Manchuria and Japan. The part used is the seed; these are produced in pods that grow in clusters of 3–15. The pods, 3–7 cm long and 1 cm wide, are slightly curved and hairy. They differ in colour according to the variety: some are yellow, others grey, tawny or even black. The seeds are spherical or flattened and occur 1–5 in a pod, although most varieties contain 2–3 seeds per pod. The seeds (beans) of *Glycine max* are best known as the source of an edible oil and the plant is now cultivated on a large scale in the U.S.A. for this purpose (see Chapter VI, Oil Plants). In the Far East soya beans are also eaten as a vegetable either immature or ripe; the unripe seeds are eaten together with the pod. Sometimes the soya beans are fermented by *Aspergillus oryzae* for human consumption and used for preparation of a sauce or in Indonesia for a kind of cake called *tempe*. Another way in which they are consumed is as seedlings; for this purpose the beans are germinated in darkness so that the seedling is blanched. The sprouting is terminated after one week, when the soya beans develop the first true foliage leaves. Soya beans may also be ground into flour which is mixed with cereal flour in bakeries of the Far East as well as in the U.S.A. In the English-speaking countries fermented soya beans are used for preparation of special sauces, e.g. Worcester sauce in Britain.

Soya beans are especially important because of their richness in proteins. As was mentioned in the introductory chapter, soya beans are used all over the world for mixing with meat products as a meat substitute, and in Japan "steaks" are marketed that consist entirely of soya proteins. Soya beans may

57a. Twig with fruit (x0·33)

57b. Seeds (x0·5)
57. BEAN, SOYA (*Glycine max*)

prove to be the solution to the problem of protein famine in underdeveloped countries, but unfortunately the attempts to introduce the cultivation of soya beans into Africa, India and the West Indies have not met with success. However, the U.S.A. has recently become a substantial producer of them, particularly for oil extraction. The plant was introduced there as early as 1691 but it was cultivated only sporadically up to the nineteenth century; it was the Second World War that gave the impetus to cultivation of soya beans on a large scale.

There are many cultivars of *Glycine max* and different forms are used for particular purposes. They fall into three groups according to their period of growth: (i) the early types requiring 85–95 days for growth and producing stems 30–70 cm long; (ii) intermediate types including cultivars that ripen in 95–110 days and in which the stems vary in length from 50–100 cm; (iii) late cultivars with a 110–125 day growth period and producing tall plants.

58. Bean, Tepary

58. BEAN, TEPARY (*Phaseolus acutifolius*) (x0·25)

Tepary bean or *Phaseolus acutifolius* var. *latifolius* (family Leguminosae) is native to Arizona and Mexico and its cultivation is chiefly confined to these areas. It was cultivated in Mexico more than 5000 years ago and it grows very well in arid regions of the tropics. The tepary bean is a suberect plant about 25 cm tall, yielding compressed pods 5–9 cm long and 0·8–1·3 cm wide, on average 5-seeded. The pods are hairy when young. The edible part is the ripe and dried seed which is used as a pulse.

59. Bean, Yam

Yam bean, *Pachyrhyzus erosus* of the family Leguminosae, is mainly cultivated for its watery root tubers which are eaten either raw or boiled;

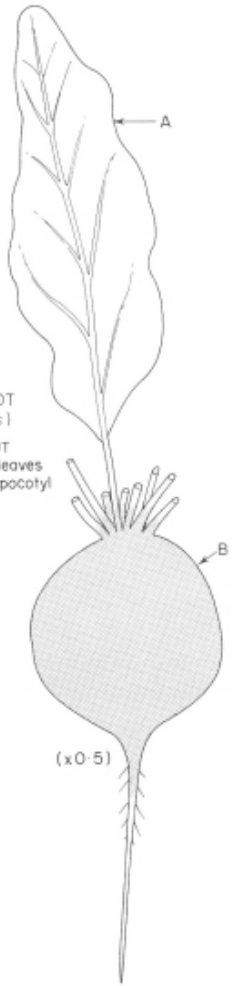
but the young unripe pods (about 7·5–14 cm long) are also eaten. The tubers should be harvested after 4–8 months, since after that they become too fibrous to be palatable. The roots and ripe seeds contain a poisonous substance, rotenone ($C_{23}H_{22}O_6$) which in the case of *Derris elliptica*, another member of the Leguminosae, is extracted and used as a fish poison. The yam bean is native to Central America where they were cultivated long before the Conquest. The type of yam bean growing in South America and in parts of the West Indies is another species called *P. tuberosus*. This is native to the Amazon basin and its tubers are larger than those of *P. erosus*.

59. BEAN, YAM (*Pachyrhyzus erosus*) (x0·5)

60. Beetroot

The beetroot is one of the forms of *Beta vulgaris* var. *vulgaris* (family Chenopodiaceae) to which all the cultivated beets belong, while the wild beet from which this variety is derived is called *B. vulgaris* var. *maritima*. The wild beet or sea beet is native to Europe, North Africa and Asia, and spread from Britain to India. It grows there wild on the sea shore today. The variety *vulgaris* and *maritima* are often considered as species (*B. vulgaris* and *B. maritima*), and in this case beetroot may be specified as *Beta vulgaris* var. *rapacea* f. *alba* or *rubra*.

Its edible part is the swollen structure which is mainly swollen hypocotyl—the short part of the stem below the cotyledons, which appears above the ground and terminates in the taproot, the root that develops from the radicle or embryonic root. Only a part of the root is incorporated into the



60. BEETROOT (*Beta vulgaris*)

60a. BEETROOT
A. One of the leaves
B. Swollen hypocotyl

swelling. The swelling is caused by secondary thickening which is an anomalous structure of all kinds of beet varieties with swollen roots; several concentric vascular cambia are formed outside the original vascular core. From these secondary cambia is derived xylem (centripetally) and phloem (centrifugally); both split into bundles, units divided from one another by parenchyma. The secondary xylem and phloem themselves are parenchymatous and thus soft. The vascular cambia are short-lived and therefore many of them must be produced successively; these concentric cambia are quite distinct to the naked eye as rings in the transverse section of a beetroot.

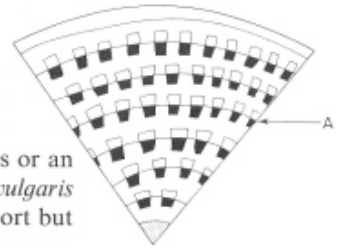
The flesh of the beetroot is red to dark crimson, the colour being due to a glucoside called betanin which is dissolved in the central vacuole of the cells.

Beetroot was known as a vegetable as early as 300 B.C. but improved forms were introduced as late as the sixteenth century: in Germany about 1558 and in Britain about 1576. It is used boiled, or pickled in vinegar, and the boiled form may be consumed cold in the form of a salad, or hot like many other root vegetables. Beetroot is also very popular in Russia, where it is mainly used as the basis for the soup called *borsch*.

