A COMPENDIUM OF FOOD-MICROSCOPY

E. G. CLAYTON

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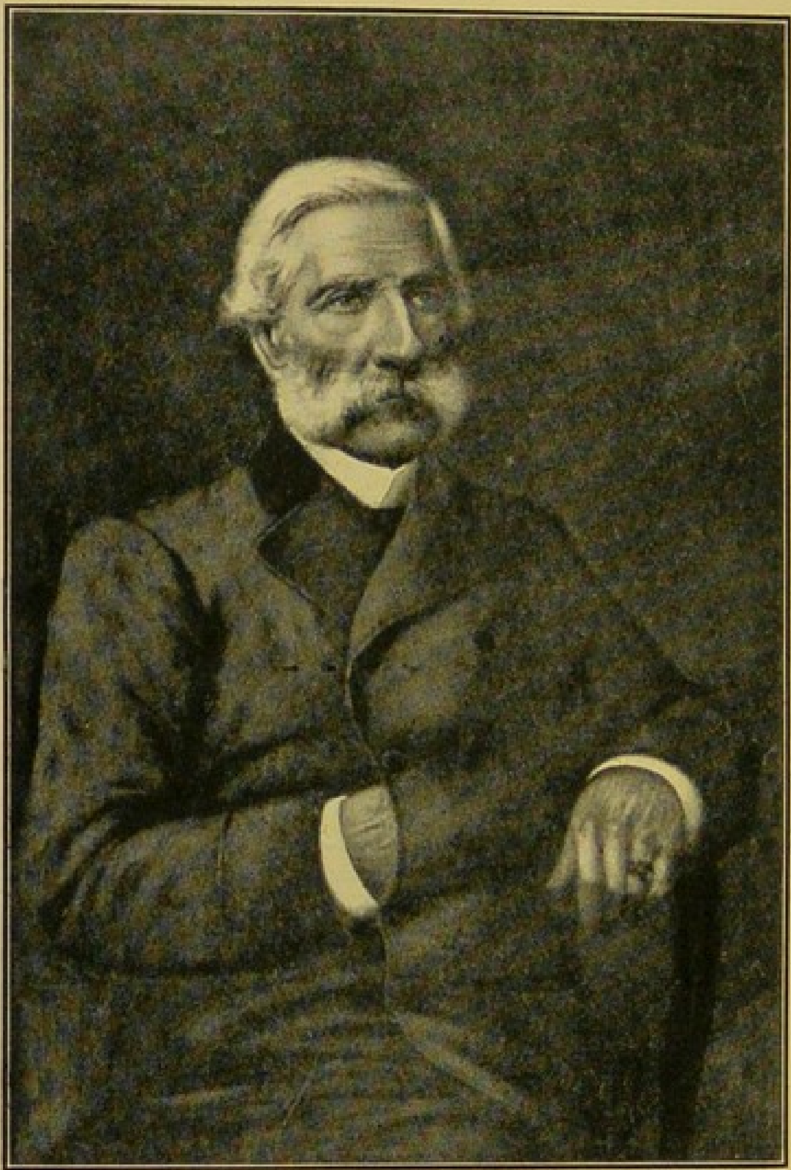

DR. ARTHUR HILL HASSALL

AUTHOR OF "FOOD: ITS ADULTERATIONS AND THE METHODS FOR THEIR DETECTION"; AND OTHER WORKS

From the Picture, by Signor Italo Sabatini, in the Board Room at the Offices of the Royal National Hospital for Consumption and Diseases of the Chest.

Photograph by Messrs. Clark and Mann, 6, York Buildings, Duke Street, Strand.

A COMPENDIUM OF
FOOD-MICROSCOPY

WITH SECTIONS ON DRUGS, WATER,
AND TOBACCO

COMPILED, WITH ADDITIONS AND REVISION, FROM THE
LATE DR. A. H. HASSALL'S WORKS ON FOOD

BY

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MENS · SANA · IN · CORPORE · SANO

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1909

TO THE MEMORY OF

ARTHUR HILL HASSALL, M.D., M.R.C.P.,

PIONEER IN PUBLIC HYGIENE,

IS DEDICATED

THIS BOOK,

WHICH OWES ITS BEING TO HIS

UNTIRING LABOURS.

PREFACE

Thirty-two years have passed away since the appearance of 'Food: Its Adulterations and the Methods for their Detection.' At the suggestion of the Author of that work, it was the present writer's intention, hitherto frustrated, long ago to publish a new edition. The late Dr. A. H. Hassall had discussed with the undersigned the plan of the fresh work, when his death occurred in 1894. Many matters, coupled with a knowledge of the existence of several then recently-dated textbooks, dealing with food analysis generally, and of a cluster of handbooks on separate branches of the subject, led to a postponement of the project. The writer now at length issues his long-contemplated revision of the microscopical portions of Dr. Hassall's works; and, a considerable period having elapsed since the production by other English chemists of any new general treatises on hygienic or public analysis, he hopes at no distant date to supplement this volume by another, devoted mainly to chemical, physical, and bacteriological methods of investigation, which in his own or other laboratories have been found practicable and trustworthy. Thus will be accomplished a design which for several years the Author has had in his mind.

The present volume represents but a fractional part of the work of one who 'was truly the father of public analysis'; who taught public analysts 'most of their knowledge of the microscopic structure of food substances'; who was 'The Apostle of Anti-Adulteration'; and 'left his mark beneficially on a number of divisions of natural science, although he had to work under conditions of poverty and ill-health which would have proved an effectual bar to persons less energetic and mentally less active.'[1]

The writer's simultaneously published memoir[2] epitomizes the initiation of effectual legislative and other action in this country against the supply of impure water and the adulteration of food and drugs; and plainly shows the profound influence of the late Dr. Hassall's inquiries and efforts, in bringing about the sanitary legislation so pressingly needed at the period of his greatest activity. But for his strenuous life, the systematic hygienic analysis of food, water, and drugs would scarcely yet have been organized; nor would it have become in a few decades what now undoubtedly it is—an autonomous science of State-Chemistry, with an ever-widening scope, and a constantly growing importance to the Empire.

Those parts of Dr. Hassall's text, included in the following pages, have been revised and re-arranged so far as appeared to be necessary. The amount of revision, of course, was very great: nevertheless the original descriptions have been altered as little as possible. They are plainly worded, and free from the superabundance of botanical detail, and elaborate subdivision, which characterize some of the later books on the same subject. This lucidity of treatment is one of the best features of Dr. Hassall's work. Great elaboration and minuteness of description, however admirable from the purely scientific point of view, can be carried to such an extent as to be a hindrance to a practical worker, whose main desire, probably, is no more ambitious than to examine ground ginger for added barley-meal, or cacao powder for maize-starch.

Additional matter is scattered through the book. The original text in many places has been recast and considerably amplified; as in the pages devoted to the parasitic diseases of grains, to mildews and moulds, arrowroots, cocoa, saccharine substances, mustard, annatto and hops.

[1] Obituaries in the *Analyst* and the *Medical Press*, 1894.

[2] 'Arthur Hill Hassall, Physician and Sanitary Reformer: A Short History of his Work in Public Hygiene, and of the Movement against the Adulteration of Food and Drugs.' Messrs. Baillière, Tindall and Cox, 1908.

The sub-sections on proprietary wheaten foods; nut foods; fruit preserves and jellies, including an account of the distinguishing microscopical features of fruits; pickles, sauces, and preserved vegetables; flesh; animal parasites; fish; milk; butter; cheese, and lard, are either quite new, or they have been almost entirely re-written. Nearly the whole of Section II. (Foods derived from Animal Sources), apart from certain of the figures, is fresh matter. This applies also to Section IV. (Water).

In Germany especially, during the past twenty years, various important treatises have appeared, dealing with the microscopical investigation of food. These, and numerous other authorities, British and foreign, have been consulted during the preparation of the present volume. Particular mention may here be made of the works by Meyer, König, Blyth, Bell, Macé, Hager-Mez, Allen, Hanausek, von Vogl, Angell, Moeller, Winton, Tschirch and Oersterle, Villiers and Collin, Planchon and Collin, Greenish, Galt, and W. Griffiths. In the chronological bibliography on pp. 399-406 are cited these and many more authorities, some of which are indispensable to the ardent student of applied microscopy.

The Author has essayed further simplification by adopting, so far as he could, an atlas-arrangement; with, wherever possible, all the figures of each foodstuff or drug, together, on a few successive pages, and, generally facing or beneath them, the descriptions. This system was not followed in the late Dr. Hassall's works, and to the best of the writer's knowledge, has not been consistently adopted in any book in English, covering the same ground.

The glossary on pp. 393-398 may be useful for reference, in view of the numerous botanical terms unavoidably used in the body of the work.

Included in the volume are nearly all the original figures —still without many serious rivals in other books of the kind published in the United Kingdom. This, at least, is the view of the present writer, who believes himself to be acquainted with all the more important general and specialized similar treatises, British and continental, which in latter days have appeared. The indistinct, and, for practical ends, often useless results of photo-micrography—though, peradventure, artistically attractive—and the somewhat fanciful or diagrammatic representations, to be met with in some of these works, have strengthened his opinion, that no other pictures have been issued, of the same class of objects, better than, if, indeed, equally serviceable with, the illustrations now reproduced. The Author has, moreover, been convinced by twenty-seven years' travail as a microscopist and analyst, and by knowledge gained while for nearly eight years he filled, however imperfectly, the difficult and thankless office of public analyst for a London district of a hundred thousand inhabitants, that few other representations of the minute structures of food-materials are, for usefulness to the labourer in this particular field, comparable with careful drawings made by the aid of the camera lucida.

Many fresh illustrations will be found in the present volume. The Author is greatly indebted to Miss Faith Clayton for the careful drawings reproduced in Figs. 198, 201, and 202 (*Cysticercus cellulosæ*, *Tænia echinococcus*, and *Trichina spiralis*). He is himself responsible for forty-four sketches—prepared in many instances from the objects themselves, and, for the rest, drawn after, or to some extent inspired by, figures in the works of Leuckart, Landois, Schäfer, and others.

It must be ascribed to the late Dr. Hassall's insistence on the importance of the microscope in analysis, that the Local Government Board made proficiency in the use of that instrument a requisite qualification for persons desiring to become public analysts; and the Institute of Chemistry during recent years has recognized this necessity by including microscopical analysis in its examinations.

Dr. Hassall's exposures of adulteration, and advocacy of sanitary reform, by no means constitute his only claims to the respect and gratitude of his fellow-countrymen. Another great public service which he rendered was the foundation, and establishment on a secure basis, of the Royal National Hospital for Consumption and Diseases of the Chest, at Ventnor, Isle of Wight. To this work Dr. Hassall devoted more than ten years of his life; and it alone, had he accomplished nothing else, would be a sufficient and enduring monument.

In 1862 Dr. Hassall proposed a Petroleum Standard. In his Report on Paraffin Oil (the *Lancet*, 1862), he conferred a national benefit, by showing that much of the oil then sold in the metropolis was in a condition dangerous to the public, and by urging the adoption of a 'standard of safety' with regard to the ignition-temperature of the vapour emitted by the oil put upon the market. He strongly advocated the production of a guarantee by wholesale firms that the temperature of inflammation of the oil vended by them was not less than 130° F. This 'standard of safety,' suggested by Dr. Hassall, was for a considerable period widely recognized,[1] and was actually adopted by some official bodies, as, for example, the Town Council of Edinburgh: but eventually the Government Authorities saw fit to adopt a lower official standard, 100° F.; and, since 1879, a temperature alleged to be its equivalent, namely, 73° F., which is still in use. At all events, it may be traced very largely to Hassall's urgent representations, and repeated communications to the press, that a minimum flash-point is now obligatory.

With considerable advantage to the public, a strongly critical position was adopted by Dr. Hassall regarding the exaggerated notions which prevailed at one time as to the supposed high nutritive value of 'Extract of Meat.' In some particularly interesting correspondence on the subject of Extract of Beef, carried on in the *Lancet* of 1865 by Dr. Hassall and others, and in the *Times* of 1872, Baron Justus von Liebig himself took a somewhat querulous part; finally retiring from the fray, not the victor.

[1] 'The Sanitary Commission of the *Lancet* took as the limit of safety an oil that gave off inflammable vapour when heated to 130 degrees of Fahrenheit's thermometer, and this has been generally accepted by dealers.'—Mr. James Young, of Bathgate (letter to the *Times*, dated February 2, 1864).

'. . . the standard of safety originated by Dr. Hassall . . . nevertheless, it has been widely recognized. . . .'—Dr. Benjamin H. Paul (letter to the *Standard*, February 18, 1864).

Lastly, it is largely a consequence of Dr. Hassall's researches that students of pharmacy now receive systematic training in the use of the microscope for the determination of the quality and nature of powdered drugs. In this work he was a pioneer, more than fifty years ago. In fact, he was in advance of his time in pointing out the advantage of microscopically testing drugs, as to their identity and purity; a method of investigation which only latterly has begun to be recognized, by the General Medical Council and the Pharmaceutical Society, as in many cases of greater use than chemical operations, such as ascertaining the amount of mineral matter, and the like.

For permission to include a reproduction of the fine picture of the late Dr. Hassall, now in the Board Room of the Royal National Hospital for Consumption and Diseases of the Chest, the Author expresses his grateful acknowledgments to the Chairman and Board of Management of that Institution. He is much indebted also to Colonel Sir E. W. D. Ward, K.C.B., K.C.V.O., Secretary of the War Office, and Permanent Under-Secretary of State for War, for interesting particulars relating to the statistics of recruiting: to Mr. Ernest Morgan, Secretary of the Ventnor Hospital, and to Mr. Cuthbert E. A. Clayton, Librarian to the Manchester Medical Society and the Medical Faculty of the University of Manchester, for information on a number of points; to Madame J. Nicolas Philipp, for many valuable and helpful suggestions; and to Mrs. E. G. Clayton, for assistance kindly rendered at several stages of the work.

It is hoped that this book may be of use to medical men, analysts, and others interested in that important branch of Public Health work which is concerned with the purity of food, drink, and medicines.

E. G. CLAYTON.

LABORATORIES,
23, HOLBORN VIADUCT,
LONDON, E.C.,
December, 1908.

'De cibis & potu, qui naturalem humiditatem, quae quotidiè abſumitur, convenientiùs restaurent.

'Cibi & potus, qui convenientius naturalem humiditatem indies reſolutam 'reſtituunt, ſunt multi, eaq̃ue reſtauratio varia eſt, ſecundum complexionum 'varietatem & ſecundum ipſa Euchymia, vt Plinius ait, maxime q̃ue poſt 'tẽpus cõſiſtẽdi.'—'Of Meats and Drink, which do more agreeably restore 'the Natural Moisture, that daily is consumed. Meats and Drink, which 'more agreeably restore the Natural Moisture, which is daily wasted, are 'many: And this Restauration is various, according to the variety of Consti- 'tutions, and according to the goodness of Juices in Meats and Drinks, as 'Pliny saith, and especially after the time of full Growth.'—ROGER BACON, philosopher and Franciscan friar [1214(?)—1294]: *Libellus . . . De retardandis Senectutis accidentibus, & de Sensibus conservandis*, cap. vii., translated by Richard Browne, 1683.

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A SUMMARY OF THE LIFE-WORK OF DR. A. H. HASSALL.

On December 13, 1817, nine years short of a century ago, Arthur Hill Hassall was born at Teddington, Middlesex. His father, Thomas Hassall, and other members of the family were medical men. At that distant period men spoke of Waterloo as an affair of yesterday: the victor of Austerlitz was once for all in exile: romances from a Scottish pen in fast succession were delighting the reading world: Londoners quite recently had learnt from Frederick Winsor that coal-gas gave a better light than oil; and George Stephenson's locomotive steam-engine had still to reach its full development. To travel by road from Edinburgh to London occupied four days. To sail from the Liffey to the Thames took longer than now does a passage to New York. The usual aftermath of war was coming in. Poverty was rife; hunger and discontent were stark in the land. Excited meetings and disturbances were increasingly frequent, until at Manchester, twenty months later, they ended in 'Peterloo,' bitter memories of which remain to this day. The latter part of the eighteenth and the first quarter of the nineteenth century were marked by international strife, political upheaval, and suffering among the toilers. Cobbett, Burdett, and 'Orator' Hunt in 1817 were agitating for Parliamentary reform. Agricultural depression was extreme, and commercial probity was at its nadir. For threescore years the food of the people had been poor and dear. Contemptible and gross adulterations of all conceivable kinds were everywhere the rule. The dough of bread was mingled with alum, carbonate of lime, bone ash, potatoes, and beans. By eking out his sugar with gypsum, chalk, and pipe-clay, the sweetmeat-maker derived unholy gains; and the pigments used contained lead, chromium, mercury, copper, sometimes even arsenic. The unwholesome hues of preserved green fruits and vegetables were due to boiling in copper vessels, or to the addition of cupreous salts.[1] Cayenne pepper and curry powder were beautified by the scarlet oxide of lead. Vinegar was fortified with sulphuric acid. Canistered fish were tinted red by ferruginous earths. Tea was weighted, dyed, and 'faced' by a variety of mineral substances. Coffee was shamelessly adulterated, almost to the extent of its own effacement, with roots, grains, pease, beans, and still more worthless surrogates. Products used to falsify, as chicory, were themselves sophisticated. Drugs were mixed with inert matters, or replaced by commodities of inferior quality. Tobacco was blended with the leaves of herbs and weeds, some of which are described hereafter. The water supplied to the Metropolis carried solid and liquid filth from the sewers, reeked of odorous abominations, and teemed with offensive forms of plant and animal life. And so on; and so on.

The only machinery to cope with the adulteration of drugs and food was that of the Excise: but the Executive were appointed to protect the revenue, not the public: their supervision was exercised over a comparatively limited range of products; and even of these they were incompetent to discover some of the grosser adulterations. This state of affairs lasted, with little, if any, improvement, until the thirteenth year of Queen Victoria's reign; and so late as 1850 the Chancellor of the Exchequer, Sir Charles Wood, could announce from his place in Parliament that 'neither by chemical nor by any other mode could it be ascertained with any degree of certainty whether a mixture contained chicory or not.'

But at last the man had arrived who was to change all this, and give life to these dry bones. It was reserved for

[1] Of late years this abominable practice has in some quarters been resuscitated. The quantities of copper added are fractional as compared with those used in former days, and *may* be harmless: but the custom would be 'more honoured in the breach than the observance.'

Arthur Hill Hassall, a keen observer, a good naturalist, an able microscopist, and professionally trained in physic, to enter upon active life bent on a crusade against abuses of the kind and extent which have faintly been indicated. After calling public attention to the insanitary condition of certain western districts of London, he (1850) vigorously attacked the water-supply of the Metropolis as a whole. His writings and oral evidence on this subject lent a powerful impetus to the movement for remedial legislation (*vide* Section IV., pp. 346, 347). A little later, occupied, at the instance of the General Board of Health, in researches connected with the cholera epidemic of 1854, Dr. Hassall was the first observer to record the presence, in enormous numbers, of 'vibriones' (bacilli) in the rice-water discharges of cholera patients: so that it has been justly claimed for him that he nearly anticipated Dr. Koch in the discovery of the cause of that disease.

In 1850, the Chancellor of the Exchequer's statement, already quoted, had impelled Hassall to examine samples of the coffee sold in London; and a paper on the subject, which he read before the Botanical Society of London, led to communications between the editor of the *Lancet* and himself, as a result of which, during the years 1851, 1852, 1853, and 1854, he contributed to that journal a series of reports (known as the 'Reports of the *Lancet* Analytical Sanitary Commission') on the composition of the food, drugs, and beverages then sold in the London shops. These papers, which embodied the results of thousands of analyses, marked an epoch in the annals of public hygiene in Great Britain, and attracted an immense amount of attention in every part of the country. Even on the Continent interest was aroused. The work demanded great skill and accuracy, and as the names of the vendors were published, whether the commodities were good or bad, the matter obviously was delicate and responsible. In his investigations Dr. Hassall used all the scientific methods that were at the time available, chemical and other, for detecting the falsifications which had been practised: but a leading feature of the scheme was the prominence given to the use of the microscope, an instrument previously almost entirely neglected as a means of systematically examining, for extraneous ingredients, foodstuffs and medicaments. Hassall taught his confrères, medical and chemical, the principal microscopic characteristics of foods, and how the knowledge could be applied in the detection of admixtures. An agitation sprang up; and meetings were held, urging on the Legislature the introduction of a Bill dealing with the evils disclosed in these reports, the republication of which in book-form (1855) excited public interest to fever-heat. Vigorous articles in the *Times*, *Quarterly Review*, and other leading organs of public opinion, had the effect of compelling the appointment of a Parliamentary Select Committee, before which Dr. Hassall and others gave startling evidence regarding the prevalence of adulteration; and finally, in 1860, the first Act of Parliament was passed against the adulteration of food. This was the precursor and progenitor of all the Food Acts since passed, including the Act of 1899, at present in force.

Dr. Hassall wrote much on other topics, among them the danger attending the use of low flash-point petroleum (see Preface, p. xiii); the composition and trifling food-value of beef-extracts; the use of arsenical and other toxic pigments in wall-papers and curtain-fabrics; the occurrence of metallic poisons, such as lead, in postage stamps; and the manufacture of invalids' and infants' foods. A matter engaging much of his attention was the designing and construction of apparatus and chambers for the inhalation of antiseptic medicaments.

Dr. Hassall was for some time Public Analyst for the Isle of Wight, and in 1875 he was elected the first Vice-President of the Society of Public Analysts. For many years he was Physician (ultimately Senior Physician) to the Royal Free Hospital. He was the founder of the Royal National Hospital for Consumption and Diseases of the Chest, at Ventnor, where more than thirty years since he was advocating much of the open-air treatment now so generally adopted in cases of phthisis. Also, he was Consulting

Physician to the North British and Mercantile Insurance Company.

Dr. Hassall was early elected a Fellow of the Linnæan Society. Over thirty papers on botanical and zoological topics came from his pen; the total number of his books, papers, letters, and other signed contributions to journals reached nearly 200. One of his most interesting observations—that of the presence, in some pathological conditions, of indigo in urine—was described in papers read before the Royal Society in 1853 and 1854. Among his more important works were *A History of the British Freshwater Algæ* (1845); *The Microscopic Anatomy of the Human Body* (1849), in which were described for the first time the bodies in the thymus gland, now known to anatomists and physiologists as the 'concentric corpuscles of Hassall'; *A Microscopic Examination of the Water supplied to the Inhabitants of London and the Suburban Districts* (1850); *Food and Its Adulterations* (1855); *Adulterations Detected in Food and Medicine* (1857 and 1861); *The Urine in Health and Disease* (1859 and 1863); *Food: Its Adulterations and the Methods for their Detection* (1876); *San Remo Climatically and Medically Considered* (1883); and *The Inhalation Treatment in Diseases of the Organs of Respiration, including Consumption* (1885). Dr. Hassall in 1893 published an autobiography, *The Narrative of a Busy Life*, and in the following year (1894), on April 9, he died at San Remo, Italy, having lived a long and arduous life, of real use and lasting benefit to his fellow-men. 'One who never turned his back, but marched breast forward,' he felt, with Browning—

'Then life is—to wake not sleep,
Rise and not rest, but press
From earth's level where blindly creep
Things perfected, more or less,
To the heaven's height, far and steep.'

PROLEGOMENA.

ON THE USE OF THE MICROSCOPE IN THE EXAMINATION OF FOOD, DRUGS, AND WATER.

General Principles.

Without a microscope, evidences of organized structure can be observed in any animal or plant: but there is, in every part of each, much organization wholly invisible to the unaided sight. This minute structure differs in the several parts of the same plant or animal, and is distinct in different species, so that the histologist often can identify with the microscope exceedingly small portions of animal or vegetable tissues, and refer them to the parts or species to which they belong. Thus, one kind of root, stem, or leaf, may generally be distinguished from another, one sort of starch or flour from another, one seed from another, and so on. There are few vegetable articles of consumption (not liquids) which may not be identified by means of the microscope; and additions or admixtures of extraneous vegetable substances can similarly be discovered. Thus, the microscope can show the presence in linseed-cake, or crushed linseed, of various weed-seeds, many of them objectionable and injurious: such as purging flax (*Linum catharticum*), wild radish (*Raphanus raphanistrum*), yellow dodder (*Camelina sativa*), darnel-seed (*Lolium temulentum*), and flax-dodder (*Cuscuta epilinum*). The numerous materials introduced into mixed feeding-cakes, sometimes added to linseed-cake for the purpose of adulteration, and occasionally present through accident, such as mill-refuse, oat-husks, bran, locust- or carob-bean (*Ceratonia siliqua*), castor-oil cake (castor poonac), hemp-cake, and earth-nut (*Arachis hypogæa*), can readily be distinguished by a practised microscopist. Seeds even belonging to different species of the same genus may often be distinguished from each other by the microscope. For instance, rape-cake, after consuming which cattle have died with symptoms of gastric and intestinal inflammation, has been ascertained microscopically to be admixed with mustard seed, the undoubted cause, from the large quantity consumed, of the fatal inflammation. Seeds belonging to mere *varieties* of the same species of plants can sometimes be discriminated with the help of the microscope. These remarks apply also to vegetable drugs, whether roots, barks, seeds, or leaves. Sometimes information is gained of the processes or agencies to which substances have been subjected: whether, for instance, starch is raw, baked, or boiled: or if grain be malted or unmalted (*vide* 'Bread').

Not only when substances are alone can they be identified, but also when mixed together in different proportions. As many as nine different ingredients have been detected in certain mixtures.[1] The pulverization, and even charring, of many vegetable substances will not destroy the structures so as to render identification impossible by the microscope. Chicory and coffee may thus be roasted and pulverized, and each afterwards identified with the greatest ease. Extremely minute quantities of bodies can be discovered in admixtures: one part of turmeric, for instance, has been detected in 448 parts of mustard. By the size, form, and structure of the pollen grains in honey, which differ according to the plants whence they are derived, the microscopist can in many cases decide upon the nature of the plants which have yielded the honey, and whether it was collected from the flowers of the field, garden, heath, or mountain (*vide* 'Honey').

It is not too much to affirm that a full and accurate analysis of a proprietary food or sweetmeat; of a sauce or a condiment; of a medicinal preparation, whether pill, con-

[1] In a few instances (proprietary medicines and preparations for cattle) the writer has discovered with the aid of the microscope even a larger number of components.—E. G. C.

fection or potion; of a feeding-cake or a cattle-medicament, is usually impossible in the absence of a microscope. In some of these cases, indeed, the microscopical analysis is the more important part of the investigation. There are numerous other instances in which the microscope serves as an acceptable or even indispensable auxiliary to chemical analysis: not merely as a means of corroboration, but in the application of 'micro-chemical' reactions for starch, oil, cellulose, lignin, proteids, alkaloids and glucosides, alkaline earthy carbonates, phosphates, etc. Such tests are rapid, accurate, and convenient of employment. In toxicological investigations the microscope is particularly useful.

The following are among the more notable micro-chemical reactions:—

Starch gives a deep blue coloration with a solution of iodine in potassium iodide.

Cellulose is coloured faintly yellow by solution of iodine (blue, if subsequently treated with 50 per cent. sulphuric acid—Mangin's reaction); and violet-blue by iodized zinc chloride (Schultze's reagent). It is not coloured by acidified aniline sulphate (Wiesner's test), and dissolves in ammonio-cupric sulphate solution (Schweitzer's reagent). It is intensely stained by hæmatoxylin (logwood), but not by a solution of picric acid.

Dextrose reduces a warmed alkaline solution of copper tartrate, with the separation of red cuprous oxide.

Lignin (wood-fibre) is coloured pale yellow by solution of iodine, yellow by iodized zinc chloride, orange-yellow by alcoholic solution of thallium sulphate (Hegler's reagent), and a golden-yellow by acid solution of aniline sulphate. By treatment with iodopotassium iodide, followed by 50 per cent. sulphuric acid, which latter causes it to swell, it is not coloured blue (distinction from cellulose). It is not stained by hæmatoxylin, and is insoluble in Schweitzer's reagent.

Suber, or *Cork*, is coloured pale yellow by solution of iodine and by iodized chloride of zinc, but is not stained by acid aniline sulphate, hæmatoxylin, nor by iodine solution after treatment with 50 per cent. sulphuric acid; and it is not swollen by the acid.

Mucilage swells greatly in water, and yet more in solution of potash. It gives no blue with iodine solution, and after treatment with 50 per cent. sulphuric acid, only a faint bluish tint. It is dyed pink by corallin-soda solution, and stained deeply by hæmatoxylin.

Globules of Fixed Oil are dissolved by ether; not easily soluble in alcohol; saponified by alkalies; coloured a deep brown by osmic acid, and readily stained pink by alkanet tincture.

Globules of Volatile Oil do not saponify, and are readily soluble in alcohol.

Chlorophyll is dissolved by alcohol out of chlorophyll grains or chloroplastids.

Proteinous Matters, as the components of aleurone grains, are stained yellowish-brown by a solution of iodine in potassium iodide, intensely yellow by picric acid, and a deep red by a diluted solution of mercury in fuming nitric acid (Millon's reagent); a pink to violet-blue is yielded on the addition of a solution of sodium hydroxide, followed by very dilute solution of sulphate of copper (Rose's biuret reaction).

Crystals of Calcium Oxalate are insoluble in acetic acid, and soluble without effervescence in nitric or hydrochloric acid.

Crystals of Calcium Carbonate dissolve in acetic acid with effervescence.

Tannin gives a greenish- or bluish-black with salts of iron, and a brown precipitate with a solution of sodium acetotungstate (Baeme's reagent).

Alkaloids and *Glucosides* frequently exhibit distinctive crystalline forms, and in solution yield characteristic reactions with various general and special reagents, such as solution of potassio-mercuric iodide (Mayer's reagent), iodo-potassium iodide (Wagner's reagent), picric acid, iodic acid, bromine-water, followed by ammonia and potash, potassium, dichromate and sulphuric acid, etc.

Bile Acids give a violet colour with sulphuric acid or phosphoric acid, and cane sugar (Pettenkofer's and Drechsel's tests), and the bile-pigments exhibit changing tints on the addition of nitroso-nitric acid (Gmelin's reaction).

Fragments of the Rind of the Orange are coloured intensely green when digested in hydrochloric acid—E. G. Clayton (distinction from lemon rind).

Preparation of Objects.

Before proceeding to the microscopical investigation of a substance, the observer acquaints himself with its general appearance and structure. If the specimen be in the state of powder (*e.g.*, flour and arrowroot), a very minute portion is deposited in a drop of water on the middle of a glass slide, the powder being diffused evenly in a layer so thin that the light easily passes through it; and a square or circular thin glass cover is placed over the whole, air-bubbles being excluded. If the substance be solid, as a root, stem, or seed, thin sections must be prepared with a sharp and narrow-backed razor: some transverse, some longitudinal (radial and tangential) and others embracing the external and internal surfaces of the object, when both are present. A microtome is generally unnecessary. Occasionally the inquiry is facilitated by tearing in pieces some of the sections with needles, also by the use of glycerine or oil instead of water: especially in the examination of seeds. The structure is thus rendered more distinct.

Methods of Investigation.

When the substance is supplied in the form of powder, and there is a question as to its purity, it is necessary to procure some of the genuine powder, examine it most minutely, and thus become familiar with its morphological features. Having progressed thus far, one can examine various samples of the article, with a view to the detection of foreign admixture, if this be suspected. With a good knowledge of the structures met with in the pure substance, little difficulty should be experienced in determining whether specimens contain exotic vegetable components, or are free from alien admixture. Should a foreign body be present, its nature must be ascertained and an attempt made to refer it to the plant or substance to which it belongs. The facility with which this is done depends on the extent of one's acquaintance with other vegetable substances: if this be considerable, a glance is often sufficient. It is not always necessary to know the structure and appearances of any great number of vegetable productions, since a few comparatively inexpensive commodities, such as wheat-flour, potato-starch, sago-powder, rice, maize, etc., are added very often to many and widely different products of greater value. In such cases, all that is requisite is to be able to recognize these additions when present. More often, the demands on the scientific knowledge and judgment of the investigator are greater. For the successful examination of unknown mixtures of possibly complex constitution (*e.g.*, the numerous proprietary foods, condiments, medicines, and other articles every day confronting him), he must be very well equipped indeed.

Excluding fluids and active chemical principles, most productions of vegetable origin are made up of certain definite structures and histological elements, as cellular tissue, wood-fibre, vessels, starch-granules, and the like. Thus, in leaves there are stomata and hair-like appendages, and in seeds, aleurone cells, oil-cavities, and two or more membranes. In any endeavour to discriminate between different vegetable substances, these several tissues and structures must be most carefully compared. Thus, the cellular tissue of one vegetable product is to be examined comparatively, both for size and structure, with that of another; and the same course must be followed with the wood-fibre, starch-granules, aleurone grains, stomata, hairs, etc. Some preliminary knowledge of structural botany is here presupposed; because the observer should be acquainted with the characteristics of the chief tissues and elements entering into the organization of the several component parts of plants. He should know the structure and microscopic appearance of cellular tissue in its different forms, parenchyma, sclerenchyma, and prosenchyma; of vascular tissue, wood-fibre, chlorophyll-grains, starch-grains, and aleurone-grains; and should be familiar with the general features of roots, stems, leaves, flowers (including the pollen), and seeds. Aleurone grains are useful in the discrimination and identification of seeds, resembling starch-granules in this respect, that for the same botanical species the characteristics vary but little. Aleurone grains consist of proteinous ground-matter, mostly soluble in water and dilute alkali or acid, and containing embedded crystalloids (proteid matter, insoluble in water, soluble in dilute acid and alkali), globoids (composed of phosphatic and organic salts of calcium and magnesium), with sometimes crystals or crystal-aggregates of oxalate of calcium, insoluble in water and acetic acid, soluble in dilute hydrochloric acid. The ground-substance being soluble in water, a better medium in which to mount seeds for microscopical examination is glycerine, almond, castor, or olive oil. An introductory knowledge of vegetable morphology and histology, which will facilitate very greatly subsequent and more specialized inquiries, can be derived from ordinary botanical works, such as those of Strasburger, Vines, Goodale, Balfour, and Bentley. 'The Class-Book of Botany,' by G. P. Mudge and A. J. Maslen, also may be mentioned.

Many of the foregoing remarks apply to the microscopical examination of substances of animal origin: blood corpuscles; blood crystals; mucus; pus; epithelial cells; muscle-fibre; fat-globules, as in milk and butter, etc. With some previous knowledge of microscopic anatomy, an acquaintance with the structures and morphological characteristics of the objects named, and a familiarity with the microscopical appearances of ordinary parasites, their ova and embryos, as well as of the commoner water-organisms, the observer will be in a position to examine many articles of animal origin; in some instances to distinguish healthy food from diseased or parasitic flesh; to identify blood in liquids or on stains, colostrum in milk, many kinds of dead organic débris in polluted water, and to search for and recognize the more highly developed organisms in drinking water—crustacea, rotatoria, infusoria, and the like.[1] Some previous study of zoology, anatomy, and physiology are here assumed. Useful textbooks for reference are Huxley and Martin's 'Elementary Biology' (revised edition by G. B. Howes and D. H. Scott), Mudge's 'Class-Book of Zoology,' Landois and Sterling's 'Human Physiology,' and Quain's 'Elements of Anatomy,' edited by E. A. Schäfer and G. D. Thane.

Microscope Required.

There is much latitude in the choice of a microscope, which need not be costly. Any trustworthy English or foreign maker's instrument will be suitable, if supplied with two eye-pieces, four object-glasses (1, ½, ¼, and ⅛ inch), a polariscope and a micrometer, in addition to the usual accessories, concave mirror, condenser, movable stage, etc. The ½- and ¼-inch object-glasses are by far the most often used, but the 1-inch and ⅛-inch powers are of great assistance (the former, for instance, in making rapid preliminary investigations of substances, and the latter in the examination of the smaller starches, as those of rice and liquorice).

The magnifying power requisite varies with the nature of the object, and may be gathered from the numbers affixed to the engravings in the following pages. For more ready and accurate comparison, it is best to become accustomed always to make the principal examination of one kind or class of object (*e.g.*, starches; and the tissues of seeds) with the same powers: in this way a better idea of relative dimensions will be obtained; but for nearly all objects a 1-inch or ½-inch power (with a No. 1 eye-piece) may be used for the preliminary examination. A pocket lens is a useful adjunct.

The following table shows the number of diameters magnified by the object-glasses and eye-pieces of two well-known makers, one English, the other foreign; but it must be understood that with every maker these values differ, so that they must always be ascertained when an instrument is purchased.

1 The bacteriological or bacterioscopic examination of water is a separate subject, and does not fall within the scope of the present volume.

ENGLISH MAKER.

Eye-pieces.	Object-glasses.			
	1 inch.	$\frac{1}{2}$ inch.	$\frac{1}{4}$ inch.	$\frac{1}{8}$ inch.
A - - - - -	6	100	220	420
B - - - - -	80	130	350	670
C - - - - -	100	180	500	900
Value of each space in the micrometer eye-glass with the various object-glasses - -	$\frac{1}{970}$= ·001031	$\frac{1}{1900}$= ·0005263	$\frac{1}{4300}$= ·0002325	$\frac{1}{9000}$= ·0001111

FOREIGN MAKER.

Eye-pieces.	Object-glasses.			
	1 inch.	$\frac{1}{2}$ inch.	$\frac{1}{4}$ inch.	$\frac{1}{8}$ inch.
With draw-tube out full (No. 1) - - -	—	80	180	500
With draw-tube out full (No. 2) - - -	—	90	300	800

In addition to the microscope, glass slides, cover-glasses, mounted needles, a sharp scalpel or razor, and a clean silk cloth are wanted: also (but only if it be intended permanently to mount and preserve objects), Quekett's or some other preservative fluid, such as creosoted glycerine, or Canada balsam and xylol, in which to place the preparation; glass cells; marine glue, for fastening these to the slides; and shellac varnish, copal cement, or gold size, for securing the cover-glasses to the cells, or to the slides, where cells are unnecessary. Such permanent preservation of objects, however, will but seldom be requisite in investigations such as those described hereafter. Detailed practical instructions in the various operations are to be found in any good work on the microscope—Carpenter and Dallinger's, Van Heurck's, or Cross and Cole's, for instance. [For references to other books on the subject, see Bibliography, pp. 399-406.]

SECTION I.

FOODS DERIVED FROM VEGETABLE SOURCES.

ORD. GLUMIFLORÆ, FAM. GRAMINEÆ: CEREAL GRAINS.

FLOUR.

(A) WHEAT FLOUR (*Triticum sativum, var. vulgare*).

Histology of the Grain.—1. *The membranes surrounding the grain* (including here the *pericarp*, or fruit wall, and the *testa*, seed coat, or *spermoderm*) consist of several layers of cells, two of which are disposed longitudinally to the axis of the grain, and another transversely (cross cells). Longitudinal cells, large, with margins distinctly beaded, especially the outer layer: transverse cells, also beaded, but less distinctly.

2. *Surface of the Grain.*—Formed of large, angular cells ('gluten,' 'protein,' 'aleurone,' or 'starch-free peripheral' cells), filled with proteinous and oily matter in a granular state.

3. *Substance of the Grain.*—Composed of still larger cells (starch cells), each enclosing numerous starch granules. These parenchymatous cells are smaller near the outer parts of the grain than towards the centre.

4. *Starch.*—Composed of definite granules or particles, many very small, others of considerable dimensions, and but few of intermediate sizes. The small grains are chiefly round, rarely oval, or muller-shaped, and mostly provided with a central spot, the organic centre, sometimes coinciding with a cavity or fissure, and termed the *hilum*: the larger granules form rounded or flattened discs with thin edges. Neither hilum nor concentric stratification rings *in general* perceptible on the larger discs, although in a few cases a central tubercle may be seen, as well as indistinct *annuli*. Occasionally some of the larger grains are more or less twisted or turned up at the edges, and when seen sideways

present the aspect of a longitudinal furrow : this appearance is occasioned by the partial folding or curling of the granule, whereby a central depression is produced, the corpuscle at the same time being viewed obliquely. Frequently grains which, when stationary, have a round, disc-like appearance, in rolling over and presenting the edges to view, exhibit the longitudinal furrow described, its nature being thus clearly shown. A few granules attain a very considerable size; these are less regularly circular, and being much flattened exhibit but little shadow: sometimes their edges are marked with radiating lines. Examined with the polariscope they exhibit a well-marked cross.

Often the agency to which the starch granules have been exposed—as, for instance, whether moist baking, dry baking, or boiling—may be determined by attentive microscopical examination. The differences between the raw, moist, baked, and boiled starch grains of wheat, and the other cereals, are very marked. The distinction is less clear in the case of the dry-baked granules, which are, however, much larger on the average than the raw granules: the form is less regular, that of the smaller grains especially being a good deal altered, the shadows are less marked, and in some of the granules the concentric rings are rendered more conspicuous. These modifications of the starch grains are well exemplified in certain proprietary foods manufactured from wheat, etc., described a few pages further on.

The greatest extent of alteration is to be seen in British gum, or dextrin made from starch (by which the backs of postage stamps are rendered adhesive) : in this case the granules are mostly destroyed, but here and there grains and portions of granules may be discovered, often exhibiting concentric rings. These remnants are generally sufficient for identification, and to determine whether the gum was made from wheat or potato starch.

Extraneous Substances Detectable by the Microscope.—Barley, rice, and other cheaper flours.

[*For figures, see pp.* 5, 6, *and* 7.]

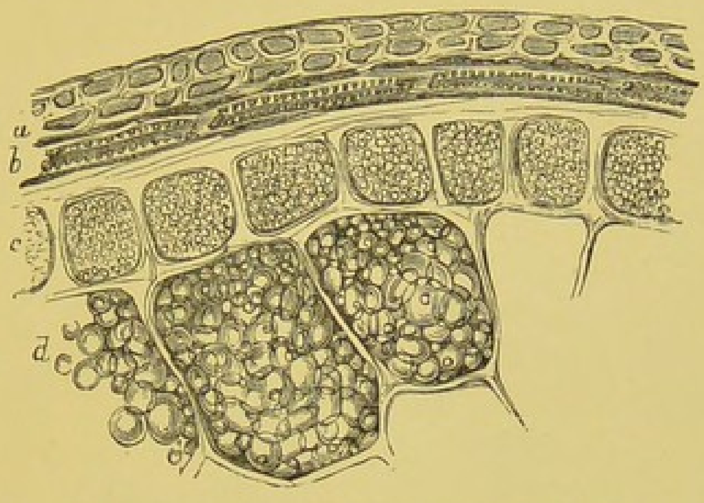


FIG. 1.—GRAIN OF WHEAT (TRANSVERSE SECTION). × 200.

a, Longitudinal cells of *epicarp*, or outer membrane of *pericarp*; *b*, middle membrane (cross cells); *c*, inner membrane, or surface cells of the grain proper (aleurone cells); *d*, substance of grain (starch cells).

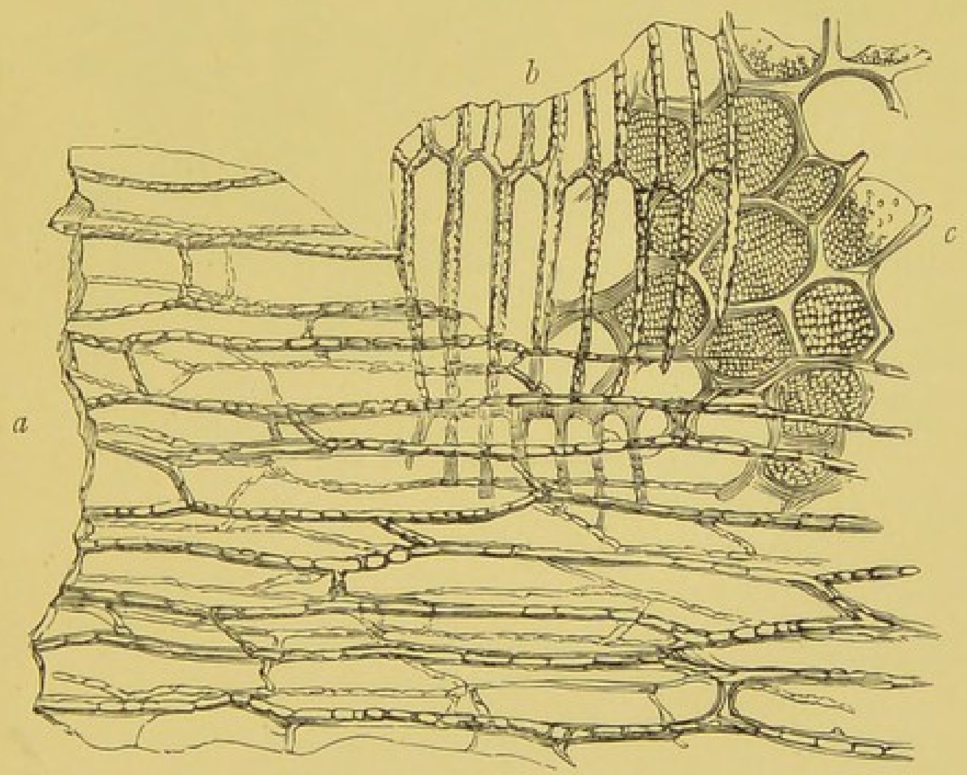


FIG. 2.—GRAIN OF WHEAT (LONGITUDINAL SECTION). × 200.

a, Longitudinal cells of *epicarp*; *b*, middle membrane (cross cells); *c*, inner membrane, or starch-free peripheral cells (aleurone cells).

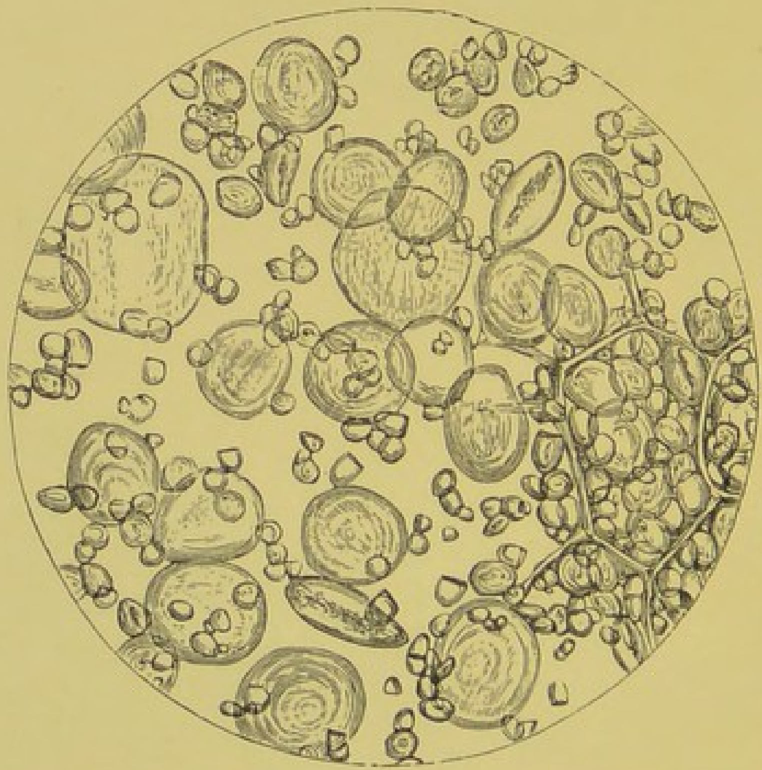


FIG. 3.—WHEAT FLOUR (STARCH GRANULES AND STARCH PARENCHYMA). × 420.

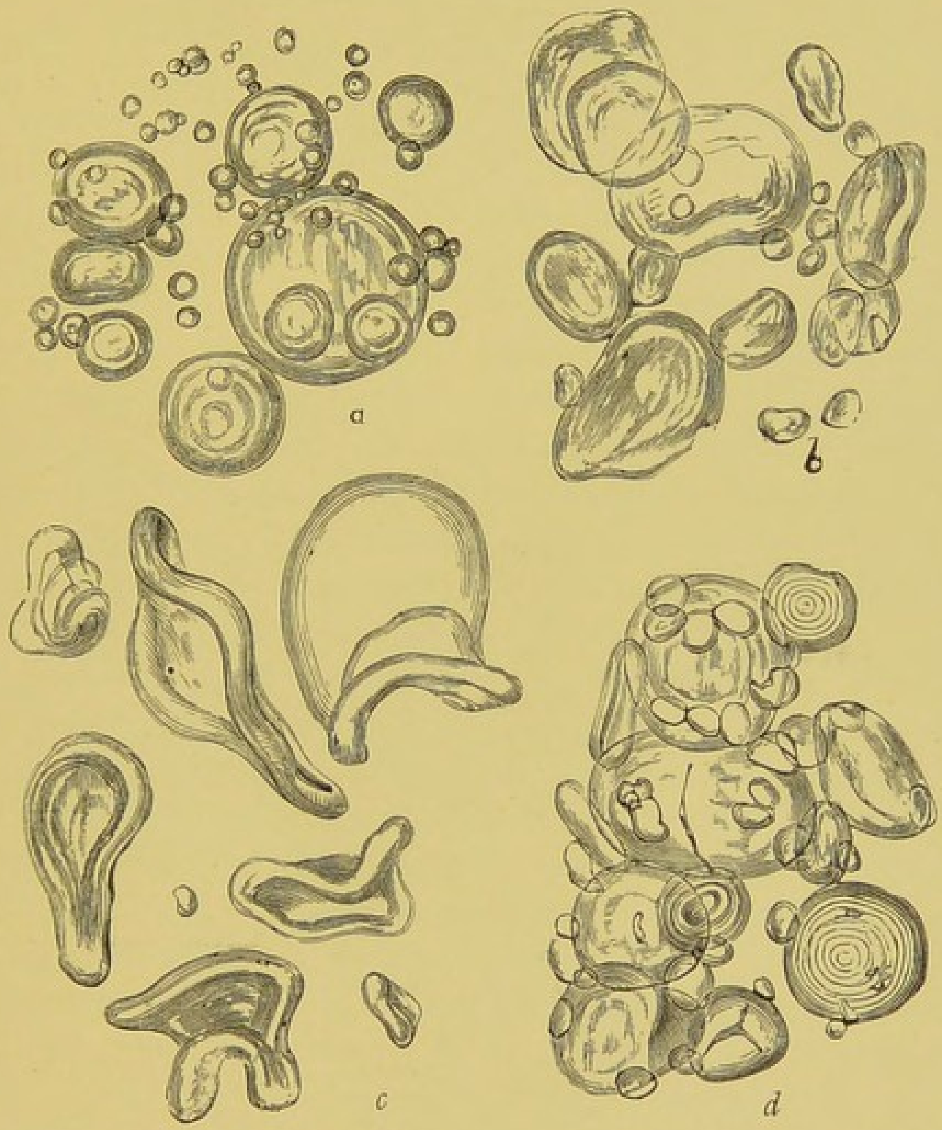


FIG. 4.—WHEAT STARCH (RAW, AND ALTERED BY HEAT). ×400.
a, Raw; *b*, baked with moisture, as in bread; *c*, boiled, as in pudding; *d*, dry-baked.

(B) BARLEY FLOUR (*Hordeum sativum*).

Histology of the Grain. — 1. *The pericarp, and testa or spermoderm*, together consist usually of at least four layers of cells, smaller than those of wheat: the longitudinal cells, of which there are three layers, are not beaded, but the cells forming the outer layer have margins slightly waved; those of the inner layer and of the transverse cells, not waved.

2. *Cells of Surface of the Grain* (peripheral, or aleurone cells).—Not nearly so large as those of wheat, and they form two, three, or four layers, instead of one as in wheat.

3. *Substance of the Grain.*—Parenchymatous cells more delicate than corresponding cells of wheat, and when emptied of starch, present a fibrous appearance.