Beetroot contains an exceptionally large amount of sugar—up to 8%. There are many cultivars differing in the shape and colour of the swollen "root": the colour of the flesh varies from red to purple, and the shape may be globular, subglobular, ovoid or elongated cylindrical. The cylindrical beetroots may reach over 30 cm in length. However, the beetroot is not harvested at its maximum size, because large, old beetroots are not of such good quality as the younger, smaller ones, and the harvest usually takes place early, before the largest "roots" reach more than 7 cm in diameter. Baby beetroots, very small swellings, are mainly used for pickling. They are normally developed from seed in the open, but early beetroots are produced from plants that were started from seed in greenhouses or hotbeds. As a cultivated

60. BEETROOT (*Beta vulgaris*)

60b. Part section of hypocotyl
A. Concentric vascular cambia developing in *Beta* spp.



plant beetroot is a biennial in mild climates or an annual in hotter regions, while the wild *B. vulgaris* var. *maritima* is a perennial plant with a short but not fleshy "root".

61. Breadfruit

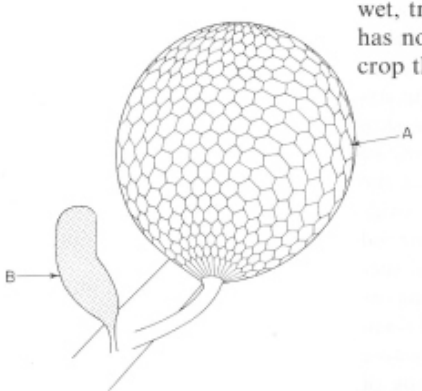
Breadfruit is the fruit of a tropical tree known as *Artocarpus altilis* of the family Moraceae. It is a monoecious evergreen, usually up to 20 m tall and native to Polynesia, where it has been cultivated since ancient times. The wild species of Micronesia, *A. mariannensis*, seems to have contributed to its origin and *A. altilis* is considered to be a hybrid. The breadfruit tree was discovered in Tahiti by Captain Cook's expedition, on which Joseph Banks was the botanist. They were enthusiastic about the "bread which can be picked from the trees", and were inspired to introduce it to the West Indies as a cheap diet for the slaves. After his return to England, Banks organized a new expedition to bring the seedlings of breadfruit trees from Tahiti to the West Indies and he suggested that the expedition should be led by William Bligh. This expedition departed from England in 1787 on the ship Bounty, the scene of the world-famous mutiny of 1789, and as a result of this the lost load of the Bounty, the breadfruit tree, also became world-famous. Bligh's life was saved and after his arrival in England he returned to Tahiti in 1792, and successfully brought to the West Indies the seedlings of the breadfruit tree. He himself planted one of them in 1793 in the botanic garden of St. Vincent, where it persists to this day. Before the expeditions of Bligh the breadfruit had already been introduced into Malaysia.

The breadfruit is a multiple fruit, a sorosis, developing from the whole female inflorescence, with a spike forming a pseudo-head, a globular structure. It measures 10–30 cm in diameter. The edible part of the fruit is derived from the perianths and receptacles, forming a thick fleshy layer (the pulp) between the rind and the core. The core is the axis of the inflorescence and the surface of the rind divided into hexagonal knobs corresponds with the fruitlets; neither the rind nor the core is consumed. Breadfruit is usually eaten immature, when its pulp is still white and mealy, and it is boiled, baked, fried or roasted, but never eaten raw.

Because of its enormously high starch content, the breadfruit is also often ground into flour and used in bread-making. Another use is to prepare cakes of dough made from the fermented pulp; such cakes are known as *mahe*.

Breadfruit trees are propagated vegetatively because their fruit is normally seedless, but there are some many-seeded cultivars that produce true fruits, brownish achenes about 2·5 cm long. Such cultivars are grown for their seeds, which are known as BREADNUTS. The pulp in such cultivars is almost non-existent because its place is taken by the crowded seeds.

Breadfruit has now been introduced into all hot, wet, tropical countries but, except in Polynesia, it has not succeeded as the economically important crop that Cook and Banks envisaged.



61. BREADFRUIT (*Artocarpus altilis*) (x0·25)
A. Female inflorescence
B. Male inflorescence

62. Broccoli

Broccoli is a variety of cabbage, *Brassica oleracea*, a member of the family Cruciferae. It is generally assumed that it was developed in Italy where it has been grown for several centuries, and because Italy has also been the main producer of broccoli up to the twentieth century it has received the botanical name of *B. oleracea* var. *italica*. Broccoli is very similar to cauliflower (*B. o.* var. *botrytis*), of which it is sometimes considered as a mere form or subvariety and thus given the name *B. o.* var. *botrytis* f. *asparagoides*. The edible part is, as in the case of cauliflower, the entire inflorescence—the degenerate flowers with their stalks. The inflorescence may form a compact head (HEADING BROCCOLI) which differs from the head of the cauliflower only in colour, which may be green, purple, copper or sulphur yellow. However, this is not the typical form of broccoli; more often it produces smaller loose heads at the termination of both the central stem and of shoots developing from buds in the axils of the leaves. This type is called SPROUTING BROCCOLI and its inflorescence may be either purple or green. The stems in sprouting broccoli are much thinner than those of the cauliflower and they are also longer, so that most of the edible part is formed by the stalks, in contrast with the cauliflower which is formed mainly from fleshy flowers. For this reason broccoli has been given the subvarietal name *asparagoides* and also its German name SPARGELKOHL (asparagus cabbage).

Broccoli is a hardier form of cauliflower and withstands not only a mild winter but also a drier and hotter climate. Usually the larger central heads with their stalks are harvested first and then the lateral shoots with smaller heads are picked successively. The removal of the central shoot stimulates the development of lateral shoots and thus a single plant yields a crop continuously for several weeks. In Britain and some other European countries broccoli has been cultivated for a long time, but has only achieved economic importance

62. Sprouting BROCCOLI (*Brassica oleracea* var. *botrytis*) (x0·25) Terminal clusters of flowers

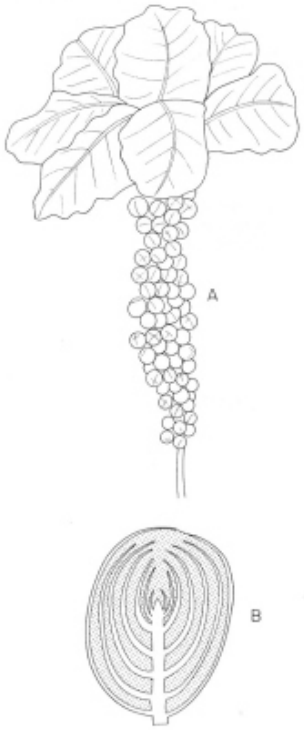
relatively recently. In the U.S.A. large plantations of broccoli date from the time of the Second World War.