4. *Starch granules* resemble very closely those of wheat, so that the description already given to some extent applies. Barley starch consists of small and large grains, with but few of intermediate size; the small grains are three or four times smaller than the corresponding wheat granules. Many of the larger grains are distinctly ringed, while a much greater proportion of them presents the longitudinal furrow previously described. These characters are sufficiently well marked to allow of the microscopical discrimination of barley and wheat. Under polarized light a cross is seen.

Extraneous Substances Detectable by the Microscope.—Rye and other meal, mineral matter, etc.

[*For figures, see pp.* 10, 11.]

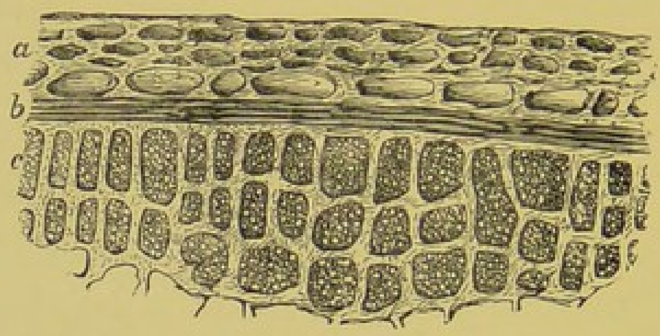


FIG. 5.—GRAIN OF BARLEY (TRANSVERSE SECTION OF PERICARP, TESTA, AND SURFACE OF KERNEL). × 200.

a, Outer layers of longitudinal cells; *b*, cross cells; *c*, inner (aleurone) cells, surface of grain.

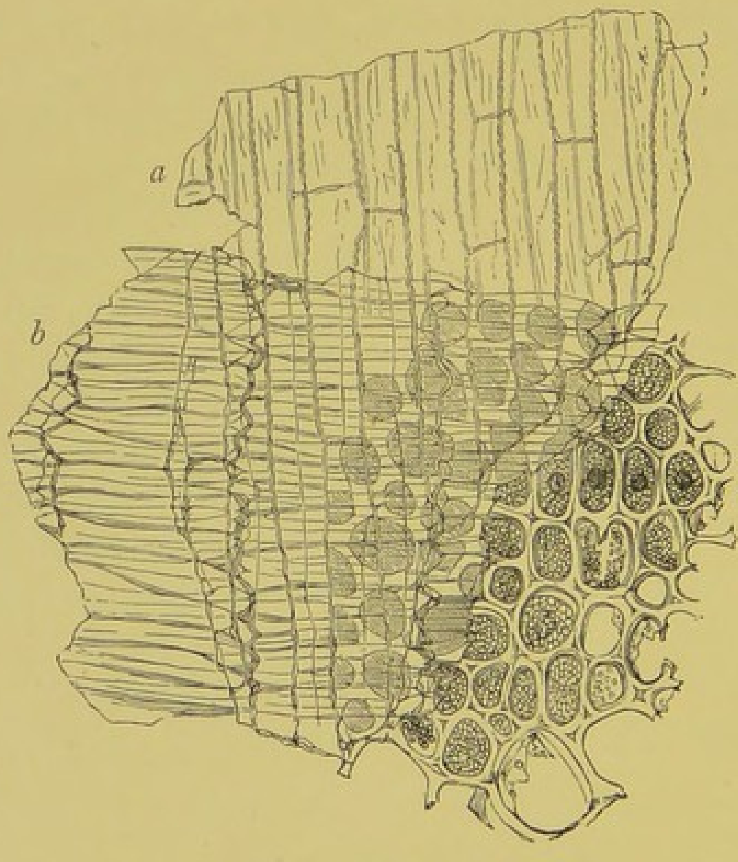


FIG. 6.—BARLEY (VIEW OF SURFACE OF GRAIN). × 200.

a, Outer layers of longitudinal cells; *b*, cross cells; *c*, inner (aleurone and starch) cells, surface and substance of grain.

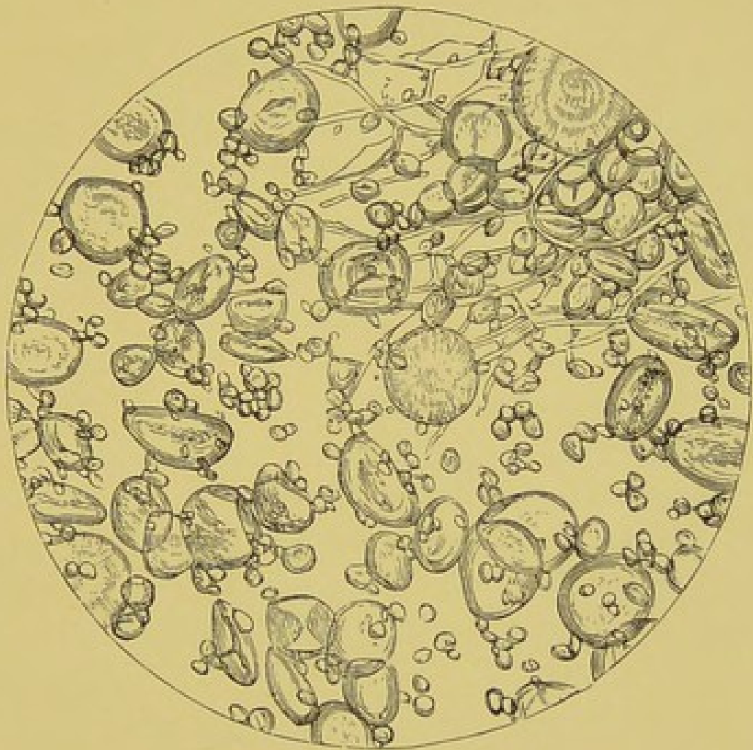


FIG. 7.—BARLEY FLOUR (STARCH GRANULES AND STARCH PARENCHYMA). ×420.

(c) Rye Flour (*Secale cereale*).

Histology of the Grain.—1. *Investing membranes* resemble those of wheat, but cells of the first and second layers smaller and much more delicately beaded: cells of third coat (cross cells) also smaller, and of a somewhat different form.

2. *Kernel.*—Cells of the aleurone layer are thicker-walled, and of less size than in *Triticum*.

3. *Starch granules* bear a general resemblance in form and size to those of wheat; but the lesser grains are decidedly smaller than the corresponding wheat granules, and many of the larger grains of rye starch have a three or four-rayed fissure, located at the hilum. Under polarized light a cross is exhibited, much more strongly marked than that seen in barley starch.

Extraneous Substances Detectable by the Microscope.—Potato and other cheap starches, mineral matter, etc.

[*For figures, see pp.* 14, 15.]

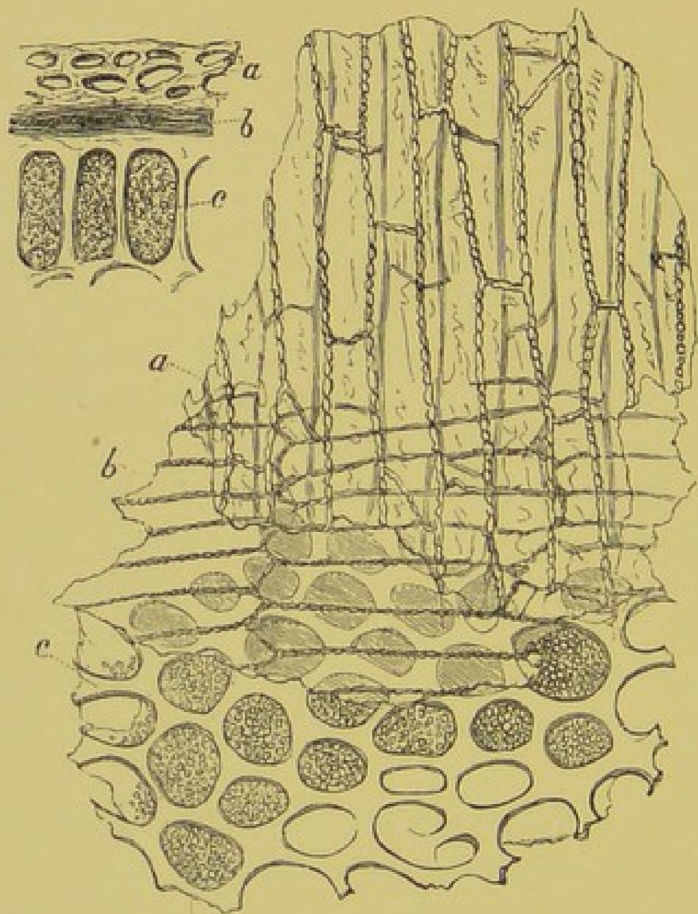


FIG. 8.—GRAIN OF RYE (VERTICAL AND TRANSVERSE SECTIONAL VIEWS OF EXTERNAL PORTION). × 220.

a, a, Outer layers ; *b, b,* cross cells ; *c, c,* aleurone layer.

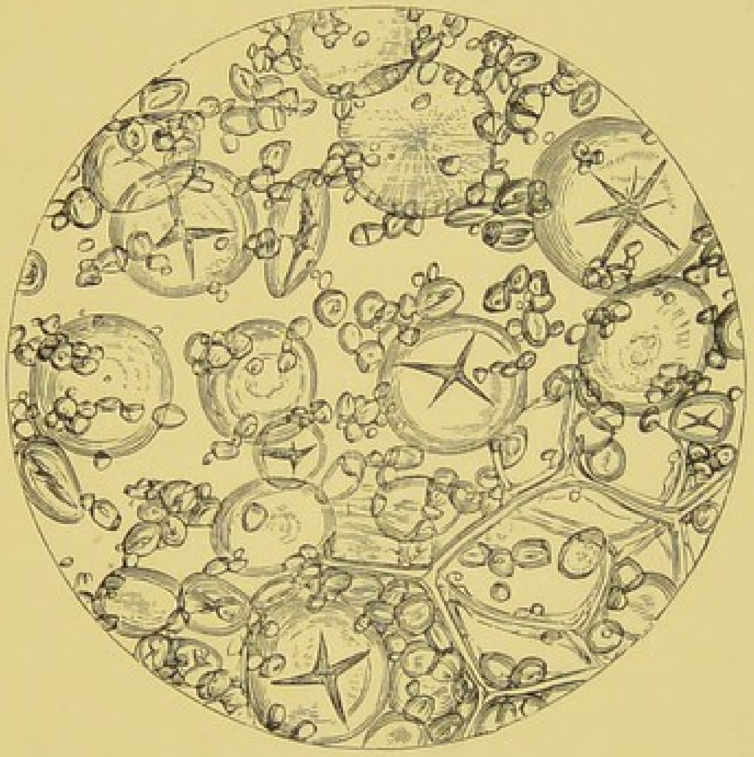


FIG. 9.—RYE FLOUR (STARCH GRANULES AND STARCH CELLS). ×420.

(D) Oat Flour and Oatmeal (*Avena sativa*).

Histology of the Grain.—1. *Pericarp.*—The longitudinal cells constituting the *epicarp* and *mesocarp*, or two outer membranes of the pericarp, form two layers; large and well defined, walls rather thin and slightly waved. From the upper and outer wall of some of the external cells springs a single long and pointed hair, the point being turned towards the summit of the grain: these hairs arise from the cells over the whole surface of the grain, but become more numerous towards the apex, where they form a beard or tuft, as in wheat. The transverse cells, forming the next investing membrane, are disposed in a single layer; walls less accurately defined, and not very much longer than broad.

2. *Surface of the Kernel.*—The peripheral cells (aleurone cells) consist of one layer, and are smaller than the corresponding cells of wheat.

3. *Substance of the Kernel.*—Parenchyma cell-walls very delicate, and, when cells emptied of starch, appear like threads.

4. The *starch granules* present well-marked structural characteristics. Smaller than those of wheat, vary but little in dimensions, are polygonal in figure, without either visible concentric rings or hila, but with central depressions and thickened edges. The great peculiarity of oat starch, however, is the coherence together of many of the grains into aggregates of a rounded or oval figure, presenting a reticulated surface indicative of their compound structure. These bodies readily escape from the cellulose, and, when oat flour is diffused through water, may frequently be seen floating about freely in the liquid. A second peculiarity is that, unlike the other cereal starches, grains of oat starch do not exhibit the usual crosses when viewed with polarized light.

Extraneous Substances Detectable by the Microscope.—Barley and other starches; husk of oat, barley, and wheat; mineral matter, etc.

[*For figures, see pp.* 18, 19.]

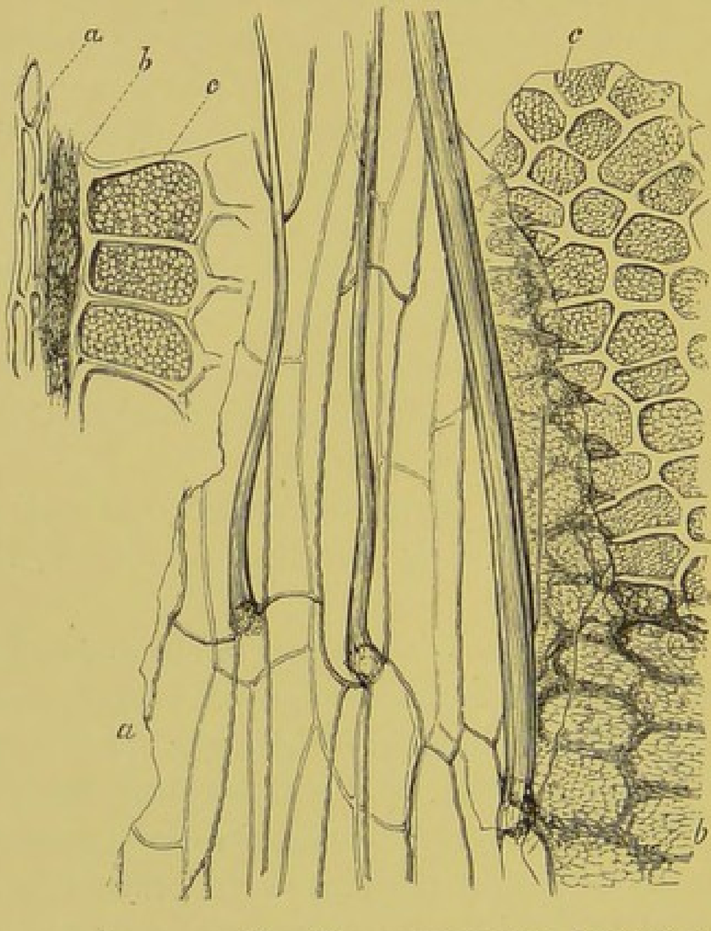


FIG. 10.—GRAIN OF OAT (TRANSVERSE AND LONGITUDINAL SECTIONS). ×200.

a, a, Outer membranes and hairs ; *b, b*, indistinctly defined cross cells ; *c, c*, aleurone layer.

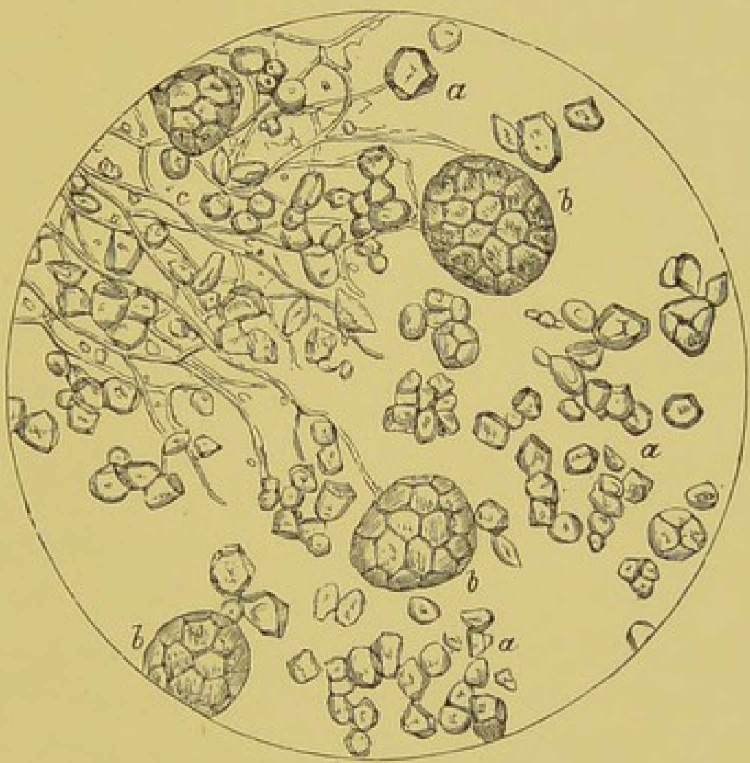


FIG. 11.—OAT FLOUR (STARCH GRANULES AND STARCH PARENCHYMA). ×420.

a, *a*, Starch grains; *b*, *b*, aggregations of starch grains; *c*, *c*, starch cells, mostly emptied.

The appearance of oatmeal, adulterated with barley meal, will be seen in Fig. 23, p. 35.

(E) Maize or Indian Corn (*Zea Mais*).

Histology of the Grain.—1. *Pericarp*, or outer investing membrane, consists chiefly of some seven or eight layers of cells all running in one direction, and about three times as long as broad; the margins of the outermost layer are beaded, the beadings being remarkable for a certain squareness of outline. Beneath these elongated cells are parenchymatous cells with intercellular spaces.

2. *Surface of the Kernel.*—The next prominent membrane is the layer of protein or aleurone cells, forming the surface of the kernel, and resembling the corresponding cells of other cereals (rye in particular), but divided by septa, shown in the figure.

3. *Cells of the parenchyma* very angular, like those of rice, but subdivided into a cellulated network, each space enclosing a separate starch granule.

4. The *starch grains*, as a rule, are somewhat polygonal in form, and present well-marked central depressions, with occasionally a divided and radiated fissure at the hilum:[1] unlike oat starch, they do not form compound bodies, and they exhibit under the polariscope well-defined crosses.

The central depression appears to be common to many of the starch granules of the cereal grasses, and, combined with the disc-like form of the grains, gives them a general but distant resemblance to the blood discs of the mammalia. When the grains, as in wheat and barley, are curved upon themselves, the depression exists, of course, only on one side of the disc.

Extraneous Substances Detectable by the Microscope.—Foreign starches, mineral matter, etc.

[1] The hilum is that part of a starch grain which was at first formed.

[*For figures, see pp.* 22, 23.]

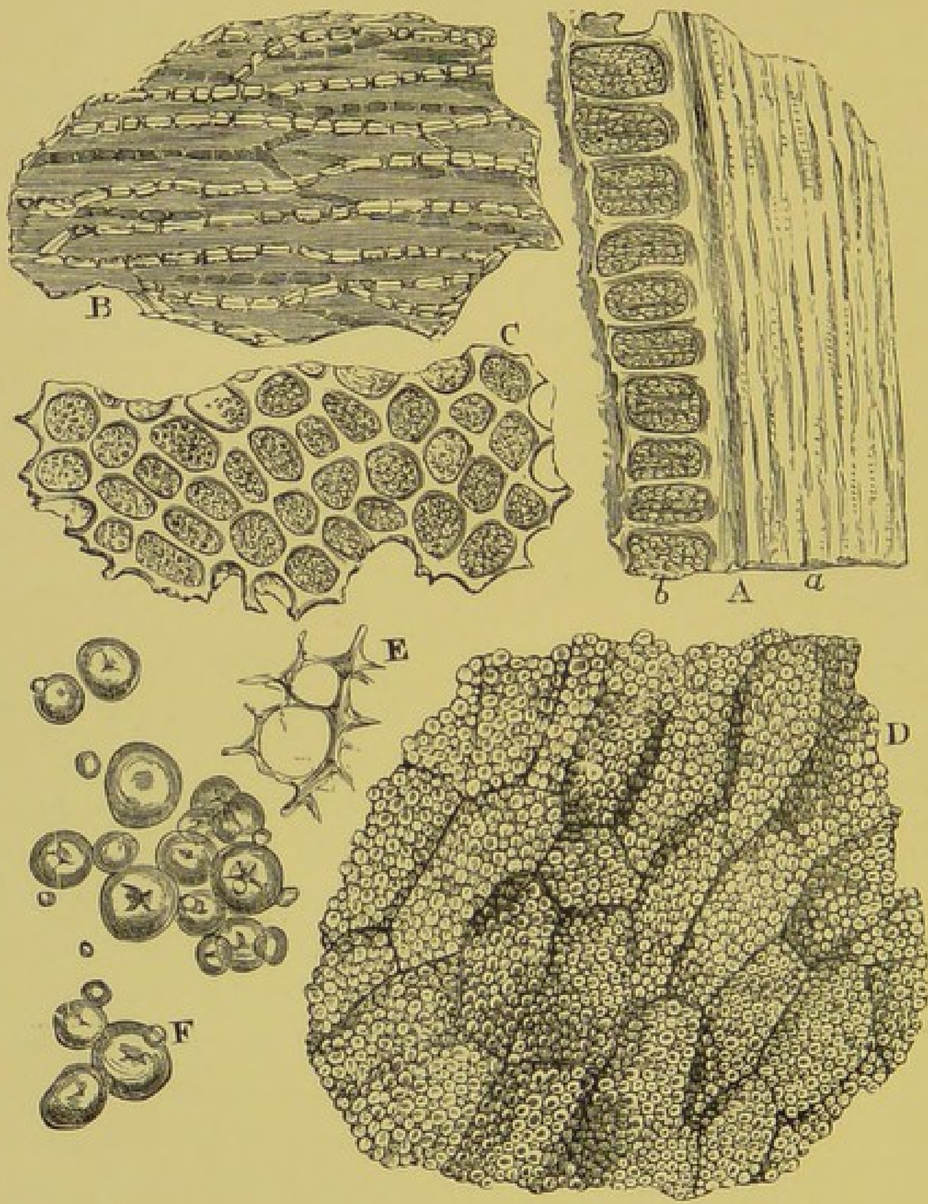


FIG. 12.—GRAIN OF MAIZE.

A, Transverse section of outer portion: *a*, elongated beaded cells; *b*, septated aleurone cells (× 100). B, longitudinal view of beaded or porous-walled cells (× 200). C, cells of *surface* of grain (aleurone cells) (× 200). D, cells of its *substance* (parenchyma) (× 100). E, cellulated network emptied of starch (× 500). F, starch granules (× 500).

FIG. 13.—INDIAN CORN FLOUR (STARCH GRANULES AND STARCH CELLS). ×420.

(F) RICE (*Oryza sativa*).

Histology of the Husk and Grain (best made out after immersion for some time in glycerol or in a 5 per cent. solution of potash or soda).—1. *Husk.*—Outer surface thrown up into ridges, arranged transversely and longitudinally, and describing between them square spaces: ridges formed in part of granular silica; here and there are openings of somewhat irregular form, which are hair-scars. Beneath this outer epidermis are several layers of rather short, narrow, sclerenchymatous fibres, some arranged longitudinally, others transversely. They are brittle: their edges are rough; and that they really are fibres is shown by their being hollow, as is seen in transverse sections. The fibrous membrane is succeeded by a thin tissue, formed of angular cells, rather longer than broad, the long axis of which is placed transversely.

2. *Kernel.*—The next membranes are made up of the several varieties of cells of the pericarp (not shown in the figure), beneath which is a layer of aleurone cells, followed by the starch parenchyma.

3. The *starch granules*, which consist largely of amylodextrin, are small, for the most part angular in shape, with well-marked central depressions and raised edges. In their polygonal form they closely resemble the starch granules of oat, but are much smaller. Many are aggregated together into compound grains (resemblance to oat flour).

Extraneous Substances Detectable by the Microscope.—Foreign starches, husks, etc.

[*For figures, see pp.* 26, 27.]

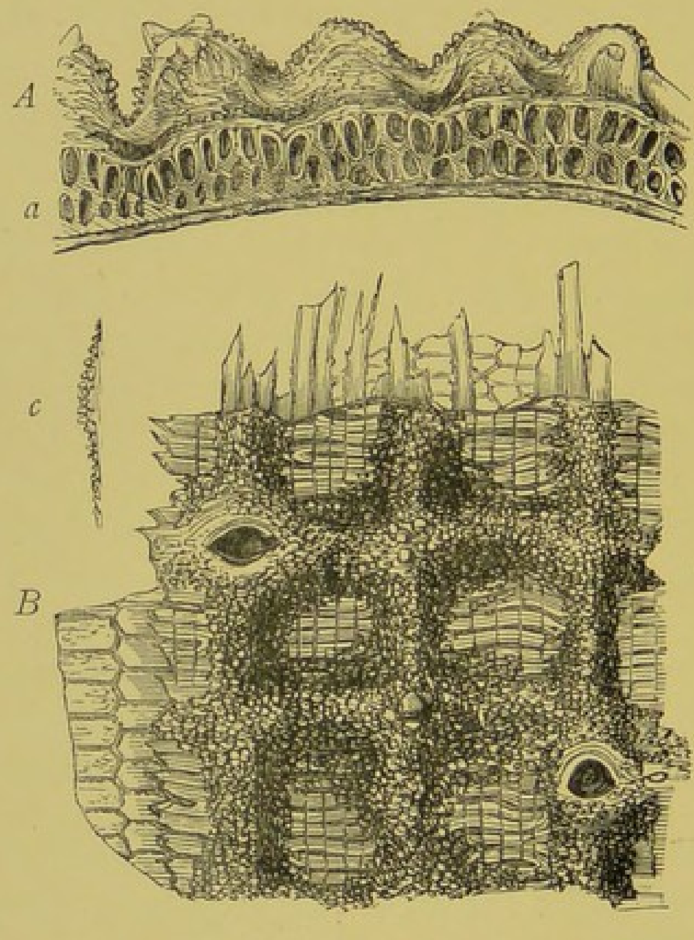


Fig. 14.—Husk of Rice.

A, Transverse section; *a*, sclerenchymatous fibres cut through (× 220); B, surface view, showing hair-scars and broken ends of sclerenchymatous fibres (× 220); *c*, edge of fibre more highly magnified.

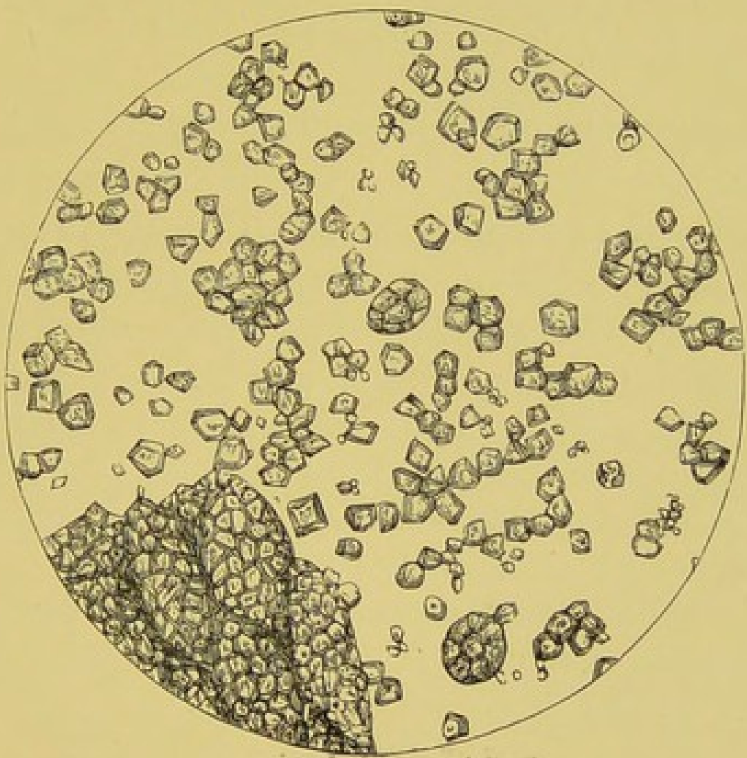


FIG. 15.—RICE FLOUR (STARCH GRANULES AND COMPOUND GRAINS). × 420.

ADULTERANTS OF, AND SUBSTITUTES FOR, WHEAT AND OTHER CEREAL GRAINS.

Fig. 16.—**Bean Flour** (*Faba vulgaris* = *Vicia Faba L.*, ord. *Leguminosæ*, fam. *Papilionaceæ*): Characterized by the thickness of the walls of the cells enclosing the starch granules, by the oval or reniform shape of the granules, and by the elongated and divided character of the fissure extending through the hilum.

Fig. 17 shows the appearance of *wheat flour* admixed with *bean flour*.

Fig. 18.—**Potato Flour** (*Solanum tuberosum*, ord. *Personatæ*, fam. *Solanaceæ*) : Easily distinguished from wheat flour by the microscope. Starch granules of potato flour vary greatly in size and shape: some very small and circular, others large, ovate, or oyster-shaped. The larger granules exhibit numerous very distinct concentric rings,[1] and the small but well-defined hilum is situated in the narrow extremity of each granule: not infrequently granules may be observed of an oval form, divided by a fine line into two portions or segments, each provided with a hilum. (For further account, *v.* under *Arrowroots*, p. 64.)

Fig. 19 represents a mixture of *wheat flour* and *rice*.

Fig. 20.—**Barley Flour**: Previously described (p. 9), but figured again here for convenience. The admixture of *barley* flour with wheat is not easy to discover, if attention be confined *only* to the starch granules of the two kinds of grain, the differences being inconsiderable; though barley starch granules are smaller than those of wheat, especially the more minute granules. But the discrimination may be effected satisfactorily by means of the fragments of husk present in the flour. The structural peculiarities of the testa and of

[1] The layers, represented by the rings or striations visible in many starch grains, differ in density and in the proportions of water which they contain.

the cells forming the surface of the grain of wheat and barley have been described (pp. 3 and 9).

Another occasional adulterant of wheat is **Maize**, of which an account has been given (p. 21).

Fig. 21 shows an admixture of *wheat flour* with *maize flour.*

Fig. 22 illustrates the aspect of *cones flour* in admixture with *rice* and *bean flours.* Genuine cones flour is the flour of a particular species of wheat called *revet*, grown in Southern Europe, and used by some bakers to dust the dough, as well as the boards on which this is made into loaves, to prevent the dough from adhering to the boards, or the loaves to each other in the course of baking. Cones flour was found by Dr. Hassall to be subject to extensive adulteration with rice, rye, barley, bean, maize, and other substances, some of the samples examined containing no wheat flour whatever.

Oat flour and oatmeal are seldom adulterated with the flour of other cereal grains: but wheat and barley husks are added occasionally. Maize also has been mentioned among the adulterants of oatmeal.

Fig. 23 represents a mixture of *oatmeal* and *barley meal.*

Fig. 24.—**Durrha** or **Dari** (*Andropogon sorghum, var. durra; Sorghum vulgare*): alleged to have been used as an adulterant of wheat flour.

HISTOLOGY OF THE GRAIN.—1. The *exterior* portion consists of three principal membranes: the *outermost*, composed of several layers of rather small, thick-walled cells, about three times longer than broad, and having the margins finely beaded, somewhat as in capsicum: a *middle* coat, consisting of several layers of thin-walled cells, filled with small, polygonal starch granules (the starch-bearing *mesocarp*): and a *third*, which is the external membrane of the kernel, and is a single layer of angular, but unusually small, 'aleurone,' or 'starch-free peripheral' cells.

2. *The substance of the grain*, mostly starch parenchyma,

resembles very closely that of maize, differing chiefly in the larger size and greater angularity of the starch granules, as well as in the stellate character of the cavity at the hilum.

In the figure on p. 37, *A* = transverse section of *external* portion of grain; *a*, outer membrane; *b*, middle coat (starch-bearing mesocarp); *c*, aleurone layer; *B*, longitudinal section; *a*, outer layers; *b*, starch-bearing mesocarp; *c*, aleurone cells; *C*, *substance of grain*, showing the large angular cells filled with starch, of which it is composed; *D*, parts of large cells, showing the pseudo-cell structure, in which the starch granules are separately lodged; *E*, *E'*, starch from substance of grain and mesocarp, respectively.

[*For figures, see pp.* 31-37.]

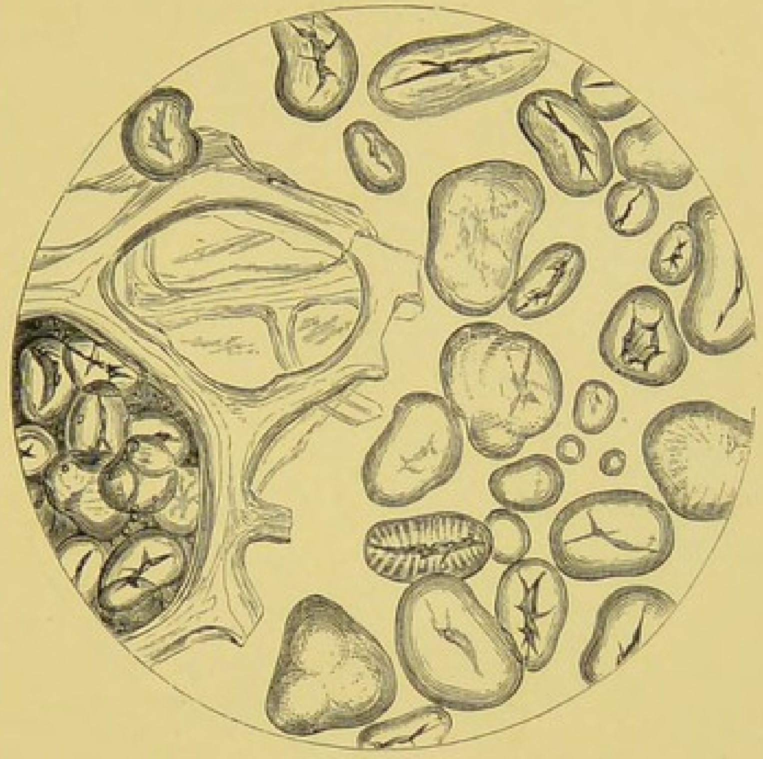


FIG. 16.—BEAN FLOUR. ×420.

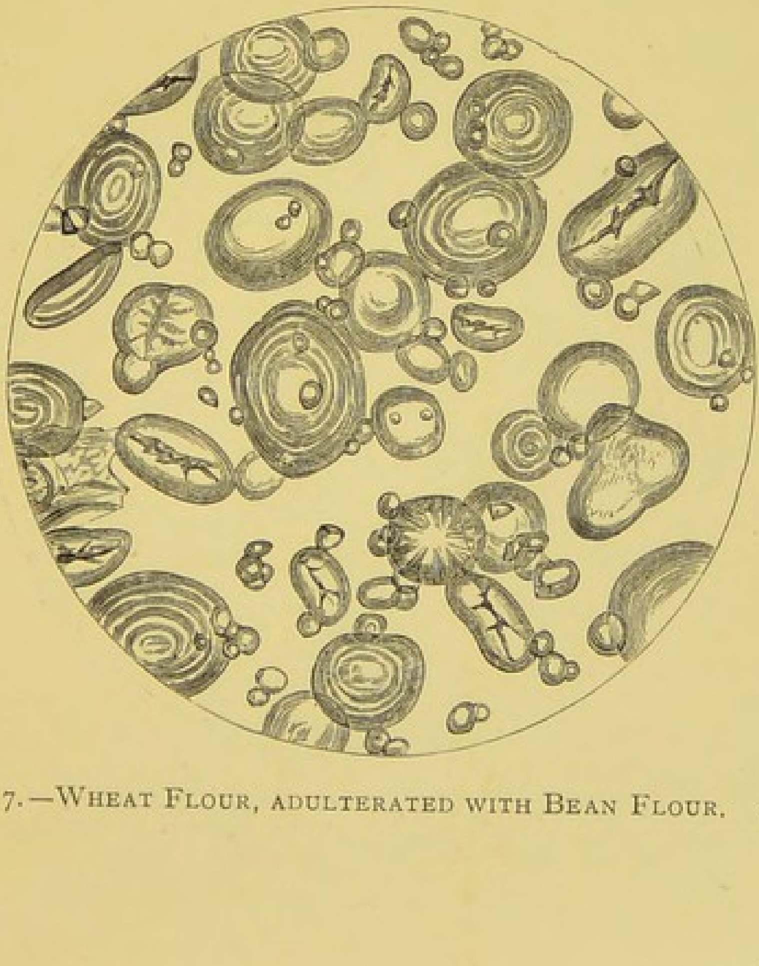


FIG. 17.—WHEAT FLOUR, ADULTERATED WITH BEAN FLOUR. ×420.

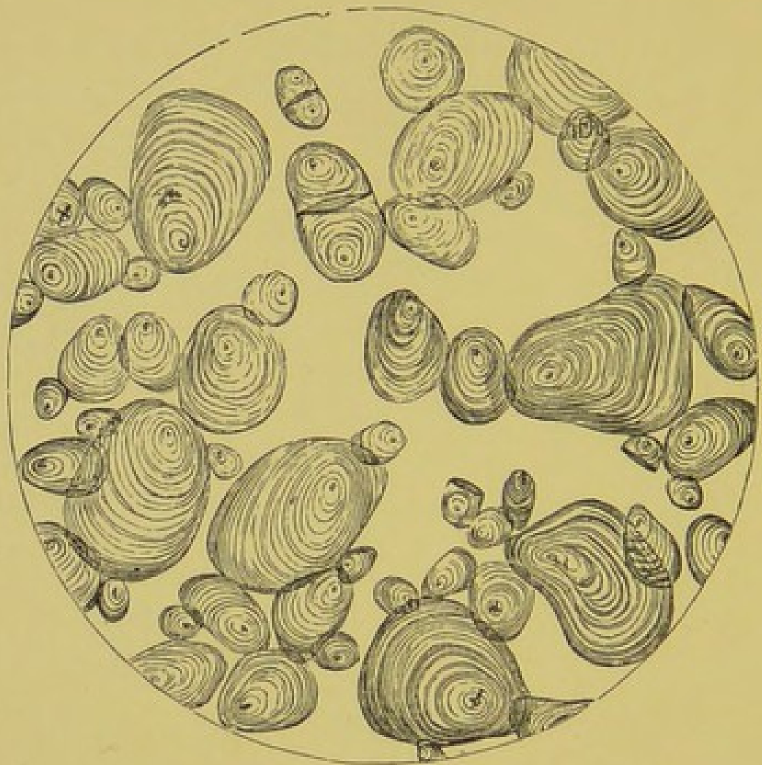


FIG. 18.—POTATO FLOUR. × 220.

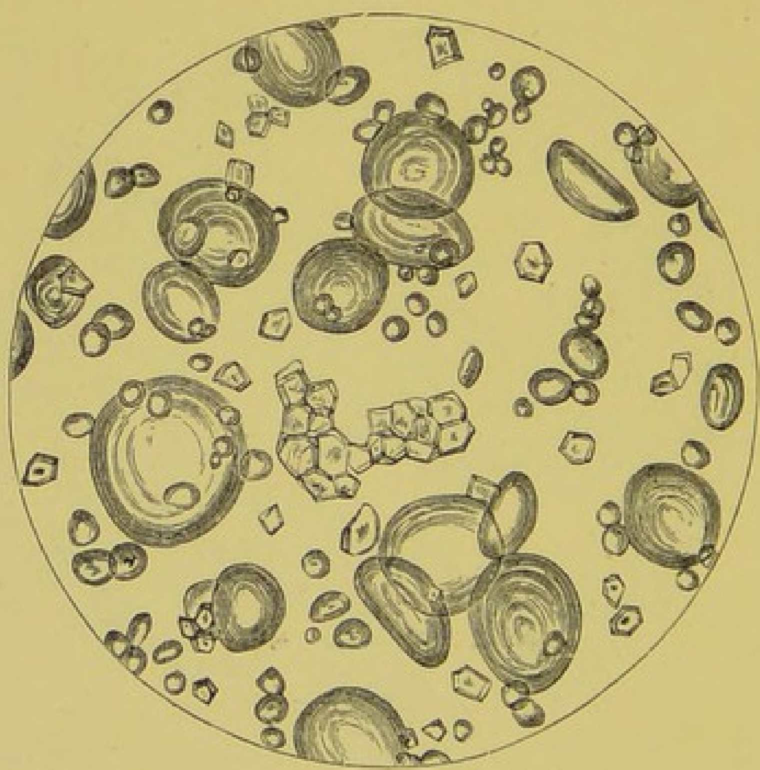


FIG. 19.—WHEAT FLOUR, ADULTERATED WITH RICE. × 420.

FIG. 20.—BARLEY FLOUR. ×420.

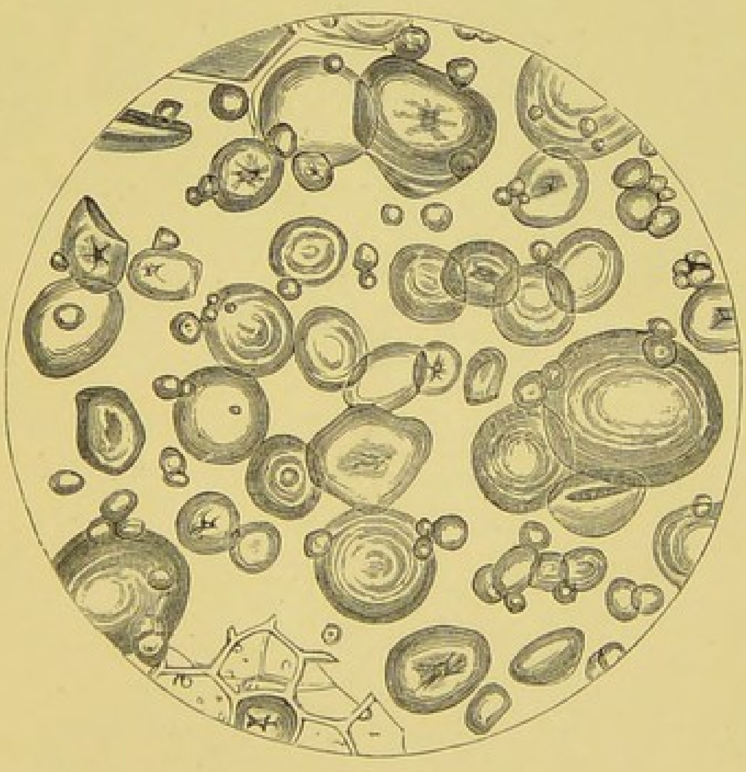


FIG. 21.—WHEAT FLOUR, ADMIXED WITH MAIZE FLOUR. ×420.

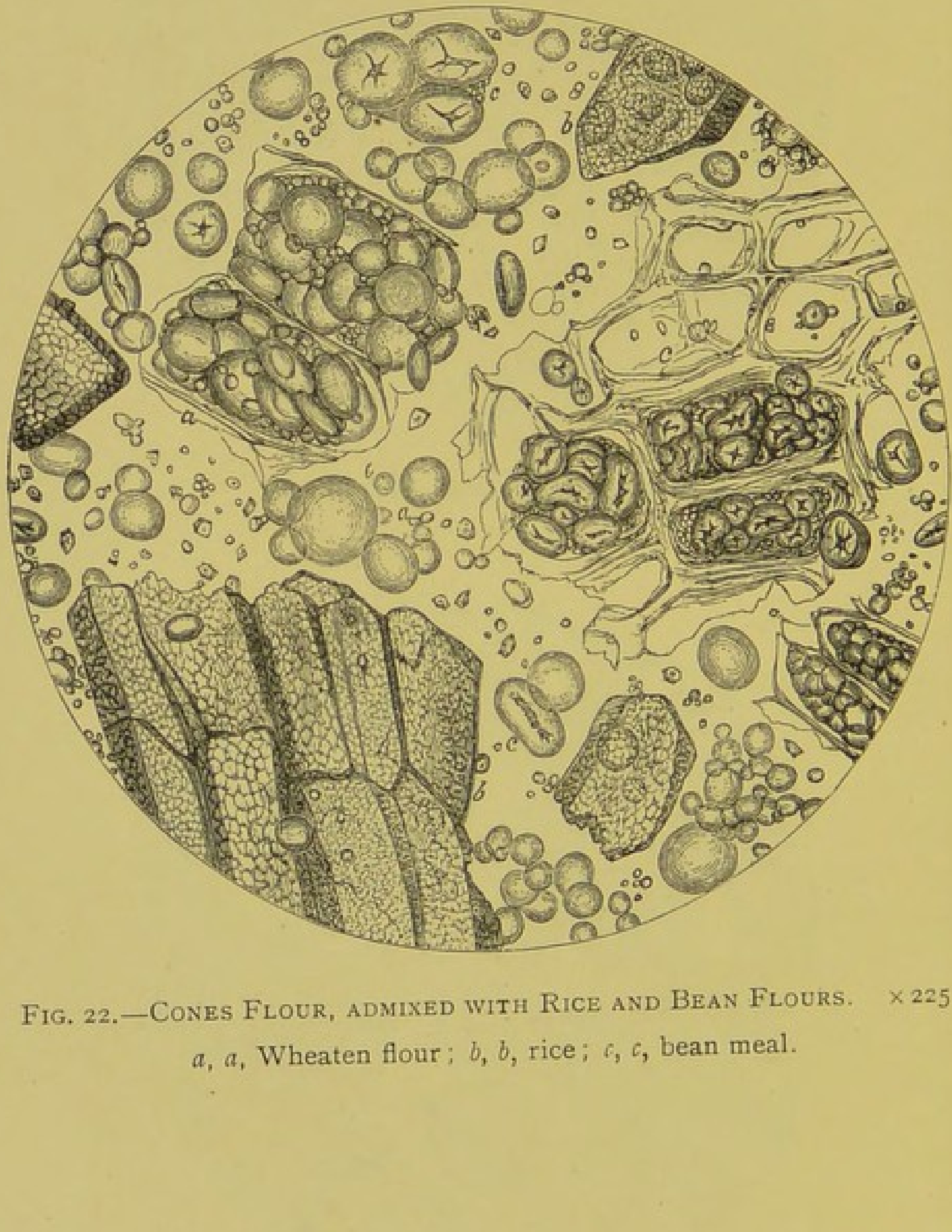


FIG. 22.—CONES FLOUR, ADMIXED WITH RICE AND BEAN FLOURS. ×225.
a, a, Wheaten flour; *b, b,* rice; *c, c,* bean meal.

FIG. 23.—OATMEAL, ADULTERATED WITH BARLEY MEAL. ×450.
a, *a*, Aggregates, or compound grains of oat starch ; *b*, *b*, barley starch.

Fig. 24.—**Durrha** or **Dari** (figure opposite: for description of the grain, see *ante*, pp. 29, 30).

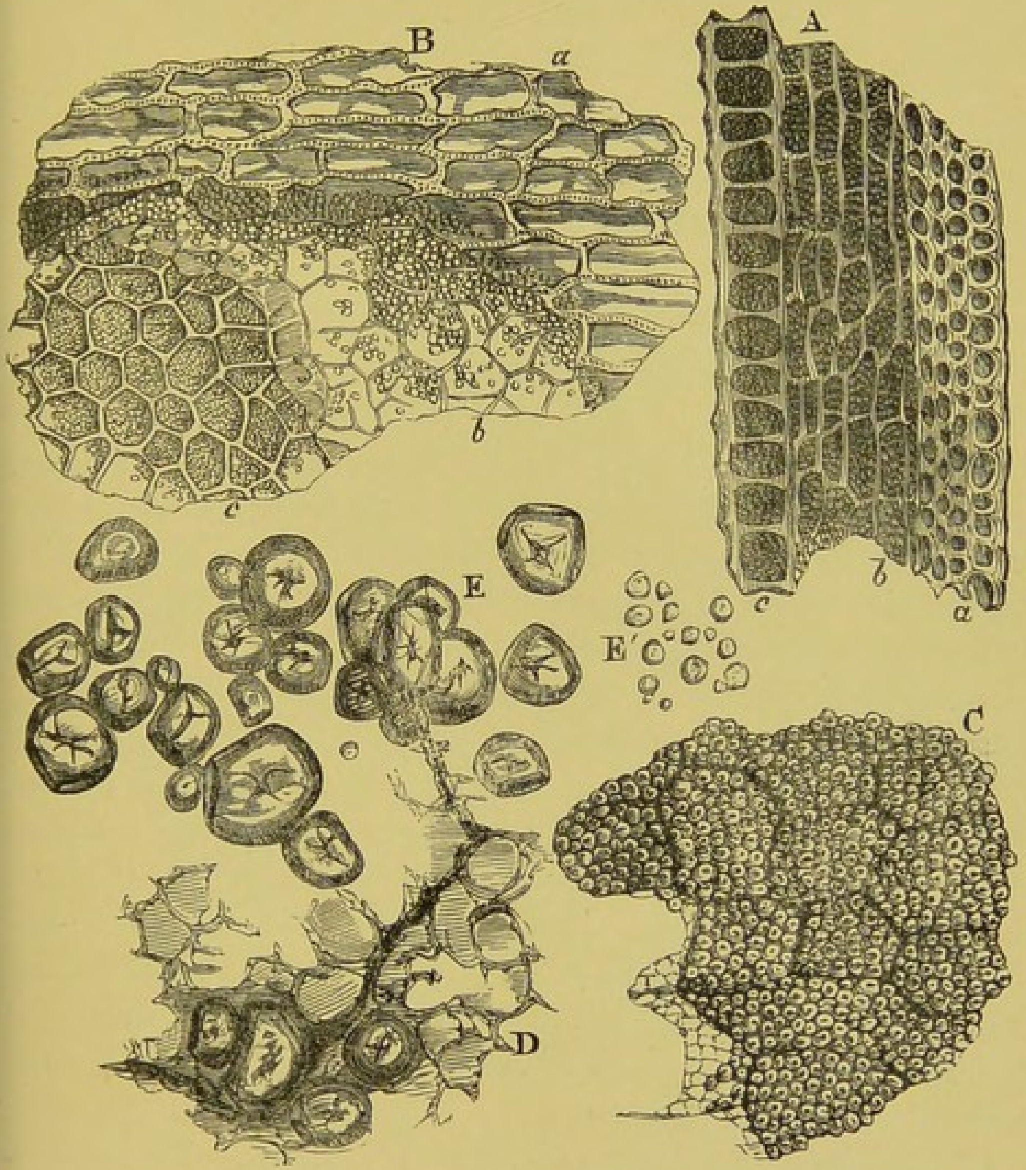


FIG. 24.—GRAIN OF DURRHA (INVESTING MEMBRANES, SUBSTANCE OF GRAIN, AND STARCH GRANULES).

A, Transverse section of external portion of grain (× 200); B, longitudinal section (× 200): *a*, *a*, layers of elongated, beaded cells; *b*, *b*, starch-bearing mesocarp; *c*, *c*, aleurone layer; C, starch parenchyma (× 100); D, pseudo-cell structure of parenchyma (× 500); E, E′, starch granules from substance of grain and mesocarp respectively (× 500).

WHEATEN BREAD.

Microscopical Characters of Wheaten Bread.

The discovery by the microscope of rye, beans, rice, etc., in wheaten bread, is very much less easy than in flour, because the heat to which bread is subjected in baking alters greatly the original form of the starch granules, so rendering their identification most difficult, and in some cases impossible. The characters of the starches of the several flours have already been described. When it is impossible to recognize the starch granules under the microscope, by reason of the changes which they have undergone, search should be made for portions of the husk of the several grains, these being much less affected by the heat and moisture than the starch granules themselves. It is often difficult to detect the presence of boiled potato in bread, especially when only a small quantity has been used. The cells and granules are entirely broken up and destroyed. If potato has been employed in larger quantity, however, the addition may easily be discovered by the microscope.

Foreign Additions Detectable by the Microscope.—Rye, beans, rice, maize, potato, bone-dust, etc.

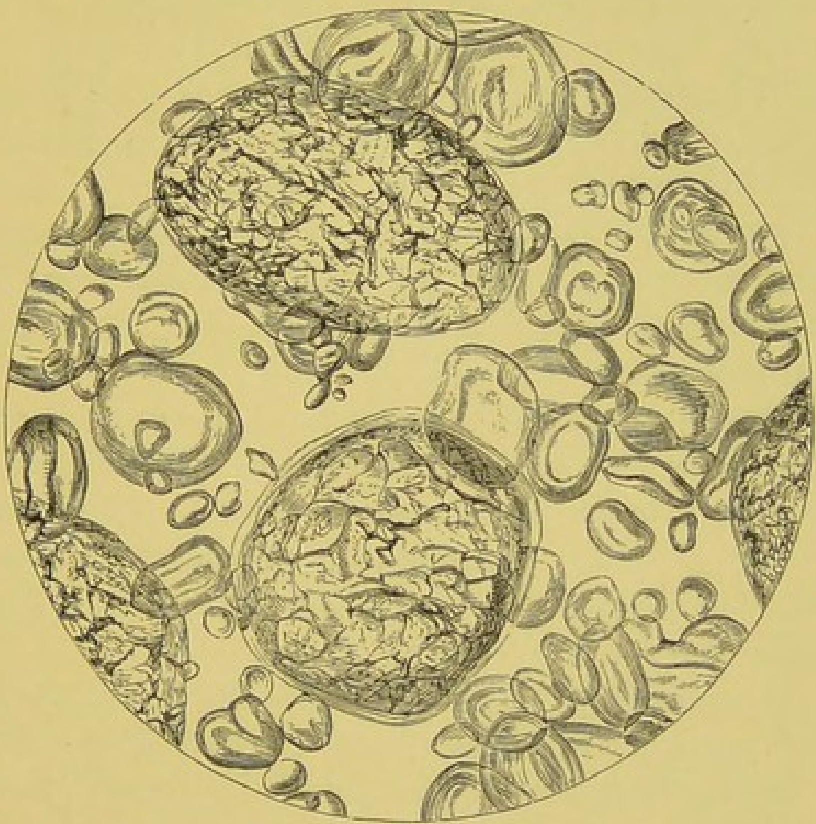


FIG. 25.—WHEATEN BREAD, WITH AN ADMIXTURE OF POTATO. × 420.

YEASTS (*Saccharomycetes*).

Including *Saccharomyces cerevisiæ* and numerous other species. [Group *Eumycetes* (the higher *mycetes*, or fungi): sub-group *Mycomycetes* (with septate mycelium): class *Ascomycetes* (with *ascospores*, or endogenous spores enclosed in an *ascus* or sac): sub-class *Gymnoasceæ* (with naked *asci*): family *Saccharomycetes*: genus *Saccharomyces*.] *Yeasts are alcohol-producing, gemmating or budding fungi, capable of developing ascospores.* This definition excludes some *Torulæ* (although they can cause alcoholic fermentation), and certain true *Saccharomycetes*.

Structure and appearance vary much. *Saccharomyces cerevisiæ* consists of spherical, slightly elliptical, or oval cells, occurring singly or in groups, and in short chains. In some other species the cells are considerably elongated and sausage-shaped. The propagation is effected by throwing off smaller cells, *gemmæ* or buds.

Several commercial varieties of yeast are used in the baking of bread: *e.g.*, brewery and distillers' yeasts, the so-called patent yeasts, and compressed yeasts. Brewers' yeast and a patent yeast are shown in the two opposite figures.

Fig. 26.—**Brewer's Yeast** (*Saccharomyces cerevisiæ*).

Fig. 27.—**Patent Yeast**: A different species of *Saccharomyces* from that shown in the previous figure: cells smaller, oval, and more often united in twos and threes.

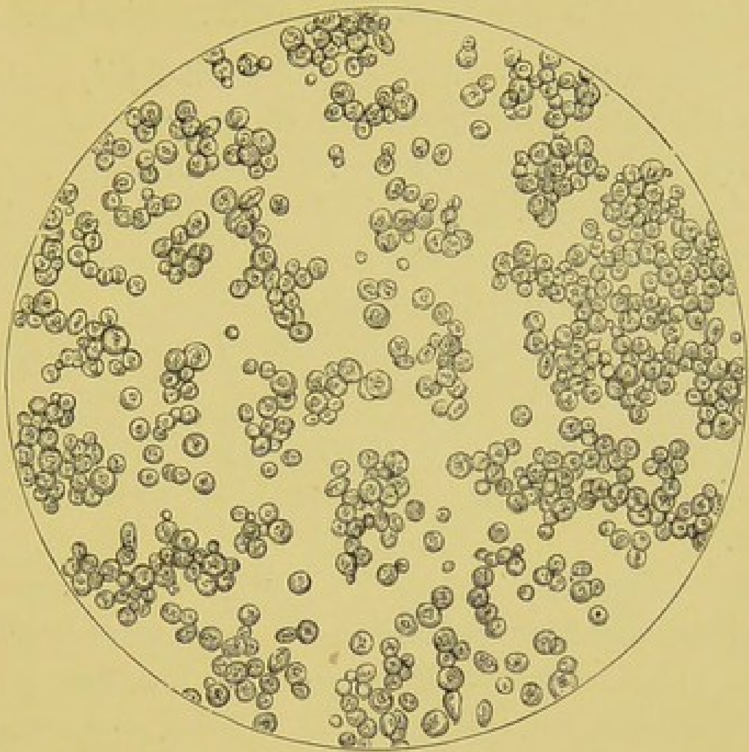


FIG. 26.—BREWERS' YEAST (SACCHAROMYCES). × 220.

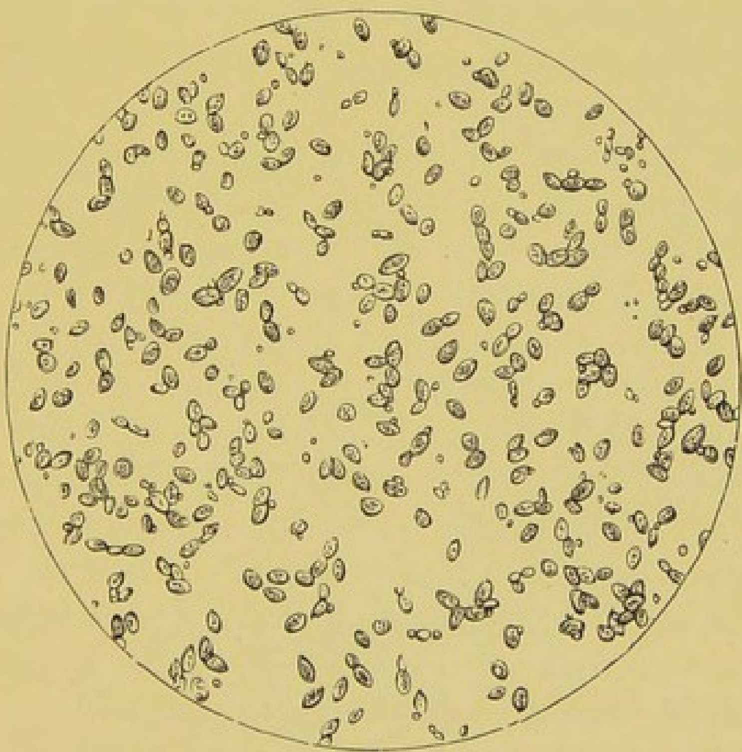


FIG. 27.—PATENT YEAST (SACCHAROMYCES). × 220.

MILDEWS AND MOULDS (*Hyphomycetes*).

Among the mycelial fungi growing on fruit, stale bread, and other articles of food, and on the surface of saccharine liquids, are *Penicillium glaucum*, the commonest mould of bread; *Mucor mucedo*, which imparts mustiness; *Eurotium Aspergillus glaucus*, *Monilia candida*, *Oïdium lactis*, and *Puccinia graminis* (mildew of grain).

Five figures on the following pages represent *hyphomycetes* in various stages:

Fig. 28.—*Hyphæ* (thread-like tubes) of fungi resembling species of **Oïdium** and **Monilia**, with *oidia*, and *chlamydospores* or *gemmæ*.

Fig. 29.—*Mycelium* (network of intertwined hyphæ with cells) of species of **Dematium**, showing *chlamydospores*.

Fig. 30.—*Mycelium* of **Penicillium glaucum**, exhibiting branching *hyphæ*, fructification by *conidia*, the *conidiophores* and *exospores*.

Fig. 31.—**Mucor mucedo** fully developed, showing globular *sporangia* and *endospores*.

Fig. 32.—Another species of **Mucor** (? *M. Racemosus*); copious growth, showing *mycelium*, with numerous *sporangiophores* and sporangia.

Puccinia graminis, *Eurotium Aspergillus glaucus*, and *Penicillium glaucum* (again), are figured further on, under 'Parasitic Diseases of the Cereal Grains' (pp. 50, 52, 53. Figs. 35, 36, 38, 39, 40).

It was at one time believed by Dr. Hassall, in common with many other investigators, who (not excepting Louis Pasteur himself) had not the advantage of being able to work with pure cultures, that the *Saccharomycetes*, or yeasts, could be developed from *Penicillium*, *Aspergillus*, and similar moulds, and, conversely, that transmutations of *Saccharomycetes* into *Hyphomycetes* were possible. In the light of later researches the consensus of opinion now is that no proofs have been obtained in support of such an hypothesis.[1]

[1] F. Lafar, *Technische Mykologie*, 1903, ii. 458.

[*For figures, see pp.* 43-45.]

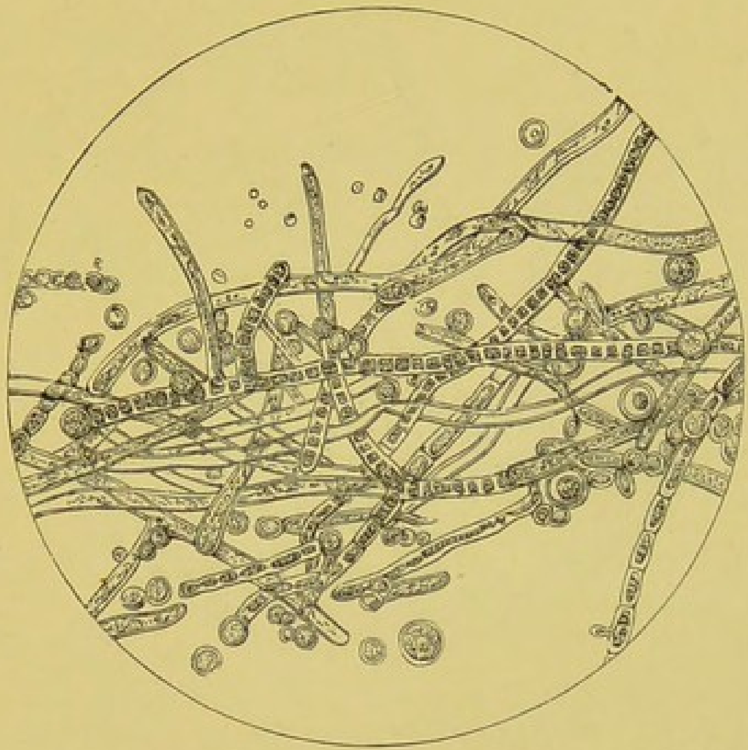


FIG. 28.—MOULDS, MYCELIAL FUNGI, OR HYPHOMYCETES. Hyphæ, oidia, AND chlamydospores OR gemmæ OF fungi resembling species of OIDIUM AND MONILIA. × *circa* 120.

FIG. 29.—A MOULD. Mycelium, WITH gemmæ, OF species OF DEMATIUM. × 100.

FIG. 30.—A COMMON MOULD. Mycelium OF PENICILLIUM GLAUCUM, showing branching hyphæ, fructification by conidia, conidiophores, and exospores. × 150.

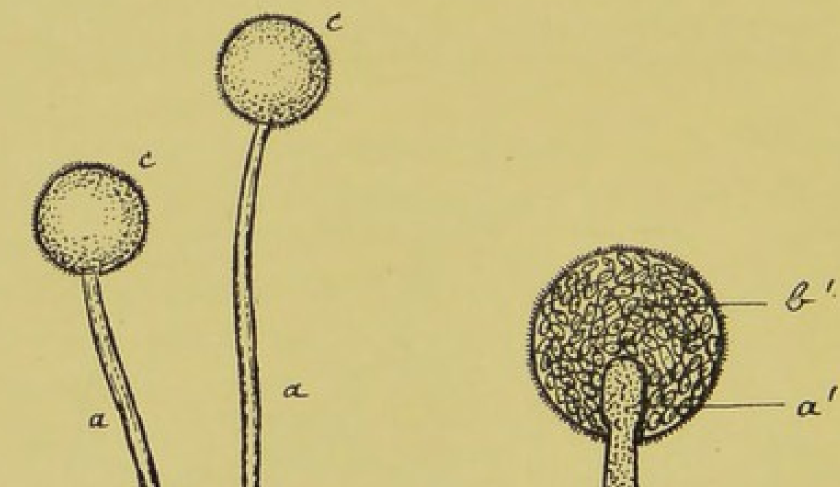


FIG. 31.—A COMMON MOULD. MUCOR MUCEDO, FULLY DEVELOPED, SHOWING GLOBULAR SPORANGIA AND ENDOSPORES.

A. *a*, *a*, Erect sporangiophores, branching from mycelium, *b*, *b*, each hypha bearing a sporangium, *c*, *c*. [× 95.] (E. G. C., *del.*).

B. Sporangium in vertical section, showing the *columella*, *a'*, and the endospores, *b'*. [× *circa* 200.] (E. G. C., *del.*, after *Brefeld*).

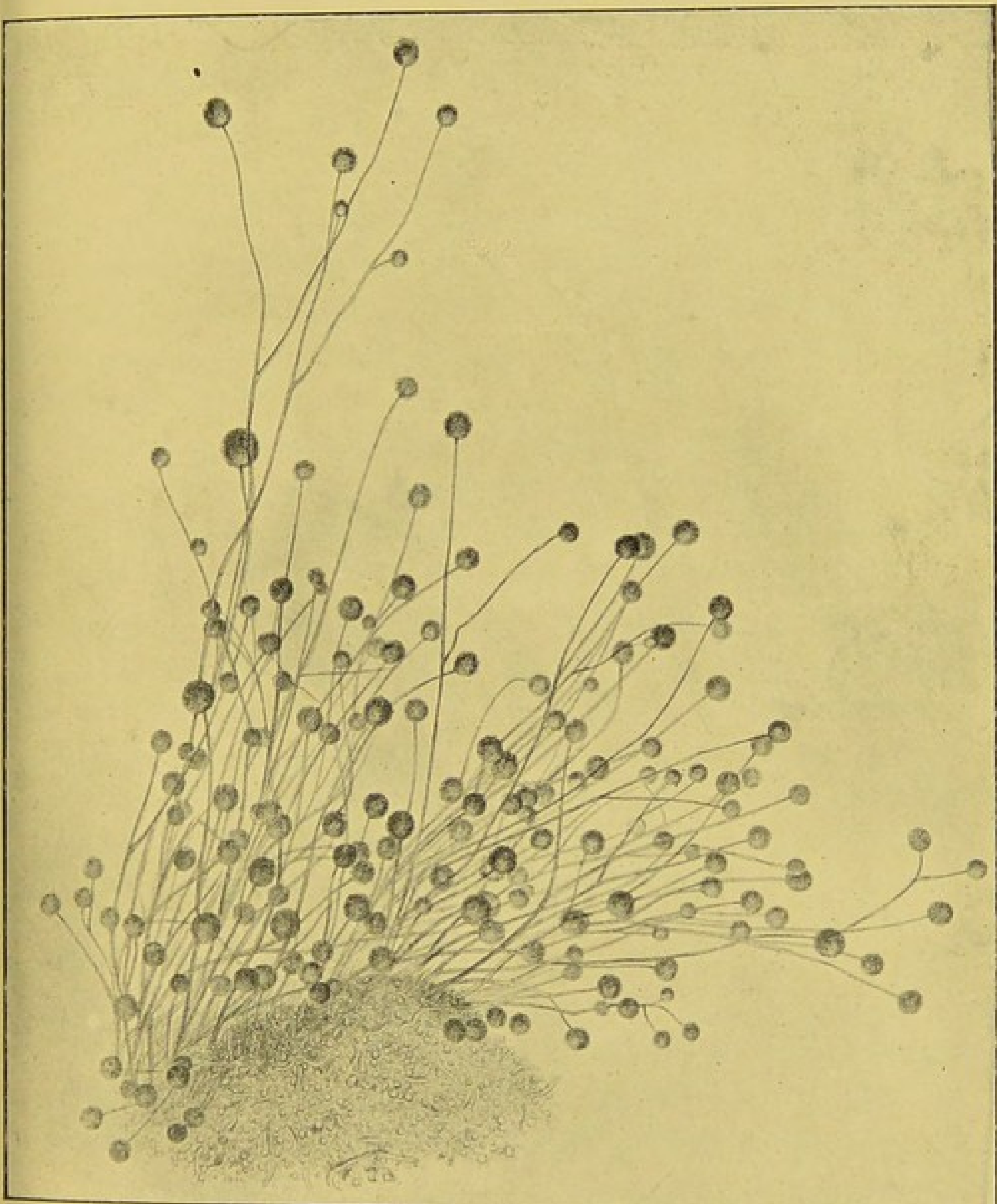


FIG. 32.—Another Species of MUCOR (*M. Racemosus* ?), showing mycelium, hyphæ, and sporangia.

[From a paper by A. H. HASSALL, M.D., *Med.-Chir. Trans.*, xxxvi., 48.]

PARASITIC DISEASES OF THE CEREAL GRAINS.

(A) VEGETABLE PARASITES.

Bunt, Smut Bolls,[1] **Smut Balls, Stinking Smut,** or **Pepper Brand** (*Tilletia tritici* = *T. caries*).—A fungus met with only in wheat, and easily to be distinguished by its disgusting smell. Spores highly characteristic, large and reticulated. Fig. 33.

Smut, or **Dust Brand** (*Ustilago hordei* and *avenæ*).—A fungus comparatively rare in wheat, not found in rye, but very common in barley and oats. Is without disagreeable odour. Spores several times smaller than the above. Fig. 34.

Rust, Red Rag, Red Robin, or **Red Gum** (*Uredo rubigo* and *U. linearis*); **Black Rust** (*Puccinia graminis*).—*U. rubigo* and *U. linearis* are merely different stages of development of *Puccinia graminis*, and form yellow and brown oval spots or bloches on the stem, leaf, and chaff. The spores of which the blotches consist are intermediate in size between those of *Tilletia caries* and *Ustilago hordei*; at first round, afterwards ovoid; and attached by a pellucid short and slender stem to the surface on which they are developed (*Uredo-spores*). After a time they become free. Figs. 35 and 36.

The ripe spores of *Puccinia graminis* are dark brown, club-shaped bodies (*Teleutospores*), having the broader end divided into two compartments filled with sporules. Fig. 36.

Ergot (*Claviceps purpurea*).[2]—Especially prone to attack rye, but observed in wheat and other cereals. Fig. 37. Transverse section of ergot: (*a*) Conidiophores, bearing

[1] Boll = a spherical pod, or vesicle. [O.E., *bolla*.]

[2] For recent work on the chemical composition and physiological action of Ergot, see papers by G. Barger and F. H. Carr, *Journ. Chem. Soc.*, xci. (1907), 337; G. Barger and H. H. Dale, *Bio-Chem. Journ.*, ii. (1907), 240; and H. H. Dale, *Journ. of Physiol.*, xxxiv., No. 3 (1906).

conidia, seen on the extremities; (*b*) compacted, septate, darker-coloured filaments, which constitute the black or purple portion of the fungus (the *sclerotium*); (*c*) cells, with contained spherules of fat, forming the body or colourless part (the *sphacelia*); (*d*, *e*, *f*) the conidia, and part of the *sphacelia* more highly magnified.

Yellow Mould (*Eurotium repens = Eurotium Aspergillus glaucus of De Bary*).—A bright yellow fungus found in stale bread. Fig. 38. Another stage of development of the same mould, possessing a dull green colour, is shown in Fig. 39.

Green or **Blue Mould** (*Penicillium glaucum*); also *P. citophilum* and *P. roseum*.—Fungi developed in stale bread. *P. glaucum*, green or bluish-green; the others greenish, brownish, or reddish-yellow. Fig. 40, *P. glaucum*, perfectly developed. The erect conidiophores are shown, with chains of conidia. [See also Fig. 30, for an earlier stage of *P. glaucum*.

Yeast (*Saccharomyces*).—Developed sometimes in bread, the baking of which has not destroyed the vitality of the ferment. (For description and figures, *vide* pp. 40, 41.)

[*For figures, see pp.* 49, 50, 51, 52, *and* 53.]

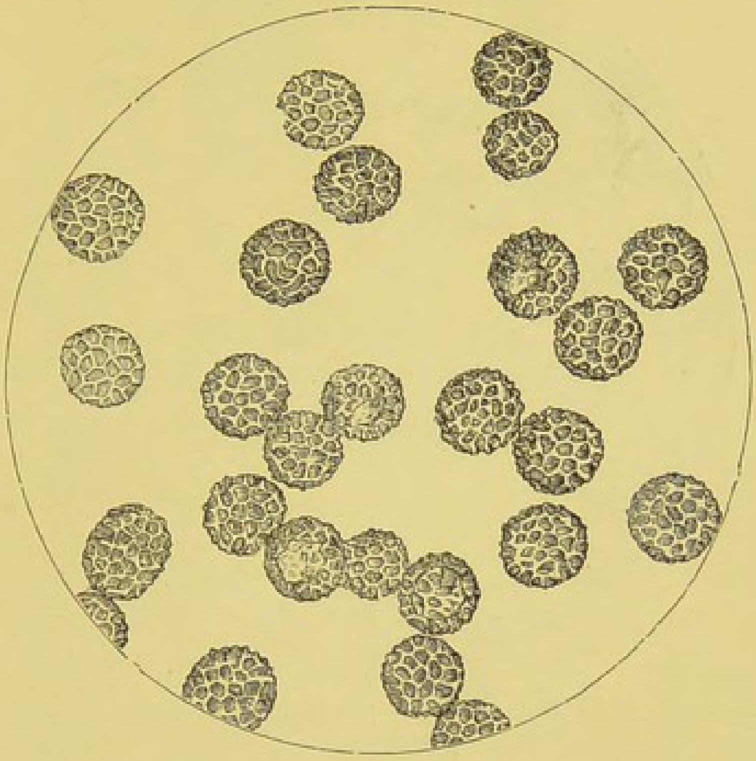


FIG. 33.—TILLETIA TRITICI = T. CARIES (BUNT, SMUT BOLLS, SMUT BALLS, STINKING SMUT, OR PEPPER BRAND). × 420.

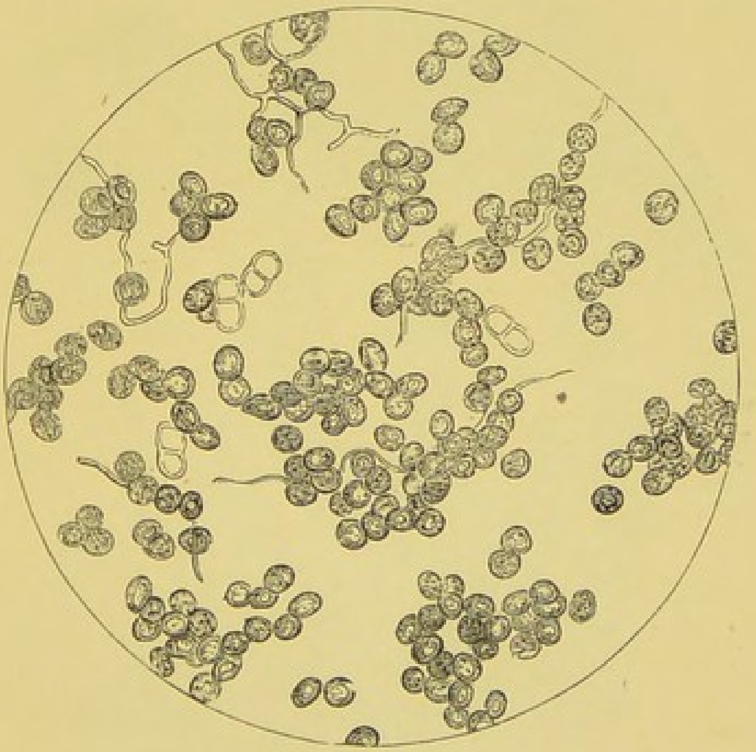


FIG. 34.—USTILAGO HORDEI (SMUT, OR DUST BRAND). × 420.

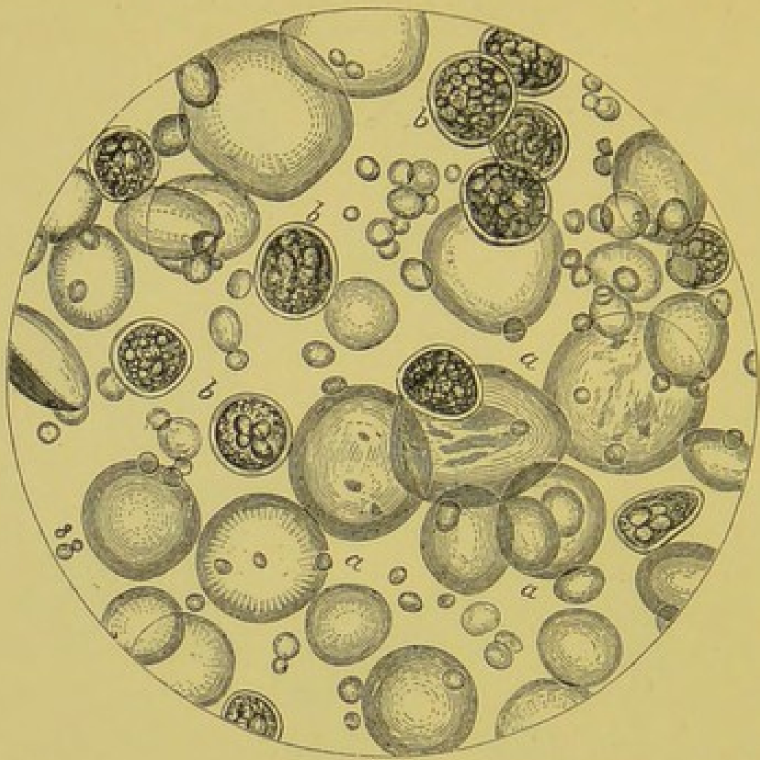


FIG. 35.—WHEAT INFESTED WITH RUST (THE UREDO RUBIGO STAGE OF DEVELOPMENT OF PUCCINIA GRAMINIS). ×420.

a, a, Wheat starch ; *b, b,* free *uredospores* of *P. graminis,* formerly believed to be a separate genus.

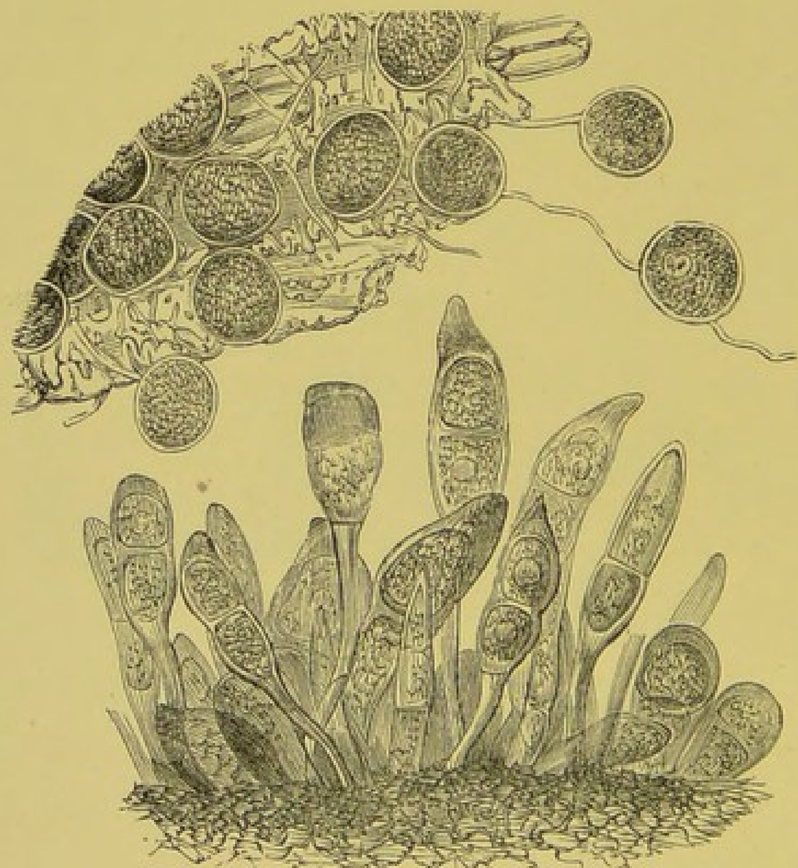


FIG. 36.—PUCCINIA GRAMINIS (BLACK RUST), DIFFERENT STAGES. ×500.

Upper part, *uredospores* on filaments ; lower part, *teleutospores.*

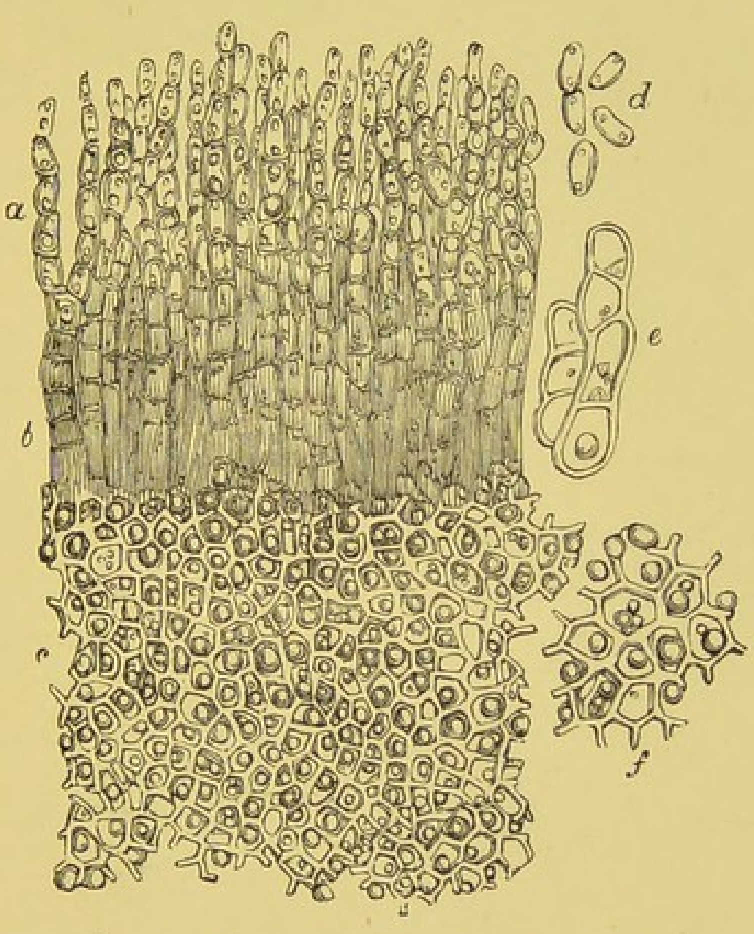


FIG. 37.—ERGOT (CLAVICEPS PURPUREA).

a, *Conidiophores* bearing *conidia*; *b*, compacted septate mycelium, which forms the *sclerotium*; *c*, *sphacelia* (×420); *d*, *e*, *f*, *conidia*, and part of the *sphacelia*, more highly magnified (×670).

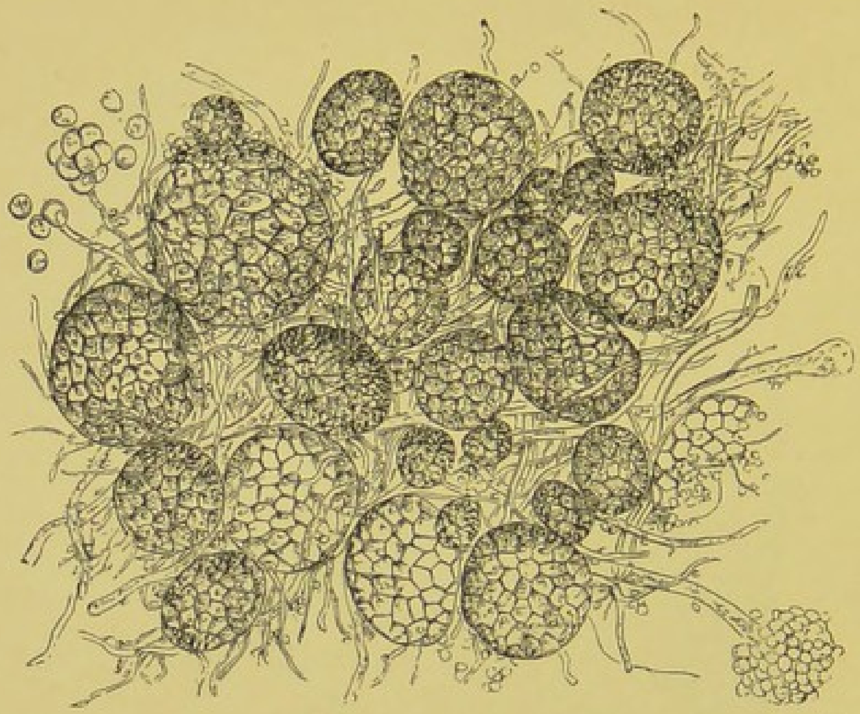


FIG. 38.—EURCTIUM REPENS = EUROTIUM ASPERGILLUS GLAUCUS (DE BARY): (A YELLOW OR GREEN MOULD).

The *ascus* fructification stage of Aspergillus glaucus: *cleistocarps, or* 'closed fruits,' consisting of spherical *perithecia*, investing the *asci*, each ascus containing eight *ascospores*. × 420.

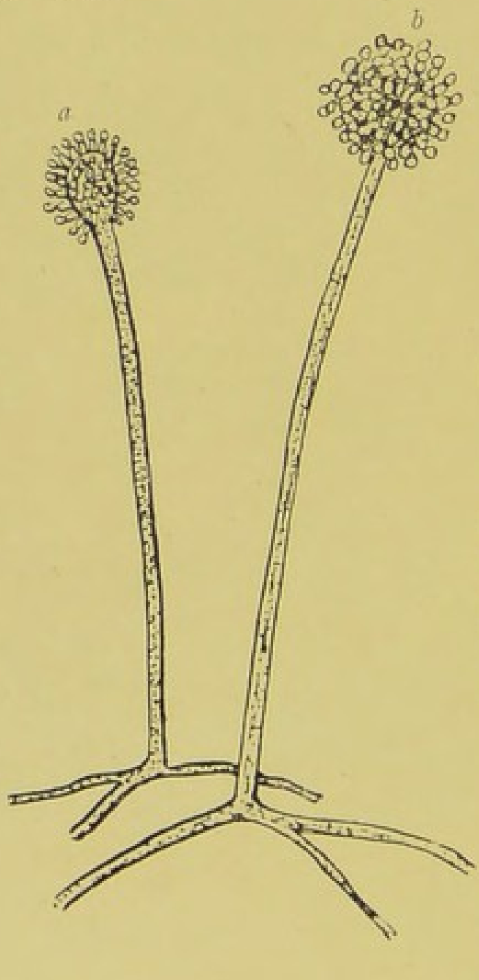


FIG. 39.—EUROTIUM ASPERGILLUS GLAUCUS.

Showing conidiophores, bearing on bulbous terminations radial *sterigmata* (*a*), from which chains of *conidia* (*b*) are abstricted. × ca. 350.

[E. G. C., *del.*]

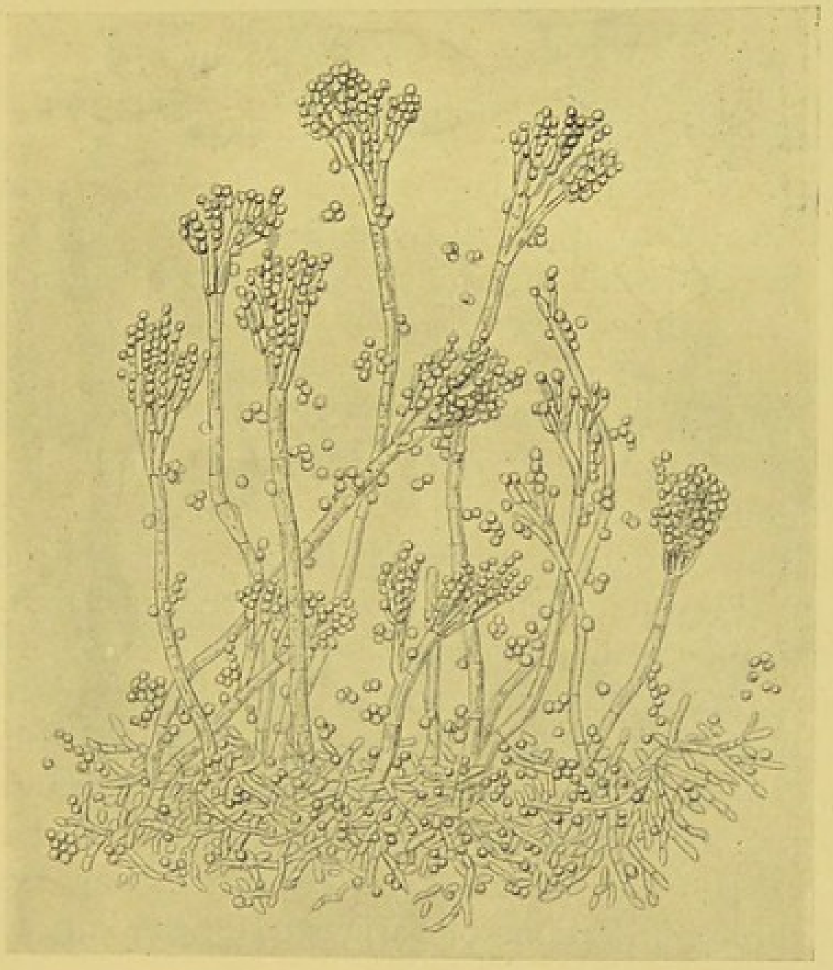


FIG. 40.—PENICILLIUM GLAUCUM (GREEN OR BLUE MOULD): Showing erect *conidiophores* bearing chains of conidia. × 220.

[A. H. HASSALL, *Med.-Chir. Trans.*, xxxvi., 1853, p. 29.]

(B) A Poisonous Grass.

Bearded or **Poisonous Darnel** (*Lolium temulentum*, fam. *Gramineæ*).—Bearded darnel has not infrequently become intermixed with wheat or other cereal grains: but its detection in flour by the microscope is easy.

Histology of the Grain.—Differs greatly from that of rice, oat, or any other of the cereals. The outer portion is formed of three principal membranes: (1) An external coat, the epidermis of the pericarp (not shown in the figure), consisting of a single layer of vertically disposed beaded cells; (2) a single layer of cells with their long axes arranged transversely, somewhat like corresponding cells in rice. But the tissues of rice-husk, and cells of the bran of *Lolium*, are very distinct in other respects. The cells of the former are long and narrow fibres: those of the latter are only between twice and thrice as long as broad. The cells of the succeeding membrane—(3), the spermoderm—are ranged in two layers, and vertically, thus differing from the rest of the cereals, excepting rice. The aleurone cells form a single layer, and resemble those of other grains. The starch granules are polygonal, like those of rice, but are much smaller, and, as is the case with oat-starch, they are often united into aggregations of various sizes, the larger groups consisting of fifty or sixty grains.

Fig. 41.—*Lolium temulentum:* Sectional surface view, and cross section; also starch aggregates, and separate granules: *a, a,* transversely disposed cells; *b, b,* two layers of vertical cells of the spermoderm; *c, c,* aleurone cells.

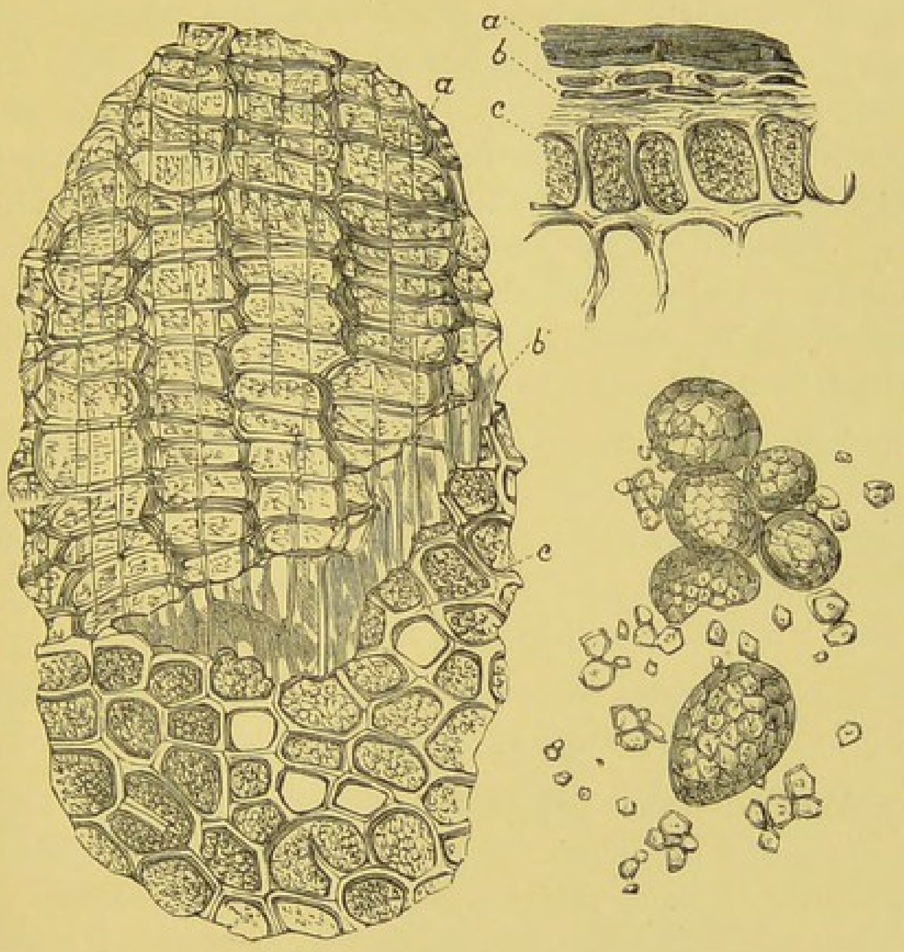


FIG. 41.—SEED OF LOLIUM TEMULENTUM, OR BEARDED DARNEL. SURFACE VIEW AND CROSS SECTION (× 200); WITH STARCH AGGREGATIONS AND GRANULES (× 500).

a, *a*, transverse cells of pericarp; *b*, *b*, vertical cells (two layers) of spermoderm; *c*, *c*, aleurone cells.

(c) Animal Parasites.

Galls of Wheat, Eelworms, Ear Cockles, Purples, Cockle Galls, False Ergot, or **Peppercorn** (*Tylenchus tritici* = *Anguillula tritici* = *Vibrio tritici*).—Grains affected turn green, and ultimately black : become rounded, resembling a peppercorn. The husks are spread out and the awns twisted, by which means the infected ears are readily observable among the standing corn. The blighted grains are filled with a moist cotton-like substance, and contain no flour. This substance consists of myriads of eel-shaped wormlets, which exhibit the most active movements when moistened with water. Other Anguillulidæ are sometimes met with in moist and damaged flour. Fig. 42.

The **Meal Mite** (*Tyroglyphus siro* = *Acarus farinæ*).—Never present in flour unless damaged. Differs considerably in structure from the sugar mite (*q.v.*). Fig. 43. *T. siro*, from the ovum to the mature state, from wheat flour : *a*, *a*, ova ; *b*, young ; *c*, male ; *d*, female.

The **Feathered Mite** (*Glyciphagus plumiger* = *Acarus plumiger*).—Another species of mite from wheat. Fig. 44.

The **Wheat Midge** (*Cecidomyia tritici*).—A two-winged fly, seen early in June, from 7 to 9 p.m., flying about wheat for the purpose of depositing its eggs within the blossoms. The eggs become hatched into yellow maggots or caterpillars, which cause the non-development of the ovary, so that the grain never advances beyond its condition when the flower first expands. Usually only grains here and there in an ear are affected. Fig. 45.

The **Weevil** (*Calandra granaria*).—A minute, dark reddish-brown snout-beetle, of frequent occurrence in damaged flour and grain. Presence revealed by a little hole on the surface of the grain, which will be found to consist chiefly of a shell with the starch eaten away. Fig. 46.

[*For figures, see pp.* 57, 58, *and* 59.]

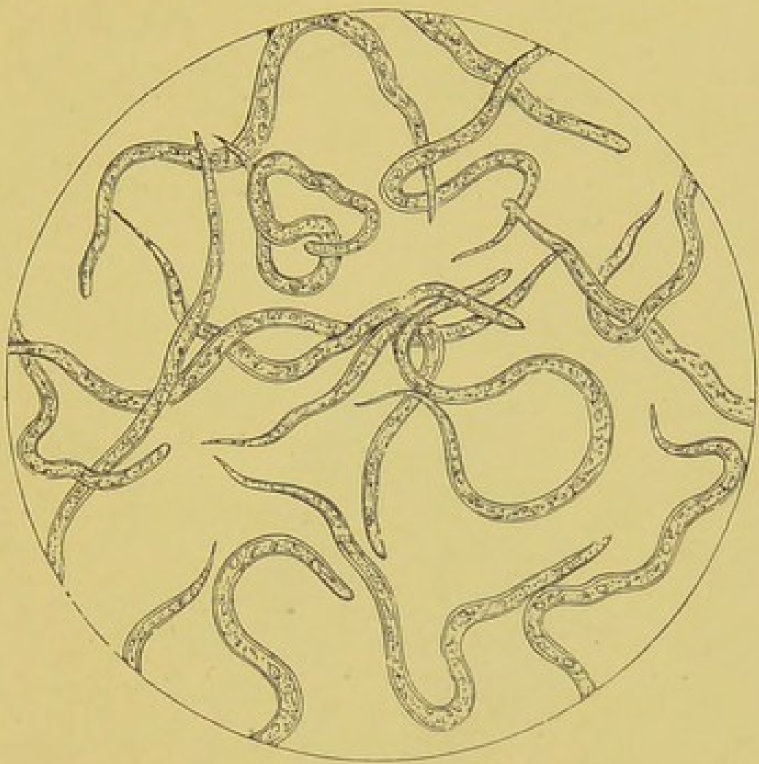


FIG. 42.—TYLENCHUS TRITICI = ANGUILLULA TRITICI : EAR COCKLES, PURPLES, OR PEPPERCORN. × 100.

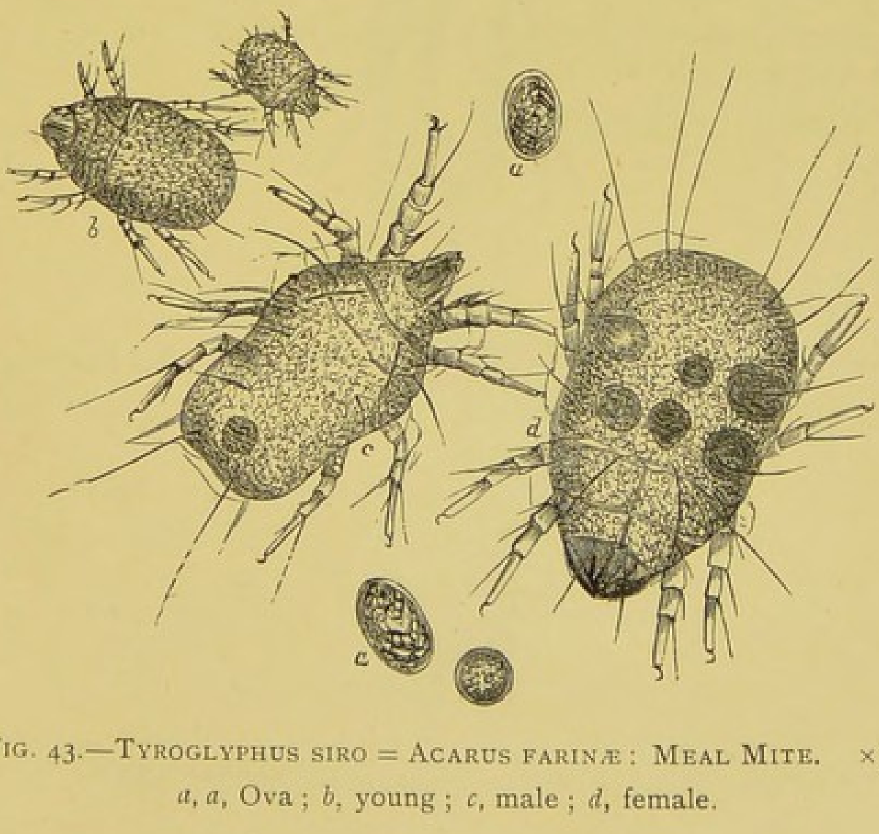


FIG. 43.—TYROGLYPHUS SIRO = ACARUS FARINÆ : MEAL MITE. × 75.
a, *a*, Ova ; *b*, young ; *c*, male ; *d*, female.

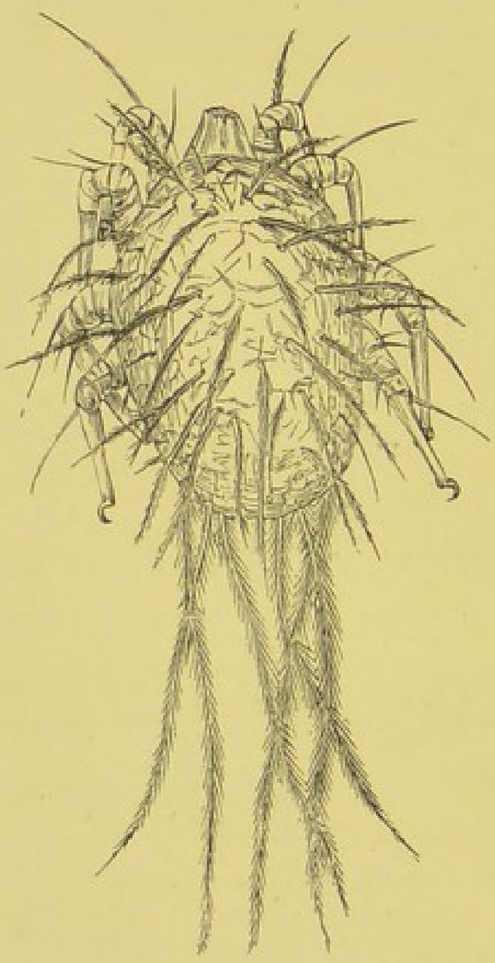


FIG. 44.—GLYCIPHAGUS PLUMIGER = ACARUS PLUMIGER, THE FEATHERED MITE. × 220.