Heading broccoli is used in much the same way as cauliflower but sprouting broccoli is usually trimmed to a length of about 15 cm and eaten boiled like asparagus or chopped like spinach. Chopped sprouting broccoli is popular mainly in the U.S.A., where the size of the heads is therefore not of much importance. The leaves are not eaten. There are many cultivars of broccoli and among the green ones the most commonly cultivated is the green Italian type called 'Calabrese'. Its heads are bluish-green, while the heads of the cultivar 'de Cicco' are pale green, as are the heads of the American cultivar 'Texas 107', which can also be grown in tropical countries.

63. Brussels Sprout

Brussels sprout is another variety of cabbage known botanically as *Brassica oleracea* var. *gemmifera* (family Cruciferae). It was first recorded in 1587 and was apparently developed in the fifteenth century in the northern part of Europe that is now Belgium. Whether or not it originated from Brussels, it was cultivated there for centuries and spread from there into other countries. It first became popular in many European countries after the First World War when consumption of vegetables increased considerably, but in the U.S.A. the Brussels sprout is still among the minor vegetables.

The edible parts are the lateral buds that appear on the stems in place of lateral branches. The stem may reach 1 m in height and on it, beneath the rosette of leaves, are crowded the sprouts, rounded buds like miniature cabbage heads about 3 cm across. These buds have a finer, better taste than the large buds of cabbage, and many different cultivars of Brussels sprout are now cultivated. Some cultivars yield small, dwarf buds while others develop very large ones, about 8 cm in diameter. The leafy top and the terminal bud, which is not compact, are occasionally eaten and appear on sale for a brief period of the year.

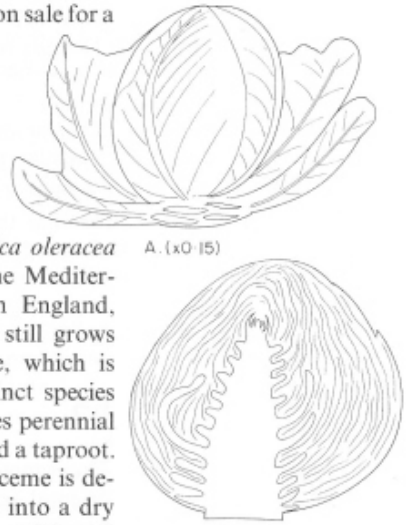


63. BRUSSELS SPROUT (*Brassica oleracea* var. *gemmifera*)
A. Entire aerial part (x0·05)
B. L.S. of a single bud (x0·5)

64. Cabbage

Cabbage is a further variety of *Brassica oleracea* (family Cruciferae), and a native of the Mediterranean region as well as of southern England, Wales and northern France, where it still grows wild on the coast. The wild cabbage, which is considered by some authors as a distinct species (*B. sylvestris*), is a biennial or sometimes perennial plant with an erect stem, large leaves and a taproot. Its inflorescence is racemose but the raceme is devoid of bracts and the flowers develop into a dry dehiscent fruit called a siliqua. The cultivated *Brassica oleracea* known as cabbage has been in use for at least 2000–2500 years and was introduced into Britain by the Romans. Its botanical name is *B. oleracea* var. *capitata*, because the leaves appearing on a shortened stem form a compact, hard head, a large, main terminal bud of smooth, fleshy leaves. The leaves are either whitish or purple. In the latter case the cabbage is known as RED CABBAGE or *B. o.* var. *capitata* f. *purpurea*.

Cabbage is normally boiled or pickled but it may also be eaten raw as a salad vegetable. It is usually shredded. Because it also grows well in cold parts of Europe and is cheap, it became a popular vegetable in Eastern Europe, particularly Poland, Bohemia, Germany and Austria, and in Russia. In Russia cabbage is commonly used for the preparation of soups, and as a stuffing for cakes. Fermented cabbage is known in English by its German name *sauerkraut*, and during the Second World War "kraut" became the common nickname for the German soldiers. The name means "sour cabbage", an Asiatic invention, and it is fermented



A. (x0·15)

B. (x0·125)

64. CABBAGE (*Brassica oleracea* var. *capitata*)
A. Entire bud with loose leaves in the front cut away
B. L.S. of the bud

by *Lactobacillus* which converts the sugar into lactic acid, responsible for the sour taste. In this form cabbage can be stored over the winter. Cabbage is an important crop in the U.S.A. where it was introduced from Europe by the earliest settlers.

There are over 200 listed commercial cultivars of cabbage. The most distinct of these is the Savoy Cabbage (*B. o.* var. *bullata*), of which the leaves forming the head are dark green and curled or blistered. Savoy cabbage is commonly considered as the best kind of cabbage. It is consumed boiled as other green vegetables.

65a. PAK-CHOI (*Brassica chinensis*)

65b. PE-TSAI (*B. pekinensis*)

65. CABBAGE, CHINESE (x0·125)

65. Cabbage, Chinese

The common name Chinese cabbage is used for two oriental species of *Brassica* (family Cruciferae)—PAK-CHOI or *B. chinensis* and PE-TSAI or *B. pekinensis*. Both are annuals and appear to be native to China, where they have been cultivated from the fifth century A.D. Pak-choi resembles spinach and has soft, green, prominently veined leaves, not forming a heart. Botanically pak-choi is related more closely to the turnip and swede than to the European cabbage. The edible part is the leaf which is treated as a green vegetable. Pe-tsai, on the other hand, forms an elongated head resembling cos lettuce. The most popular cultivars of pe-tsai are 'Chihili' and 'Wong bok'. Chinese cabbage, mainly pe-tsai, is nowadays grown also in Europe and North America as a minor crop and is used boiled as a green vegetable, or raw for salads.

66. *Capsicum*

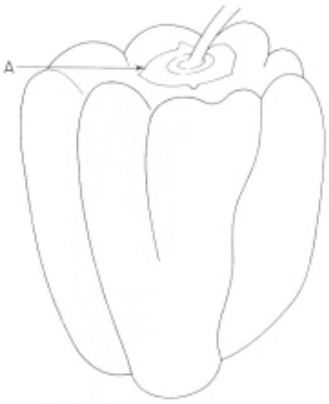
The green or red pepper, *Capsicum annuum*, is an annual belonging to the family Solanaceae. It is a native of tropical America and was cultivated by the American Indians in remote prehistoric times.

After the Discovery, *Capsicum* spread rapidly over the whole world including the warmer parts of the temperate regions. The useful part is the fruit, a berry, which is mainly used unripe, when it is still green. Most of the berries used are of milder cultivars belonging to the variety *C. annuum* var. *grossum*, or sweet pepper, but this variety also contains the Hungarian paprika which is somewhat more "hot". After the removal of the seeds, *Capsicum* may be consumed raw in the form of a salad, sliced into small pieces, the entire berries may be stuffed with rice and meat and cooked, or they may be used in composite dishes.

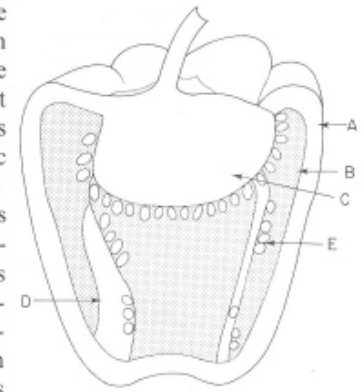
The berries of sweet pepper become red or yellow when ripe; they are indehiscent and many-seeded. The seeds occur on a large, low, free central placenta which is white in colour, as well as on false incomplete white septa. The central placenta at the base and the false septa are removed together with the seeds. The unripe berry consumed as a vegetable usually has a very dark green colour and is almost isodiametrical, slightly elongated, and at its base is partially depressed. In this depression is a disc formed by the calyx.

The first report of cultivation of *Capsicum* dates from the year 1593 in a book published by a Belgian, Charles d'Ecluse. In this book he describes the planting of *Capsicum* in Spain, chiefly in Castilia, but he also mentions its cultivation in Moravia, near Brno, which he observed himself in 1585. *Capsicum*, known in Central Europe by its Hungarian name PAPRIKA (corruption of pepper), became popular in Hungary at the end of the eighteenth century, and the first record is probably that in the gardening book by Josef Csapó published in 1775. It seems that paprika was introduced by the Turks when they were occupying Hungary.

Red pepper or paprika is also known as CHILLI and by the Spanish as PIMIENTO. Spanish pimiento is also used to stuff olives for pickling after the removal of the stone. Powdered capsicum is a spice produced by pulverization of the dried ripe berries, and is described in Chapter VII (Flavourings).



66a. *Capsicum annuum*
Entire berry
A. Disc developed from the calyx



66b. *Capsicum annuum*, L.S. of berry
A. Pericarp
B. Seedbox cavity
C. Free central placenta
D. False incomplete septa (ingrowths of the pericarp in cultivated varieties)
E. Seeds

66. CAPSICUM, SWEET

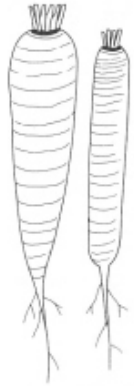
67. CARDOON
(*Cynara cardonum*)
Blanched plant (x0·25)

67. Cardoon

Cardoon or *Cynara cardunculus* (family Compositae) is probably the ancestor of the globe artichoke, *Cynara scolymus* (q.v.). It has a very similar appearance but is cultivated for the midribs of the leaves, and not for the flower buds as is the case with globe artichoke. To obtain a good quality crop, the leaves are normally blanched. Cardoon is native to the Mediterranean region and is appreciated mainly in France.

68. Carrot

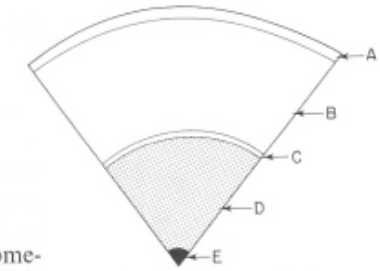
Carrot or *Daucus carota* (family Umbelliferae) is a biennial that was known to the ancient Greeks and Romans but was not introduced into other parts of Europe until the Middle Ages. The wild carrot, classified as var. *carota* to distinguish it from the cultivated carrot, *D. carota* var. *sativa*, is native to Europe, Asia and North Africa. It is very doubtful whether the carrot is also native to America. It appears that it was introduced from Europe early in the seventeenth century (1607 in Virginia), and that it became popular only among the American Indians who spread it over the whole New Continent. Of the few species of *Daucus* perhaps native to America none has any economic importance, and the species *D. bracteata* native to Australia is cultivated only as fodder for sheep. In Europe the carrot is one of the commonest vegetables but in the U.S.A. its consumption only started to any great extent after the First World War, and even today it is far less commonly used there than in Europe.



68a. Two varieties, only taproot shown (x0·25)

68. CARROT (*Daucus carota*)

The edible part of the carrot is its underground fleshy structure consisting mainly of the swollen base of the taproot but also partly derived from the hypocotyl. The swelling is produced by the single vascular cambium, which, apart from cutting off the xylem and phloem, also cuts off a large quantity of parenchyma to either side. The whole swollen structure is normally up to 15 cm long but the root



68b. Quadrant of the tranverse section of the taproot
A. Periderm
B. Parenchymatous sec. phloem
C. Single vascular cambium
D. Parenchymatous sec. xylem
E. Primary xylem

68. CARROT (*Daucus carota*)

continues in a thin form deep into the soil, sometimes reaching a depth of 60 cm or more. Thin lateral branches arise from both parts and these are cut off, together with the unswollen continuation of the taproot, before the carrot is used. The green top, which is not consumed, is usually also cut off and discarded, and the swollen part is generally all that is sold. The carrot "root" contains yellow-red pigments, α- and β-carotene, the precursors of vitamin A. These carotenes are responsible for the colour of the carrot and are present in the plastids.

Carrots are eaten either raw or boiled, and sometimes pickled. Raw carrot is often eaten grated, or sometimes only the juice expressed from it is consumed. Carrot is very often also used as a flavouring for soups and sauces, and because of the large amount of carotenes, carrot may be used as a colouring substance for many kinds of food, e.g. for colouring butter. The carotene content depends mainly on the cultivar, and Red Cored Chantenay appears to be the cultivar richest in carotenes. However, the colour also depends on the age of the carrot and on the temperature. Young carrots, and also those cultivated at a low temperature, are yellowish, while older ones, and those grown at the correct temperature, are orange. The temperature also influences the length of the swelling: increased temperature causes shorter length; but the size as well as the shape of carrots is mainly dependent on the cultivar. The swollen structure of carrot in most cultivars is elongated and tapering, but other cultivars produce either elongated, cylindrical swellings or short, stump-like ones. The elongated carrots are more popular than the stump-like types.