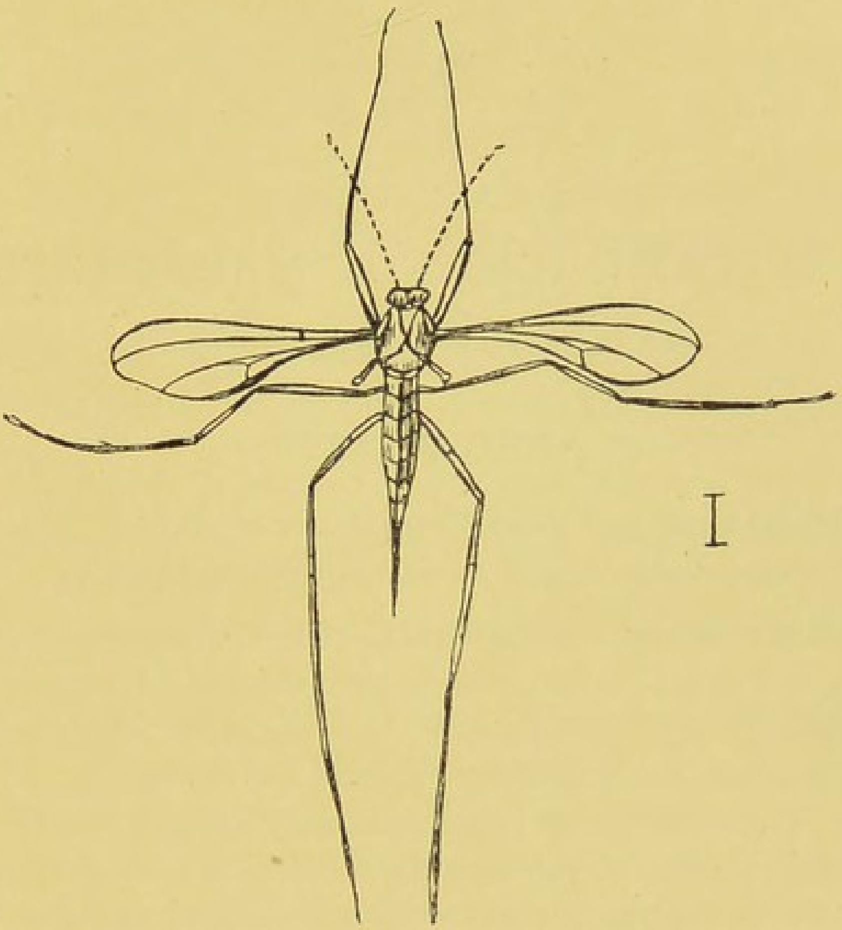


FIG. 45.—THE WHEAT MIDGE (CECIDOMYIA TRITICI), GREATLY MAGNIFIED.
[E. G. C., *del.*, after J. Curtis.]

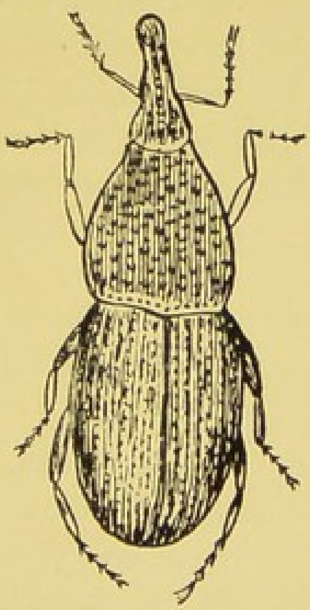


FIG. 46.—THE GRANARY WEEVIL (CALANDRA GRANARIA), MUCH ENLARGED.
[E. G. C., *del.*, after J. Curtis.]

ORD. SCITAMINEÆ, FAM. MARANTACEÆ; *et alia.*

ARROWROOTS.

(A) MARANTA, OR WEST INDIA ARROWROOT (*Maranta arundinacea*, ord. *Scitamineæ*, fam. *Marantaceæ*).

Characters of the Starch Granules.—Usually more or less oblong and ovate, sometimes mussel-shaped, or even almost triangular: vary considerably in size, each larger granule being marked by a number of delicate concentric lines or striæ: at the broad or large extremity of each the hilum is distinctly visible, sometimes as a circular spot or dot, but generally marked by a short, sharp line, running transversely across the granule. This is a distinctive feature by which Maranta arrowroot can readily be identified. By the action of boiling water the starch granules are greatly altered, swelling to twenty or thirty times their original volume, and becoming more or less rounded: at the same time the striæ and hilum are obliterated, the membrane of each grain is ruptured, and granular matter escapes from its interior. Fig. 47.

(B) CANNA, QUEENSLAND, OR TOUS LES MOIS ARROWROOT (*Canna edulis* and other species of *Canna*, ord. *Scitamineæ*, fam. *Cannaceæ*).

Characters of the Starch Granules.—Very large, flat, broad, and ovate; sometimes pointed at the narrow end. Hilum situated in the narrow extremity of the granule: concentric rings exceedingly close together and regular. Grains larger, and rings much more numerous and even than in potato starch (the most closely similar product): also under polarized light Canna arrowroot exhibits more regular crosses than potato. Fig. 48.

(c) CURCUMA, OR EAST INDIA ARROWROOT (*Curcuma angustifolia, rubescens,* etc. Ord. *Scitamineæ,* fam. *Zingiberaceæ*).

Characters of the Starch Granules.—Elongated and irregularly ovate: being flat, they present but little lateral shading. In size vary considerably; many much exceed the largest Maranta granules. The lines which mark the surface are tolerably distinct, but describe segments of circles only. Hilum usually very indistinct, and sometimes invisible; is at the narrow or pointed extremity of each granule. Fig. 49.

(d) TACCA, TAHITI, OR OTAHEITE ARROWROOT (*Tacca pinnatifida,* fam. *Taccaceæ*).

Characters of the Starch Granules.—Somewhat resemble those of sago, but very much smaller. When viewed sideways, muller-shaped, with truncate or dihedral bases: when seen endways appear circular, and occasionally angular or polyhedral. Rings few and indistinct: hilum circular, sometimes fissured in a stellate manner. Fig. 50.

[*For figures, see pp.* 62 *and* 63.]

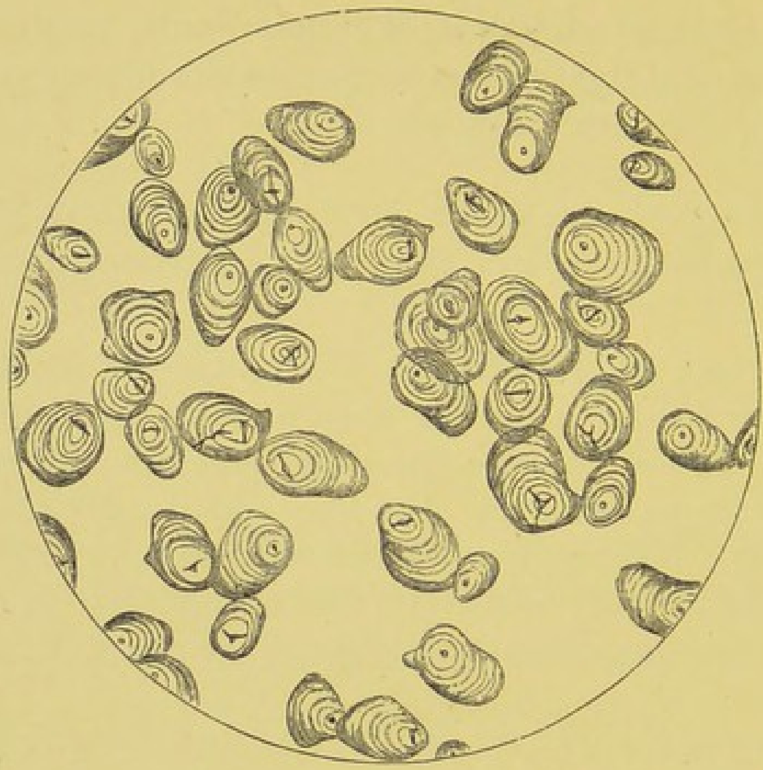


FIG. 47.—MARANTA, or WEST INDIAN ARROWROOT. × 240.

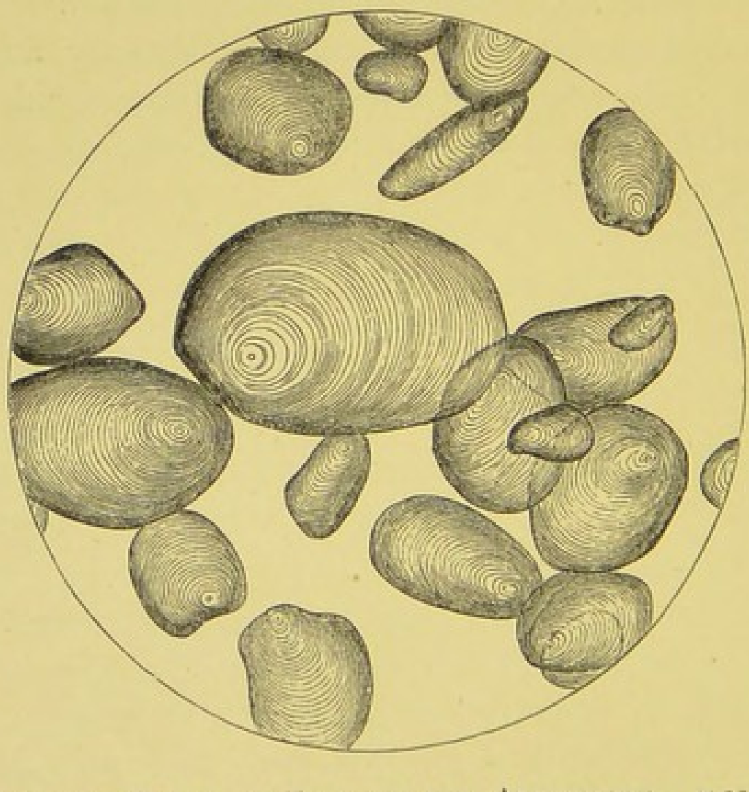


FIG. 48.—CANNA OR TOUS LES MOIS ARROWROOT. × 225.

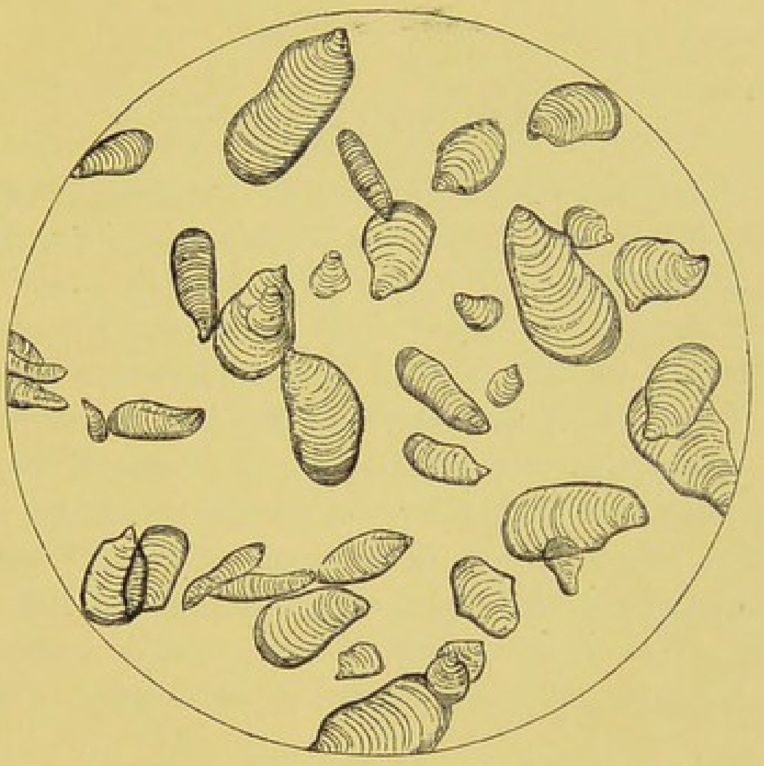


FIG. 49.—CURCUMA, OR EAST INDIAN ARROWROOT. ×240.

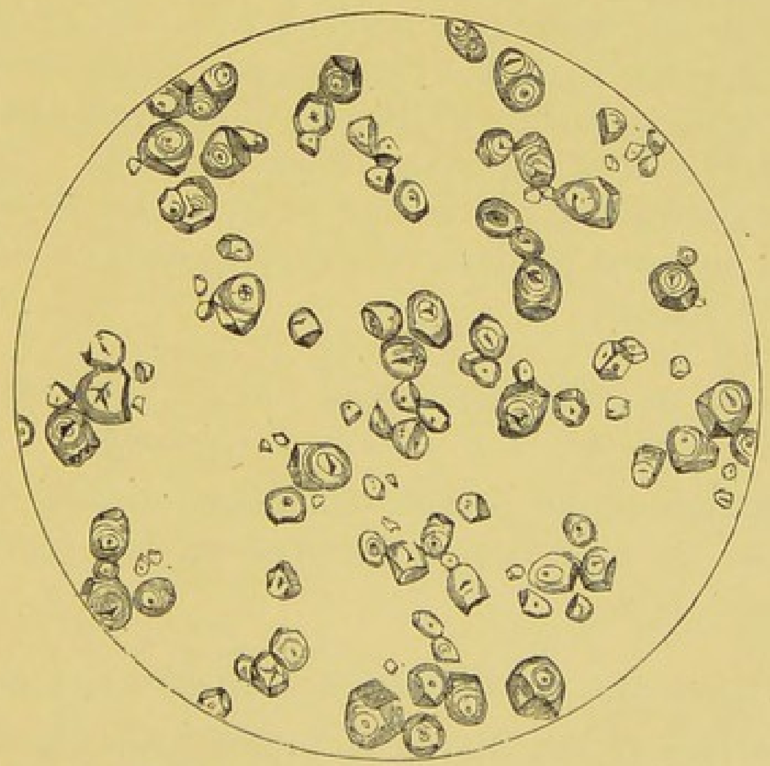


FIG. 50.—TACCA, TAHITI, OR OTAHEITE ARROWROOT. ×220.

ARROWROOTS—*continued.*

(E) MANIHOT, MANIOC, CASSAVA, OR BRAZILIAN ARROWROOT (the flour of *Manihot utilissima*, ord. *Tricoccæ*, fam. *Euphorbiaceæ*).

Characters of the Starch Granules.—Resemble rather closely those of Tacca arrowroot, but are considerably smaller, with a larger proportion of granules exhibiting a circular outline. Hilum usually fissured. Granules mostly single, but sometimes (and in the plant itself always) united into compound grains, each composed of two, three, or four granules. Hence, like those of sago, usually muller-shaped, though appearing circular when seen endways. Fig. 51.

(F) POTATO, OR BRITISH ARROWROOT (*Solanum tuberosum*, ord. *Personatæ*, fam. *Solanaceæ*).

Characters of the Starch Granules.—Vary greatly in size and shape: some very small and circular, others large, ovate, or oyster-shaped. The larger granules exhibit very distinct concentric rings: hilum small, but well defined, and situated in narrow extremity of each granule. Not infrequently, granules may be seen of an oval form, divided by a fine line into two portions or segments, each provided with a hilum. Fig. 52.

(G) MAIZE ARROWROOT, INDIAN CORN FLOUR, OR CORN FLOUR (*Zea Mais*, fam. *Gramineæ*).

Characters of the Starch Granules.—Already described (see *ante*, p. 21): figured again here, for convenience. Fig. 53.

(H) RICE ARROWROOT (*Oryza sativa*, fam. *Gramineæ*).

Characters of the Starch Granules.—Already described (see *ante*, p. 25), but shown again for comparison. Fig. 54.

(1) Arum, or Portland Arrowroot (*Arum maculatum, esculentum,* and *Italicum,* ord. *Spadicifloræ,* fam. *Araceæ*).

Not at present an article of commerce.

Characters of the Starch Granules. — Very closely resemble those of Tacca arrowroot, but are much smaller; and the difference in size is sufficiently constant and considerable to ensure ready discrimination between the two kinds of arrowroot. Fig. 55.

Sophistications Detectable in Arrowroots by the Microscope.— Use of cheaper materials, such as sago meal, potato starch. and tapioca starch, admixed with, or substituted for, the more costly Maranta arrowroot; and addition or substitution of foreign starches not usually recognized as arrowroots.

[*For figures, see pp.* 66, 67, *and* 68.]

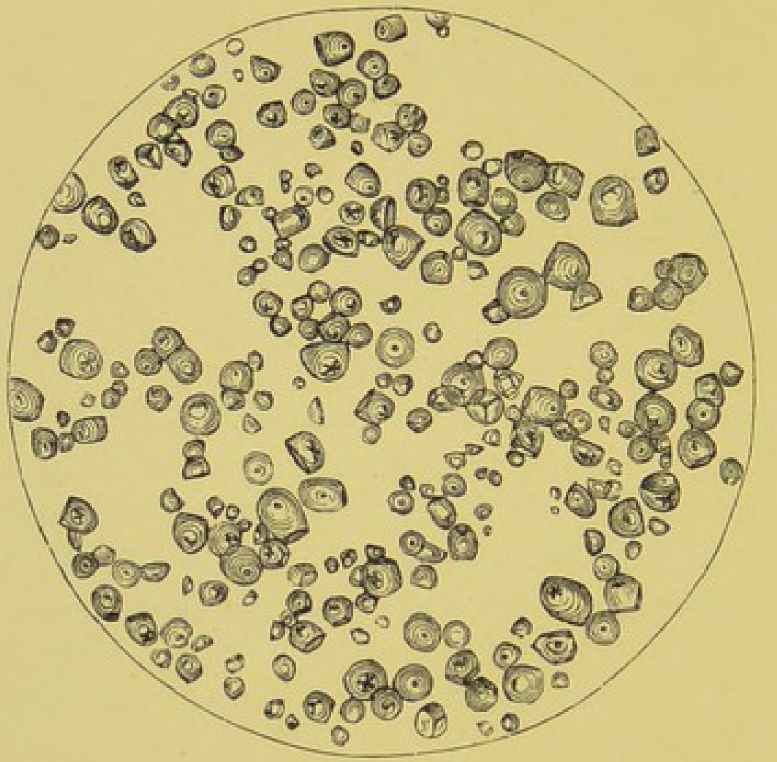


FIG. 51.—MANIHOT, OR BRAZILIAN ARROWROOT. × 225.

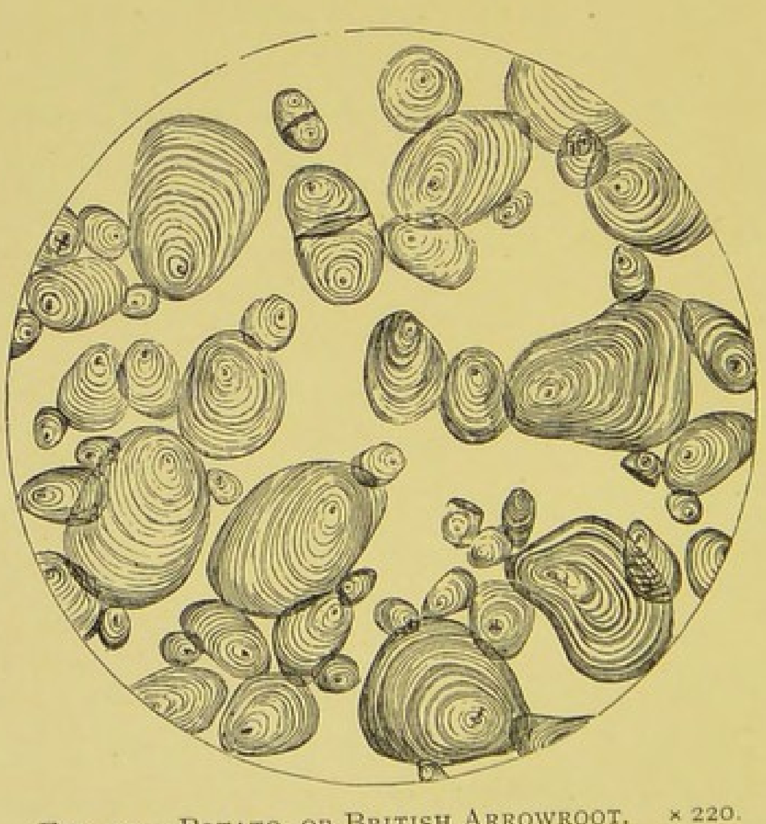


FIG. 52.—POTATO, OR BRITISH ARROWROOT. × 220.

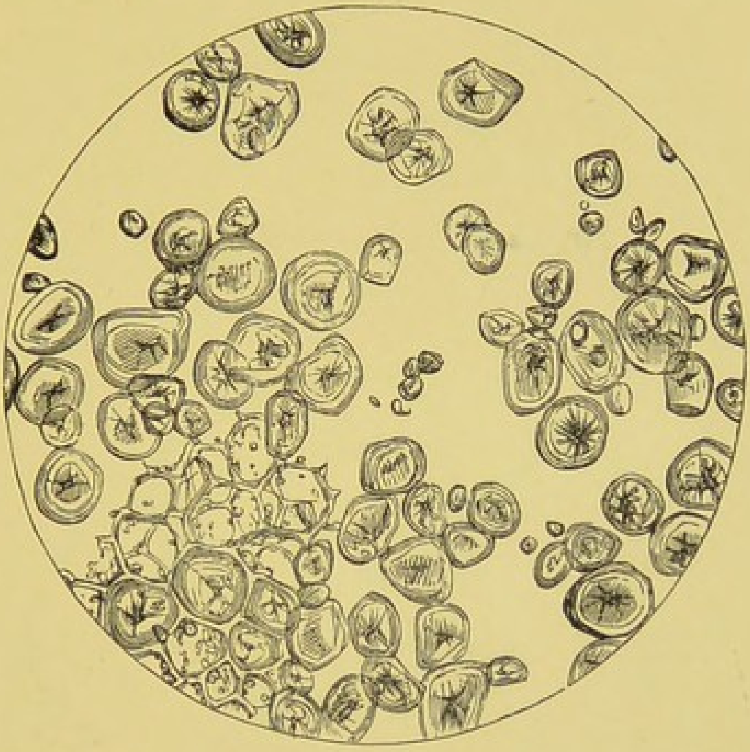


FIG. 53.—MAIZE ARROWROOT, OR CORN FLOUR. × 420.

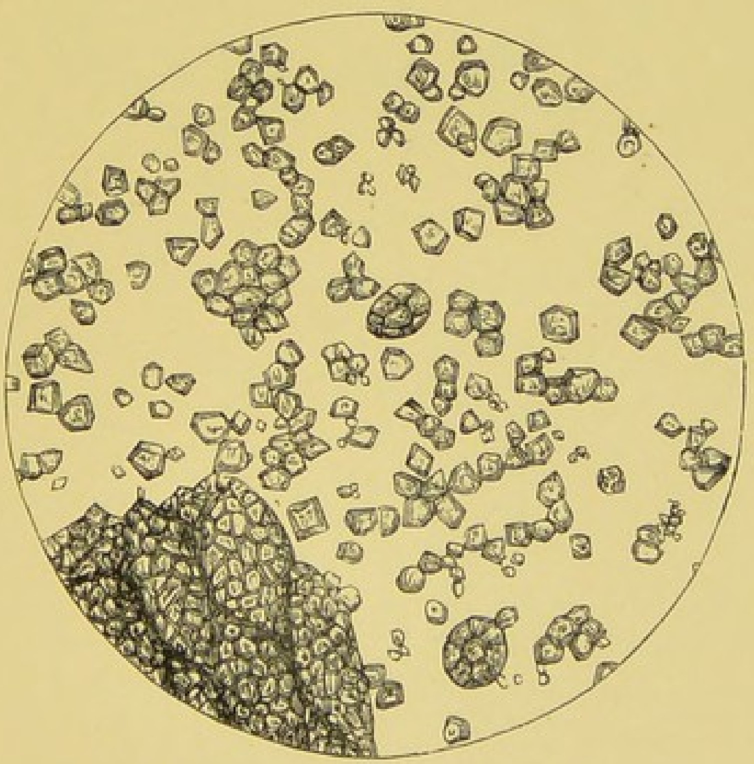


FIG. 54.—RICE ARROWROOT. × 420.

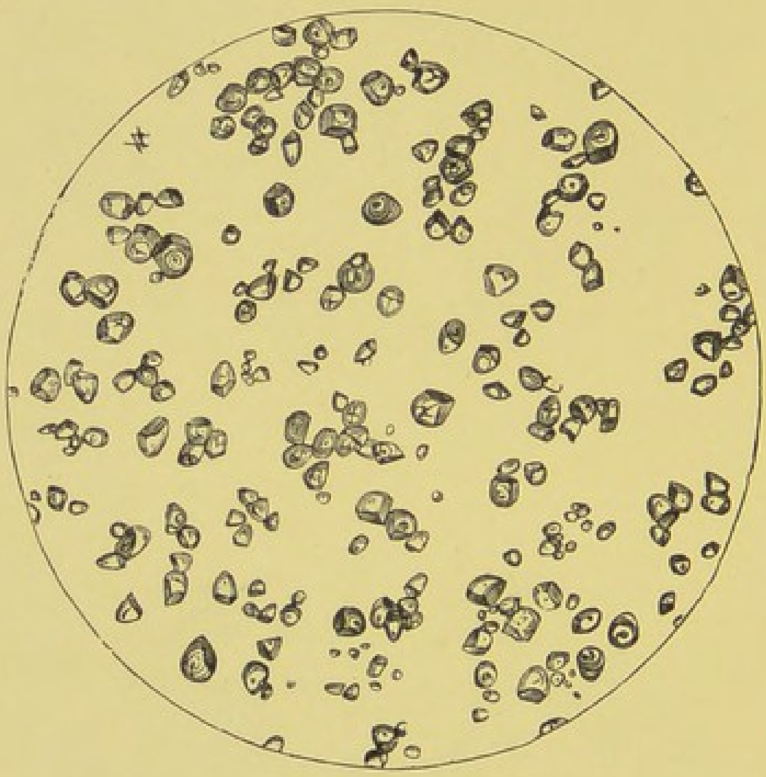


FIG. 55.—ARUM, OR PORTLAND ARROWROOT. × 240.

[Sago.

ORD. SPADICIFLORÆ, FAM. PALMÆ; AND ORD. CYCADINÆ, FAM. CYCADACEÆ.

SAGO.

THE starch obtained from *Metroxylon læve* (*Sagus lævis*), *M. Rumphii* (*Sagus Rumphii*), *M. Sagu*, etc., ord. *Spadicifloræ*, fam. *Palmæ:* also from *Cycas circinalis* and *C. revoluta*, ord. *Cycadinæ*, fam. *Cycadaceæ.*

Characters of the Starch.—(*a*) *In Raw Sago-Meal and Flour.* The granules are of considerable size, elongated, usually rounded at one end, which is sometimes the larger, and, owing to mutual pressure of the adjacent particles, truncated at the other extremity. *Hilum* sometimes denoted by a circular dot, but often fissured, when it appears as a slit, cross, or star. Surrounding it, a few indistinct rings may usually be perceived in some of the granules. Examined with the polariscope, generally a black cross is seen, the hilum being the centre. Fig. 56.

(*b*) *In Granulated and Pearl Sago.* The foregoing characters can be traced only imperfectly in the majority of the granules, the effect of the heat applied being greatly to alter the appearance of the starch. Fig. 57.

Extraneous Matters Detectable by the Microscope.—Potato flour, from which factitious sago has frequently been made. Fig. 58.

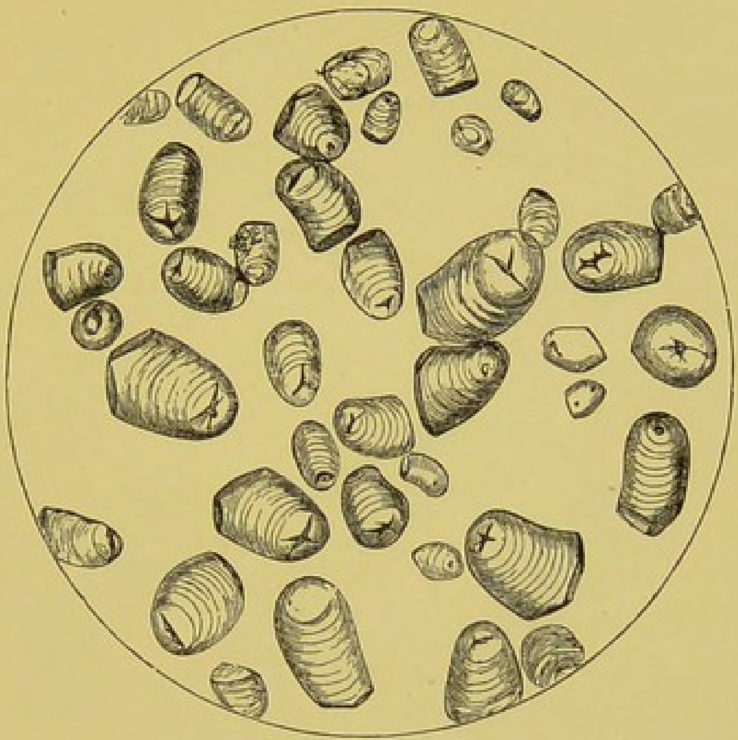


Fig. 56.—Sago Starch, as seen in Sago Meal and Flour. ×225.

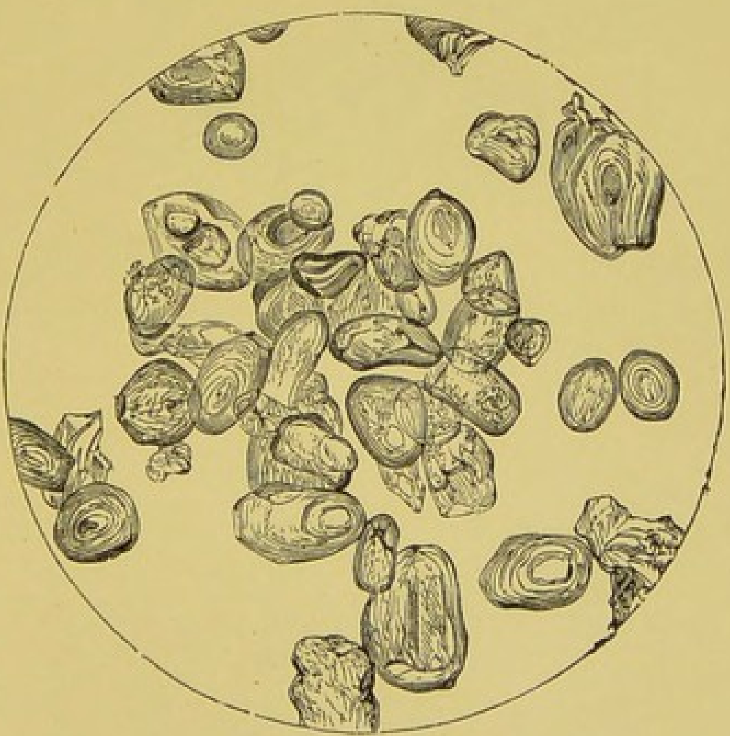


Fig. 57.—Sago Starch, altered by Heat, as seen in Granulated Sago. ×225.

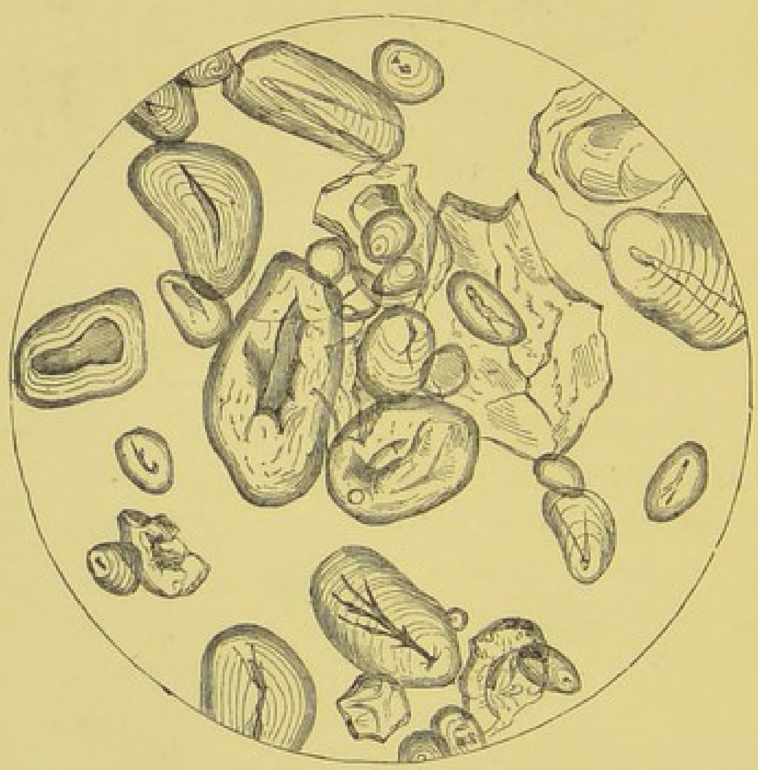


Fig. 58.—Factitious Sago, composed of Potato Flour. × 225.

Showing the granules of potato starch swollen, irregular in shape, sometimes ruptured and with the striæ effaced.

[TAPIOCA OR CASSAVA.

Ord. TRICOCCÆ, Fam. EUPHORBIACEÆ.

TAPIOCA OR CASSAVA.

The starch obtained from *Manihot utilissima*, *M. aipi*, *M. Janipha*, etc., ord. *Tricoccæ*, fam. *Euphorbiaceæ*.

Characters of the Starch.—(*a*) *In the Meal or Flour*, washed and dried without the employment of heat (*Manihot* or *Brazilian Arrowroot*). Already described and figured (pp. 64, 66, fig. 51), but for convenience shown again here. Fig. 59.

(*b*) *In Granulated Tapioca* (dried on hot plates). The starch granules are swollen by the heat, and many caused to burst: at the same time they adhere together in small irregular masses. Fig. 60.

Extraneous Matters Detectable by the Microscope.—Sago and potato starch, occasionally added.

FIG. 59.—TAPIOCA STARCH, UNALTERED, AS SEEN IN THE MEAL OR FLOUR (MANIHOT OR BRAZILIAN ARROWROOT). ×225.

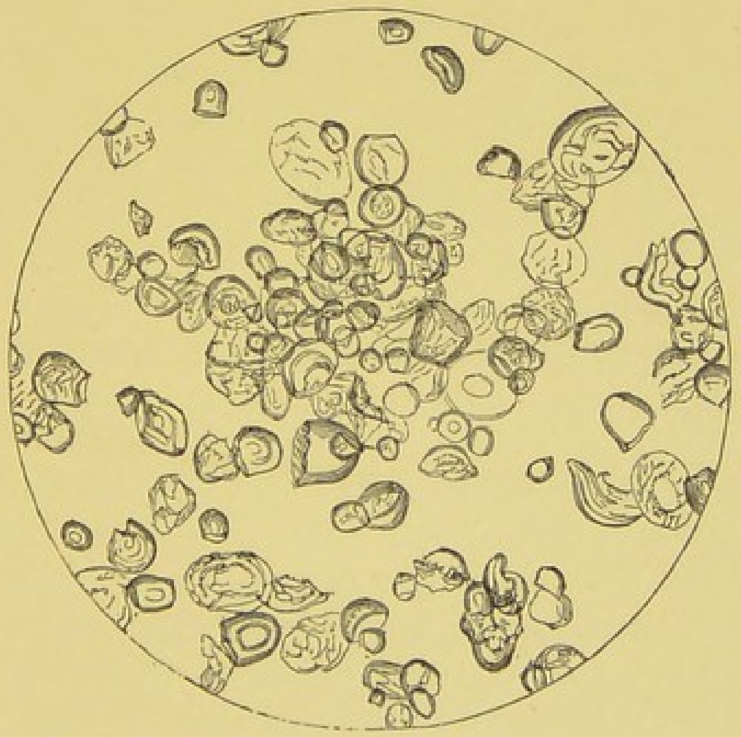


FIG. 60.—TAPIOCA STARCH, ALTERED BY THE HEAT USED IN ITS PREPARATION, AS SEEN IN GRANULATED TAPIOCA. ×225.

PROPRIETARY FOODS CONTAINING OR CONSISTING OF WHEAT, ETC.

NUMEROUS preparations of wheat, in a cooked or partially cooked condition, have in latter days been introduced to consumers. In the United States, especially, considerable enterprise is shown in the manufacture and export of such foods; and the titles of several fancifully named American products are as familiar to 'the man in the street' walking in London, as to the citizen of New York or Buffalo. Four or five preparations only, but these fairly representative of a large class, can be mentioned here.

'**Grape Nuts.**'—This product, the ingeniously chosen name of which is distinctly notable among non-descriptive appellatives, is manufactured from whole wheat by cooking and malting operations. The producers state that it is 'pre-digested,' and 'made by especial treatment of entire wheat and barley.'

Under the microscope exceedingly clearly are seen all the characteristic features of wheat, described on pp. 3, 4, and shown in Figs. 1, 2, 3. Though the starch grains have been changed by the processes of manufacture, they are mostly well defined and recognizable. It is remarkable that there is scarcely so much alteration as in some varieties of bread. The microscopical appearance of this preparation is represented in Fig. 61, p. 78. [And see Fig. 4, starch granules changed by cooking; also Fig. 25, p. 39, bread.]

'**Force**' (an article associated in the mind of the public with the features of a jocund little gentleman called 'Sunny Jim'—whoever he may be) is sold in the form of light flakes of malted entire wheat, steam-cooked; and it is described as a 'partly digested' food, prepared from the 'whole of the Wheat and Barley malt, by a process of careful malting and heating.' Easy digestibility is claimed for it, and probably with accuracy.

The microscope shows that in this preparation the starch granules are almost completely broken down, and the field is mainly covered by the débris: but the cross cells with characteristically beaded walls are abundant and clearly observable. Other features of wheat, such as epicarpal tissue and hairs, are less frequently visible. Apparently the stripping of the grain has been carried rather far. 'Force' is shown in Fig. 62.

'Shredded Wheat' is another well-known preparation of the entire grain, which has been subjected to an operation of mechanical flaking or shredding, and, without any malting, cooked to the state of a biscuit. It is claimed that nothing is added in the course of manufacture.

A microscopical examination shows that the starch grains are twisted and otherwise altered, somewhat more than in bread (Fig. 25, *loc. cit.*): but they are not broken down, as in 'Force.' The cellular structure of the wheat is well shown.

'Triscuits' are a similar preparation: but the cake or biscuit is much thinner and slightly more compact.

The microscopical characters are similar to those of 'shredded wheat,' but perhaps less cellular tissue is visible.

'Farola,' 'Granola,' and **'Granose'** are other products manufactured from wheat: the former from the endosperm, the two latter from the entire grain.

Invalids' and Infants' Foods.—On the market are very many preparations belonging to this class, of which wheat and other cereal grains, occasionally oat, but especially maize and barley, or the starches obtained from them, are the main ingredients. Such foods are frequently baked, malted, or both; and some contain desiccated milk, or eggs.

The microscopical characters of the principal constituents likely to be present in foods of this kind have already been described under the proper titles of the grains, and under *Arrowroots*. See also Fig. 63, p. 79.

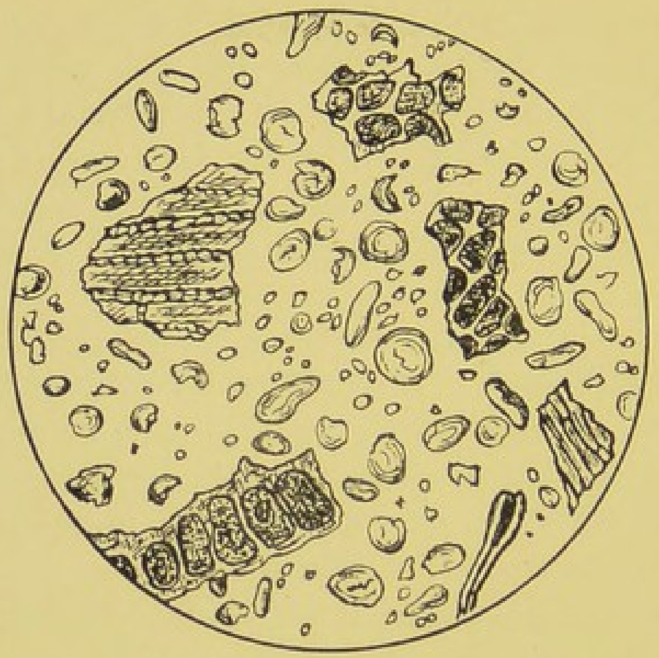


FIG. 61.—GRAPE NUTS. × 100. [E. G. C., *del.*]

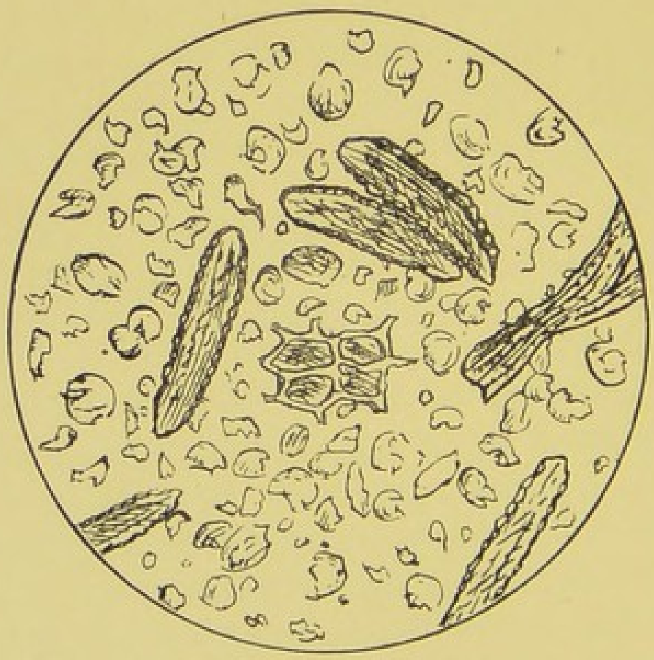


FIG. 62.—'FORCE.' × 100. [E. G. C., *del.*]

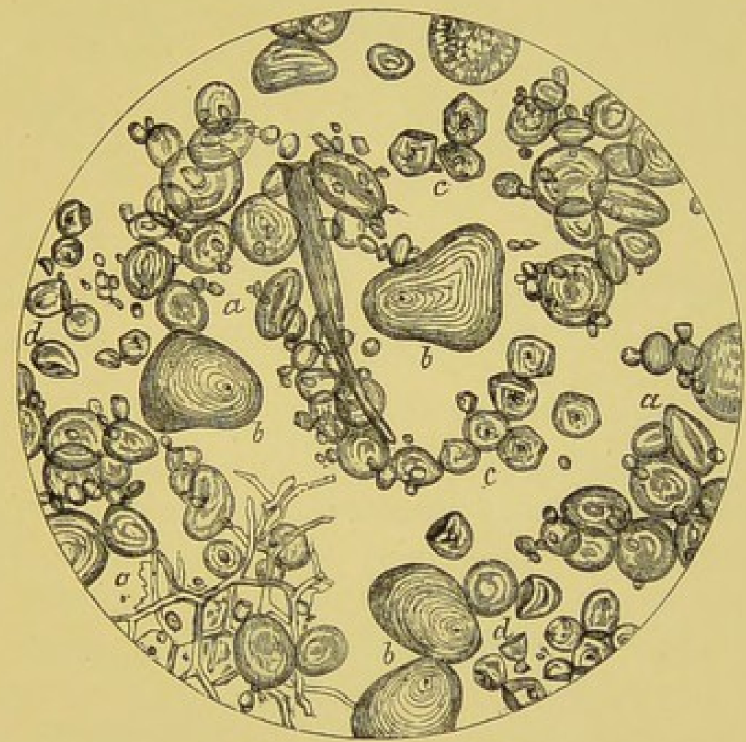


FIG. 63.—A PROPRIETARY FOOD COMPOSED OF WHEAT, POTATO, MAIZE, AND TAPIOCA. ×200.

a, *a*, Wheat; *b*, *b*, potato; *c*, *c*, maize; *d*, *d*, tapioca.

Ord. LEGUMINOSÆ, Fam. PAPILIONACEÆ; *et alia.*

PROPRIETARY FOODS CONTAINING LENTIL IN ADMIXTURE WITH CEREAL GRAINS.

Various preparations have at different periods been introduced, containing Lentil, as well as Barley, Maize, etc.

Appearance of Lentil Starch (*Lens esculenta* = *Ervum Lens*, fam. *Papilionaceæ*).—Extremely similar to pea-starch (*Pisum arvense*, *P. sativum*, fam. *Papilionaceæ*): granules oval, of moderate size, and characterized by a strongly marked fissure at the hilum, seen most frequently as a thick, dark line bisecting the granules, but very frequently cruciform and stellate.

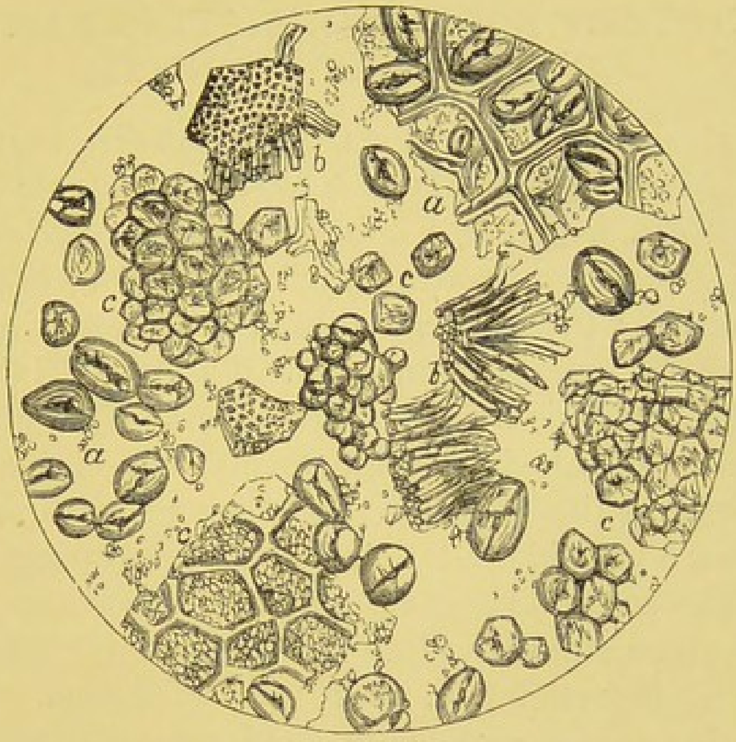


FIG. 64.—PROPRIETARY FOOD, COMPOSED OF LENTIL AND MAIZE OR CORNFLOUR. × 200.

a, *a*, Starch granules of the French lentil ; *b*, *b*, fragments of the husk ; *c*, *c*, starch granules and masses of maize or Indian corn meal.

FIG. 65.—SIMILAR FOOD, CONSISTING OF LENTIL AND BARLEY. × 200.

a, *a*, Starch granules of the Arabian lentil, some loose, others lying in the cells of the parenchyma ; *b*, *b*, starch granules of barley flour.

PROPRIETARY FOODS, CONSISTING PARTIALLY OR ENTIRELY OF NUTS.

Highly nutritious foodstuffs have latterly been manufactured from walnuts (*Juglans regia*), chestnuts (*Castanea sativa*), filbert, hazel, and cob-nuts (*Corylus avellana*), sweet almonds (*Prunus communis*), Brazil nuts (*Bertholletia excelsa*, etc.), coco-nuts (*Cocos nucifera*), and other varieties of nuts. Many writers, among them A. H. Church, A. Haig, and R. Hutchison, have pointed out the dietetic value and wholesomeness of nuts,[1] which undoubtedly will be more widely appreciated, as time goes on. Most nuts contain little or no starch, much proteid matter, and very large proportions of oil or fat. The chestnut is exceptional: it is deficient in oil, but contains much starch, and a moderate quantity of protein.

Though, unfortunately, they bear somewhat weird and unattractive names, many very good nut-foods are now obtainable. Among the products of this class are 'nutmeal,' 'nuttose,' 'protose,' 'bromose' (malted nuts), 'nutmeat,' 'alnut,' 'nutton,' and 'nutvejo.' A production called 'nutrose' is made from pea-nuts (*Arachis hypogæa*), which are scarcely nuts in the ordinary sense, but belong to the *Leguminosæ*, and are among the most highly proteinous of vegetable foodstuffs. From the oils expressed from nuts, numerous 'vegetable butters' are made, such as 'cocos butter,' 'nucoline,' and 'nuttolene.'

Under the microscope, nuts and nut-preparations exhibit less individuality than cereal grains. The *shells* are mostly constituted of compact aggregations of sclerenchyma or stone cells: while the 'flesh' of the kernels usually consists of parenchyma, with aleurone grains and oil globules, or occasionally starch (as in the chestnut and acorn). Chestnut starch (shown in Fig. 66) is remarkable for irregularity in the shape of the granules; and the large aleurone grains of the Brazil nut are characteristic. Some of the microscopical appearances presented by the last-named are shown in Fig. 67. Acorn starch is depicted in Figs. 75, 83, pp. 89, 97.

[1] 'Breads we have of several grains, roots, and kernels; . . . some do nourish so, as divers do live on them, without any other meat, who live very long.'—Francis, Viscount St. Albans (1561-1626), *New Atlantis*.

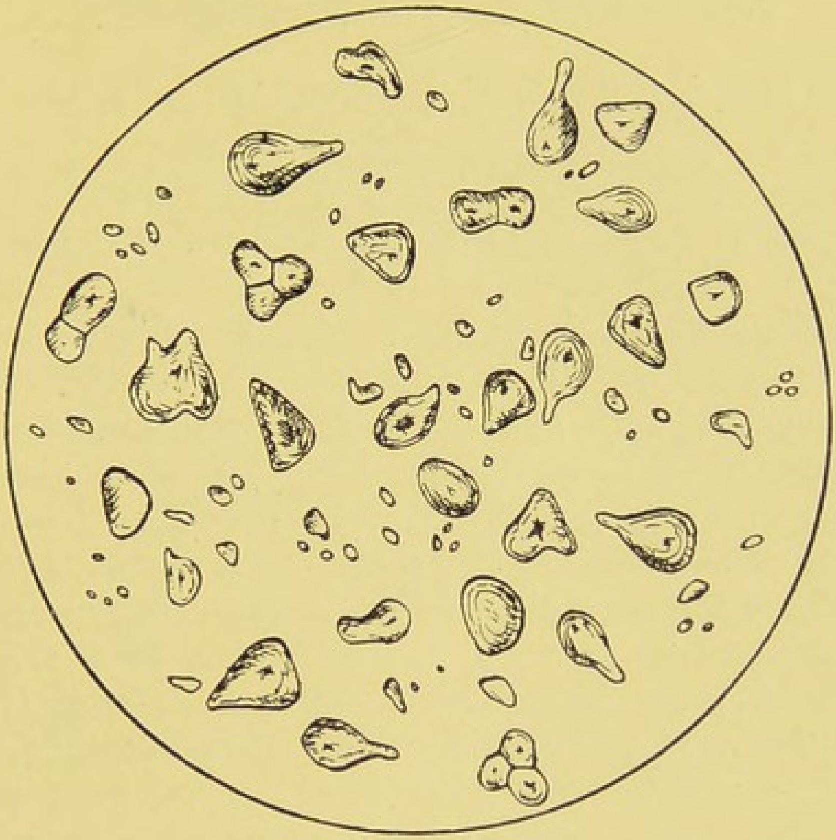


FIG 66.—CHESTNUT. × 420.