69. Cassava

Cassava is the common name for *Manihot esculenta* (syn. *utilissima*), family Euphorbiaceae; it is native to tropical America but is not known in the wild state. It is a short-lived shrub 1–5 m tall, propagated by stem cuttings, and has been cultivated by American Indians for many thousands of years. It is also known as MANIOC, YUCA and TAPIOCA. Cassava is cultivated for its root tubers, swellings on the adventitious roots, which may be either tapering or cylindrical. The flesh, as well as the cork layers covering the tuber, may be whitish, yellow or reddish. Usually a single plant yields 5–10 tubers which are 15–100 cm long and 3–15 cm thick. The tubers contain a glycoside which yields highly poisonous hydrocyanic acid (HCN), and this is responsible for their bitter taste. This varies in quantity and distribution between two extremes—bitter and sweet tubers. Sweet tubers contain the glycoside only in the phelloderm (the tissue cut off centripetally by the cork cambium) while the bitter types have the cyanogenic glycoside distributed throughout the entire tuber. HCN has to be destroyed from the bitter cassava by various types of processing, such as soaking, boiling or roasting, while sweet cassava tubers may be eaten as a vegetable like potatoes, which they substitute in many tropical countries; but they are also used to prepare a coarse flour called *farinha* in South America and *garri* in West Africa. This is used to make types of bread or cakes, and cassava thus acts as a substitute for cereals in some tropical countries, but its disadvantage is the very small percentage of proteins that it contains.

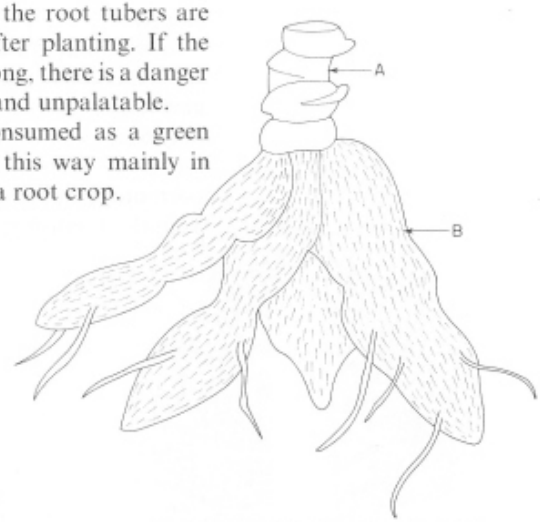
The best known product of the cassava tuber, mainly of the bitter varieties, is tapioca. The diluted cassava meal is boiled, stirred, and then dried on hot plates, or the starch-bearing liquor squeezed out from pulped roots during some South American processing methods may be treated similarly. The starch grains burst and agglutinate into small semi-transparent lumps known as tapioca which are used

in the preparation of puddings, biscuits and confectionery.

Today the largest plantations of cassava are in West Africa rather than in their home, the neotropical countries.

The plant is propagated by stem cuttings 15–20 cm long, and normally the root tubers are ready to harvest 6 months after planting. If the tubers are kept in the soil too long, there is a danger that they will become fibrous and unpalatable.

The leaves may also be consumed as a green vegetable (cassava is used in this way mainly in Africa), but its main use is as a root crop.



69. CASSAVA (*Manihot esculenta*) (x0·125)
A. Stem
B. Root tuber

70. Cauliflower

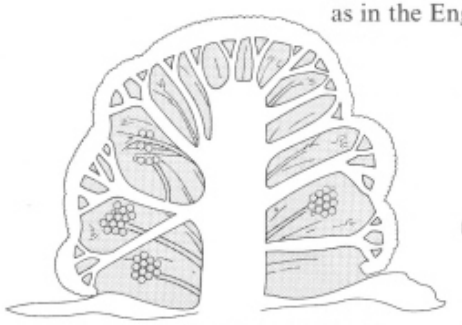
Cauliflower is a variety of *Brassica oleracea* (family Cruciferae), similar to broccoli (q.v.) and called *B. o.* var. *botrytis*. It was introduced into Britain in the seventeenth century from Cyprus, but it appears to be native to Asia Minor. However, cauliflower was already known in Europe in the sixteenth century, as is proved by its oldest known description in a book by the Dutch botanist Dodoeus published in 1559.

Its edible part is the solid head formed by its racemose inflorescence on a shortened central stem. The inflorescence is degenerate and consists of fleshy flowers and stalks, both usually white or whitish in colour. The brilliant whiteness of the inflorescence is often achieved by blanching—by tying the large green leaves over it to exclude light. In the U.S.A., heading broccoli is classified as

cauliflower, and this tends to muddle the terminology.

Cauliflower, used as a vegetable, is usually boiled and eaten with various sauces or cooked *au gratin*, or it may be fried and covered with breadcrumbs. It is also used for soups, and is often pickled in vinegar.

Cauliflower grows best in cool and moist parts of the temperate regions. Large, white heads are generally required, and a large head of cauliflower may exceed 20 cm in diameter. It is propagated by means of seeds, and is now one of the most important vegetables in all European countries as well as in the English-speaking countries overseas.



70b. L.S. of the inflorescence (x0·33)

70a. Entire fleshy inflorescence, leaves of the rosette cut away in the front (x0·25)

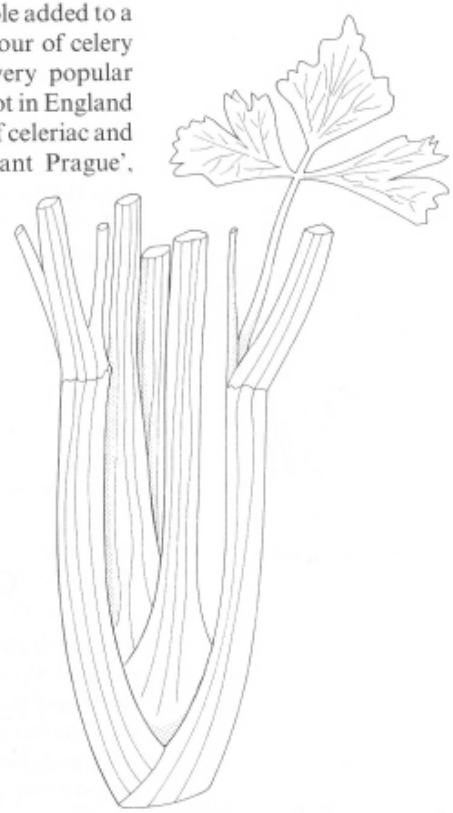
70. CAULIFLOWER
(*Brassica oleracea* var. *botrytis*)

71. CELERIAC (*Apium graveolens* var. *rapaceum*) (x0·25)
Underground structure

71. Celeriac

Celeriac is a variety of *Apium graveolens* (family Umbelliferae), a biennial up to 1 m tall, native to marshy areas of the temperate regions of Eurasia, South Africa, South America and New Zealand. It is known botanically as *A. graveolens* var. *rapaceum*. This variety yields a large, roundish turnip-like swelling, about 10 cm across, mainly derived from the hypocotyl but also incorporating part of

the taproot and stem. The swollen structure, which has whitish flesh, is consumed boiled, usually in the form of a salad or as a separate vegetable added to a main dish. Celeriac has the typical odour of celery (q.v.) due to a volatile oil. It is a very popular vegetable in Continental Europe but not in England or the U.S.A. There are few cultivars of celeriac and the most important of these are 'Giant Prague', 'Apple' and 'Early Paris'.



72. CELERY (*Apium graveolens*)
Petioles (x0·25)

72. Celery

Celery is another variety of *Apium graveolens*, but is cultivated for the etiolated leaf stalks rather than for the underground swelling as is the case for the variety *rapaceum*. The botanical name is *A. graveolens* var. *dulce* (family Umbelliferae). Celery was first recorded as a food plant in France in 1623 and it seems that it was developed there or in Italy. The edible parts are its young, swollen leaf stalks (petioles) which are normally blanched by covering with paper, boards or soil. The use of soil for blanching is the most economical method and it also serves to protect the plant from injury by

frost. Blanching improves the taste of celery as well as its nutritional value, as it contains more vitamin A in the etiolated stalks than in the green ones. Celery, which has the same odour as celeriac, is consumed raw as a salad vegetable, or boiled, or a soup may be prepared from it. It is grown from seed, the seedling normally being raised in outdoor seed beds and the young plant later transplanted into the fields. Celery is popular mainly in Britain and other English-speaking countries, and the largest producer is the U.S.A.

73a. SPINACH BEET (x0·1)

73. Chard, Swiss

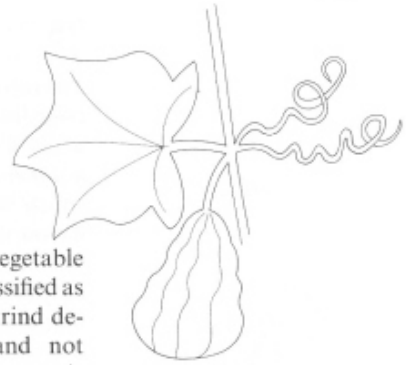
The name chard is sometimes given to the blanched summer shoots of globe artichoke (40) and also to the young flowering shoots of salsify (108), but true chard is Swiss chard or SEAKALE BEET. It is a variety of cultivated beet known as *Beta vulgaris* var. *cicla* (family Chenopodiaceae). It is a foliage beet, i.e. it is cultivated for its leaves rather than its "roots". The green leaf blades are used like spinach while the stout fleshy white petioles and midribs are eaten like asparagus. SPINACH BEET is another foliage beet closely related to Swiss chard; this is a form of *B. v.* var. *cicla* with long green petioles that are used together with the leaf lamina like spinach.

73b. CHARD (x0·125)

73. CHARD
(*Beta vulgaris* var. *cicla*)

74. Chayote

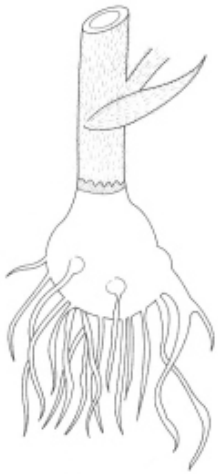
Chayote, or CHOYOTE, is a member of the family Cucurbitaceae called *Sechium edule*. It is a robust perennial monoecious climber, up to 12 m long,



74. CHAYOTE (*Sechium edule*)
Twig with fruit (x0·25)

producing fruits that are consumed as a vegetable in the same way as pumpkins. Its fruit is classified as a pepo, a berry-like structure with a hard rind developing from the torus (receptacle) and not separable from the rest of the fruit. Chayote is indigenous to Mexico and Central America, and both its fruits and large root tubers were common vegetables of the Aztecs, Mayas and other American Indians long before the Europeans discovered America. The fruit is either pyriform (pear-like) or almost spherical and its surface ranges in colour from dark green to ivory. The surface is smooth in the spherical type while the pyriform fruit is deeply furrowed. The pepo is one-seeded and the flat seed is 3–5 cm long. The entire fruit may weigh up to 1 kg and its flesh is edible after boiling, baking or roasting. The root tubers, also, must be boiled, baked or roasted before consumption; they weigh up to 10 kg and taste similar to yams. Apart from the fruits and root tubers, the young leaves may be used like spinach, while the young shoots are sometimes used as a substitute for asparagus.

The quality of chayote fruits varies according to the presence or absence of fibres. Some are without fibres while in others the seedcoat is pronounced and the fibres radiate from it into the flesh. In subtropical regions the fruit of chayote is more widely used than the root tubers, but in tropical regions the root tubers are more important. Chayote is still an important vegetable in the American tropics and the West Indies and is also cultivated in many tropical parts of other continents. It is now grown in the southern parts of the U.S.A., in California and in the Gulf Coast states, where it has now achieved some economic importance.



75. CHERVIL, TURNIP ROOTED (*Chaerophyllum bulbosum*) Tap root with part of the stem (x0·5)

75. Chervil, Turnip-rooted

The turnip-rooted chervil is a member of the family Umbelliferae and its botanical name is *Chaerophyllum bulbosum*. It is not to be confused with another umbelliferous plant, *Anthriscus cerefolium*, which is called merely chervil and is used as a flavouring like parsley. Turnip-rooted chervil is a biennial, native to Eurasia and cultivated today only on a small scale, mainly in Europe. It is almost unknown in America. The edible part is its carrot-like subterranean swelling derived mainly from the swollen base of the taproot. It is smaller and shorter than the carrot and has a dark grey colour, but its flesh is yellowish-white. It is normally boiled and has a pleasant sweetish taste.

76. Chicory

76. CHICORY (*Cichorium intybus*) Blanched leaves (x0·5)

Chicory is the common name of a species of the genus *Cichorium*, *C. intybus* (family Compositae). It is a perennial plant native to Europe and adjacent parts of Asia, but it was not recorded as a vegetable until the thirteenth century. Much later, when coffee drinking spread across Europe, chicory began to be cultivated more for its taproot which was roasted and ground, and used as a substitute or adulterant for coffee. The large fields of blue flowering chicory, about 1 m tall, disappeared after the end of the Second World War with the rise of the affluent society. As a vegetable, chicory is also known as FRENCH ENDIVE, but endive is itself the correct common name for another species of *Cichorium*, *C. endivia* (83).

Chicory is propagated from roots which are raised beforehand from seed. The harvested roots are stored and may be planted at any time from autumn to spring; they are set in the soil so that the crown of the taproot is level with the surface or slightly below it. The crowns are then topped with fine soil, sand or sawdust up to 20 cm to blanch the leaves and prevent them from spreading.