[E. G. C., *del.*]

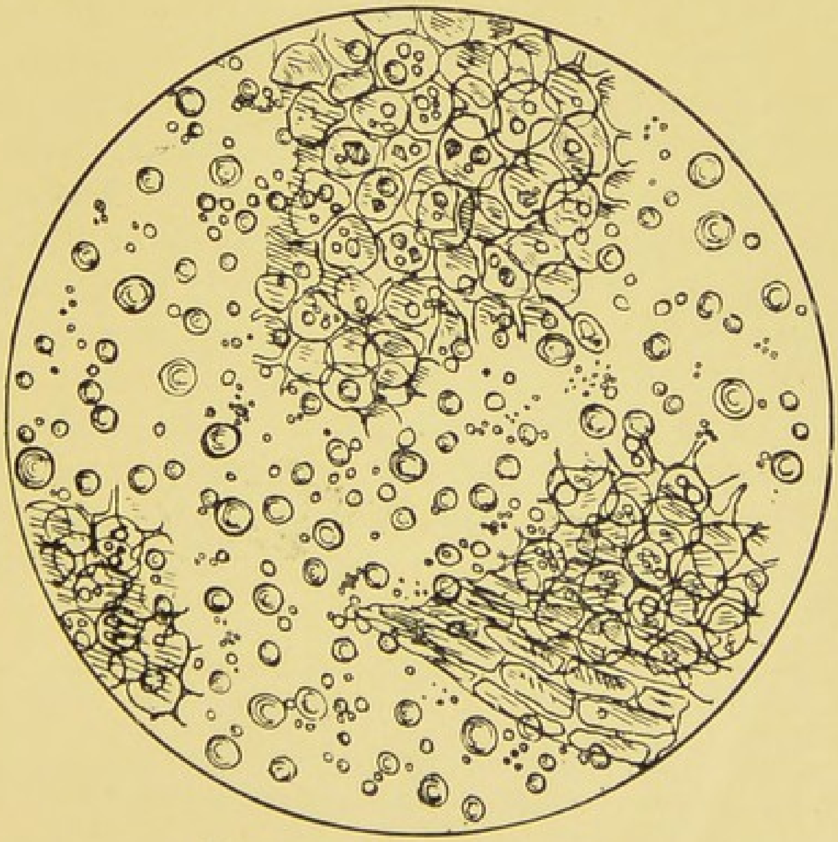


FIG. 67.—BRAZIL NUT. × 140.

[E. G. C., *del.*]

VEGETABLE SUBSTANCES USED IN THE PREPARATION OF BEVERAGES.

ORD. RUBIINÆ, FAM. RUBIACEÆ.

COFFEE.[1]

THE seed or berry of *Coffea Arabica*, ord. *Rubiinæ*, fam. *Rubiaceæ*.

Histology of the Raw Seed, as Sold Commercially.—1. *Substance of Berry* (the endosperm). Thick-walled angular cells, tough and hard, adhering so firmly that they break into pieces rather than separate as entire cells. Globules of oil enclosed within the cell-cavities. No starch. 2. The *Testa, Investing Membrane*, or *Spermoderm*. A single layer of elongated adherent cells (sclerenchyma cells), presenting oblique markings on their surface, resting on a thin, indistinctly fibrous, transparent membrane, consisting of partially obliterated parenchyma cells. Oil generally present between the berry and its covering. 3. *In the Raphe or Groove of the Berry*, usually a few small double spiral vessels.

The Roasted Seed.—Although the tissues are partially charred, the characteristics are preserved, except the oil-globules, which have been dissipated by the heat. The testa, separated during the roasting, is called 'coffee-flights,' fragments of which are often seen in the ground product.

Extraneous Substances Detectable by the Microscope.—Chicory (*Chicorium Intybus*, fam. *Compositæ*); dandelion-root (*Taraxacum officinale*, fam. *Compositæ*); mangold wurzel (*Beta vulgaris* var. *campestris*, fam. *Chenopodiaceæ*); carrot (*Daucus carota*, fam. *Umbelliferæ*); parsnip (*Pastinaca sativa*, fam. *Umbelliferæ*); wheat, rye, pease (*Pisum sativum*, fam. *Papilionaceæ*); beans (*Faba vulgaris*, fam. *Papilionaceæ*), date-stones (*Phœnix dactylifera*, fam. *Palmæ*); lupine seeds (*Lupinus luteus*, etc., fam. *Papilionaceæ*); acorn (*Quercus pedunculata*, etc., fam. *Cupuliferæ*).

[1] In the cheaper, ready-made 'coffee' infusions of commerce, it is sometimes necessary to seek by chemical tests very minutely for the coffee. Eleven of these liquids, bought in coffee palaces and similar places, were analyzed in 1897 in the writer's laboratory, and found to contain an average proportion of only about 2 parts of coffee in 100.—The *Analyst* (1897), xxii. 172.

[*For figures, see pp.* 85, 86.]

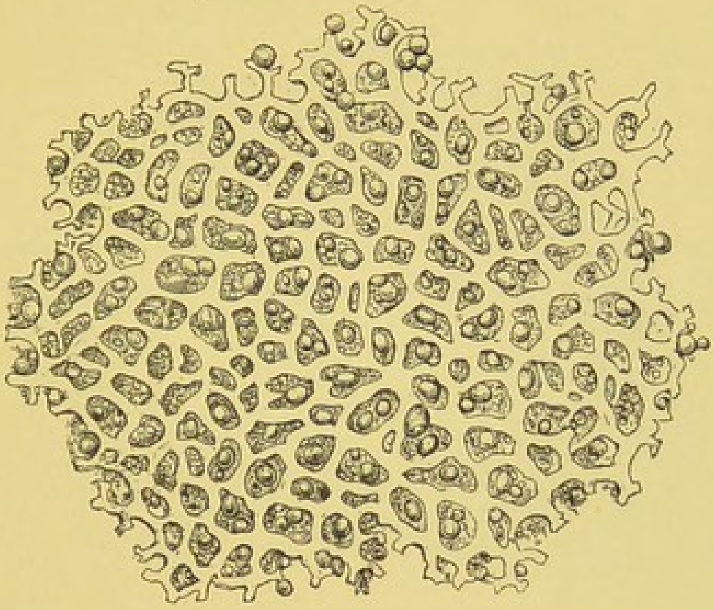


FIG. 68.—UNROASTED COFFEE-BERRY.

Thick-walled, angular cells of the endosperm, containing oil-globules. × 140.

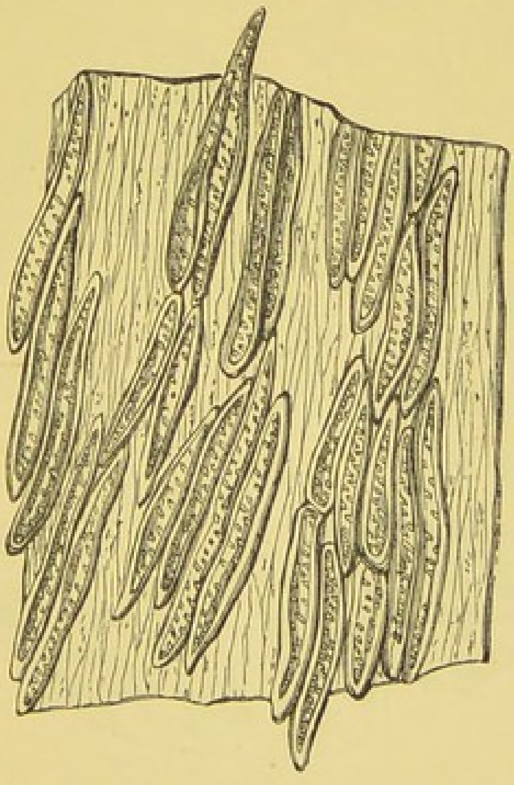


FIG. 69.—UNROASTED COFFEE-BERRY.

Sclerenchyma cells and parenchymatous membrane, forming the testa or spermoderm. × 140.

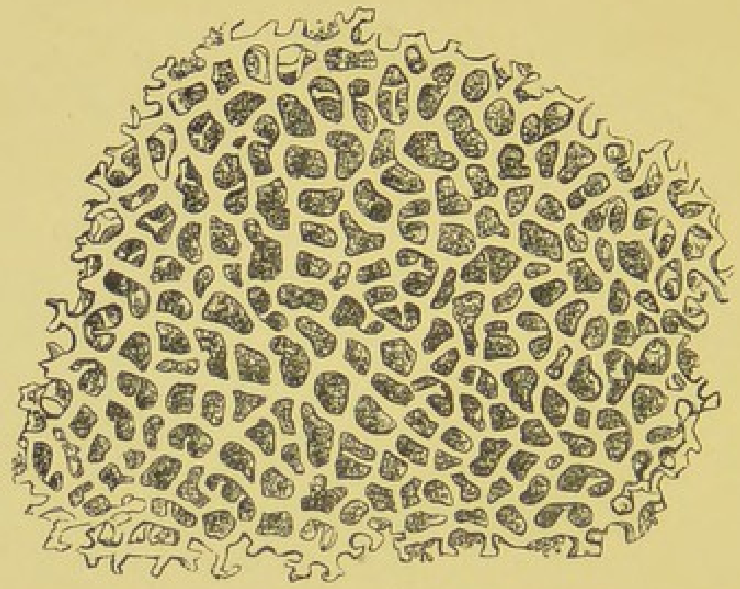


FIG. 70.—ROASTED COFFEE-BERRY.
Thick-walled, angular cells, no oil. × 140.

FIG. 71.—ROASTED COFFEE (GROUND):
General appearance. × 140.

MIXTURES OF COFFEE WITH VARIOUS ADULTERANTS AND SUBSTITUTES.

Fig. 72.—**Coffee and Chicory**: *a, a*, coffee; *b, b*, chicory.

Fig. 73.—**Coffee, Chicory, and Roasted Wheat**: *a, a*, coffee; *b, b*, chicory; *c, c*, wheat.

Fig. 74.—**Coffee, Chicory, and Roasted Beans**: *a, a*, coffee; *b, b*, chicory; *c, c*, beans.

Fig. 75.—**Coffee, Chicory, and Ground Acorn**: *a, a*, coffee; *b, b*, chicory; *c, c*, acorn (starch granules of acorn highly characteristic).

Fig. 76.—**Mangold Wurzel Root**: cells composing it. (In mangold wurzel, carrot, and parsnip, no latex tubes: in the cells of parsnip, small, regularly-formed starch granules.)

Fig. 77.—**Coffee, Chicory, and Mangold Wurzel**: *a, a*, coffee; *b, b*, chicory; *c, c*, mangold wurzel.

Fig. 78.—**Roasted and Ground Lupine Seeds** (*Lupinus luteus*, etc.). (These have been sold under the name of 'Coffina.')

[*For figures, see pp.* 88, 89, 90, *and* 91.]

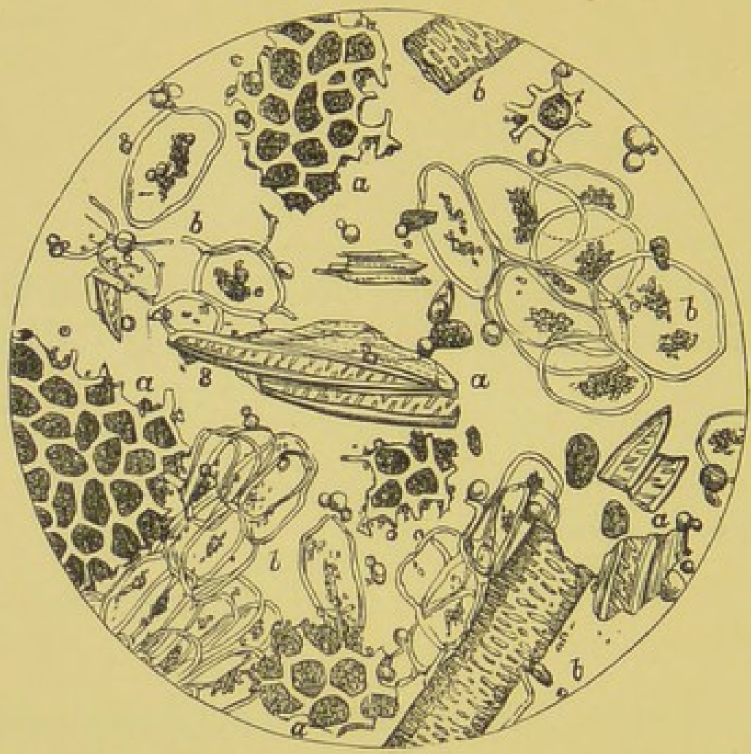


FIG. 72.—COFFEE AND CHICORY. ×140.
a, *a*, Coffee; *b*, *b*, chicory.

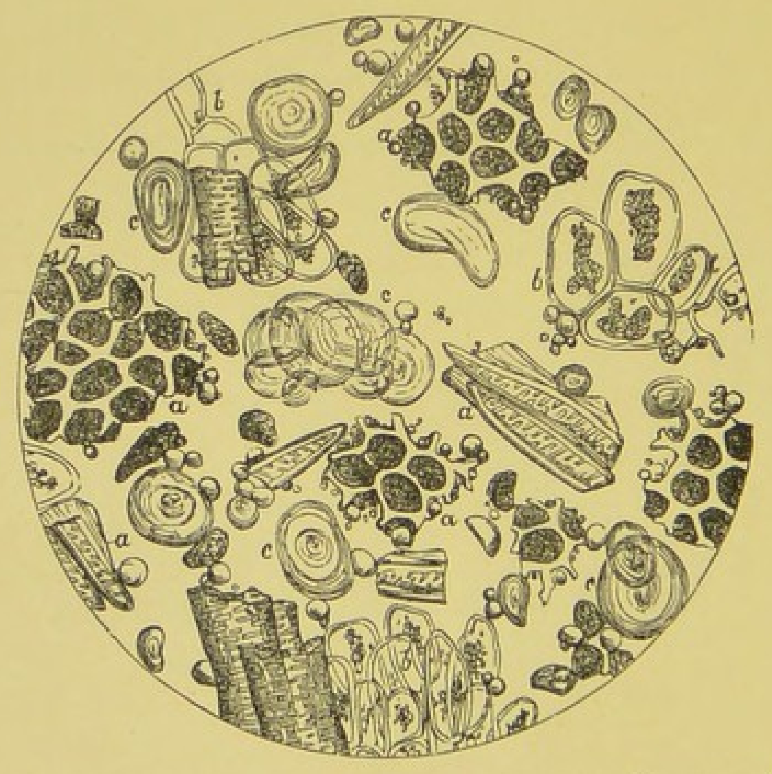


FIG. 73.—COFFEE ADULTERATED WITH CHICORY AND ROASTED WHEAT. ×140.
a, *a*, Coffee; *b*, *b*, chicory; *c*, *c*, roasted wheat flour.

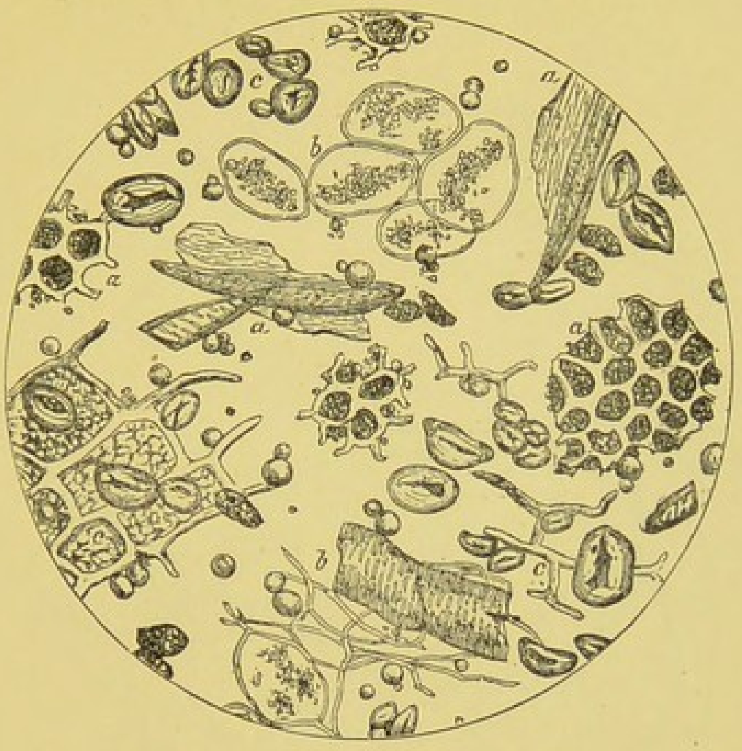


FIG. 74.—COFFEE, TOGETHER WITH CHICORY AND ROASTED BEANS. × 140.

a, a, Coffee ; *b, b,* chicory ; *c, c,* roasted bean flour.

(The substance of the seed of the bean is made up of cells, each containing several oval or reniform starch granules, with an *elongated central cavity*, from the margin of which short rays or processes may be seen radiating, and with occasionally a few strongly-marked concentric rings.)

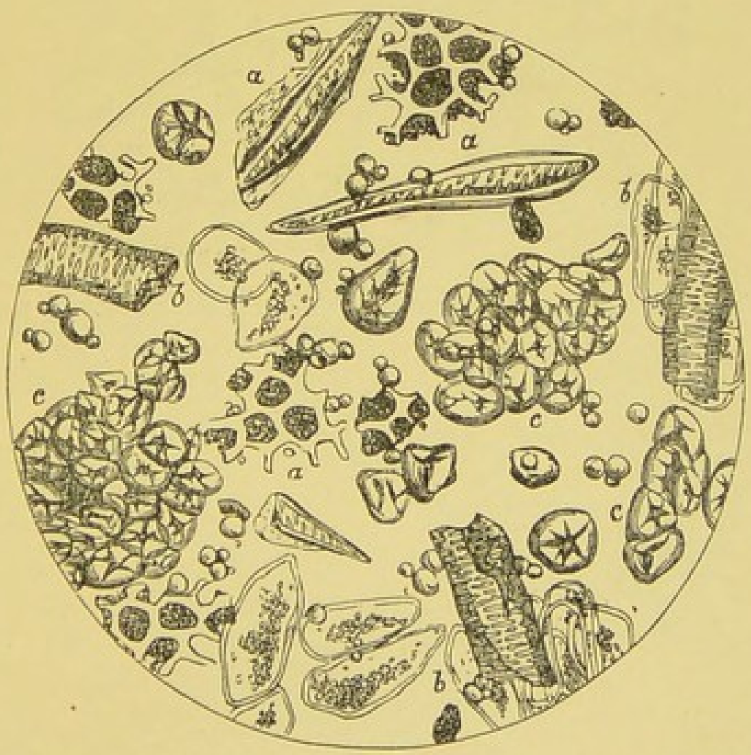


FIG. 75.—COFFEE, CHICORY, AND GROUND ACORN. × 140.

a, a, Coffee ; *b, b,* chicory ; *c, c,* acorn.

The microscopical features of ground acorn are shown also in Fig. 83, p. 97.

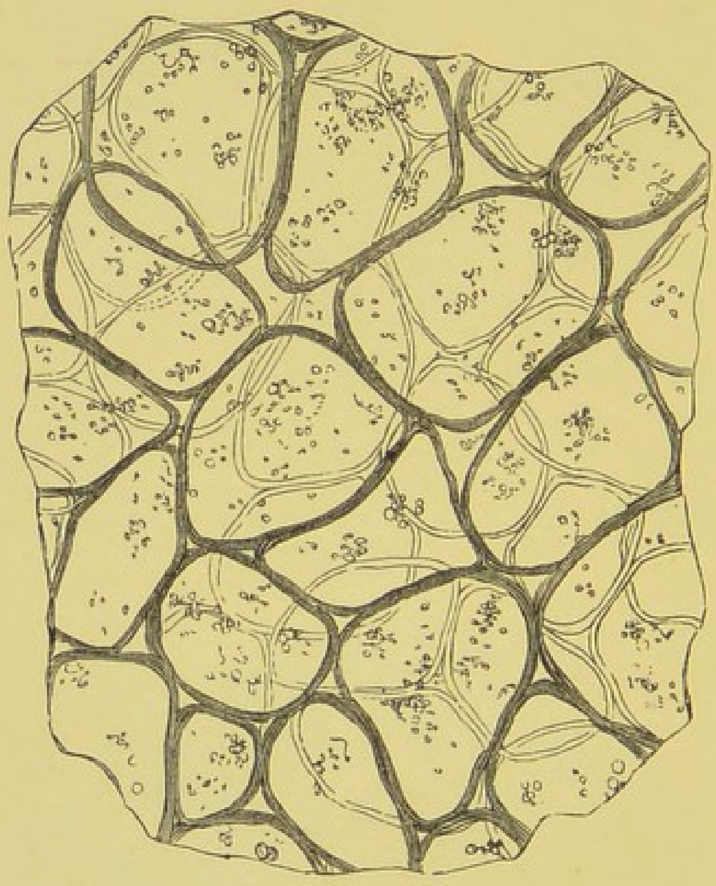


FIG. 76.—MANGOLD WURZEL. CELLS OF ROOT. × 140.

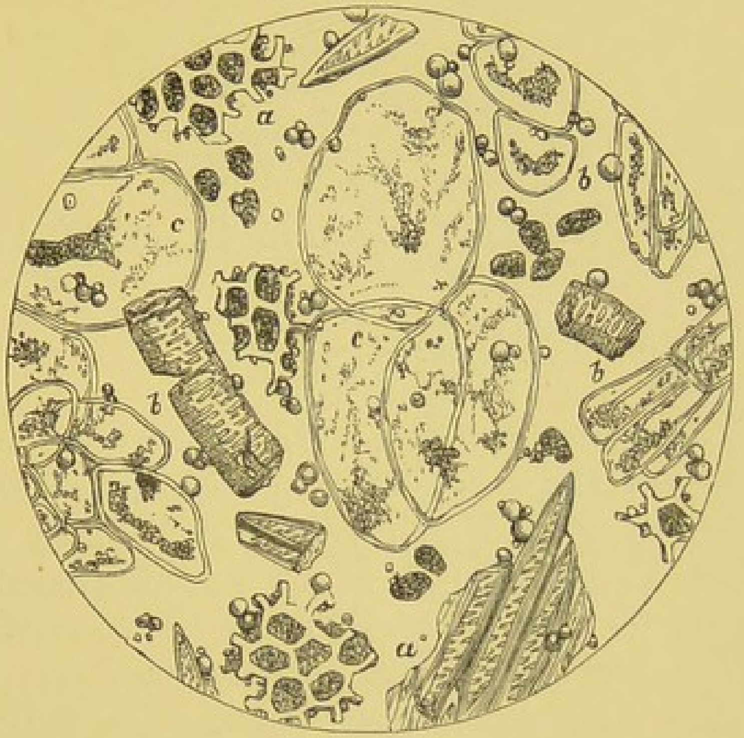


FIG. 77.—COFFEE ADMIXED WITH CHICORY AND MANGOLD WURZEL. × 140.
a, *a*, Coffee; *b*, *b*, chicory; *c*, *c*, mangold wurzel.

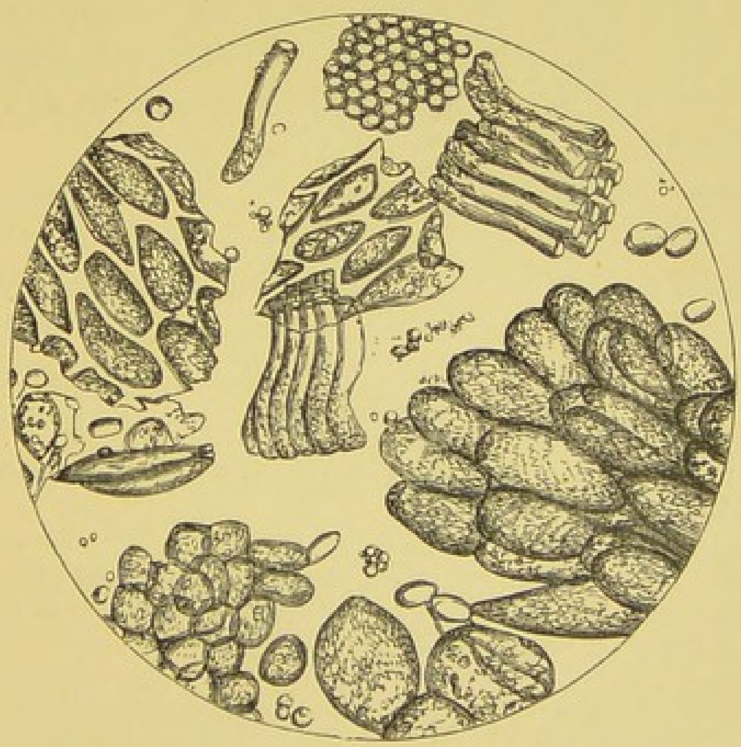


FIG. 78.—LUPINE SEEDS, ROASTED AND GROUND. × 140.

ORD. AGGREGATÆ, FAM. COMPOSITÆ.

CHICORY.

ROOT of *Chicorium Intybus*, ord. *Aggregatæ*, fam. *Compositæ.*

Histology of the Root.—The chief characteristics are: (1) *Utricles, or cells* (parenchyma cells), usually rounded, but narrow and elongated in the neighbourhood of the vessels (Fig. 79); (2) *dotted or pitted vessels*, traversing in bundles the central and harder parts of the root, consisting of cylindrical, unbranched tubes, tapering to a point at each extremity, and exhibiting depressions or pores of moderate length, describing around the vessels an interrupted spiral course (Fig. 80); (3) *wood fibre*, small in quantity, and not distinctive (Fig. 80); (4) *the latex tubes, vasa lactescentia*, branched and frequently anastomosing tubes, of smaller diameter than the dotted vessels, with smooth membranous parietes, and having a milky juice or sap (Fig. 81). *Starch granules* absent.

Extraneous Substances Detectable by the Microscope.—The following have been used or described: roasted wheat, rye, beans, pease, acorns, carrots, mangold wurzel, burnt sugar,[1] and beetroot. Also sawdust, baked livers, Venetian red, 'coffee-flights' (the testa of coffee-berry), spent tan, and oak-bark powder, have been mentioned. But it is very improbable that these grosser forms of adulteration prevail at the present time.

[1] Some years since, the author found in certain samples of chicory quantities of added sugar, ranging from 10 to about 40 per cent.—The *Analyst*, (1895), xx. 12, paper on 'Roasted Chicory.'

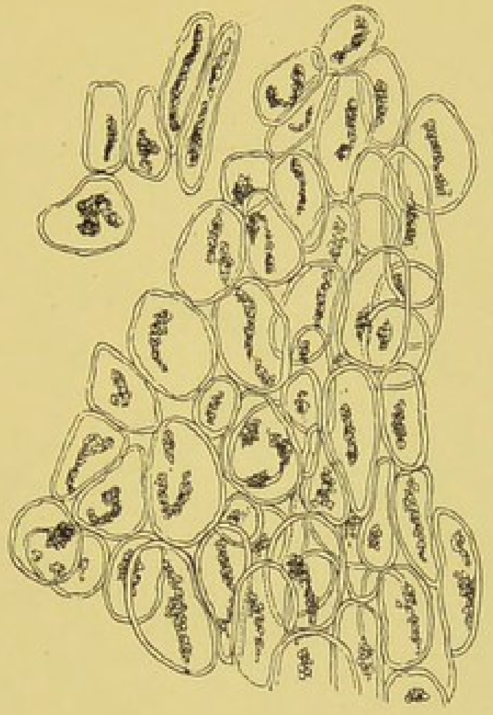


FIG. 79.—ROASTED CHICORY: THE PARENCHYMA CELLS OF WHICH IT IS CHIEFLY CONSTITUTED; ROUNDED WHERE THE PRESSURE IS LEAST AND THE ROOT SOFT, ELONGATED NEAR THE VESSELS. × 140.

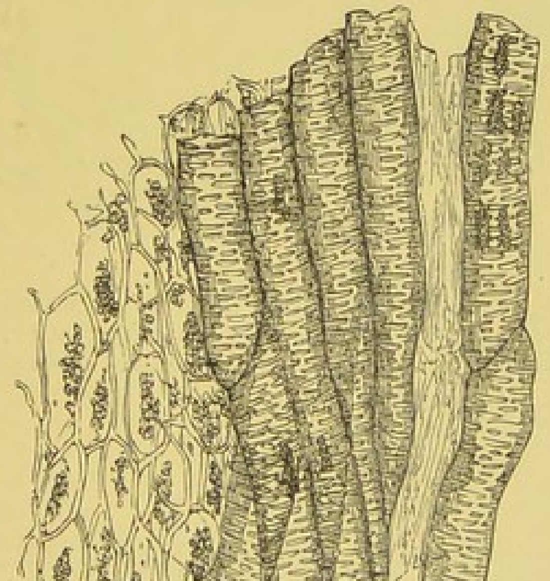


FIG. 80.—ROASTED CHICORY: SHOWING PARENCHYMA CELLS; THE DOTTED, PITTED, OR INTERRUPTED SPIRAL VESSELS, WHICH PASS IN BUNDLES THROUGH THE CENTRAL PARTS OF THE ROOT; AND WOOD-FIBRES. × 140.

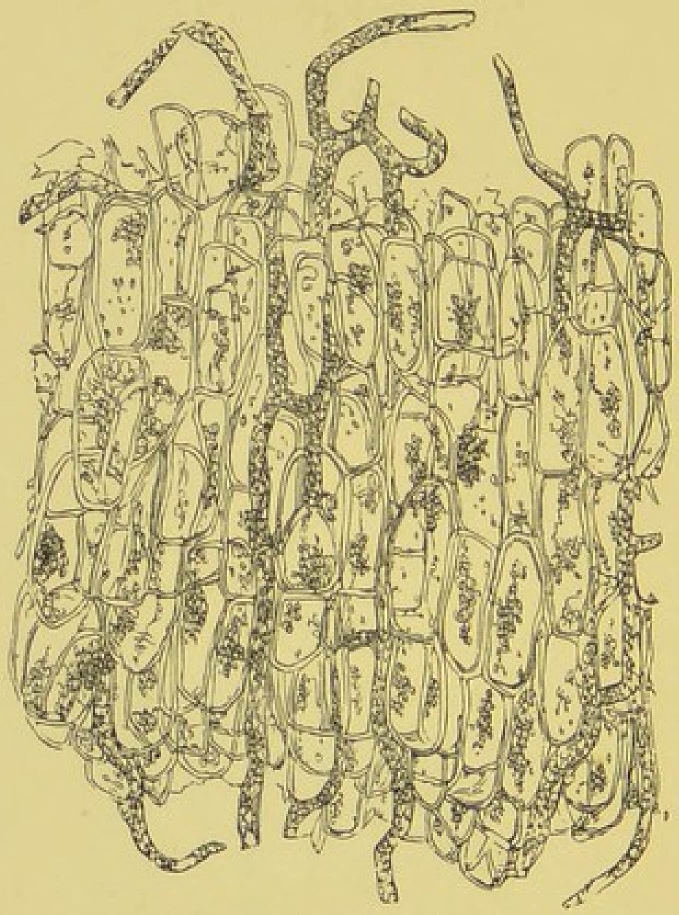


FIG. 81.—CHICORY: THE NARROW AND BRANCHED VESSELS OF THE LATEX (LATICIFEROUS TUBES), WHICH CONVEY THE MILKY JUICE. THEIR RELATION TO THE PARENCHYMA CELLS ALSO SHOWN. × 140.

[ADULTERANTS OF, OR SUBSTITUTES FOR, CHICORY.

ADULTERANTS OF, OR SUBSTITUTES FOR, CHICORY.

Fig. 82.—**Chicory and Roasted Wheat Flour**: *a, a,* chicory; *b, b,* wheat starch.

Fig. 83.—**Chicory and Ground Acorn**: *a, a,* chicory; *b, c, d,* starch granules and brown parenchymatous membrane from the pericarp of ground acorn.

Fig. 84.—**Oak-bark Powder**: showing wood fibres, stone cells, wood parenchyma, and crystals.

Fig. 85.—'**Croats,**' an article used in Norfolk for fuel: a variety of tan-bark. The figure shows parenchymatous tissue, reticulated vessels, and crystals.

Such crude forms of chicory adulteration as the two last-mentioned probably no longer survive. Their inclusion among the examples given will illustrate the queer devices of a past era; and the figures may help in the recognition of allied or identical substances.

Dandelion (*Taraxacum officinale*, fam. *Compositæ*) occasionally is used as a substitute for chicory in coffee mixtures. Microscopically, it very closely resembles chicory: the latex tubes, parenchyma cells, and pitted or reticulated vessels, are all similar, though the transverse pores of the last-named organs are somewhat more elongated.

Beetroot (*Beta vulgaris*), another chicory substitute, presents extremely similar microscopical characteristics.[1]

[1] It would be injudicious to attempt with the microscope alone to distinguish one of these three roots from another if any very onerous matter depended on the decision.—See a paper and remarks, by the present writer, on 'Roasted Beetroot' in the *Analyst* (1904), xxix. 279.

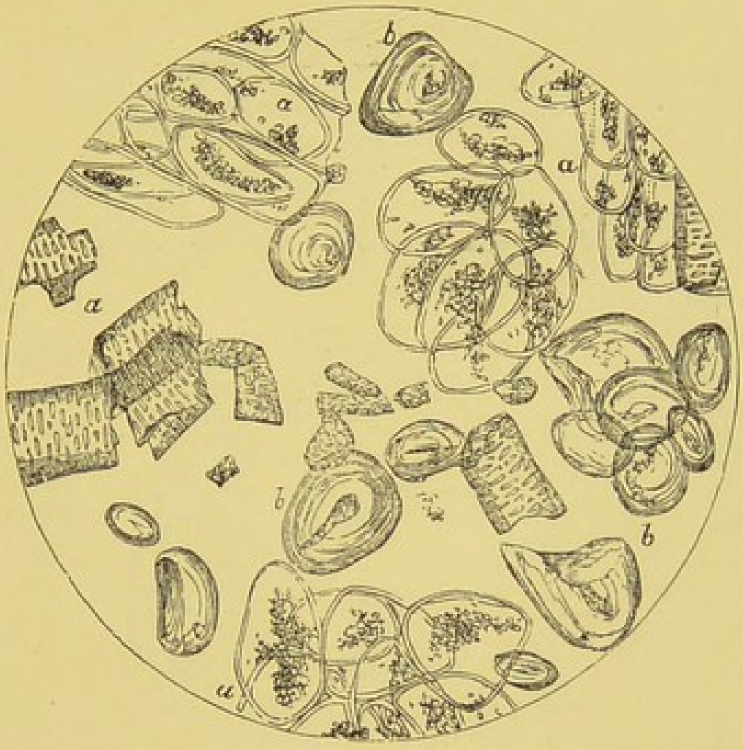


FIG. 82.—CHICORY AND ROASTED WHEAT FLOUR. × 140.
a, *a*, Chicory ; *b*, *b*, starch granules of wheat.

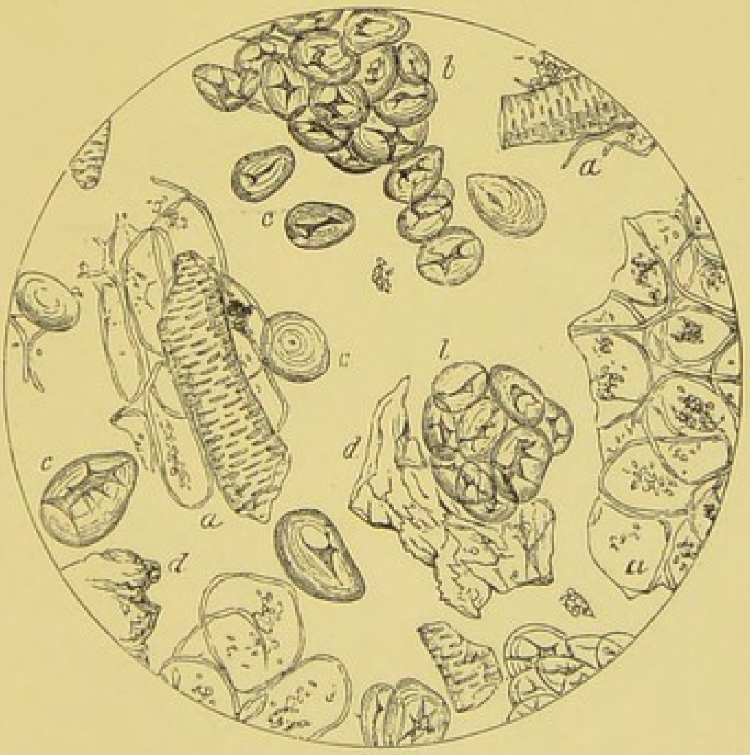


FIG. 83.—CHICORY AND GROUND ACORN. × 140.
a, *a*, Chicory cells ; *b*, *b*, starch grains of the acorn, in groups ; *c*, *c*, separate starch grains ; *d*, *d*, brown parenchymatous membrane from the pericarp of acorn.

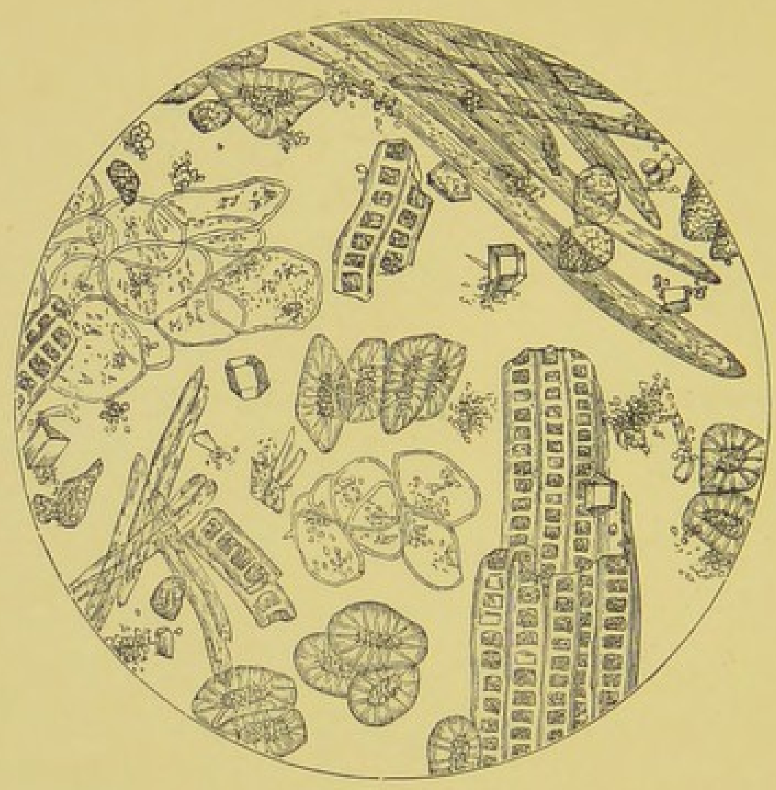


FIG. 84.—OAK-BARK POWDER: WOOD FIBRES, STONE CELLS, WOOD PARENCHYMA, AND CRYSTALS. × 140.

FIG. 85.—'CROATS,' A SPECIES OF TAN-BARK USED FOR FUEL: SHOWING RETICULATED VESSELS, CRYSTALS, AND PARENCHYMA. × 140.

ORD. COLUMNIFERÆ, FAM. STERCULIACEÆ.

COCOA.

THE 'bean' or seed of *Theobroma Cacao*, ord. *Columniferæ*, fam. *Sterculiaceæ*.

Histology.—1. *Shell.*—On the surface are usually seen large tubular fibres, containing granular matter and minute corpuscles, mostly running parallel to each other in the course of the long axis of the seed (Fig. 86). These fibres do not form part of the seed, but belong to the seed-vessel or *pericarp*, and are derived from the spongy substance of the fruit surrounding the seeds. More abundant on some seeds than others. Beneath the tubular fibres are several tunics or membranes, the outermost of which is the inner or endocarp layer of the pericarp, and consists of elongated cells adapted to each other; disposed in a single layer, with their long diameters placed transversely to the axis of the seed. This is the 'cross-cell' layer (Fig. 87, *a*, *a*). The next membrane, composed of polygonal cells, is the outer epidermis of the seed coat, *testa*, or *spermoderm* (Fig. 87, *b*, *b*), and is followed by larger angular cells, superimposed in several closely connected layers. Towards the centre of the membrane formed by them, the cells increase greatly in size, their parietes become thin and diaphanous, and their cavities filled with a mucilaginous substance, which, in the bean soaked in water for some hours, is seen to be considerable in quantity. As these mucilage cells (Fig. 87, *c*, *c*) approach the surface of the seed, they lose their mucilaginous character, become smaller, and return to their original size. *Spiral vessels*, together with woody tissue, in fibro-vascular bundles embedded among parenchyma cells (Fig. 88), constitute several raised lines, which will be observed on the surface of the seed, beginning at the end attached to the seed-vessel, spreading themselves out over the surface, and terminating at the distal extremity of the seed.

2. *The Seed*, deprived of its husk, is seen to consist of two *cotyledons* or lobes, remarkable and irregular in form: under pressure these readily separate from each other, and the seed

breaks further into pieces which are known as 'nibs.' The pale, thin, and delicate tissue, portions of which adhere to the inner surface of the husk or shell, is the *perisperm*, and consists superficially of small angular cells containing minute globules of fat (Fig. 89, *a*, *a*). Beneath is a membrane, clear, transparent, of indistinct cellular and (apparently) fibrous structure (Fig. 89, *c*). On its surface are many small crystals, as well as numerous elongated bodies, rounded at both extremities, divided into several compartments or cells, and frequently known as 'Mitscherlichian bodies' (Fig. 89, *d*, *d*). These exceedingly distinctive features of the cacao bean were first observed, described, and figured in 1851 by Arthur Hill Hassall, M.D., and with greater justice should be termed '*Hassallian bodies*' [*Lancet*, 1851, i., pp. 553, 554]. Their discovery has been incorrectly attributed to a German writer, Alfred Mitscherlich, who described them, much later, in a little book, 'Der Cacao und die Chocolade,' published in 1859 at Berlin. They are multicellular hairs, appendages to the epidermis of the cotyledons, from which they become detached and adherent to the perispermal inner membrane. The greater portion of the perisperm usually clings to the seed lobes: it not only covers the surface of the cotyledons, but dips down between them, furnishing each of the opposite sides with a covering. Nevertheless, it is most evident on the external surface. On its removal, cells composing the substance of the lobes are often torn away with it.

Beneath an epidermis of polygonal cells, with the associated hairs already described, the cotyledons are composed of very many minute cells, of a rounded form, filled with starch granules and fat globules (Fig. 90). On the surface of the seed these cells are rendered angular by compression, and are usually of a deep red colour, or sometimes spotted with purple, and even deep blue. The *starch grains* of cocoa are small in size, of a rounded form, and often present an obscure, radiate, or stellate hilum. At one extremity of the seed is the *embryo*, consisting of cellular tissue, enclosing numerous starch granules and oil globules.[1]

Extraneous Substances Detectable by the Microscope.—Sugar, foreign starches, etc.

[1] On the chemical composition of some commercial cocoa-preparations, see a paper by the writer, *Chem. News* (1902), lxxxvi., p. 51.

[*For figures, see pp.* 102-109.]

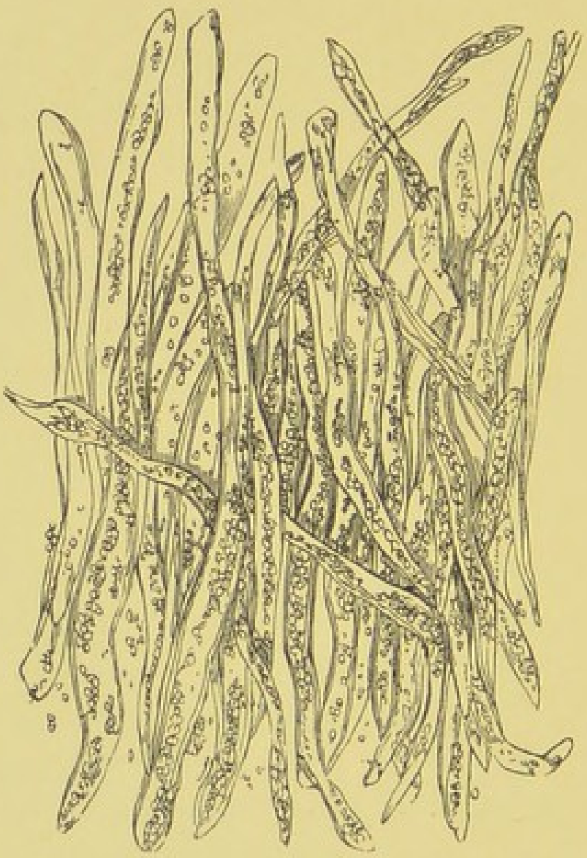


FIG. 86.—COCOA. TUBULAR FIBRES OF THE PERICARP, OBSERVED ON THE SURFACE OF THE HUSK OR 'SHELL.' × 100.

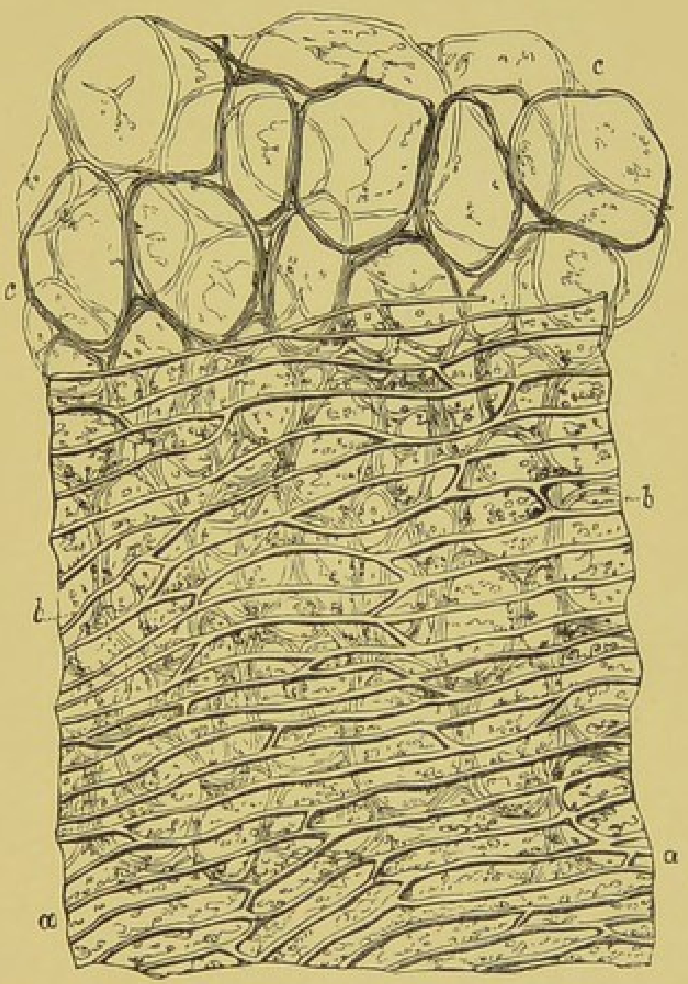


FIG. 87.—COCOA. OUTER MEMBRANES OF SHELL. × 220.

Cross cells (*a*, *a*) of the inner or *endocarp* layer of the *pericarp*; beneath them, polygonal cells (*b*, *b*), succeeded by very large mucilage cells (*c*, *c*).

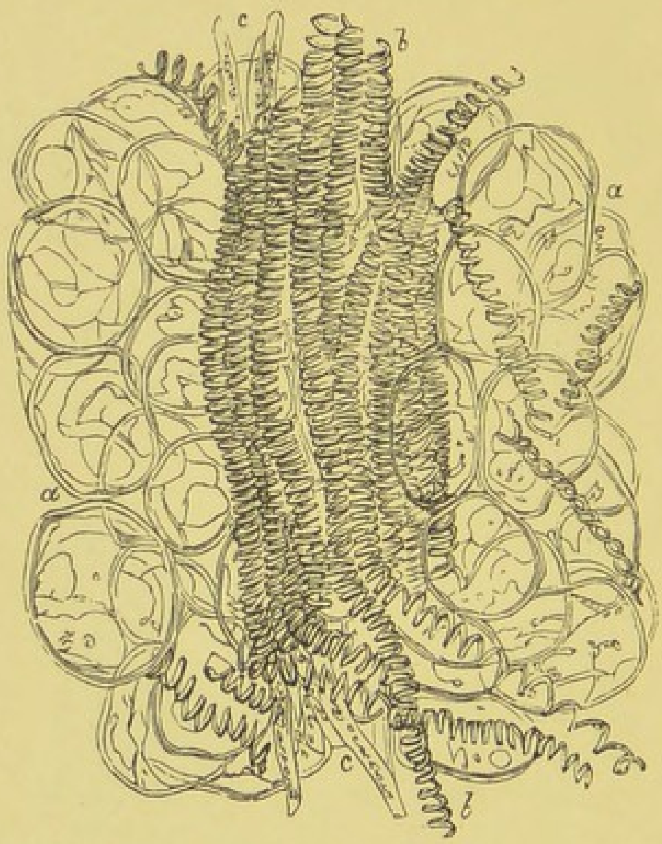


FIG. 88.—COCOA. ROUNDED CELLS, FIBRES, AND SPIRAL VESSELS, CONSTITUTING DEEPER PART OF HUSK. × 220.

a, a, Parenchyma cells; *b, b,* spiral vessels; *c, c,* wood fibres.

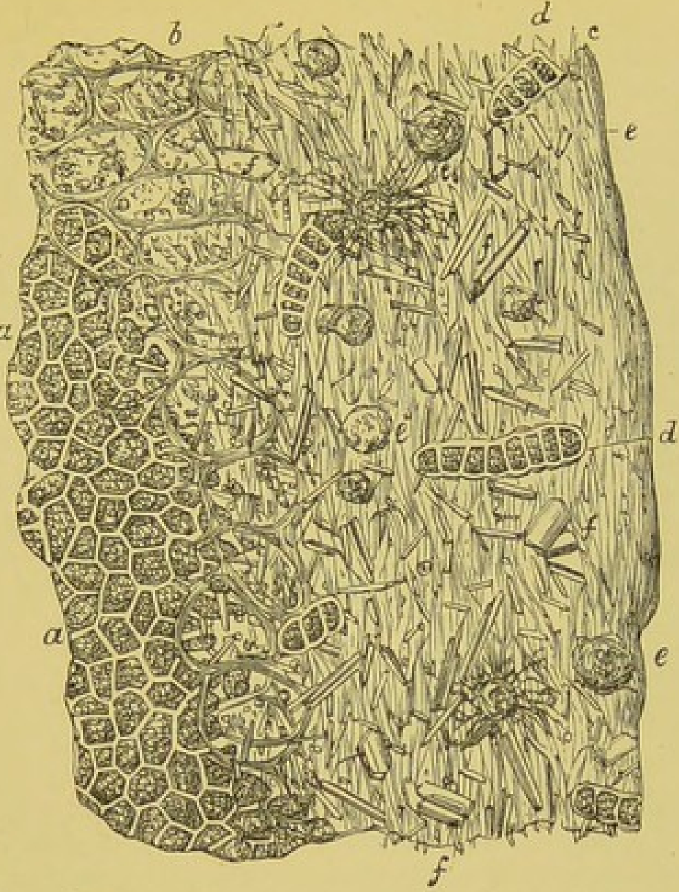


FIG. 89.—COCOA. MEMBRANES OF THE PERISPERM. × 220.

a, a, Small polygonal cells, containing fat globules; *b, b*, rounded cells derived from husk (*vide* Fig. 88. *a, a*), lying upon the polygonal cells, and situated at the lines of junction of the lobe; *c, c*, transparent fibrous tunic; *d, d*, multicellular hairs (the Hassallian, or so-called 'Mitscherlichian bodies');[1] *e, e*, rounded masses of crystallized fat; *f, f*, crystals.

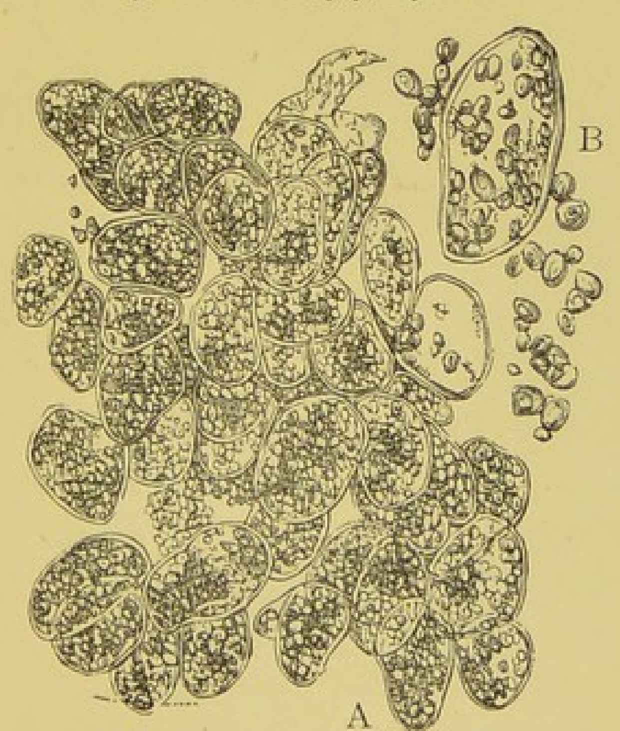


FIG. 90.—COCOA. CELLS FORMING THE SUBSTANCE OF THE COTYLEDONS, WITH THE CONTAINED STARCH GRANULES. A × 220, B × 500.