Blanching reduces the bitter taste of the leaves and by preventing the leaves from spreading compact heads are formed. If the roots are planted outdoors, the soil, sand or sawdust is further covered with horse manure, bringing the crown to a depth of 60 cm. The manure generates heat and protects the developing plant from frost. Chicory is harvested when the head starts to emerge and its tip shows through the top covering. The head, formed from the closed rosette of leaves, is oblong and whitish apart from the light green tips of the leaves and resembles cos lettuce in shape.

77. Cress, Garden

77. CRESS (*Lepidium sativum*) Seedling (x0·5)

Cress, or garden cress, is an annual herb with a pungent taste known botanically as *Lepidium sativum* (family Cruciferae). It is native to Europe, or perhaps to western Asia. Its leaves may be picked continuously if the crown is not damaged, and they are used for salads and garnishing. However, in Britain, garden cress is mainly used in the form of seedlings, sold usually together with white mustard seedlings ("mustard and cress"—see 118). The seedlings are sold at the cotyledonous stage and consist of roots, hypocotyl and two deeply three-lobed green cotyledons. The seedlings are cut near to the root and used for salads, and are often put into sandwiches.

A similar plant to garden cress is another member of the Cruciferae, commonly called SPRING (also WINTER or LAND) CRESS. Its botanical name is *Barbarea verna* and it is used for salads.

78. Cress, Water-

Watercress or *Nasturtium officinale* (family Cruciferae) is a perennial aquatic plant native to Europe and western Asia. It was formerly used as a medicinal plant and was mentioned in the "Herball" by John Gerarde published in 1597; he recommended

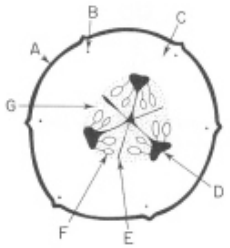
78. WATER CRESS, cultivated variety (*Nasturtium officinale*) (x0·5)

that watercress was eaten in broth to heal "the greensickness of maidens". Later, watercress was gathered as a wild food plant, and in the nineteenth century the first attempts were made to cultivate it. The edible parts are the leaves and adjoining parts of the stem and the pungent taste, as in other Cruciferae, is due to a glycoside, nasturtin, which yields the so-called mustard oil. Watercress is consumed raw as a salad vegetable, or it is used as a condiment, e.g. in soups; or it may be used as a mere garnish to decorate a dish.

The name watercress is also given to a hybrid between *N. officinale* and a wild species, *N. microphyllum* or one-rowed watercress. This hybrid type of watercress has smaller leaves.

79. Cucumber

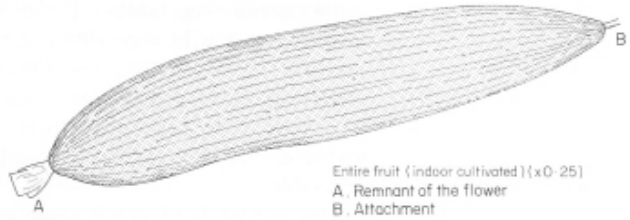
79. CUCUMBER (*Cucumis sativa*)



T. S. of fruit (x0·5)
A. Rind not separable derived from receptacle and epicarp
B. Vascular bundles
C. Mesocarp and endocarp
D. Placenta arising from the centre (axil)
E. Carpellary borders
F. Seed
G. Dotted area – placental tissue

Cucumber, *Cucumis sativa* (family Cucurbitaceae), is a trailing or climbing plant producing an edible fruit distinguished as a pepo. It is believed to be native to southern Asia or Africa and has been cultivated there for 4000 years. Cucumber was known to the ancient Egyptians, Greeks and Romans and they are mentioned by Pliny. Before the Christian era (between 140 and 86 B.C.) they were introduced to China, but they did not reach France until the ninth century A.D. and only became common in England in the fourteenth century.

The fruit is dark green and elongated. There are many cultivars which may be grouped horticulturally either according to their use or to the way in which they are cultivated. There are both outdoor and greenhouse cultivars; the outdoor ones, grown in fields, are shorter than those grown under glass, which are normally 30–40 cm long and are produced parthenogenetically because if pollinated they develop an unpalatable, bitter fruit. The



Entire fruit (indoor cultivated) (x0·25)
A. Remnant of the flower
B. Attachment

79. CUCUMBER (*Cucumis sativa*)

outdoor cultivars are ridged, with prickles, while indoor ones are not ridged and are almost smooth. The other kind of grouping, according to their use, is familiar in the U.S.A. and divides the cultivars into slicing and pickling types, although some slicing cultivars may also be used for pickling. Among exotic cucumbers, some have a yellow or brownish-red rind, e.g. the Japanese KAGA and the Indian SIKKIM. Another curious cultivar is the apple cucumber which is rounded in shape.

Cucumbers are today cultivated all over the world, either outdoors or indoors according to the climate. Usually they are used raw and sliced (peeled or unpeeled) for salads, or pickled. In some countries they are also consumed boiled or stewed and a sauce may be prepared from them. The popular small, pickled, cucumber-like fruits called GHERKINS are derived from another species, *C. anguria*, native to the West Indies. They are usually pickled but in the West Indies they are also cooked. Most of the gherkins sold nowadays are not in fact true gherkins but small cucumbers of special pickling cultivars. Large quick-pickled cucumbers flavoured with dill (244) are popular in Germany and Eastern Europe.

80. Dandelion

Dandelion, or *Taraxacum officinale* (family Compositae) is a perennial, native to the temperate zones of all continents. However, most of the *Taraxacum* species are indigenous to Eurasia and only two are native to America. The young leaves, which appear in rosettes, are often eaten raw as a salad vegetable or may be boiled like spinach and

80. DANDELION (*Taraxacum officinale*)

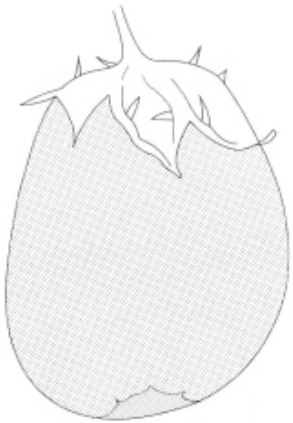
80a. Single leaf (x0·5)

80b. Entire plant (x0·05)

other green vegetables. Dandelion is mainly gathered as a wild vegetable and is rarely sold in markets. However, they are cultivated on a small scale, mainly in greenhouses, and some cultivars have even been developed. In emergencies, as in wartime, dandelion has become a common vegetable.

The root of dandelion is sometimes ground and roasted and used as a substitute for coffee; and the inflorescence (capitulum) is used for flavouring and colouring dandelion wine.