[1] See p. 101.

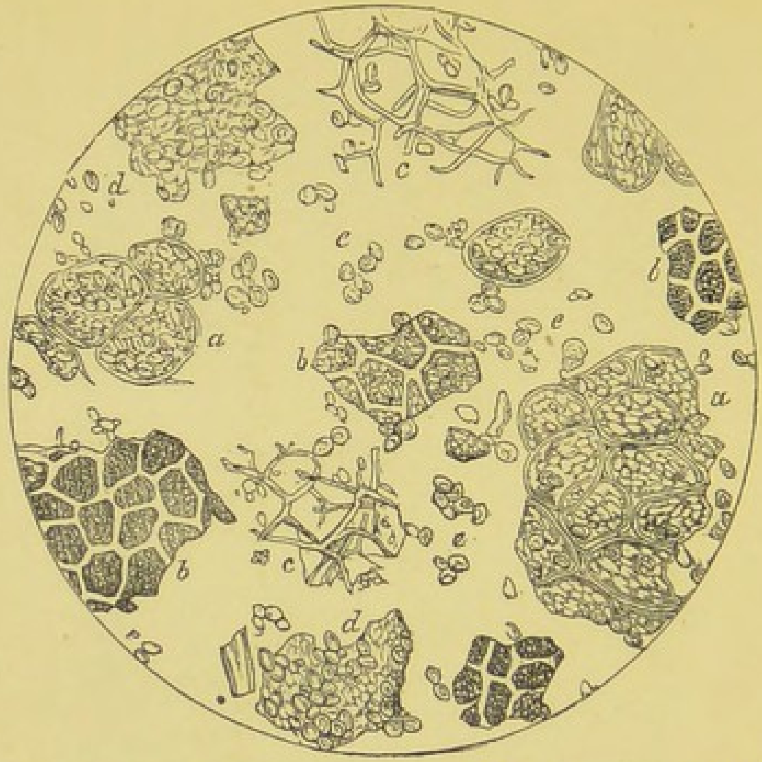


Fig. 91.—Pure Trinidad Cocoa (Decorticated and Pulverized). × 220.

The tissues forming the husk of cocoa are absent, and many of the cells of the seed are ruptured, so as to permit the escape of the starch grains and fat.

a, a, Starch cells of the seed; *b, b*, epidermal polygonal membrane of the seed-lobes; *c, c*, tissues of embryo; *d, d*, free masses of starch; *e, e*, loose starch granules.

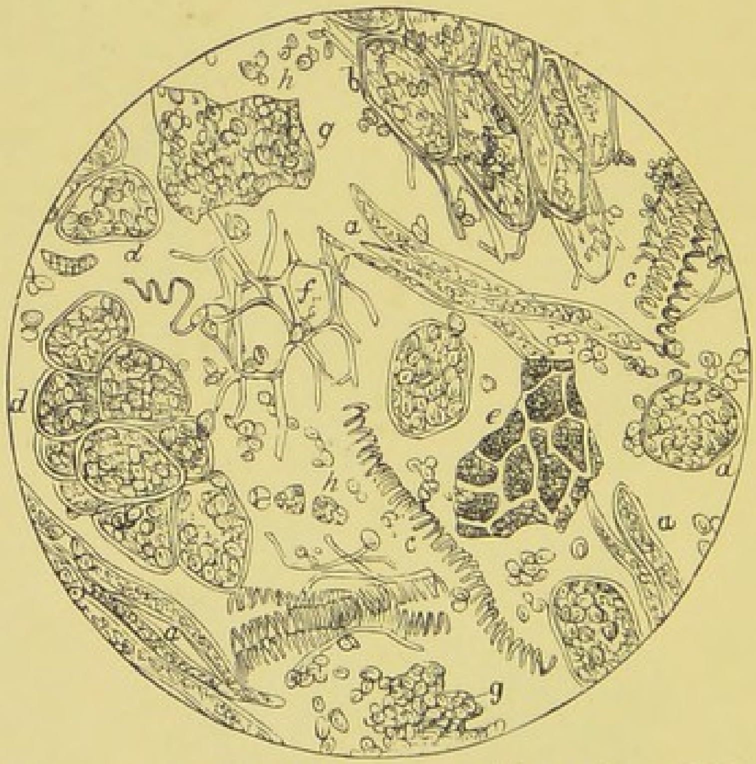


Fig. 92.—Pure Flaked Cocoa (Ground). × 220.

Usually contains both seed and shell. *a, a*, Tubular fibres on surface: *b, b*, inner membrane of husk; *c, c*, spiral vessels; *d, d*, cells of kernel; *e*, membrane covering lobes; *f*, tissue of embryo; *g, g*, free masses of starch granules: *h, h*, loose starch granules.

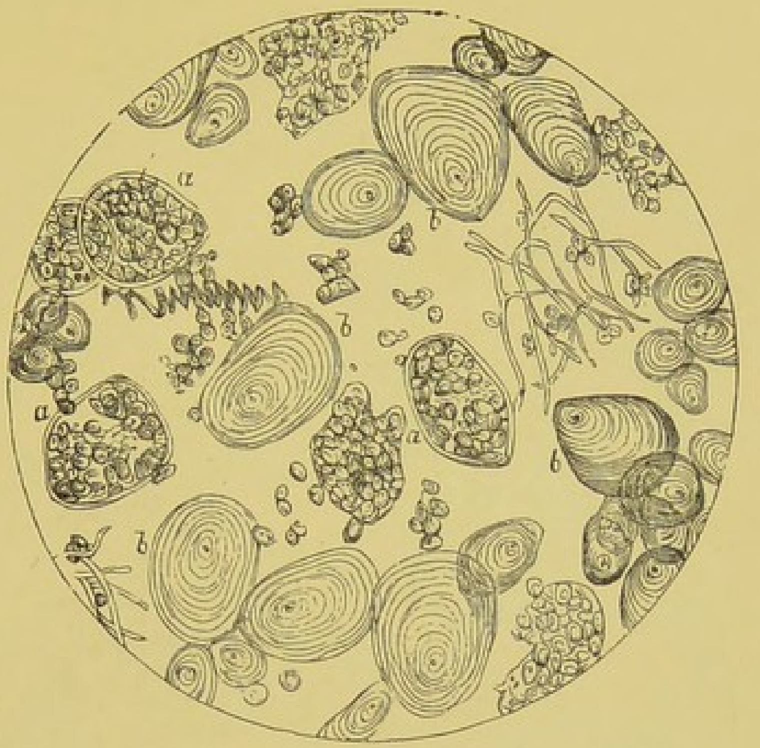


FIG. 93.—A SO-CALLED 'SOLUBLE' COCOA, MIXED WITH POTATO STARCH. × 220.
a, *a*, *a*, Cocoa ; *b*, *b*, *b*, potato starch.

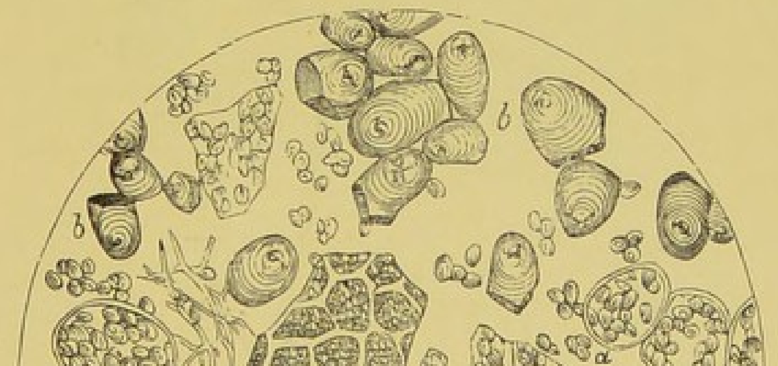


FIG. 94.—'HOMŒOPATHIC' COCOA, CONTAINING SAGO STARCH. × 220.
a, *a*, *a*, Cocoa ; *b*, *b*, *b*, sago starch.

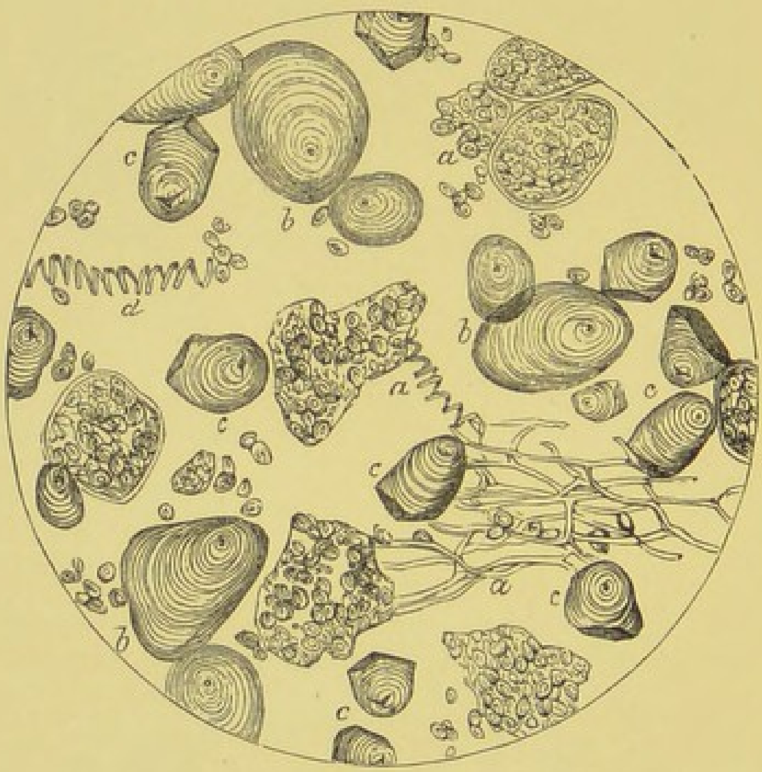


FIG. 95.—ANOTHER 'SOLUBLE' COCOA, MIXED WITH POTATO AND SAGO STARCHES. × 220.

a, a, a, Cocoa ; *b, b, b*, potato starch ; *c, c, c*, sago starch.

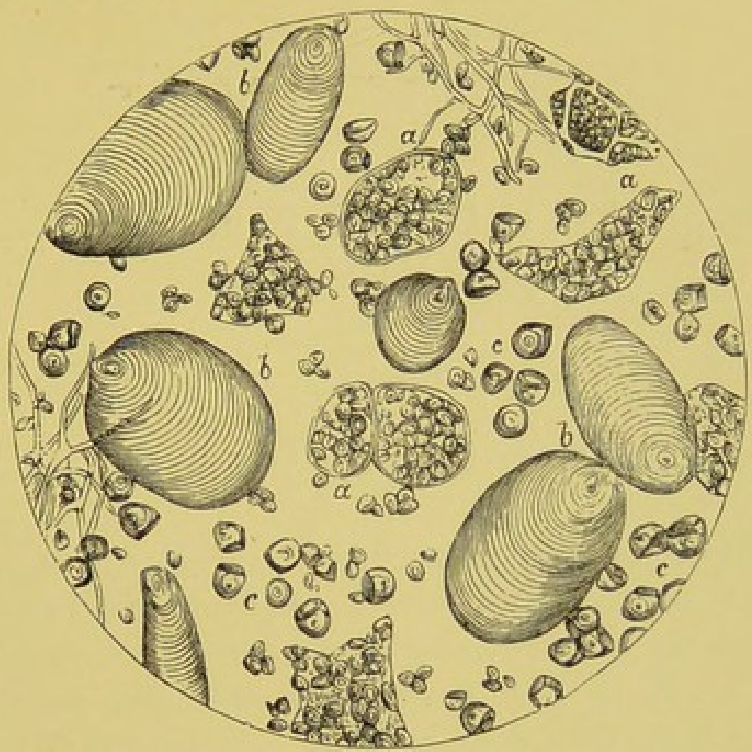


FIG. 96. 'HOMŒOPATHIC' COCOA, CONTAINING TOUS LES MOIS, ARROWROOT, AND TAPIOCA. × 220.

a, a, a, Cocoa; *b, b, b,* canna starch or *tous les mois;* *c, c,* tapioca.

FIG. 97.—SO-CALLED 'GENUINE UNADULTERATED CHOCOLATE,' CONTAINING TAPIOCA, MARANTA AND CURCUMA ARROWROOTS, WITH MAIZE AND POTATO STARCHES. × 220.

a, a, a, Cocoa; *b, b, b,* tapioca; *c, c, c,* maranta arrowroot; *d,* maize; *e, e,* potato; *f, f,* curcuma arrowroot.

ORD. CISTIFLORÆ, FAM. TERN-STRŒMIACEÆ.

TEA.

LEAVES of *Camellia Thea*, ord. *Cistifloræ*, fam. *Ternstrœmiaceæ*.

Morphology of the Leaves.—Youngest leaves narrow, downy, and but slightly serrated. Leaves next in age and size delicately serrated, but venation little perceptible. Leaves of medium and large sizes strongly, deeply and widely serrated, with well-marked venation, a series of characteristic loops being formed along each margin of the leaves.

Histology.—1. *Upper* epidermal cells small and only slightly angular, in leaf of medium size; but larger, more angular, and with walls more distinctly visible, in the old and hard leaf. Hairs and stomata absent. *Parenchyma cells* similar to those of most other leaves, and not very distinctive. 2. Cells of the *lower* epidermis larger than those of the upper surface, and associated with stomata and hairs. *Stomata*, oval or sometimes nearly round, formed of two reniform cells (guard cells) encircling a very apparent aperture; rather numerous, and confined to the under surface of the leaves. The epidermal cells are themselves curved in the neighbourhood of the stomata. *Hairs* short, pointed, and undivided; confined to the under surface of the leaf: very numerous on young leaves, less abundant on old leaves. *Wood fibre* not characteristic.

Extraneous Substances Detectable by the Microscope.—Foreign leaves, 'lie-tea,' various mineral substances.

[*For figures* (tea), *see pp.* 111, 112, *and* 113; also (substitutes or adulterants), pp. 115-124.]

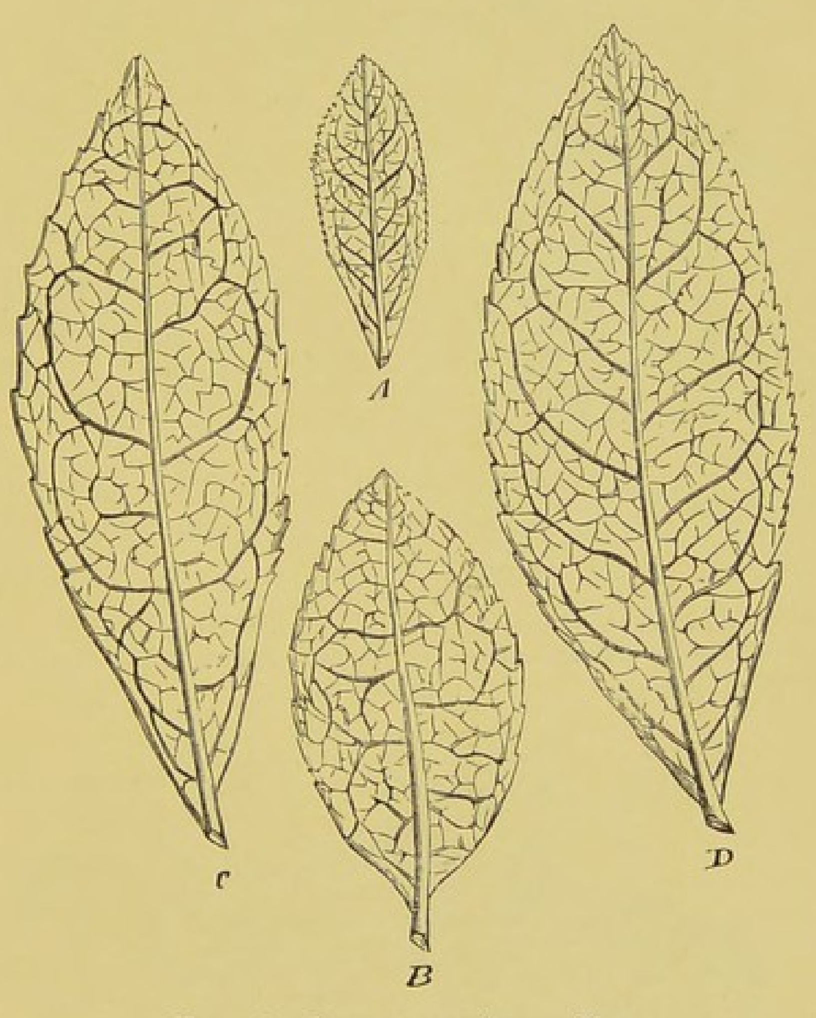


FIG. 98.—LEAVES OF CHINA TEA.

A, Young leaf ; *B*, leaf of black tea of medium size ; *C*, a larger leaf of the same ; *D* leaf of the green variety of the tea-plant.

FIG. 99.—LEAF OF ASSAM TEA: VENATION AS IN THE PRECEDING, BUT SERRATIONS SLIGHTLY DIFFERENT, BEING ALTERNATELY LARGE AND SMALL—A DIFFERENCE PROBABLY NOT CONSTANT.

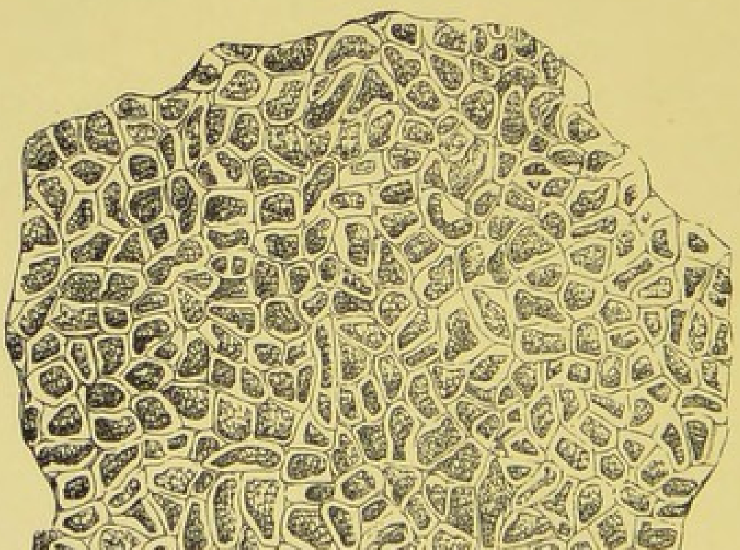


FIG. 100.—TEA-LEAF (UPPER SURFACE), SHOWING CELLS OF THE UPPER EPIDERMIS. × 350.

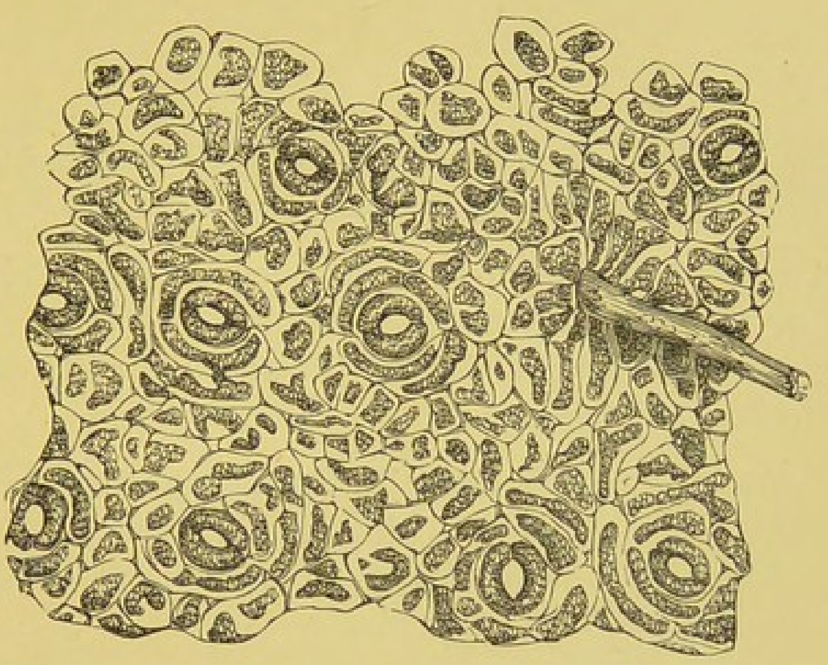


FIG. 101.—TEA-LEAF (UNDER SURFACE), SHOWING CELLS OF THE LOWER EPIDERMIS, STOMATA, AND A PORTION OF A HAIR. ×350.

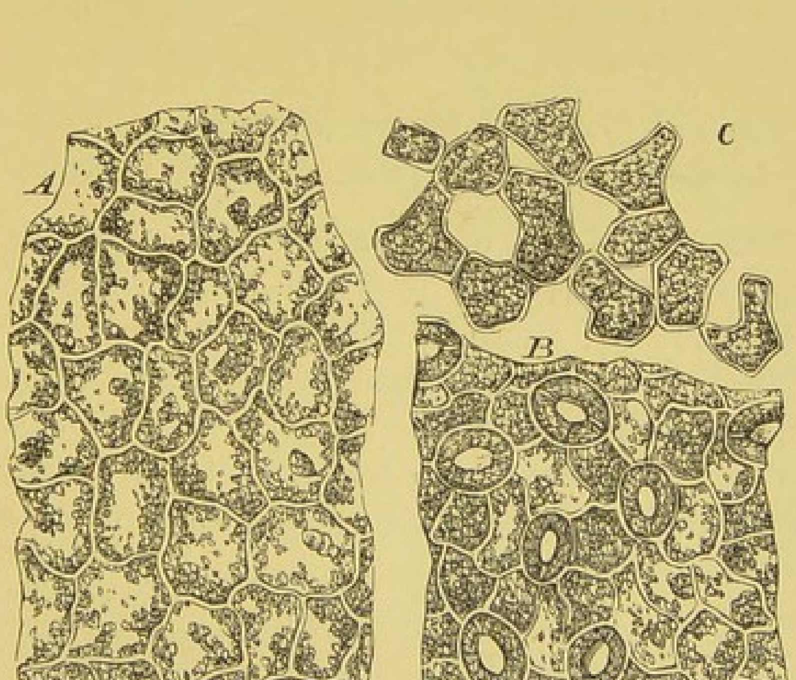


FIG. 102.—TEA-LEAF.

A, Upper epidermis of a fully-developed leaf, showing the cells more highly magnified than in Fig. 100; *B*, under surface, showing cells and stomata; *C*, cells of the chlorophyll parenchyma. ×420.

8

LEAVES WHICH HAVE BEEN USED IN ADMIXTURE WITH, OR AS SUBSTITUTES FOR, TEA.

Fig. 103.—**Leaves which have been used in Admixture with, or as Substitutes for, Tea**: *A*, leaf of *Chloranthus inconspicuus*; *B*, leaf of *Camellia Sasanqua* (Sasanqua Tea). Used to impart fragrance.

Fig. 104.—**Leaves of Camellia Sasanqua**, found in sample of Twankay: *A*, *A*, upper epidermis, showing cells; *B*, *B*, under surface, showing cells of lower epidermis, and stomata; *C*, *C*, chlorophyll cells.

Fig. 105.—**Leaf of Plum** (*Prunus domestica*), found in sample of Twankay: *A*, upper surface; *B*, under surface; *C*, spinous hair.

Fig. 106.—*A*, **Leaf of Willow** (*Salix*, sp.; fam. *Salicaceæ*); *B*, **Leaf of Poplar** (*Populus*, sp.; fam. *Salicaceæ*).

Fig. 107.—*C*, **Leaf of Plane** (*Platanus*, sp.; fam. *Platanaceæ*); *D*, **Leaf of Oak** (*Quercus*, sp.; fam. *Cupuliferæ*).

Fig. 108.—*A*, **Leaf of Hawthorn** (*Cratægus*, sp.; fam. *Rosaceæ*); *B*, **Leaf of Sloe** or **Wild Plum** (*Prunus spinosa*, fam. *Rosaceæ*); *C*, **Leaf of Beech** (*Fagus sylvatica*, fam. *Cupuliferæ*); *D*, **Leaf of Elder** (*Sambucus nigra*, fam. *Caprifoliaceæ*); *E*, **Leaf of Elm** (*Ulmus campestris*, fam. *Ulmaceæ*).

[All the entire leaves, except that of the Camellia, are figured on their under surfaces. The elm, plane, and oak leaves were of small size.]

[*For figures, see pp.* 115, 116, 117, 118, *and* 119.]

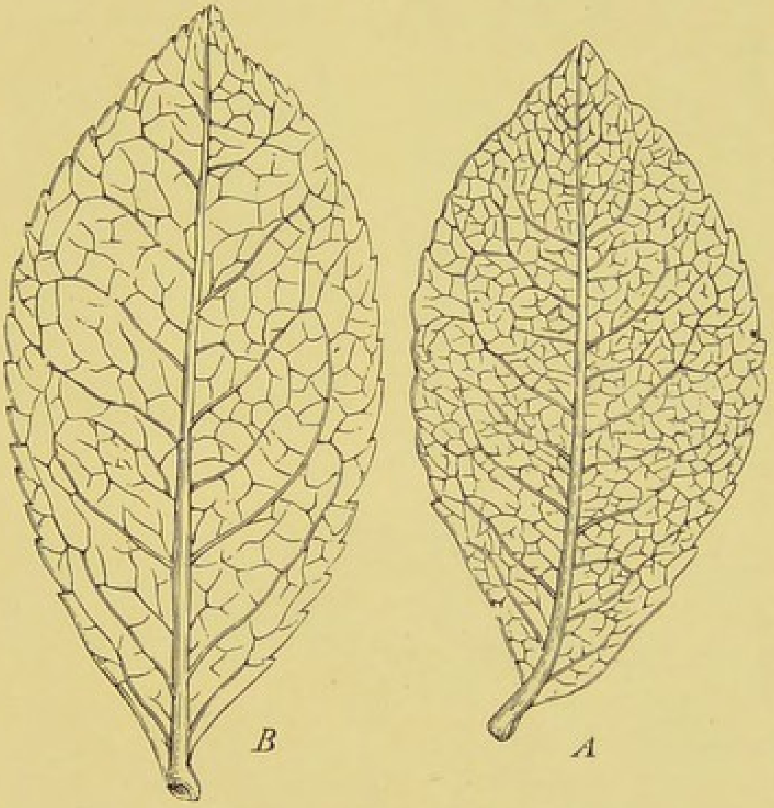


FIG. 103.—LEAVES WHICH HAVE BEEN USED IN ADMIXTURE WITH, OR AS SUBSTITUTES FOR, TEA.

A, Leaf of *Chloranthus inconspicuus*; *B*, leaf of *Camellia Sasanqua* (Sasanqua Tea). Used to impart fragrance.

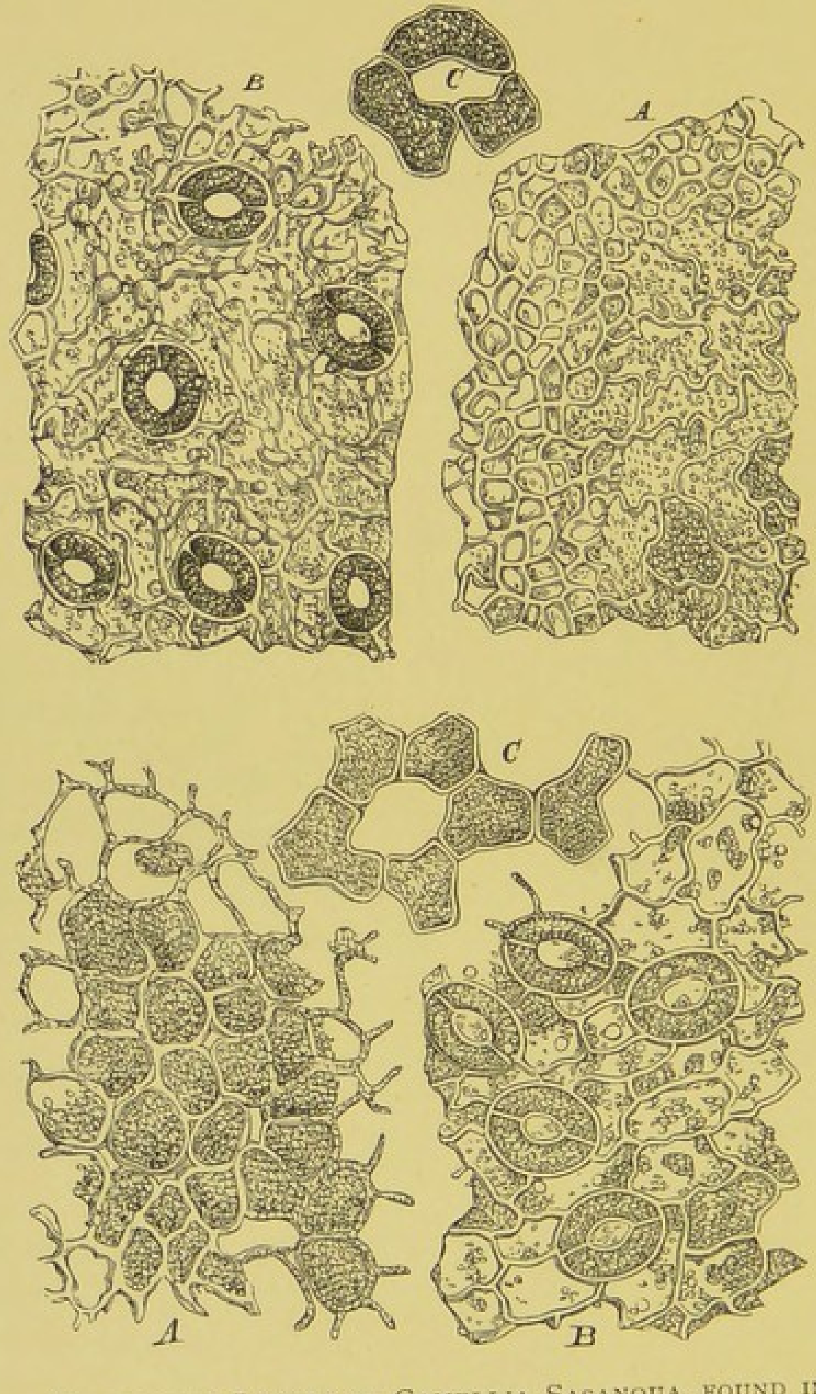


FIG. 104.—PORTIONS OF LEAVES OF CAMELLIA SASANQUA, FOUND IN SAMPLE OF TWANKAY. ×420.

A, A, Upper epidermis; *B B*, under surface, showing cells of nether epidermis, and stomata[1]; *C C*, chlorophyll cells.

[1] The guard-cells are very clearly indicated in *B, B*.

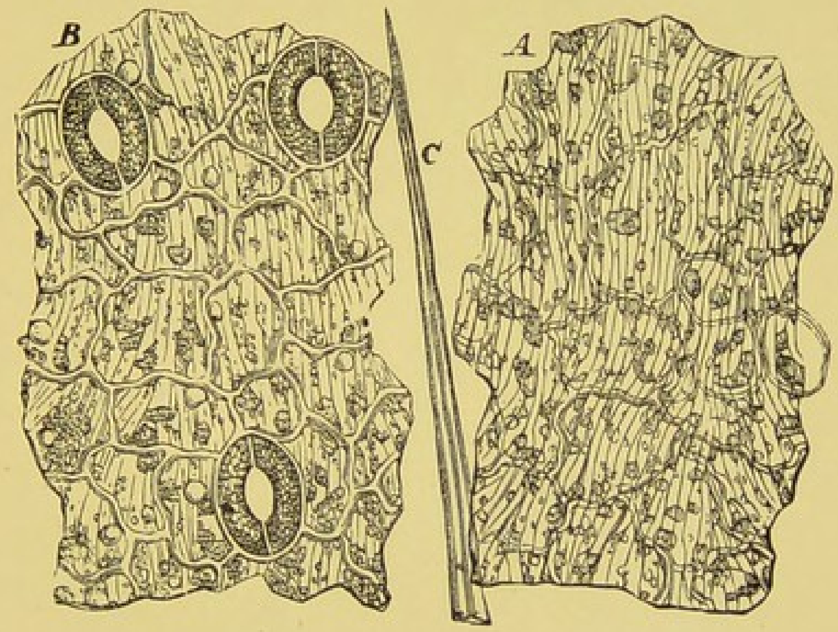


FIG. 105.—LEAF OF PLUM (PRUNUS DOMESTICA), FOUND IN SAMPLE OF TWANKAY. × 420.

A, Upper surface ; *B*, under surface ; *C*, spinous hair.

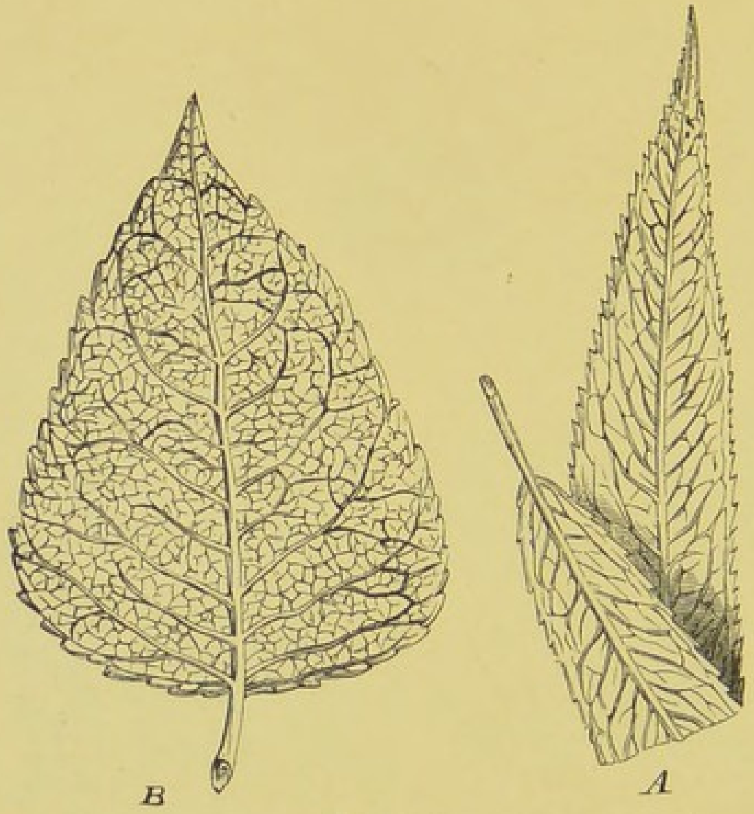


FIG. 106.
A, Leaf of Willow ; *B*, leaf of Poplar.

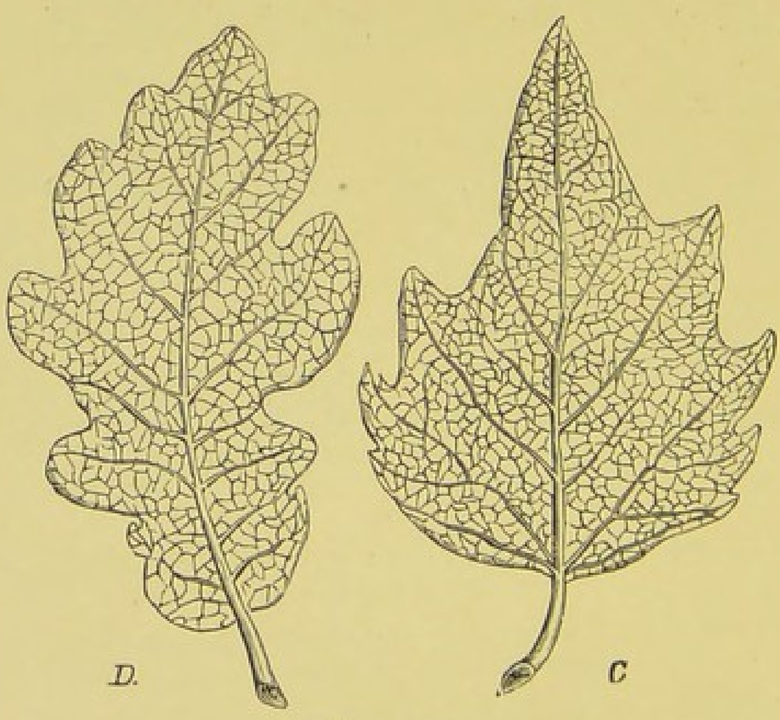


FIG. 107
C, Leaf of Plane ; *D*, leaf of Oak.

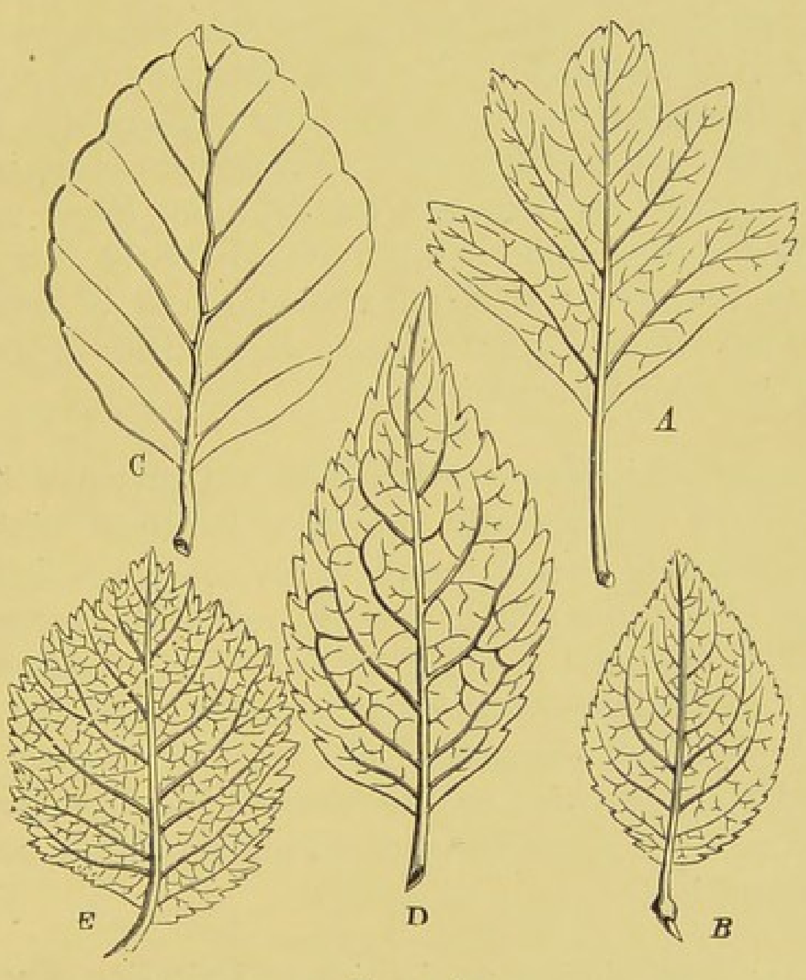


FIG. 108.

A, Leaf of Hawthorn ; *B*, leaf of Sloe-tree ; *C*, leaf of Beech ; *D*, leaf of Elder ; *E*, leaf of Elm.

FACTITIOUS TEAS, AND ADULTERANTS OF TEA.

Fig. 109.—**Foreign Leaf and other Extraneous Bodies in a Sample of China Tea of low quality, mainly composed of 'Lie-Tea'** (see *infra*): *a*, *a*, upper surface (upper epidermis) of a foreign leaf; *b*, under surface (nether epidermis), showing the cells composing it, with their slightly-beaded margins, also the stomata; *c*, chlorophyll parenchyma cells of the *mesophyll*, or inner substance of the leaf, near the lower surface, branching, and so disposed as to form large areolæ; *d*, elongated cells found on upper surface of the leaf in the course of the veins; *e*, spiral vessel; *f*, cell of turmeric; *g*, *g*, fragments of Prussian blue; *h*, particles of a white powder, probably China clay.

Fig. 110.—**'Lie-Tea'** (a factitious tea prepared by the Chinese, and benevolently provided by them with this appropiate name. Some samples may contain a little tea-dust. It is doubtful whether lie-tea now finds its way into the English market): *a*, upper surface of a leaf other than tea; *b*, lower surface with stomata; *c*, chlorophyll cells of the mesophyll; *d*, elongated cells; *e*, part of one of the branched spinous hairs on the under surface of the leaf; *f*, cell of turmeric; *g*, *g*, fragments of Prussian blue; *h*, particles of white powder.

Fig. 111.—(A similar production.) **Imitation Caper or Gunpowder Tea**: *a*, *a*, fragments of the tea-leaf or tea-dust; *b*, *b*, particles of sand; *c*, *c*, starch granules; *d*, *d*, plumbago; *e*, *e*, mica (?); *f*, *f*, turmeric; *g*, *g*, fragments of indigo.

Fig. 112.—**A Preparation formerly supplied for the purpose of mixing with Tea;**[1] consisting chiefly of *sumach leaves* (*Rhus*, sp.; fam. *Anacardiaceæ*), and *catechu*, the astringent extract made from *Acacia catechu*, fam. *Mimosaceæ!*

[1] It is extremely unlikely that such articles as these in this country are anywhere obtainable at the present time. They are described here as curiosities of the past.—E. G. C.

The directions were: '*Put a quarter of a teaspoonful into the teapot, with two teaspoonfuls of tea, and it will doubly increase the strength, and improve the flavour.*' In the figure, *a, a* = fragments of *sumach leaves; b, b,* particles of *catechu; c, c,* crystals present in catechu.

Fig. 113.—**A Rival Preparation**, sold at the same period,[1] consisting of catechu and wheat flour. In the figure, *a, a* = starch granules of wheat; *b, b,* fragments of catechu; *c, c,* crystals.

[1] See note on preceding page.

[*For figures, see pp.* 122, 123, *and* 124.]

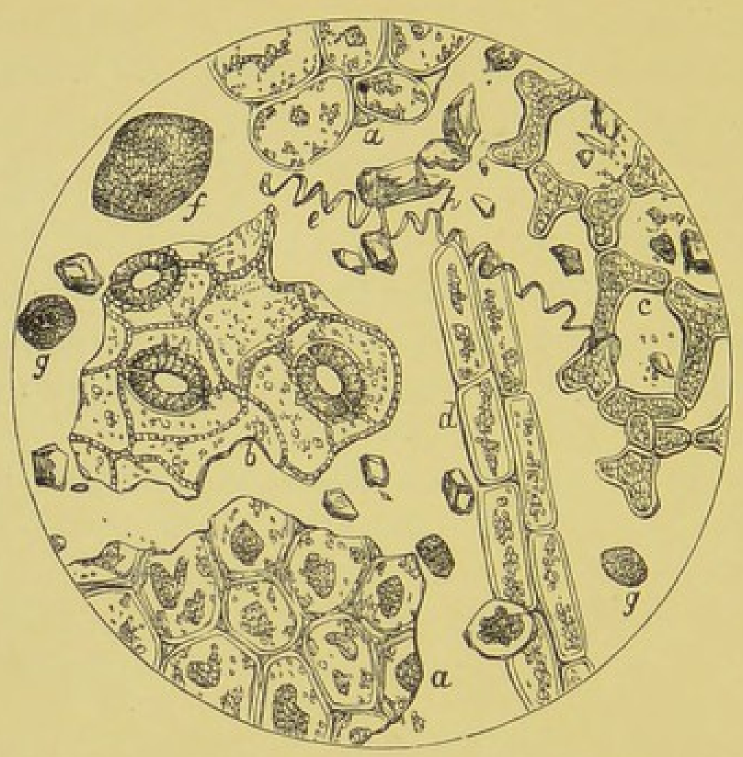


Fig. 109.—Foreign Leaf and other Extraneous Bodies in a China Tea of low quality, mainly composed of 'Lie-Tea.' ×350.

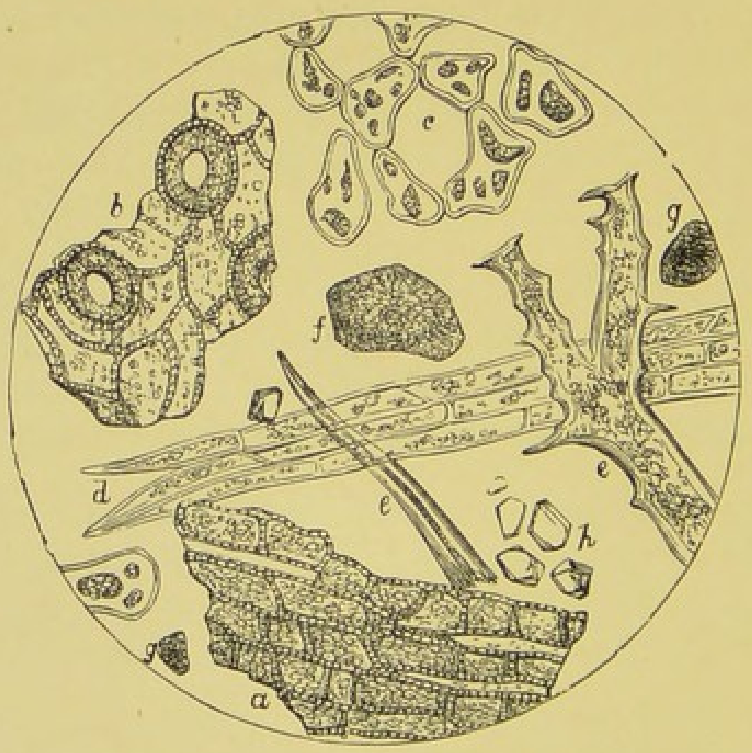


Fig. 110.—'Lie-Tea.' ×420.

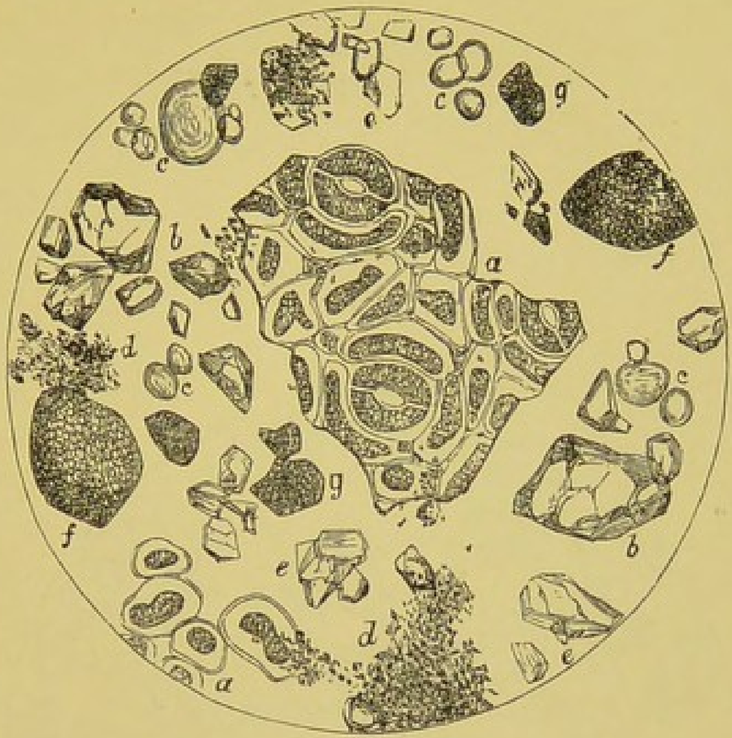


FIG. 111.—IMITATION CAPER OR GUNPOWDER TEA. × 350.

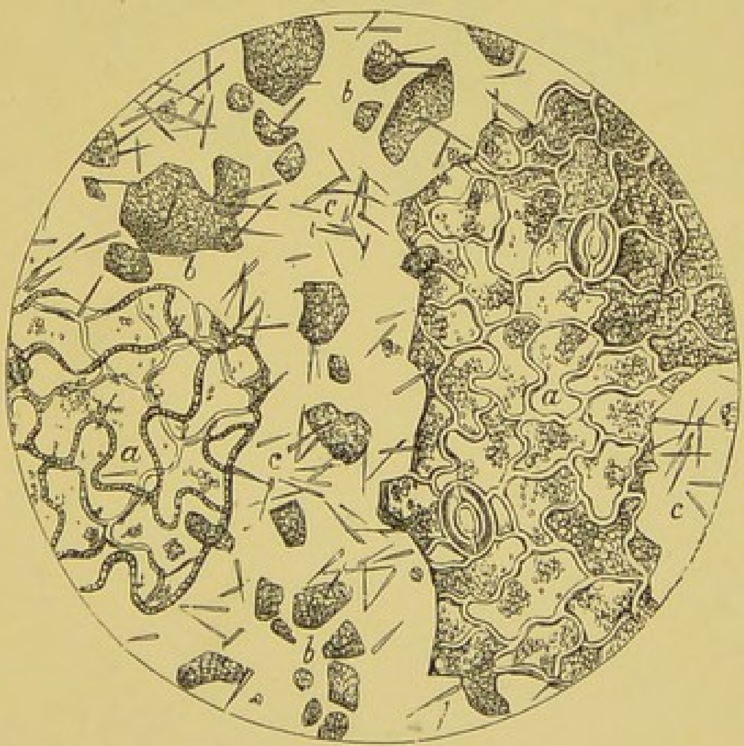


FIG. 112.—A TEA 'ECONOMIZER': SUMACH AND CATECHU. × 350.

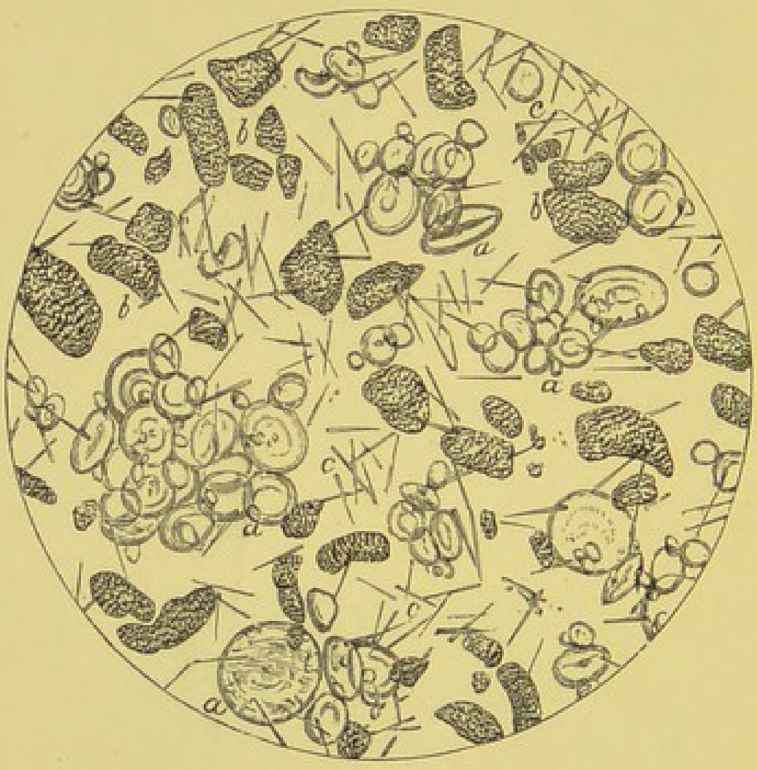


FIG. 113.—A RIVAL 'ECONOMIZER': CATECHU AND FLOUR. × 350.

[SACCHARINE SUBSTANCES.

SACCHARINE SUBSTANCES.

ORD. GLUMIFLORÆ, FAM. GRAMINEÆ (SUGAR-CANE); AND ORD. CENTROSPERMÆ, FAM. CHENOPODIACEÆ (SUGAR-BEET).

CANE SUGAR, SUCROSE, OR SACCHAROSE.

A HIGHLY soluble sweet carbohydrate, belonging to the class of *Saccharobioses,* obtained by evaporating the cell-sap of the sugar-cane (*Saccharum officinarum*), of the sugar-beet (*Beta vulgaris*, var. *altissima*), and other plants.

Histology of the Sugar-Cane.—Parenchyma composed of utricles or cells, rectangular in shape, usually rather longer than broad, and several times larger in the central part of the bamboo than in its outer and harder portions. Walls of the cells all finely dotted or punctated—a very characteristic feature. The juice is enclosed in the cavities of these cells. Fibro-vascular bundles traverse the cane longitudinally, giving to transverse sections a dotted appearance: these bundles are constituted of greatly elongated cells (wood-fibres), and enclose vessels generally more or less reticulated or dotted. The *vessels*, one or more of which are generally included in the centre of each bundle, are of two kinds—the interrupted spiral or pitted vessel, and the simple or continuous spiral vessel. The pitted vessels are sometimes cylindrical, but frequently polygonal, from the compression exerted upon them by the surrounding wood-fibres, the markings of the cells forming which are often seen upon their surfaces. The spiral vessels are found chiefly in the outer, harder part of the stem. The *epidermis*, or *cuticle*, is known by the elongated cells composing it, and the presence of stomata. At the distal extremity of each internode of the cane, the ordinary epidermic cells are replaced or overlaid by a layer of cells totally different in character (stone cells): they are usually anisodiametric, more or less rounded or oval in shape, and possessed of very thick walls traversed by pores, disposed in a radiate manner. These cells are similar to the cells found in the stones of fruit, and form by their union a smooth, hard zone round the cane, about one-third of an inch deep.

Appearance (of sugar crystallized from its solutions).—Crystals, large transparent monoclinic prisms, variously modified, usually with hemihedral faces.

Extraneous Matters Detectable by the Microscope.—In brown sugar: *glyciphagi* or sugar-mites, fungus-sporules, fragments of various woods, etc.

[*For figures, see pp.* 128 *and* 129.]

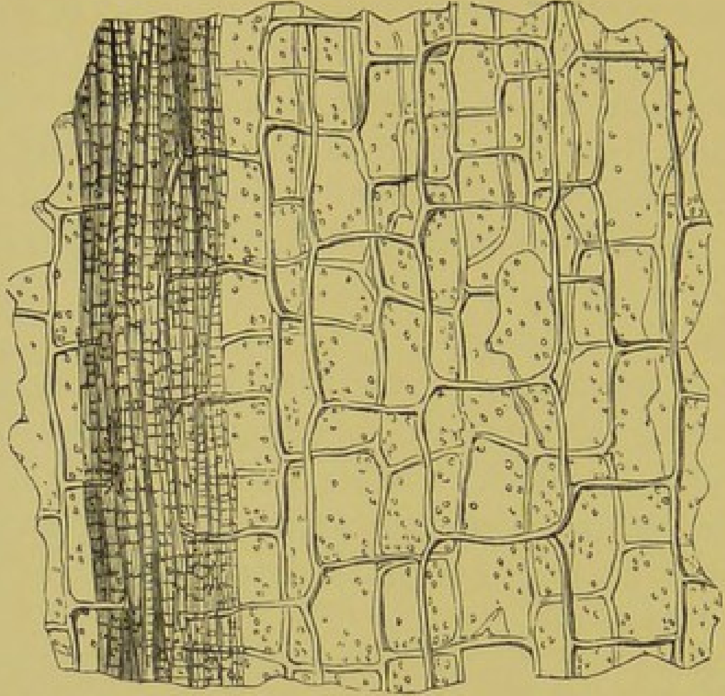


FIG. 114.—SUGAR-CANE, LONGITUDINAL SECTION: FRAGMENT FROM NEAR THE CENTRE OF THE STEM, SHOWING PARENCHYMATOUS CELLS AND A FIBRO-VASCULAR BUNDLE. × 100.

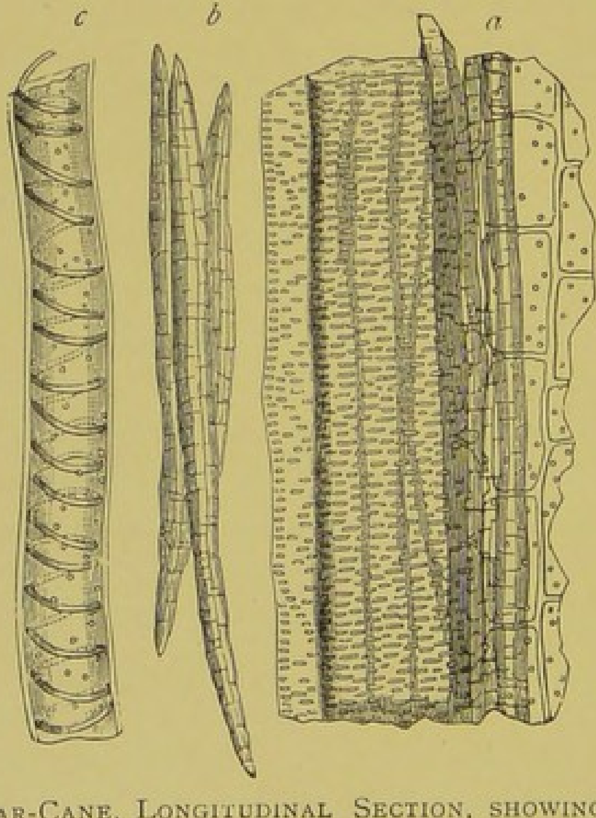


FIG. 115.—SUGAR-CANE, LONGITUDINAL SECTION, SHOWING STRUCTURE OF THE TWO KINDS OF VESSELS, AND THE CELLS CONSTITUTING THE WOOD-FIBRE. × 200.

a, Dotted vessels embedded in wood-fibre; *b*, cells of fibre; *c*, spiral vessel.

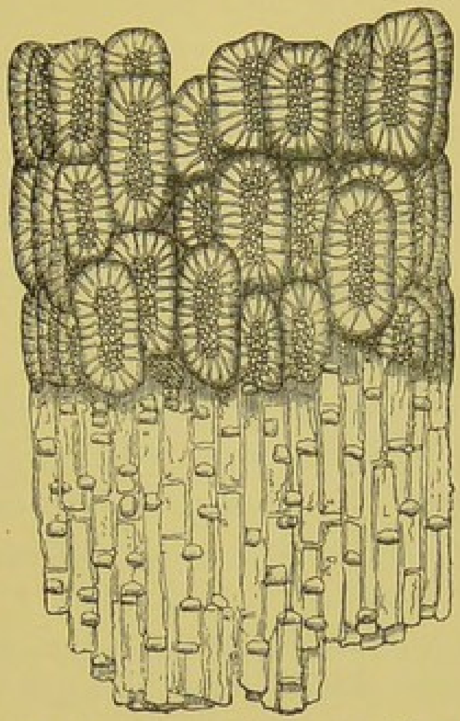


FIG. 116.—SUGAR CANE: EPIDERMAL LAYERS, IN SURFACE VIEW; SHOWING, ABOVE, THE STONE CELLS, AND, BENEATH, THE ELONGATED CELLS × 200.

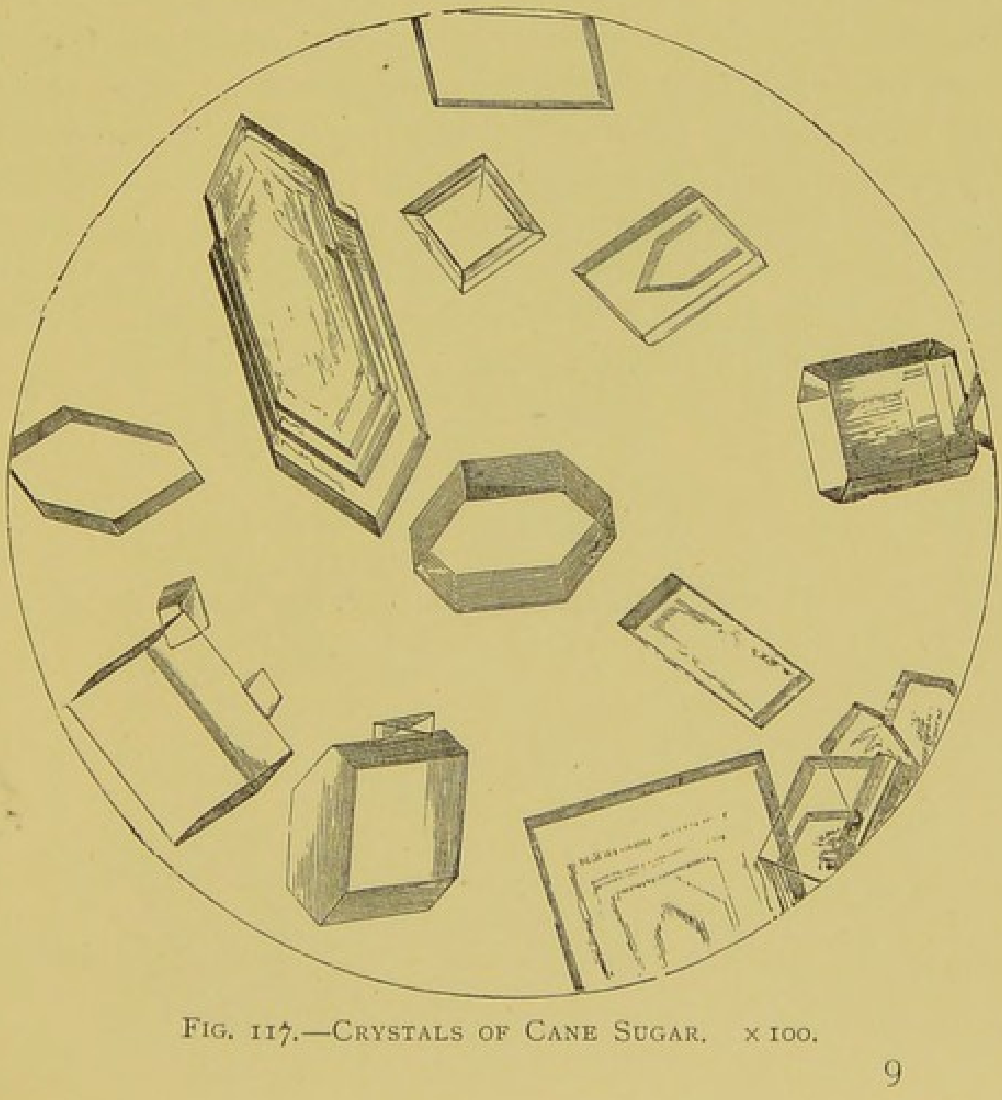


FIG. 117.—CRYSTALS OF CANE SUGAR. × 100.

IMPURITIES WHICH HAVE BEEN FOUND IN SUGAR.

Foreign Matters Detectable by the Microscope.—Minute, semi-transparent, apterous insects, belonging to the family *Acaridæ*, or 'mites,' at one period were commonly present in immense numbers in the coarser brown sugars of commerce. This fact was first discovered by Dr. A. H. Hassall, recorded by him in the *Lancet* of 1851, and subsequently mentioned in his works on food. The disclosure led to a considerable improvement in the quality of the cheaper sugars put upon the market, and to a more general use of refined sugar by the public. Several specimens of *Acarus sacchari* (= *Glyciphagus cursor*, etc.) are depicted in the figures.

In raw sugars, fungus-spores, fragments of wood, sand, and other extraneous matters may frequently be discovered. Glyciphagi still sometimes occur in preserving sugars and the like. Quite recently several of these little insects were observed by the present writer in a sample of whole-fruit strawberry jam under microscopical investigation. White sugar is usually extremely pure.

[*For figures, see pp.* 131, 132, *and* 133.]

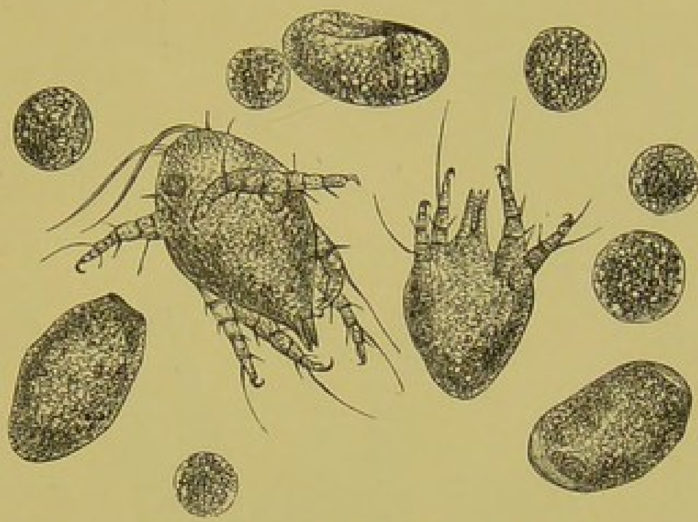


FIG. 118.—GLYCIPHAGUS, OR ACARUS SACCHARI: THE SUGAR-MITE. OVA AND YOUNG. × 200.

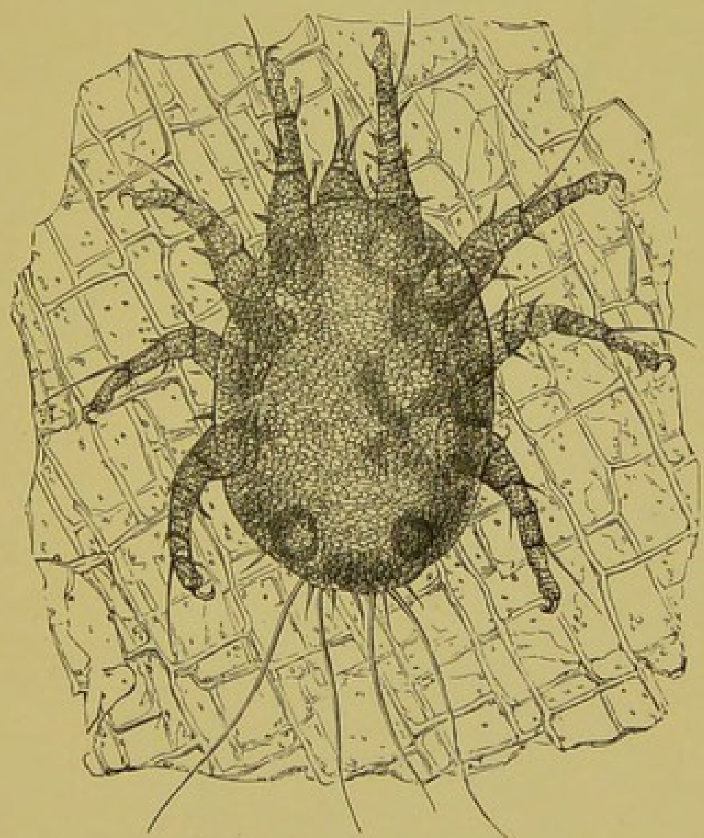


FIG. 119.—GLYCIPHAGUS OF MEDIUM SIZE, ALIVE AND CRAWLING ON A FRAGMENT OF CANE. × 200.

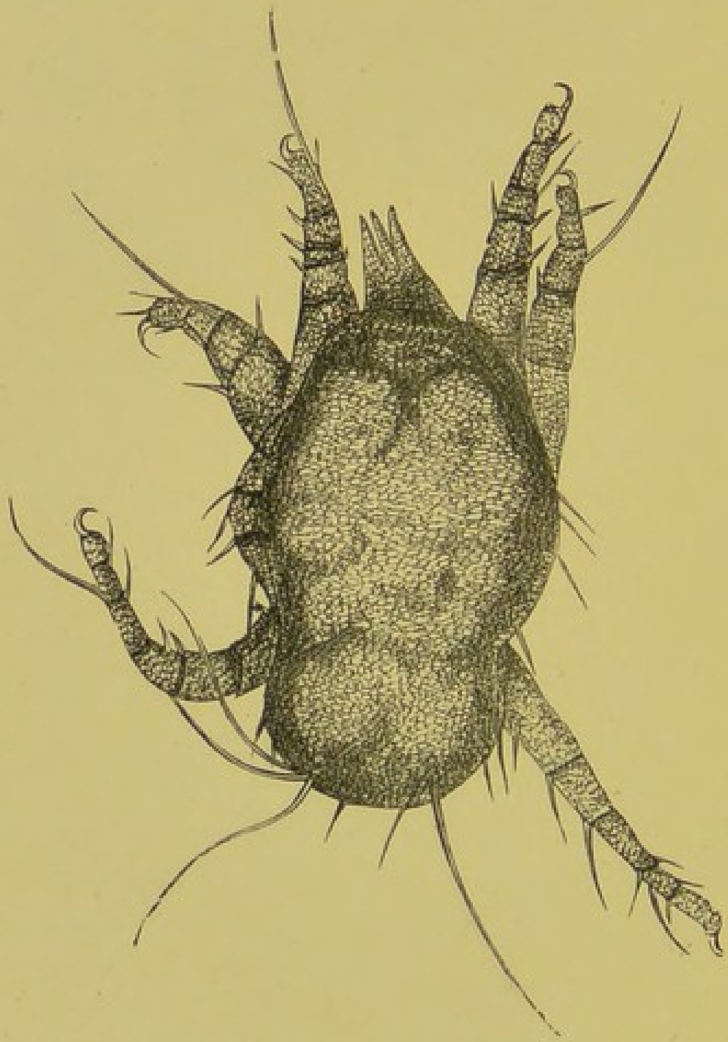


FIG. 120.—GLYCIPHAGUS WHICH HAS NEARLY ATTAINED FULL DEVELOPMENT; AS IT FREQUENTLY APPEARS WHEN DEAD. × 200.

FIG. 121.—SPORES OF A FUNGUS, PROBABLY A SPECIES OF TORULA, FOUND IN BROWN SUGAR. ×420.

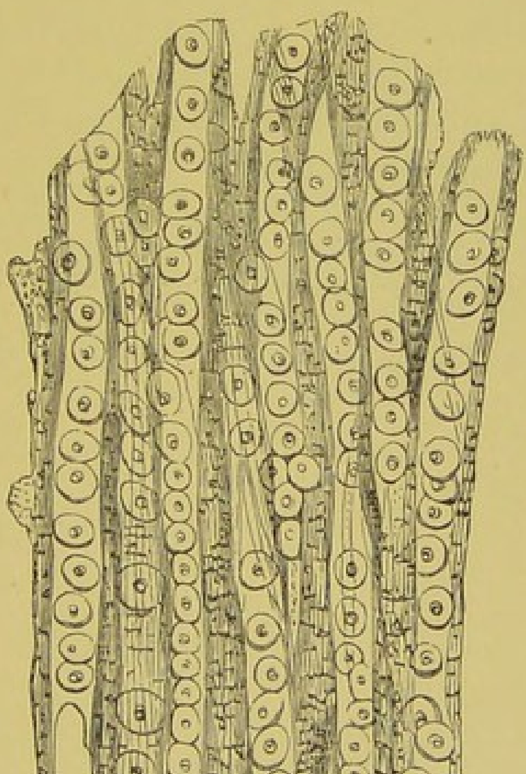


FIG. 122.—FRAGMENT OF DEAL, OR FIR-WOOD, PROBABLY DERIVED FROM CASKS OR OTHER VESSELS. ×200.

HONEY.

This substance, which is composed of the sugars called dextrose and lævulose, mixed in about equal proportions, together with water and very small quantities of wax, mannite, ash, organic acids, and alcohol, is collected and garnered by the honey-bee (*Apis mellifica*).

Appearance of Solid Portion.—Thin, transparent, brittle, six-sided prisms, often broken and imperfect, intermingled with pollen granules of different forms, sizes, and structures. From these characters the plants from which the honey has been procured may often be determined.

Extraneous Matters Detectable by the Microscope.—Potato and wheat starch, and in some cases—doubtfully—added cane sugar. It is averred that chalk, gypsum, pipe-clay, and other inorganic substances have sometimes been introduced; such additions must be extremely rare.

[*For figures, see pp.* 135, 136, *and* 137.]

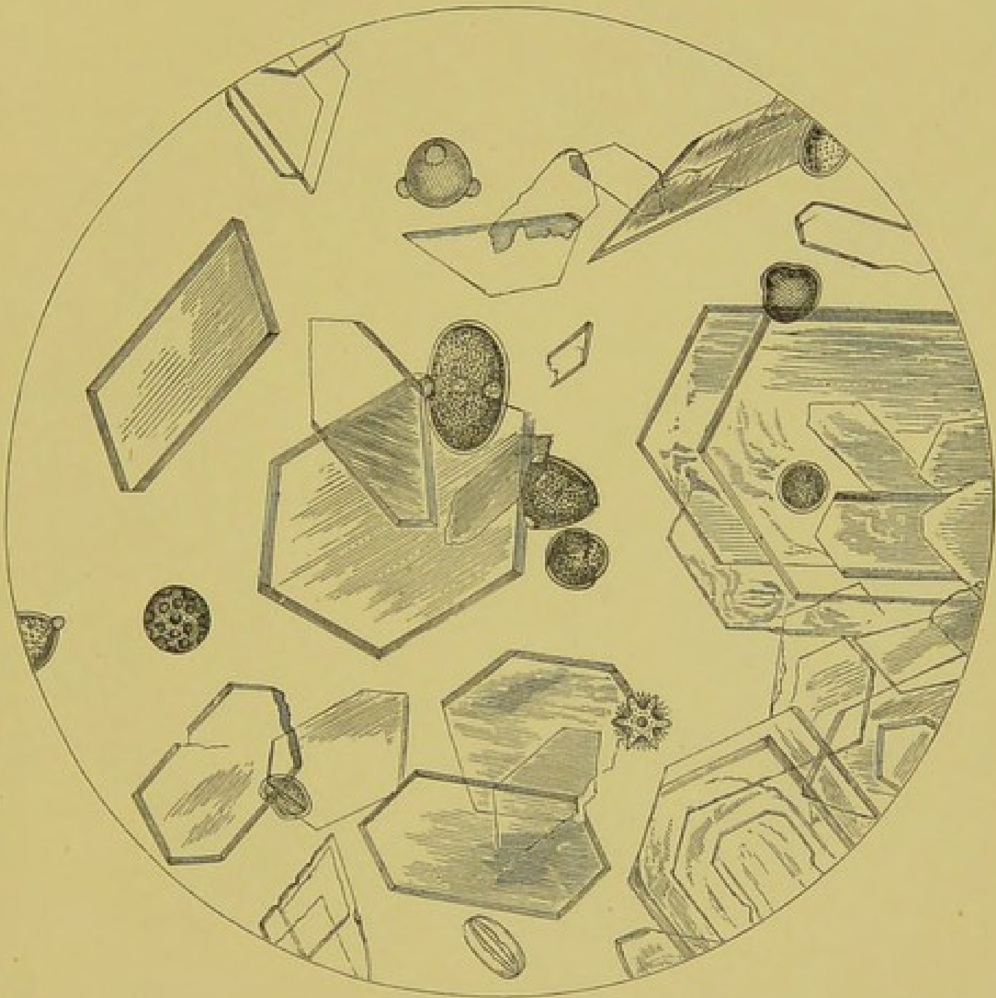


FIG. 123.—HONEY: SHOWING CRYSTALS AND POLLEN GRANULES. ×225.

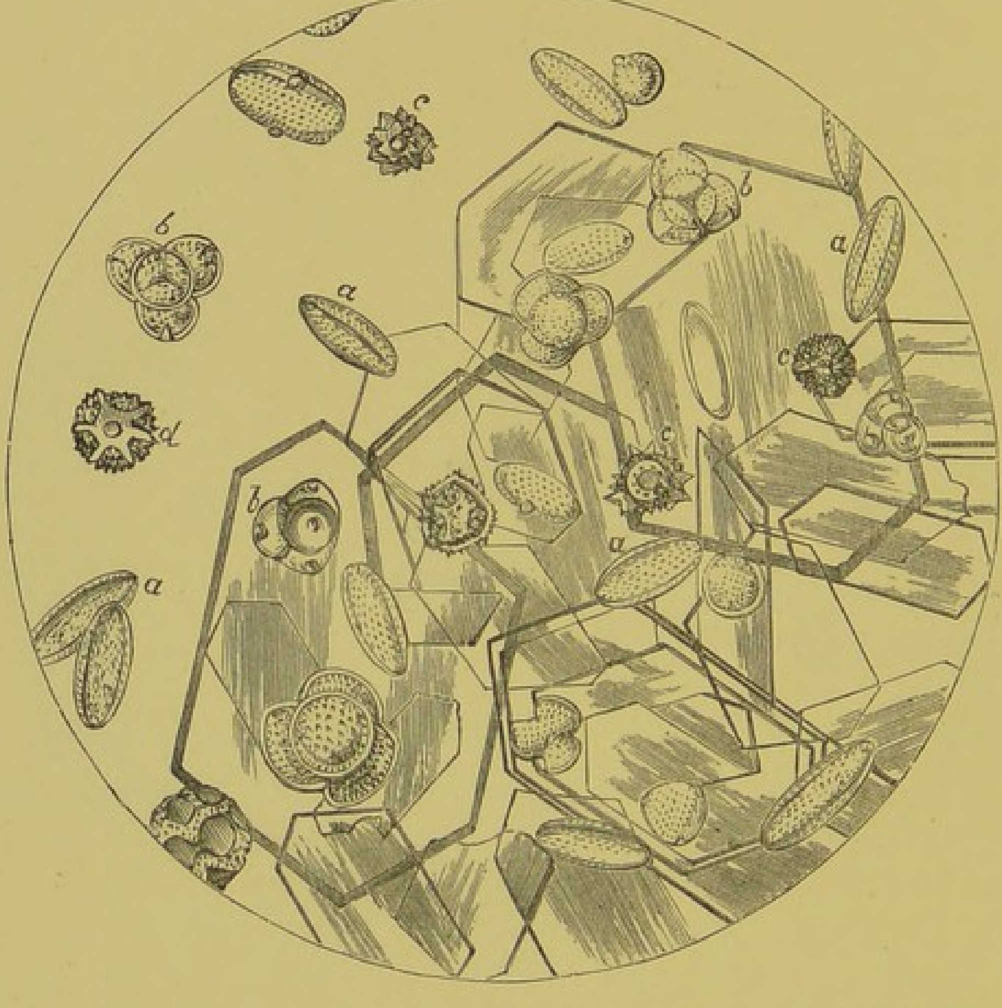


FIG. 124.—HONEY: SHOWN BY THE POLLEN GRANULES PRESENT TO HAVE BEEN COLLECTED CHIEFLY FROM A HEATH. × 225.

a, Pollen granules of furze (*Ulex*, sp.); *b*, pollen of heath (*Erica*, sp.); *c*, pollen of one of the *Compositæ*.

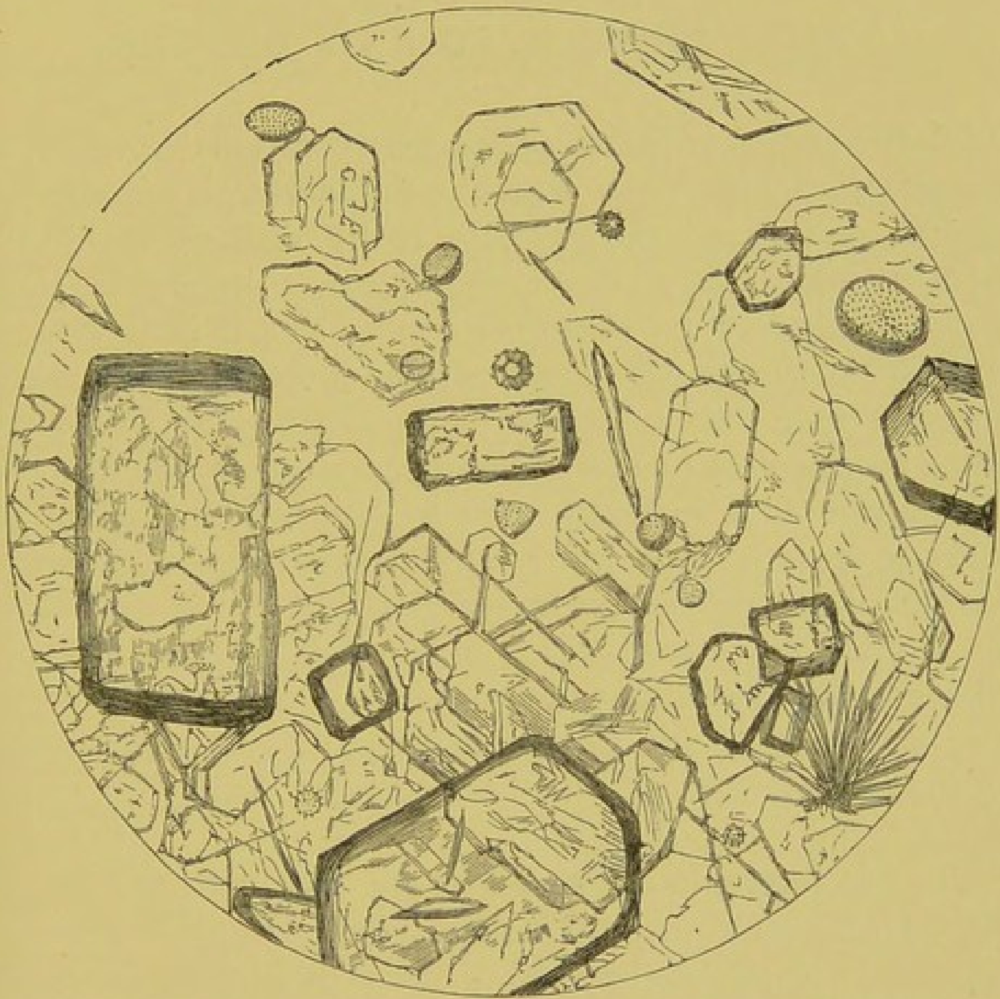


FIG. 125.—HONEY, ADULTERATED WITH CANE SUGAR: THE THICK IRREGULAR CRYSTALS ARE THE ADDED SUGAR. × 200.

FRUIT PRESERVES AND JELLIES.

Of the many varieties of fruit preparations supplied to consumers, jellies, from which solid matter is usually excluded, can as a rule be least easily dealt with by the microscopist. The diagnosis of the components must generally depend on chemical tests. But it is unwise to omit a microscopical examination, because, by careful investigation, even in jellies can sometimes be discovered hairs, fragments of cellular tissue, or seeds, which disclose the nature of the materials used by the manufacturers. In other preparations of fruit, whether candied, dried, sliced, pared, canned or bottled in syrup, boiled down with sugar (as in jams and marmalades), or otherwise treated, some or all (according to circumstances) of the characteristic microscopical features are invariably present, and the identity of the components of the preserve may readily be established.

The admixture, in conserves, of one fruit with another, or the addition of turnip, beet-pulp, apple, vegetable marrow, etc., can usually be detected, if the structure of the seeds, pips, cuticle, hairs and parenchyma, of the several fruits and vegetable substances be very carefully studied previously. Also, separate specimens of the foreign ingredients suspected to be present should be comparatively examined, side by side with the jam or preserve under investigation. It is scarcely necessary to add that a discriminative megascopic scrutiny of fruit preserves should precede the microscopical examination; often, indeed, the former alone is sufficient.

An approximate estimate of the proportions of the different fruits in a preserve may sometimes be arrived at by counting the several kinds of seeds present: the numbers of seeds in various fruits being known to be as follows:

Gooseberry ...	... 25 to 35,	average	30
Strawberry ...	... 70 to 100,	„	85
Raspberry ...	... 55 to 65,	„	60
Black Currant ...	... 35 to 40,	„	40
White and Red Currants...	3 to 5,	„	4

Seeds of some of the commoner fruits are represented in Fig. 126, p. 140.

Fruit for preserving should be fresh, sound, and clean: the places where it is made into jam should at least be sanitary; and the workers should be paid enough to enable them to maintain an average degree of bodily health, cleanliness, and comfort. It is more than doubtful whether these conditions are fulfilled in all British jam-factories. For an idea of the revolting and abominable state of affairs prevailing in certain fruit-preserve and other food-factories, the reader is referred to Chapter V. of 'The Soul Market,' by Olive C. Malvery.[1] In sober truth, we in the United Kingdom have our own 'Jungle.'

It is too much to hope that fruit will always be free from parasitic germs. Il'ya Mechnikov has pointed out that strawberries especially are liable to convey the *ova* of intestinal worms. But well-made jam should have been submitted to so high a temperature that the danger from this source is removed.

It is not here attempted systematically to enumerate and describe in order, nor to illustrate, all of the very numerous histological elements present in the fruits ordinarily eaten. Certain of these elements, such as the cells of the parenchyma or pulp, the fibro-vascular bundles and spiral vessels, and the epidermal tissues, with slight modifications of form and variations in size, are common to nearly all the succulent fruits, and even to some of the roots and tubers used as adulterants. But fortunately it is the case that almost every fruit exhibits one or more distinctive microscopic features by which its presence can be recognized in a mixture. The

[1] W. Heinemann, 1906.

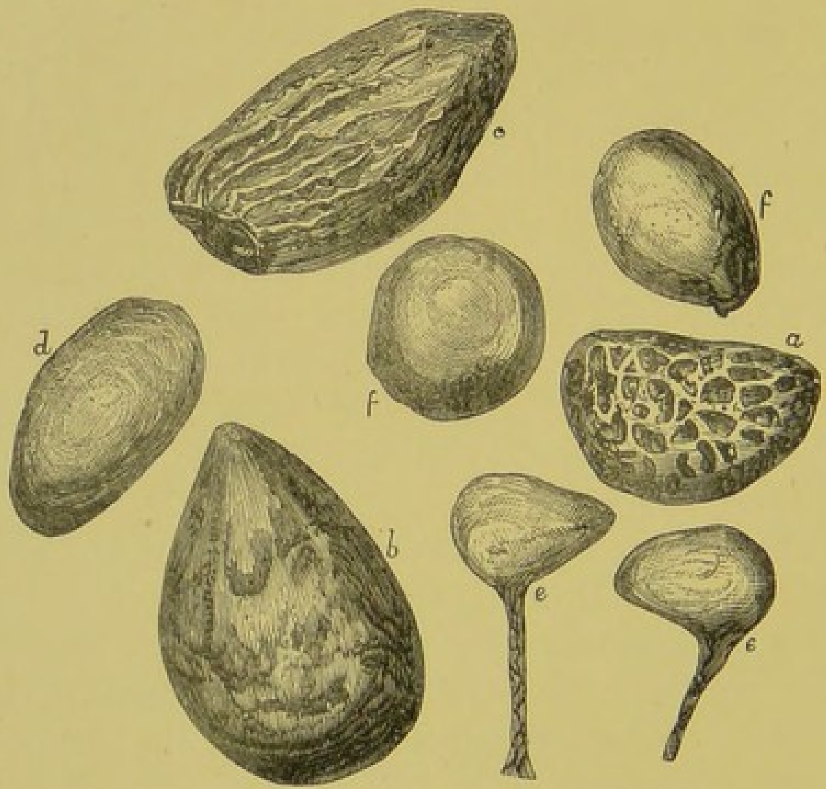


FIG. 126.—SEEDS OF VARIOUS FRUITS:

a, Raspberry; *b*, gooseberry; *c*, white currant; *d*, black currant; *e*, *e*, strawberry; *f*, *f*, fig-' seeds.'

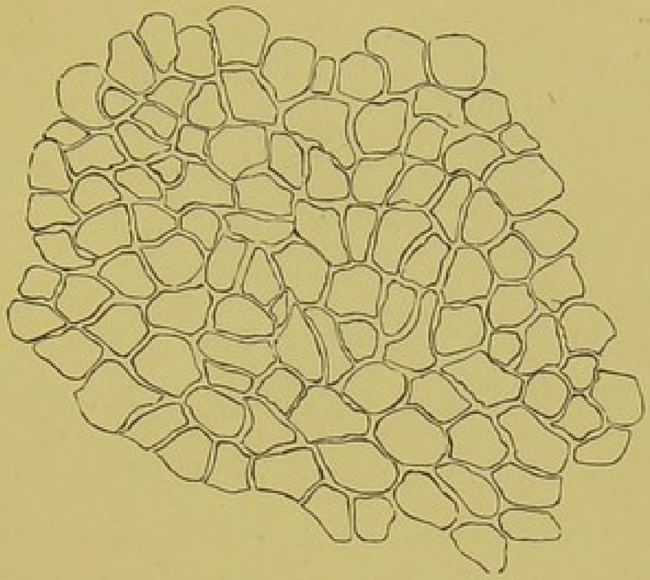


FIG. 127.—APPLE: EPIDERMIS, CONSISTING OF SOMEWHAT THICK-WALLED, OFTEN QUADRANGULAR CELLS.[1]

[1] Sometimes called 'window cells.'

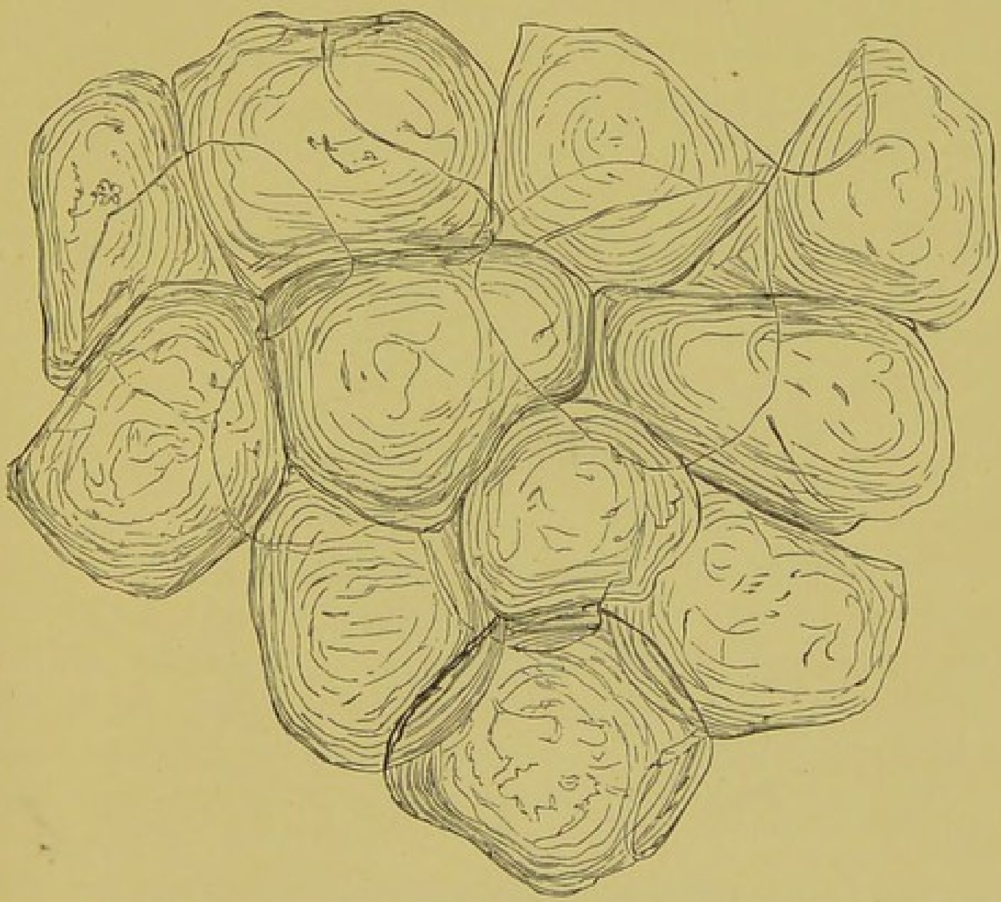


FIG 128.—APPLE: THE EXTREMELY LARGE, LOOSE, THIN-WALLED, TRANSPARENT CELLS OF THE PARENCHYMA, CONSTITUTING THE FLESH OF THE FRUIT.

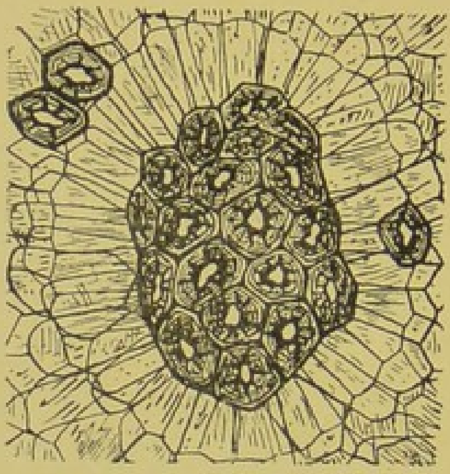


FIG. 129.—THE PEAR. × 150.

Group of Stone Cells, with radiating Parenchyma Cells.

[E. G. Clayton, *del.*]

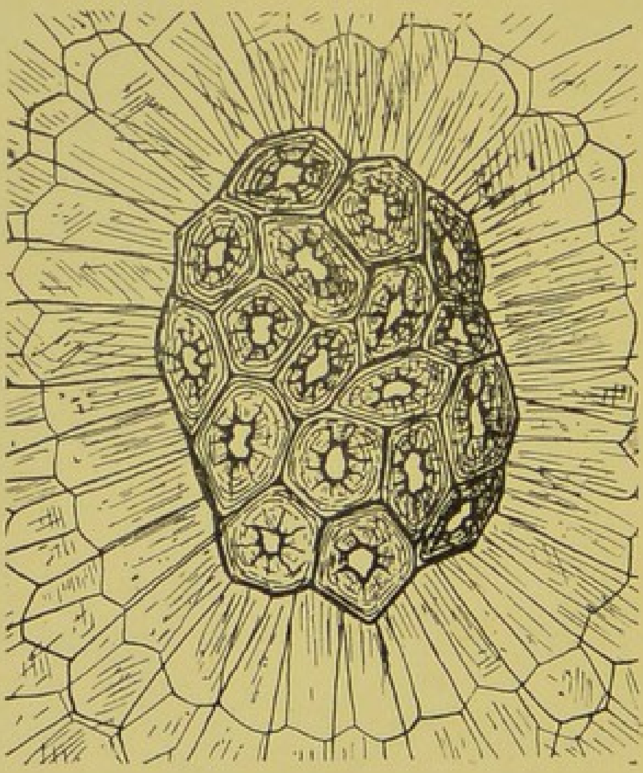


FIG. 130.—THE QUINCE. × 150.

Group of Stone Cells, with Parenchyma.

[E. G. Clayton, *del.*]

most important of these histological indices are summarized below, and shown in the figures accompanying the text.

Among the distinguishing characters of ordinary fruits are:

1. In the **Apple** (*Pirus malus*, ord. *Rosifloræ*, fam. *Rosaceæ*): the roughly quadrilateral, subdivided 'window-cells' of the epicarp (Fig. 127, p. 141); the large, circular, ovate, polygonal, or parenchyma cells (Fig. 128, p. 141); the sclerenchymatous fibre-cells of the 'core,' crossing at various angles; and, sometimes apparent at the sutures of the five carpels, the jointed multicellular hairs described by Malfatti.

2. In the **Pear** (*Pirus communis*, ord. *Rosifloræ*, fam. *Rosaceæ*): similar epicarpal cells, smaller than those of the apple; groups of thick-walled, porous, stone cells, distributed throughout the parenchyma, the cells of which radiate from, and are elongated in the vicinity of, the stone cells (Fig. 129); also jointed hairs akin to those of the apple.

3. In the **Quince** (*Cydonia vulgaris*, ord. *Rosifloræ*, fam. *Rosaceæ*): histological elements mostly as in the pear, but the groups of sclerenchymatous cells, distributed through the parenchyma, are more numerous, and the epicarp is hairy (Fig. 130).

4. In the **Sweet** and **Bitter Orange** (*Citrus aurantium*, varieties *Sinensis* and *amara*, ord. *Terebinthinæ*, fam. *Rutaceæ*): the polygonal cells of the epicarp, or outer layer of the rinds (see Fig. 138, 'Orange Marmalade,' p. 150), with numerous almost circular stomata and orange-tinted chromatophores; in the tissue beneath (the hypoderm), besides giant cavities containing the essential oil, small collenchymatous cells, many enclosing acicular crystals of the glucoside *hesperidin*, and others oblique crystals of calcium oxalate; the star-shaped, narrow-armed cells of the spongy mesocarp, with large intercellular *lacunæ* (Fig. 138, p. 150); and, in the seeds, the epidermal sclerenchyma cells of the spermoderm, with beak-like processes extending into the mucilaginous envelope.

It was shown by the present writer, in 1894,[1] that the rind

[1] 'Note on Lemon and Orange Peel' (E. G. Clayton).—The *Analyst* (1894), xix., p. 134.

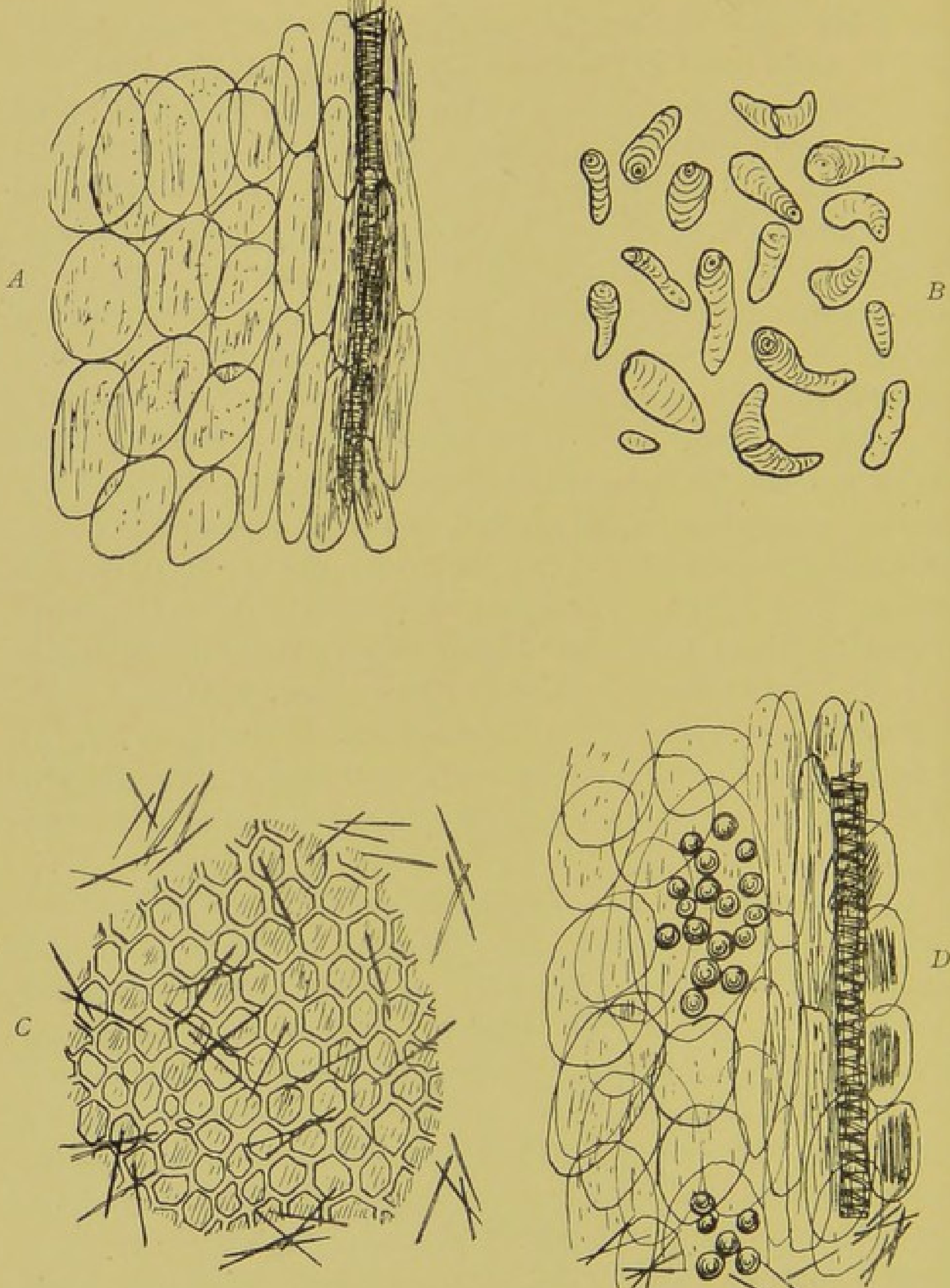


FIG. 131.—THE BANANA.

Pulp.—*A*, parenchyma cells of mesocarp, the inner layers catenated; also spiral vessels. × 150. *B*, starch granules. × 230.

Rind.—*C*, polygonal cells of epicarp, with raphides. × 150. *D*, hypoderm, or outer part of mesocarp: thin-walled cells, with very large loose spirals, and giant cavities containing oil-globules; also oval cells with bundles of raphides, resembling similar groups observed in the pineapple. × 150.

[E. G. Clayton, *del.*]

of the orange assumes a deep, rich green colour, when moistened with hydrochloric acid. This colour reaction readily distinguishes orange from lemon rind, which, when free from fungoid patches and stains, scarcely alters in colour if immersed in hydrochloric acid. Experience has shown that the test is serviceable in the examination of marmalades and the like.

5. In the **Lemon** (*Citrus limonum*, ord. *Terebinthinæ*, fam. *Rutaceæ*) similar histological elements are present. For differentiation from the orange, see under that fruit.

6. In the **Banana** (*Musa sapientum*, ord. *Scitamineæ*, fam. *Musaceæ*) the spiral vessels, and the series of elongated, thin-walled, often catenated, parenchyma cells of the inner portions of the pulp, or mesocarp, are characteristic (Fig. 131, *A*); as are also the numerous long, narrow, excentrically striated, irregular starch grains (Fig. 131, *B*). In the tissues composing the rind, the thick-walled, polygonal cells of the epicarp, with numerous acicular crystals beneath (Fig. 131, *C*), the large loose spiral vessels, the giant cells containing globules of oil in clusters like bunches of grapes, and the oval cells with bundles of raphides, resembling those in the pine-apple, are conspicuous features (Fig. 131, *D*).[1]

Several classes of banana preparations are sold: among them 'banana meal,' consisting of the decorticated and pulverized fruit, and 'Guiana arrowroot,' composed of the starch only.

7. In the **Plantain** (*Musa paradisaica*, ord. *Scitamineæ*, fam. *Musaceæ*), a larger fruit closely allied to the banana, corresponding structures are present.

8. In **Red** and **White Currants** (*Ribes rubrum*), and **Black Currants** (*Ribes nigrum*, ord. *Saxifraginæ*, fam. *Saxifragaceæ*): characteristic histological elements are the non-hirsute epicarp; the epicarpal cells with porous beaded walls, many stomata (and, in the case of the black currant only, multicellular disc-shaped glands, resembling those of the hop, and attached to the epicarp by a stalk); also, in

[1] So far as the writer is aware, the presence of the raphides in the rind of the banana has not previously been mentioned: nor has he observed any direct reference to the clusters of oil-drops.