81. Egg-plant



81. EGG-PLANT or AUBERGINE (*Solanum melongena* var. *esculenta*) (x0·5)

Egg-plant is the common name of *Solanum melongena* var. *esculenta*, a member of the family Solanaceae. Its French name, AUBERGINE, is also used in English. It is a perennial plant with a spreading or erect stem, up to 150 cm tall, and is probably native to India. Some authors believe that a description of European origin dating from the fifth century A.D. refers to the egg-plant, but the ancient nations of the Mediterranean region hardly knew this vegetable.

The edible part is the fruit, which is a berry, usually egg-shaped with a smooth and shiny surface, deep purple in colour, and usually 10–20 cm long by 5–8 cm wide. Some cultivars belonging to the variety *S. melongena* var. *serpentinum* may be extremely long, slender and snake-like; other cultivars are oblong, sausage-shaped, dwarf, etc. The colour also varies and some cultivars are whitish, yellow or black with 5–7 lobes. The large green calyx at the base of the berry is persistent. In the flesh of the fruit are imbedded numerous seeds which are small, and brown in colour.

The fruits are eaten boiled, fried or stuffed and baked. It seems likely that the egg-plant was introduced from India by Arabs into Spain and Africa, and today it is cultivated in almost all tropical and subtropical regions and also in warmer temperate regions, e.g. southern Europe and the southern states of the U.S.A. Egg-plant is most important in India and the Far East.

82. Elder

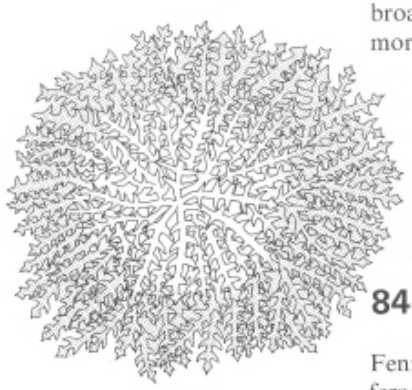
Elder, *Sambucus nigra* (family Caprifoliaceae), is a deciduous shrub or small tree 3–10 m high and native to Europe, western Asia and Asia Minor. It produces umbel-like inflorescences, flat-topped cymes composed of many tiny white flowers. The fruits are small black drupes, giving it the specific name *nigra* and in Germany the common name *schwarzer Flieder* meaning black lilac. In Britain the juice is expressed from the drupes and used for soft drinks or for preparation of a wine, and the inflorescences are also used in wine-making. In Central Europe (Germany, Austria, Bohemia, etc.) the inflorescence is often eaten, wrapped in a thin layer of dough and fried in lard or butter like a slice of meat. (Similar fritters are made in the South of France from the inflorescences of *Acacia* (wattle) trees, wrongly called *Mimosa*.)

82. ELDER (*Sambucus nigra*) Inflorescence (x0·33)

83. Endive

Endive, like chicory (76) belongs to the genus *Cichorium* (family Compositae), but it is the species *C. endivia*. The edible structure is the rosette of leaves. As a salad vegetable or pot herb it was used by the ancient Egyptians, Greeks and Romans and it seems to be native to India. Endive is an annual or biennial plant which today is distributed all over the world, but it needs a rich and well drained soil. In England it thrives best in Cornwall, where it is not threatened by frost. Like chicory, endive has a bitter taste and for this reason it is often blanched by covering it with boxes. There are two types of endive: one kind develops narrow curled leaves,

while the other kind which is called ESCAROLE has broad leaves. The type with curled leaves is the more popular.



83. ENDIVE (*Cichorium endivia*) (x0·25)
Rosette of curled leaves

84. Fennel

Fennel or *Foeniculum vulgare* (family Umbelliferae) is a well known flavouring, but its variety *F. vulgare* var. *dulce* is used for the swollen bases of the petioles. These fleshy bases are normally blanched and consumed raw as a salad. It seems that this variety of fennel was developed in Italy, and this is indicated in its frequently used English name, Florence fennel. (Its Italian name is FINNOCHIO DOLCE.)

The thick broad bases of the leaf stalks form a structure similar to a bulb, and as well as being used raw they may also be cooked. Florence fennel has a taste similar to that of celery. Although it is eaten mainly in Italy and France it has also become popular in Britain.

84. FENNEL (*Foeniculum vulgare*) (x0·35)

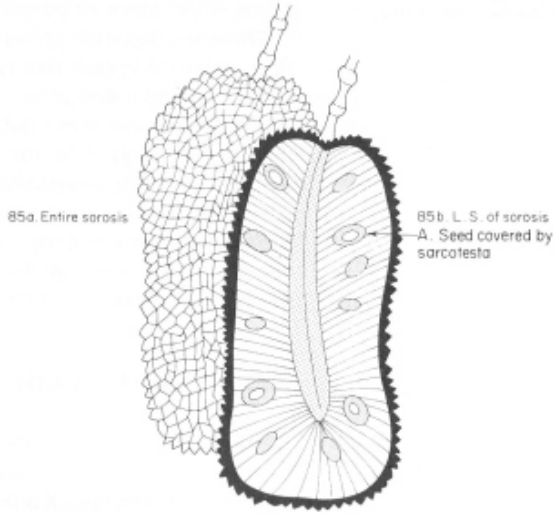
85. Jack-fruit

Jack-fruit (also JAK-FRUIT) or *Artocarpus heterophyllus* (syn. *A. integrifolia* or *A. integra*) belongs to the same family (Moraceae) and the same genus as breadfruit. It is a handsome evergreen monoecious tree, reaching up to 20 m in height, and is probably native to India, where it has been cultivated from time immemorial. It is now grown in all tropical countries but is of economic importance only in tropical Asia, mainly in India and Ceylon.

It has a compound fruit, a sorosis, developed

from the entire female inflorescence, which is a spike as in the breadfruit but differs from it conspicuously in size and shape. The jack-fruit is usually a pear- or barrel-shaped structure reaching an enormous size—it may be 90 cm long and 50 cm thick. It attains a weight of up to 20 kg and some authors even claim that fruits of twice that weight have been recorded. Whether or not these claims are true, jack-fruit is certainly one of the largest cultivated fruits. Its surface is covered with fleshy hexagonal spines; it is dark green in colour when unripe and becomes brown when mature. As in the breadfruit, the edible part is the pulp which develops from the fleshy perianths and receptacles of the female inflorescence. But the jack-fruit always consists of many large fruits, achenes covered with gelatinous perianths, distinct from the surrounding perianths of the abortive flowers.

The unripe fruit is used as a vegetable, either boiled or roasted, and when ripe it is used as a dessert fruit. The seeds, also, are edible if boiled or roasted.



85. JACK-FRUIT (*Artocarpus heterophyllus*) 30–90 cm long, 25–50 cm wide, weight up to 20 kg