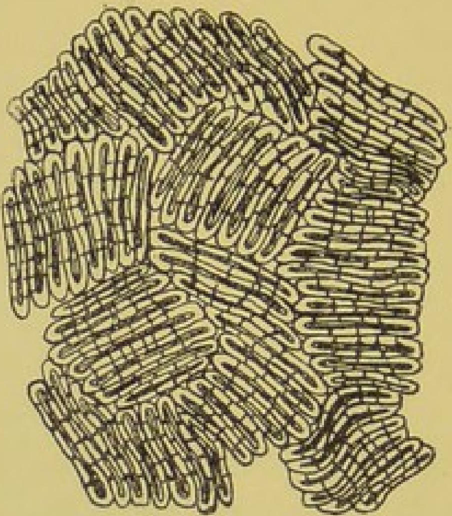


FIG. 132.—RED CURRANT.
Groups of sclerenchyma cells composing the endocarp. × 150.
[E. G. Clayton, *del.*]

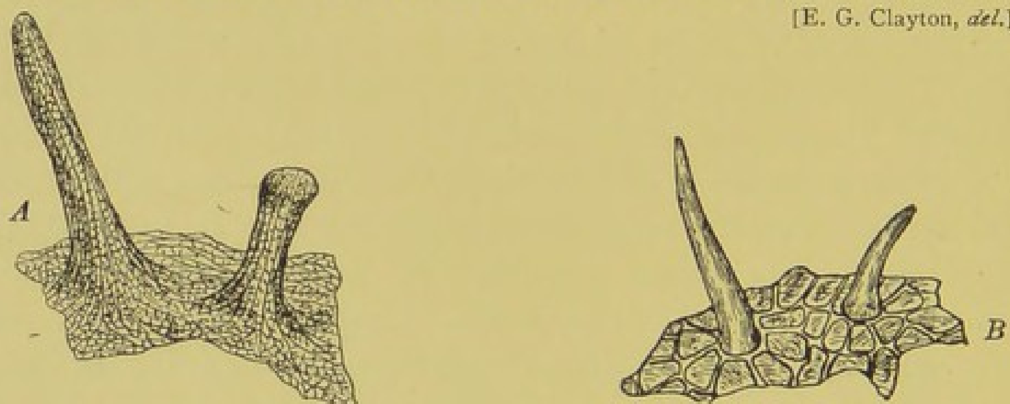


FIG. 133.—THE GOOSEBERRY.
A, portion of epicarp, with blunt and globular-headed prickles. × 40.
B, portion of epidermis of calyx, showing rosette-shaped arrangement of cells, around two of the hairs. × 150. [E. G. Clayton.]

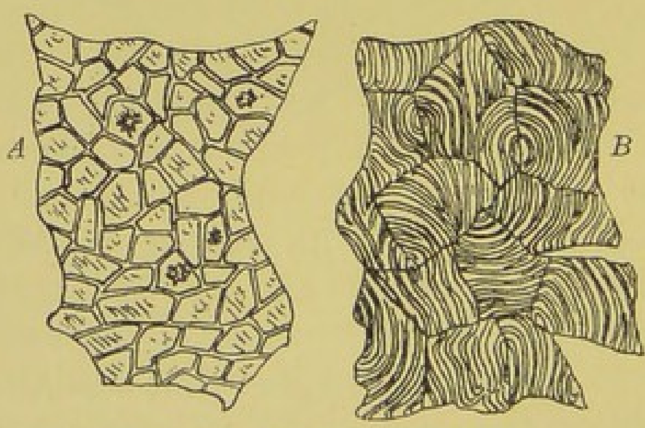


FIG. 134.—THE STRAWBERRY.
A, Cells of epidermis. × 150.
B, Epidermis of the spermoderm. × 150.
[E. G. Clayton.]

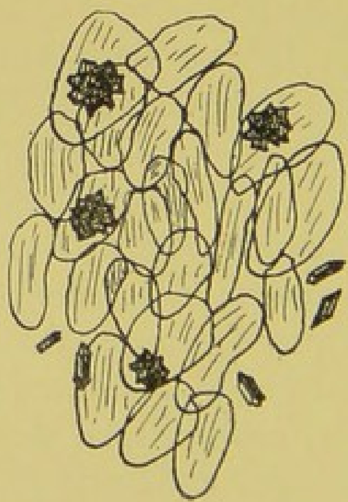


FIG. 135.—THE CHERRY.
Pulp cells, with raphides.
× 150.
[E. G. Clayton.]

the spermoderm, the polygonal, yellow-tinted cells of the 'crystal layer,' and the elongated, thin-walled, brown cells of the inner epidermis. In black and red currants the cells of the epicarp are charged with colouring matter, and the pigment is of great intensity in the case of *Ribes nigrum*. But by far the most distinctive feature which currants exhibit is the remarkable tissue of sclerenchyma cells composing the endocarp (Fig. 132). These very narrow, parallel-sided stone cells, which are best seen in red and white currants, are in bundles of from six to twelve, lying side by side, the bundles being disposed at all angles relatively to each other. Examined under polarized artificial light, with a selenite plate, this tissue constitutes one of the most beautiful microscopic objects known to the present writer. In his experience it is unique, no other fruit, nor any extraneons substance, having been found to exhibit a histological feature at all closely resembling it. In a preparation submitted to him a few years since, alleged to be an 'Indian' secret remedy, and containing a considerable number of diverse ingredients, the presence of red currant was diagnosed entirely by the help of the discovery of fragments of this singular tissue, together with portions of the inner epidermis of the spermoderm. In connection with the same matter, a careful study was made of the histological elements composing more than three hundred substances, rare and otherwise, of the most various kinds: fruits, vegetables, drugs, barks, roots, rhizomes, seeds, berries, leaves, flowers, etc.: but in not one instance was a tissue discovered bearing any near resemblance to the endocarpal layer of the currant.

9. In the **Gooseberry** (*Ribes Grossularia*, ord. *Saxifraginæ*, fam. *Saxifragaceæ*) the epicarp is generally somewhat hairy or prickly: most of the structures resemble those of currants, but the endocarp widely differs; and the (frequently) club-like hairs are characteristic. Fig. 133, *A*, *B*.

10. In the **Strawberry** (*Fragaria vesca*, *F. Virginiana*, etc., ord. *Rosifloræ*, fam. *Rosaceæ*): the cells of the epidermis (Fig. 134, *A*), with crystals, a few stomata, and long, tapering

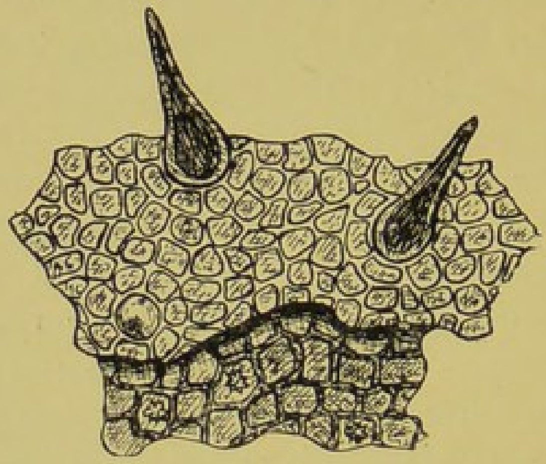


FIG. 136.—THE FIG.

Epidermis of the receptacle, showing hairs and a circular hair scar: beneath, cells of the hypoderm, with aggregates of calcium oxalate crystals. × c. 150.

[E. G. Clayton.]

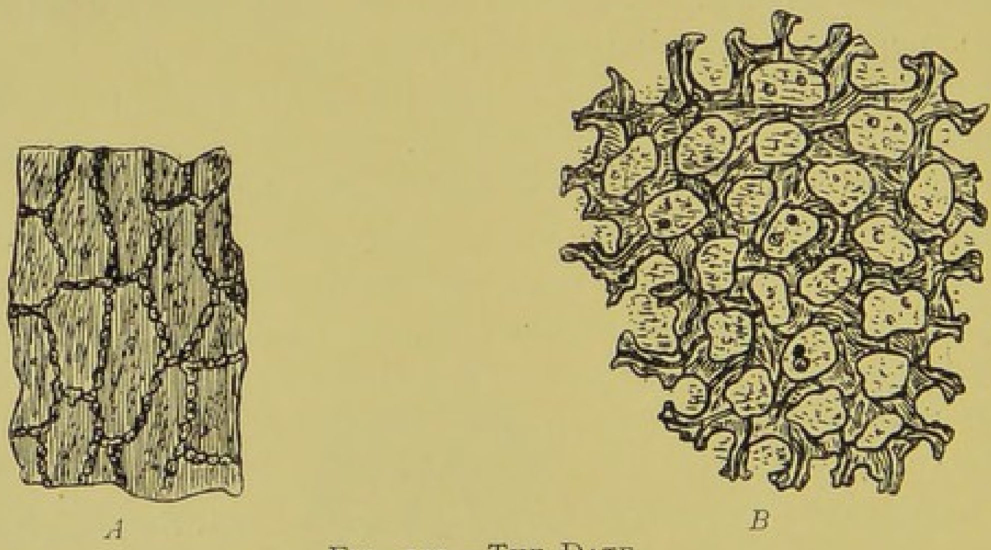


FIG. 137.—THE DATE.

A. cells of the epidermis of the spermoderm, with beaded walls. × 200.
B, endospermal cells. × c. 150.

[E. G. Clayton.]

hairs[1]; in the pericarp of the fruitlets, achenes, or 'seeds,' the crystal layer, each polygonal cell containing a single crystal; and the reticulated epidermis of the spermoderm (Fig. 134, *B*), with convolutions somewhat recalling the appearance of the finger-prints, by the aid of which criminals now are often identified.

11. In the **Grape** (*Vitis vinifera*, ord. *Frangulinæ*, fam. *Vitaceæ*): only the seeds show distinctive features;—in the spermoderm, the very thick-walled stone cells, above them parenchyma cells with raphides, and beneath, cells of the inner epidermis with beaded walls. Dried grapes (raisins) exhibit similar characters; and sugar crystals sometimes occur in the cells.

12. In the **Cherry** (*Prunus cerasus*, ord. *Rosifloræ*, fam. *Rosaceæ*) the surface is smooth, the epicarpal cells are large, clearly defined, and charged with pigment. Both spiral and reticulated vessels are present in the mesocarp; and raphides of calcium oxalate occur in the pulp-cells (Fig. 135).

13. In the **Raspberry** (*Rubus Idæus*, ord. *Rosifloræ*, fam. *Rosaceæ*): the polygonal cells, with numerous hairs, of the epicarp of the drupelets, the rosettes of cells about the bases of the hairs, the crystal cells distributed through the mesocarp, and the elongated, sclerenchymatous fibre-cells of the outer endocarp.

14. In the **Plum** (*Prunus domestica*, ord. *Rosifloræ*) the epicarp is devoid of hairs (distinction from the peach and apricot): the cells are beaded; and much colouring matter is present, except in the green varieties.

15. In the **Blackberry** (*Rubus fruticosus*, ord. *Rosifloræ*, fam. *Rosaceæ*): structures mostly akin to those seen in the raspberry; drupelets less hairy: seeds larger, also the wrinkles on them.

16. In the **Peach** (*Prunus Persica*, ord. *Rosifloræ*, fam. *Rosaceæ*): the polygonal cells of the epicarp, the numerous hairs of various lengths, and stomata; the isodiametric stone cells of the endocarp, also the presence of reticulated and absence of spiral vessels.

[1] Not shown in the figure.

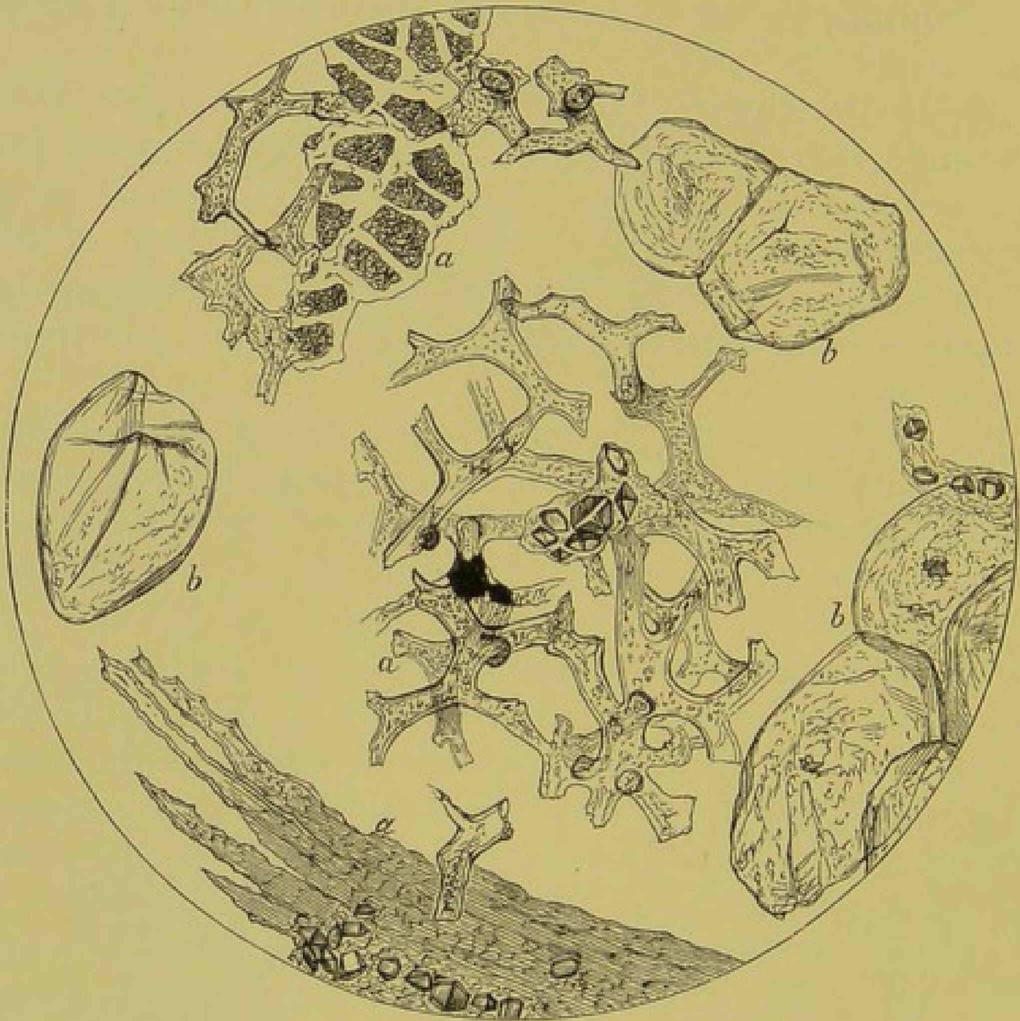


FIG. 138.—ORANGE MARMALADE, CONTAINING APPLE OR TURNIP. × 100.

a, a, a, Tissues of orange: *above*, angular cells of *epicarp*, or superficial layer, showing parenchyma of mesocarp underneath: *centre*, loose parenchyma, with intercellular spaces, constituting the woolly part of the rind, or *mesocarp*, and showing crystals and spherical masses of the glucoside *hesperidin*: *below*, fibro-vascular bundles with similar crystals. *b, b, b*, Parenchymatous cells of added ingredient.

17. In the **Apricot** (*Prunus Armeniaca*, ord. *Rosifloræ*, fam. *Rosaceæ*): structures almost exactly like those of the peach, but the epidermal stone cells of the spermoderm are smaller.

18. In the **Fig** (*Ficus Carica*, ord. *Urticinæ*, fam. *Moraceæ*): epicarpal cells, here and there in rosettes around hairs or hair scars (Fig. 136); in the pulpy part of the fruit, very many large latex cells, and spiral or reticulated vessels of moderate size. The 'seeds,' which are really fruitlets, have in the pericarp an outer layer of small stone cells, and an inner stratum of much larger, very thick-walled stone cells.

19. In the **Date** (*Phœnix dactylifera*, ord. *Spadicifloræ*, fam. *Palmæ*): the most notable features are the delicate tissues constituting the silky layers of the endocarp, next to the stone; and, in the stone, the sclerenchyma cells of the epidermis, with beaded parietes (Fig. 137, *A*), as well as the greatly thickened porous walls of the endospermal cells (Fig. 137, *B*).

Falsifications Detectable by the Microscope in Fruit Preparations.—Some have already been mentioned. Apple and other cheap fruit-pulps are added to costlier preserves, such as strawberry and raspberry jams: vegetable marrow, turnip, rhubarb, beetroot, and carrot also are occasional adulterants; and agar agar has been employed as a stiffening agent in fruit jellies. Starch is stated to have served the same useful but perverted end.

Marmalade, in particular, is alleged often to be adulterated with the pulp of apple, turnip, or vegetable marrow. These the microscope easily discovers. Apple-jelly, of course, is more difficult to find. Marmalade admixed with apple-pulp or turnip is shown in Fig. 138.

[*For descriptions and figures of turnip, beetroot, vegetable marrow, carrot, and rhubarb, see pp.* 154-156.]

Raspberry Jelly has been stated sometimes to consist of cheaper fruit jelly, flavoured with orris rhizome, or 'root'; and foreign seeds have intentionally been introduced into imitation raspberry and other jams. The microscopic characters of orris are depicted in Fig. 139.

As for the remaining fruit-substitutes of probable occurrence, not previously figured in the present work, the structure of

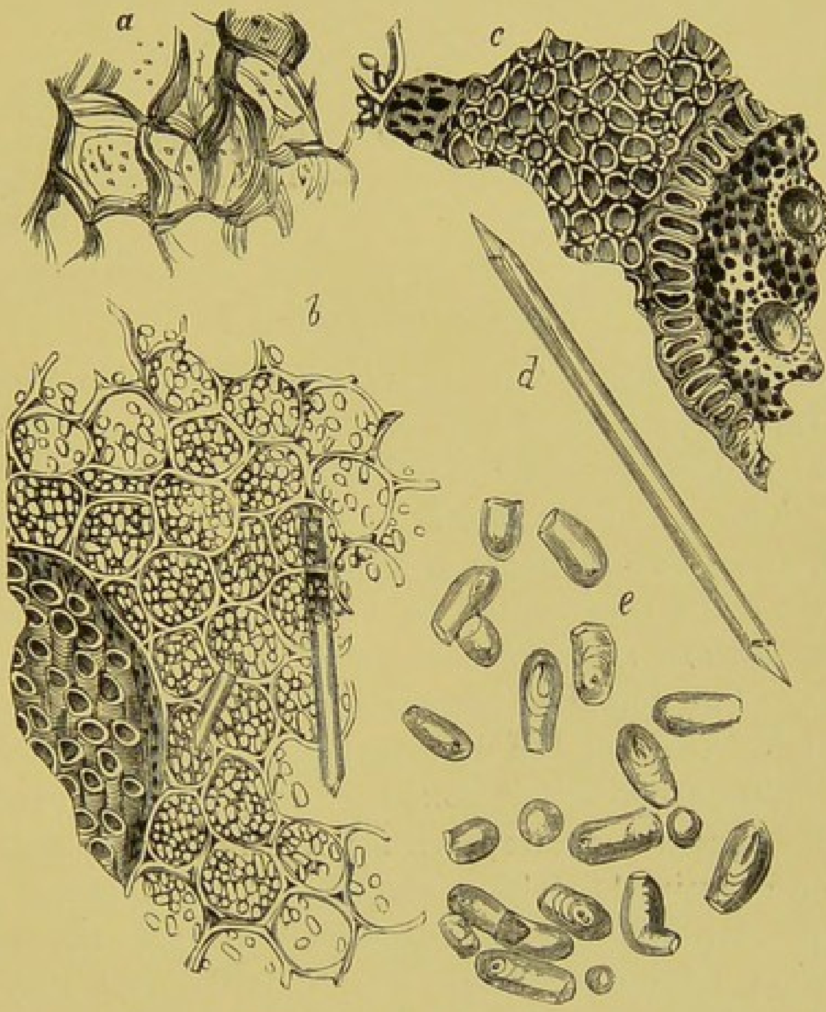


FIG. 139.—ORRIS 'ROOT.'
(THE RHIZOME OF IRIS GERMANICA, I. PALLIDA, AND I. FLORENTINA.)

a, *Epidermis;* *b*, transverse section of rhizome, showing cells filled with *starch*, long prismatic *crystals* of calcium oxalate, and a fibro-vascular bundle cut across; *c*, section of *rootlet;* *d*, oxalate *crystal;* *e*, *starch granules.*
[*a*, *b*, *d*, × 100 : *d*, × 200 : *e*, × 500.]

[*Read on from p.* 152.]

turnip (*Brassica Rapa*, fam. *Cruciferæ*) is shown in Figs. 140 and 141, p. 155: that of *beetroot*[1] (*Beta vulgaris*, fam. *Chenopodiaceæ*) in Fig. 142, p. 156: the more characteristic histological elements of the *vegetable marrow* (*Cucurbita ovifera succada*, fam. *Cucurbitaceæ*) and *carrot* (*Daucus carota*, fam. *Umbelliferæ*) are represented in Figs. 143 and 144, p. 156: *rhubarb* (*Rheum rhaponticum*, fam. *Polygonaceæ*) is seen in Fig. 145. The detection of *agar agar* (*Gracilaria lichenoides, et cetera*) is based on the discovery of the diatoms which it contains: the fruit jelly is boiled with 5 per cent. sulphuric acid, subsequently treated with potassium permanganate, and then examined. The microscopical characters of some common diatoms are illustrated in many of the figures in the last section (Section IV.) of this book, 'Water' (*e.g.*, Figs. 269, 270, 271, 272, 273, 274 and 275).

[1] Microscopically, beetroot is not easily distinguished from certain other roots, such as chicory and dandelion.—See *ante*, p. 96, footnote.

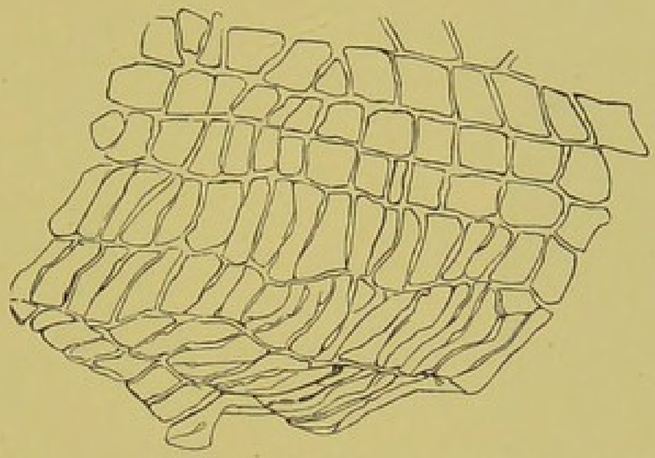


FIG. 140.—TURNIP: EPIDERMIS (CELLS SOMEWHAT MORE REGULAR IN FORM THAN THE 'WINDOW-CELLS' OF APPLE-CUTICLE). × 180.

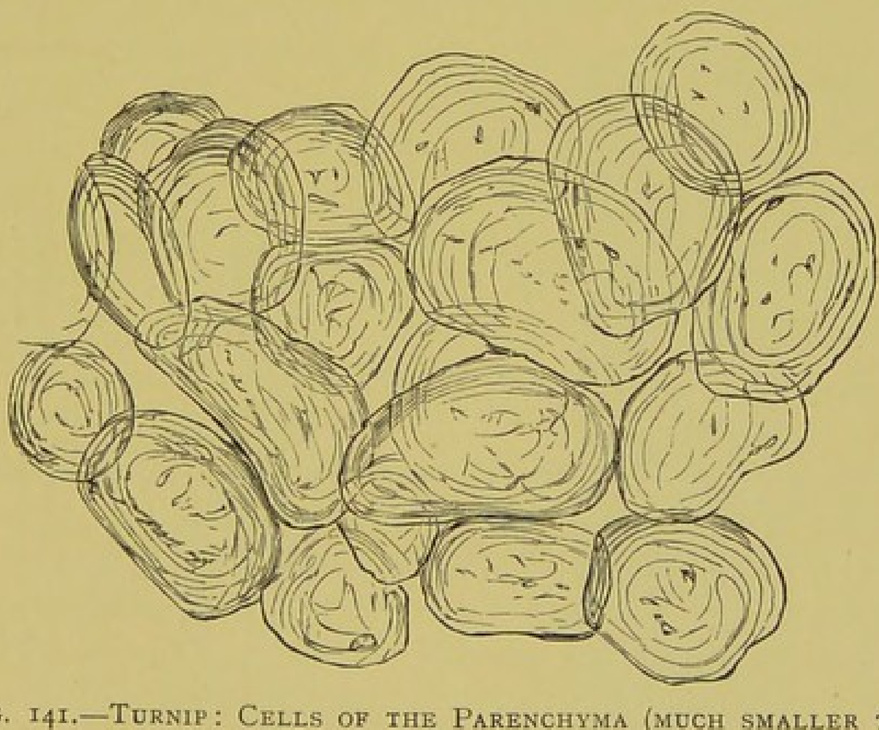


FIG. 141.—TURNIP: CELLS OF THE PARENCHYMA (MUCH SMALLER THAN THE CORRESPONDING CELLS OF APPLE-PULP).

Pitted vessels (not shown in the figure) are also present in the turnip. × C. 100.

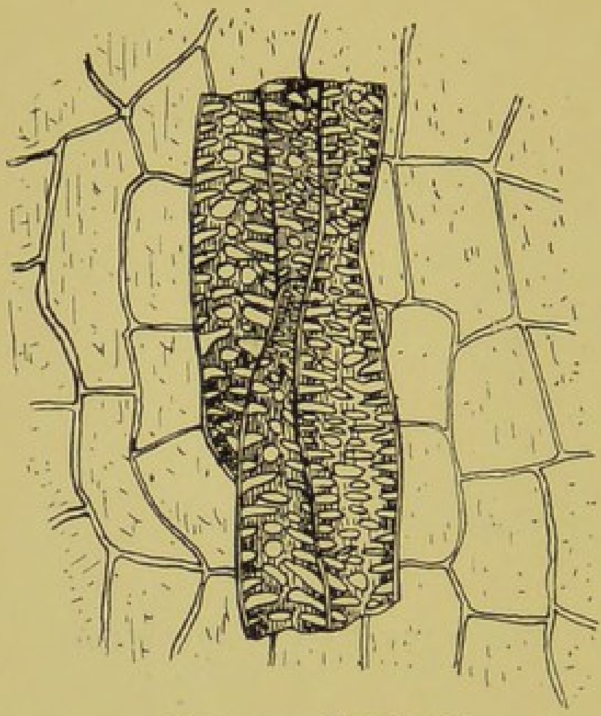


FIG. 142.—BEETROOT.

Reticulated vessels with wide pores, and parenchyma cells. × 150.

[E. G. Clayton.]

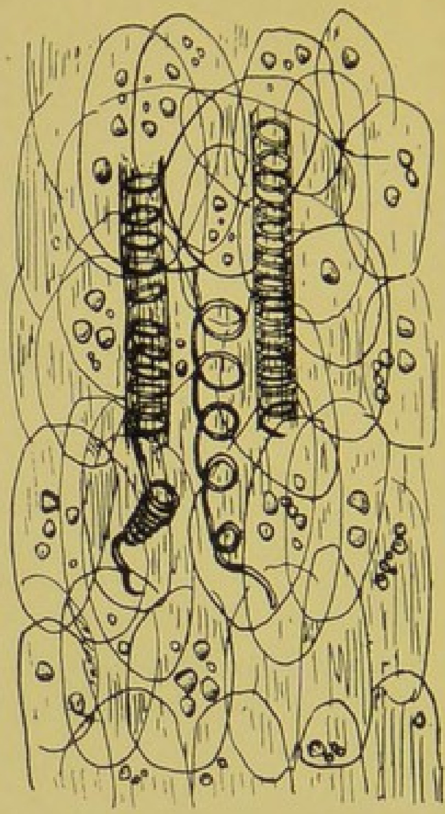


FIG. 143.—VEGETABLE MARROW.

Large, loose parenchyma cells, partly unwound spiral vessels, and numerous small starch granules, some truncated. × c. 150.

[E. G. Clayton.]

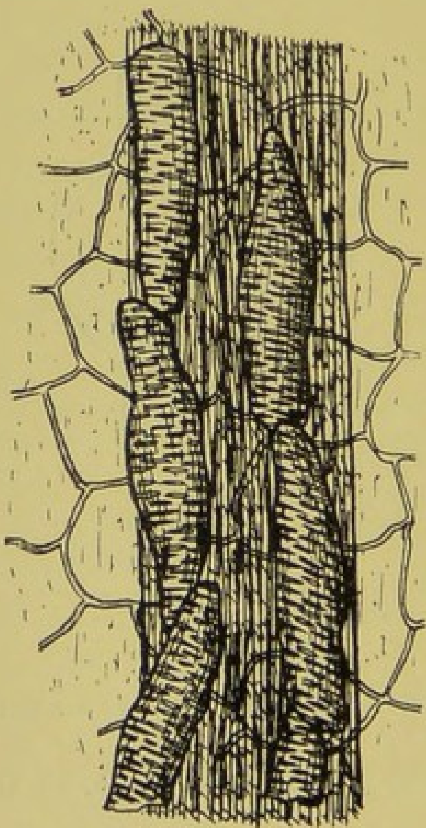


FIG. 144.—CARROT.

Reticulated vessels, with side junctions, wood fibre and parenchyma. × 150.

[E. G. Clayton.]

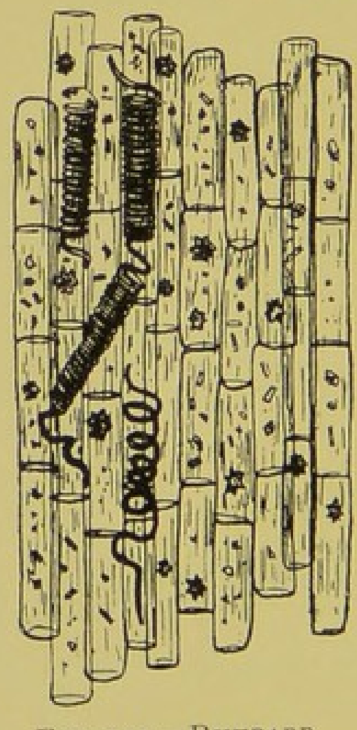


FIG. 145.—RHUBARB

Cylindrical cells of the leaf-stem or petiole, showing spiral vessels, with raphides and sphæraphides of oxalate of calcium. × c. 100.

[E. G. Clayton.]

PICKLES, SAUCES, AND PRESERVED VEGETABLES.

Pickles, sweet and sour, and **Preserved Vegetables** bottled or canned, frequently require a megascopical examination only: but when they are subdivided, or an opaque liquor is present, the microscope is necessary. With **Sauces** the case is somewhat different. The constituent substances are nearly always in a state of fine division, and of a multifarious nature. Microscopical research, with usually a preliminary macroscopic scrutiny, can never be omitted. Almost any of the fruits and vegetables already mentioned, and many other ingredients, such as garlic (*Allium sativum*), onion (*Allium cepa*), shallot (*Allium ascalonicum*), soy (*Dolichos soya*), tarragon (*Artemisia Dracunculus*), fennel (*Foeniculum vulgare*), and parsley (*Petroselinum sativum*), may enter into the composition of a sauce. **Tomato** (*Lycopersicum esculentum*, fam. *Solanaceæ*), the structure of which is shown in Fig. 146, p. 158, is a favourite component. In sauces occur also many of the condiments and spices described and figured in the next portion of the present work. Ingredients in solution must for the most part be identified by chemical methods: but even here the microscope can often be applied with advantage to the examination of filtered and evaporated extracts, for crystals and the like.

Fresh Vegetables.—Unless especial search must be made for parasitic organisms, or their ova (See *post*, Section II., pp. 238-250), the necessity seldom arises for a microscopical investigation of esculent pot-herbs which usually are sold in the fresh condition and in comparatively large bulk. Descriptions of asparagus (*Asparagus officinalis*), spinach (*Spinacia oleracea*), cauliflower (*Brassica oleracea*), cabbage (*Brassica oleracea*), seakale (*Crambe maritima*), and parsnip (*Pastinaca sativa*), therefore are omitted; also, for the same reason, details are not given of the microscopic structures of certain ingredients of salads, among them lettuce (*Lactuca sativa*), celery (*Apium graveolens*), endive (*Cichorium endivia*), radish (*Raphanus sativus*), and water cress (*Nasturtium officinale*). Incidentally, however, the more striking histological features of a few vegetables, such as beans and pease, potato, turnip, carrot, rhubarb, etc., have been dealt with in the foregoing pages

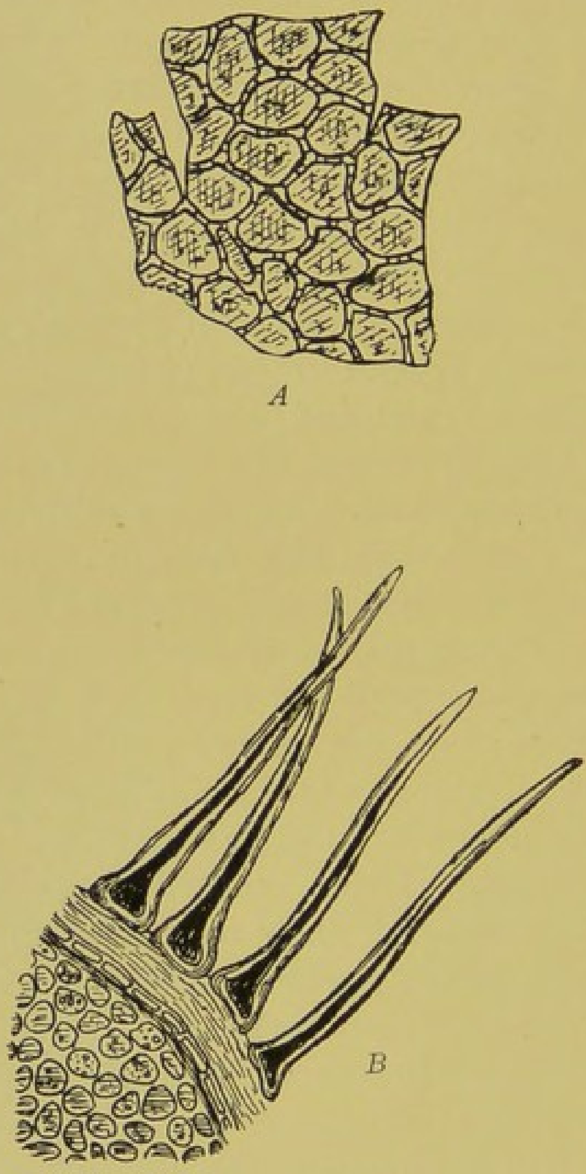


FIG. 146.—TOMATO.

A, Epicarp (of tomato-skin). × c. 180. *B*, section of seed, showing tapering hairs on spermoderm; epidermal cells; and aleurone cells of the endosperm. × 150.

[E. G. Clayton, *del.*]

[CONDIMENTS AND SPICES.

CONDIMENTS, SPICES, AND OTHER VEGETABLE ADJUNCTS OF FOOD.

ORD. RHŒADINÆ, FAM. CRUCIFERÆ.

MUSTARD.

THE seed of *Sinapis alba* and *Brassica nigra*, ord. *Rhœadinæ*, fam. *Cruciferæ*.

Mustard seed consists of two parts: the husk and seed proper.

Histology of the Seed.—1. The *Husk, Spermoderm,* or *Seed Coat* (of white mustard seed) is constituted of several membranes, the *outer* of which (the mucilaginous epidermis) is transparent, and consists of a single layer of large hexagonal cells filled with stratified mucilage, the centre of each cell being perforated by funnel-shaped tubes, which seem to terminate on the surface of the seed (Fig. 147). Immersed in water, these cells swell up to several times their original volume, are ruptured, and become much wrinkled or corrugated, the extremities of the tubes sometimes being seen protruding from the proximate termination of the cells. When white mustard seeds are digested in water, a thick mucilaginous liquid is obtained, the mucilage in which is derived from the cells forming the tissue above described. Beneath the epidermal membrane are two layers of large cells (*collenchyma* cells, the walls of which are characterized by being thickened at the angles): these, which are not shown in the figures, are succeeded by the *middle* tunic, consisting of a single layer of much smaller angular cells, called 'palisade' cells, from their appearance in side view (Fig. 148, A: upper portion shows these cells in surface view). In the walls of the palisade cells most of the yellow colour of the husk is seated. The inner layers of the testa are composed of a colourless parenchyma resting upon the outer membrane of the seed substance or *aleurone* layer, which is shown in the lower half of Fig. 148, B; also in Fig. 150, *c*.

[In the husk of *black mustard* the large hexagonal transparent mucilage cells are not perforated in the centre, like those of white mustard, and have beneath them still larger transparent cells: the other structures resemble those of white mustard, except that the palisade cells are of unequal lengths, the longest coinciding with the external ridges of the seed, and are superposed on one or two layers of pigment cells.]

2. The *Seed* proper has externally a single layer of large polygonal cells, with fat globules and granular proteid matter (the *aleurone* layer, Figs. 148, B ,150, *c*), internally is bright yellow, of a soft, waxy consistence, and is constituted of innumerable minute cells (the cotyledon cells, Figs. 149, *a*, *a*, 150, *d*), which contain the oil and other active principles, aleurone, myrosin, etc. Fig. 149 also shows some of the aleurone cells (*b*, *b*). There are no starch granules in ripe mustard seed.

Extraneous Substances Detectable by the Microscope.—Wheat flour, turmeric, Cayenne pepper, ginger, *Sinapis arvensis*, or charlock, potato flour, ground rice, pea flour, radish and rape seed, linseed meal, etc.

[*For figures, see pp.* 162, 163.]

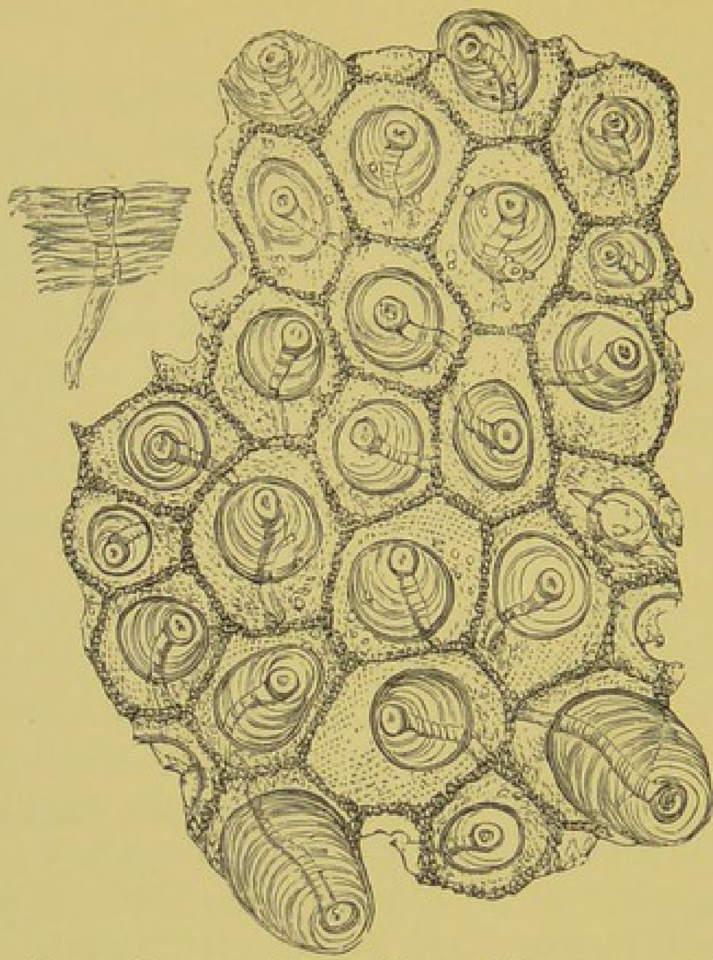


FIG. 147.—WHITE MUSTARD SEED. OUTER MEMBRANE OF HEXAGONAL MUCILAGE CELLS, ONE SHOWN IN SECTION. ×220.

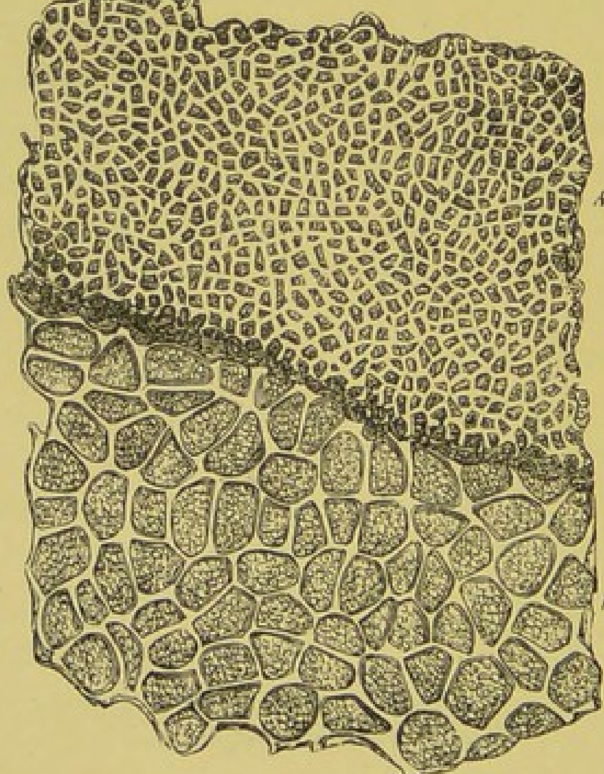


FIG. 148.—WHITE MUSTARD SEED IN SURFACE VIEW. MIDDLE, OR PALISADE LAYER OF HUSK, AND OUTER OR ALEURONE LAYER OF SEED SUBSTANCE, THE FORMER LYING OVER A PART OF THE LATTER. ×220.

A, Middle tunic of husk; *B*, aleurone layer of seed.

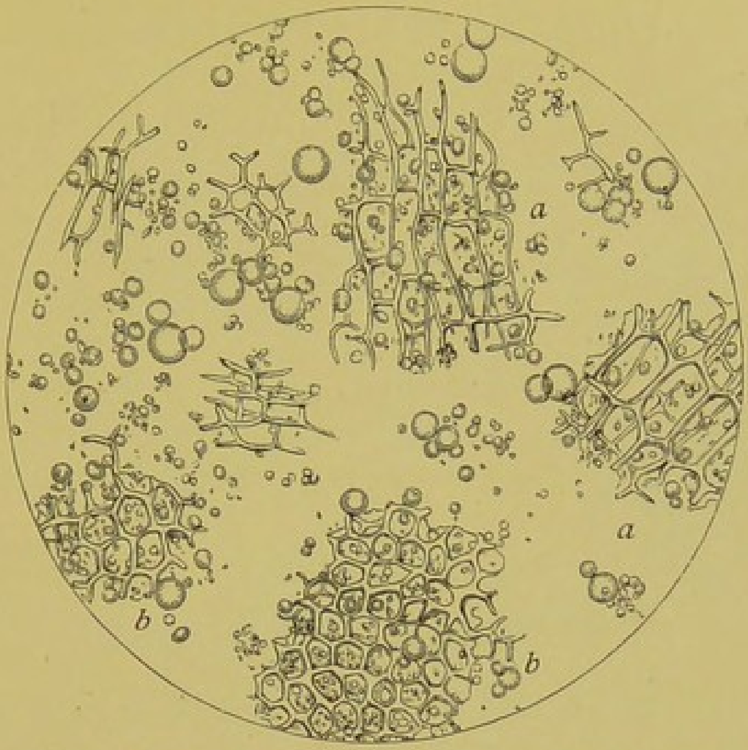


Fig. 149.—White Mustard. Substance of the Seed, ground; showing Cotyledon Cells, *a*, *a*, Oil Globules, and Aleurone Cells with Granular Matter, *b*, *b*. × 220.

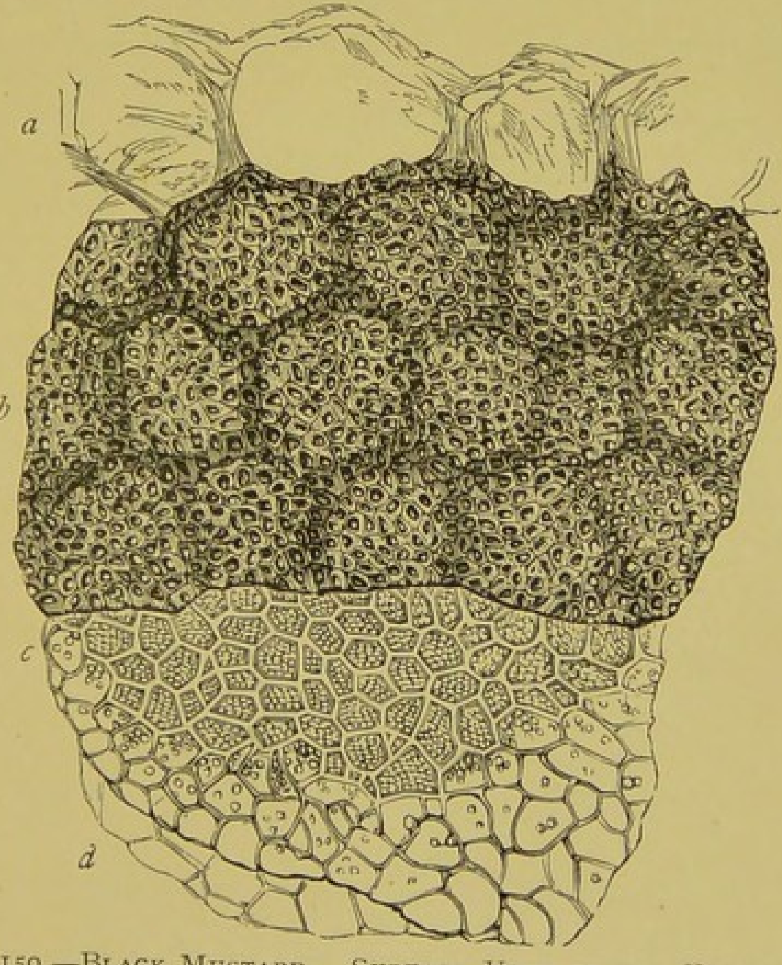


Fig. 150.—Black Mustard. Surface View of the Principal Structures. × 220.

a, Large mucilage cells; *b*, palisade cells with ridges; *c*, aleurone cells; *d*, cotyledon cells.

ADULTERATED MUSTARD.

Fig. 151.—**Mustard**, ground, and mixed with wheaten flour and turmeric (*Curcuma longa*, fam. *Zingiberaceæ*): *a, a*, wheaten flour; *b, b*, turmeric; *c*, husk of black mustard; *d*, cells of outer layer, white mustard seed; *e, e*, fragments of the seed substance.

Fig. 152.—**Mustard**, ground, and mixed with wheaten flour, turmeric, and Cayenne pepper (*Capsicum frutescens*, fam. *Solanaceæ*): *a, a*, mustard; *b, b*, wheaten flour; *c, c*, turmeric; *d, d*, Cayenne pepper.

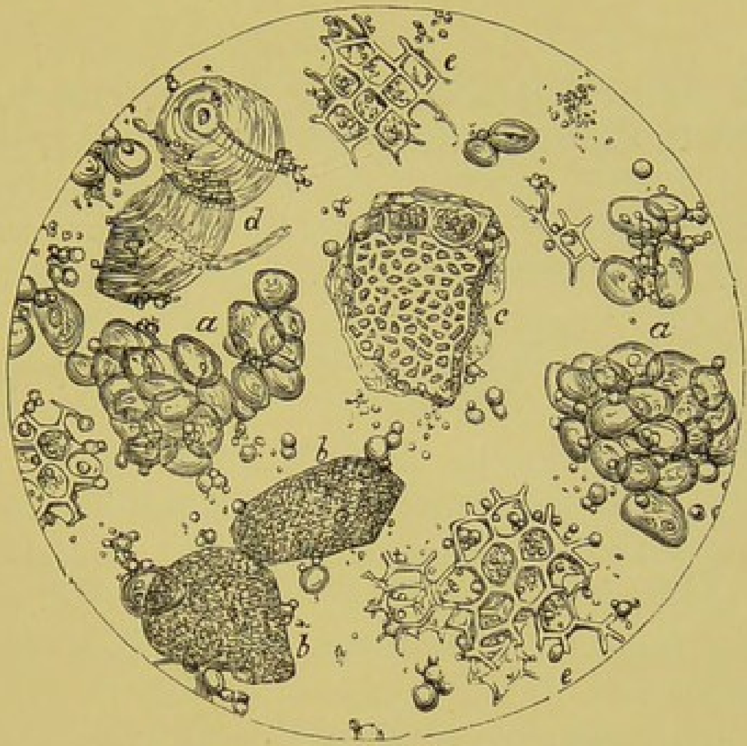


FIG. 151.—GROUND MUSTARD, ADMIXED WITH WHEATEN FLOUR AND TURMERIC. ×225.

a, *a*, Wheaten flour ; *b*, *b*, turmeric ; *c*, husk of black mustard ; *d*, cells of outer layer, white mustard husk ; *e*, *e*, fragments of the seed substance.

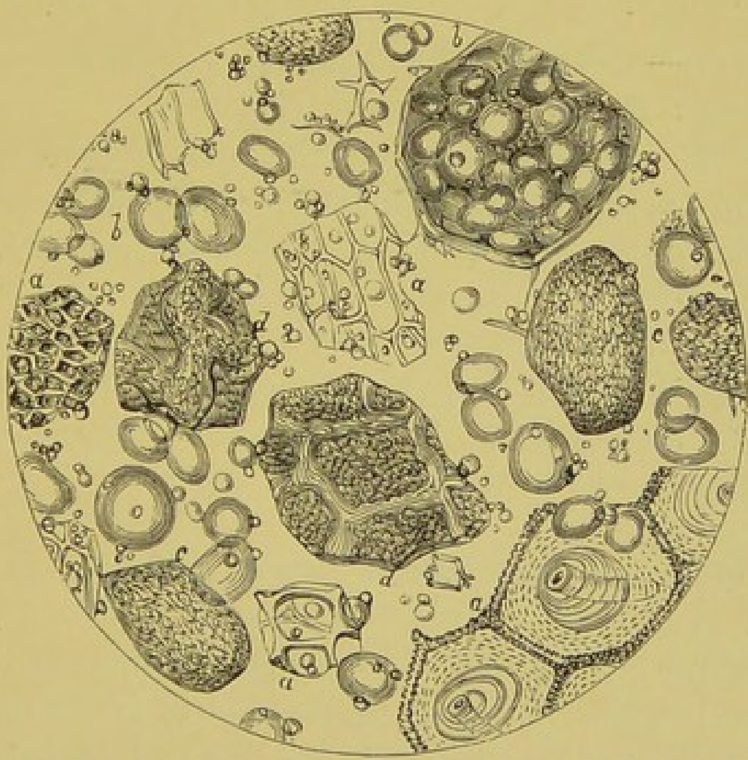


FIG. 152.—GROUND MUSTARD, ADMIXED WITH WHEATEN FLOUR, TURMERIC AND CAYENNE PEPPER. ×225.

a, *a*, Mustard ; *b*, *b*, wheaten flour ; *c*, *c*, turmeric ; *d*, *d*, Cayenne pepper.

SEEDS RESEMBLING MUSTARD, OR WHICH HAVE BEEN USED AS SUBSTITUTES.

Fig. 153.—Husk of a seed found in some imported rape cake, from the consumption of which certain cattle died: transverse and vertical sections. This is probably **Sarepta** mustard (*Brassica Besseriana*), a species largely grown in Russia.

Characters.—Nearest to those of *Brassica nigra*, but the cells of the outer coat perforated by funnel-like tubes, and of this and the palisade layer much larger. In the considerable size of the palisade cells, this seed somewhat resembles rape, in the husk of which, however, there is no outer coat of large colourless cells.

The figure shows particularly well, in sectional and surface views:—*a, a*, the mucilage cells; *b, b*, the palisade, paling, or fence cells, with the surface reticulations; and *c, c*, the aleurone layer.

Fig. 154.—**Charlock Seed**, *Sinapis arvensis* (= *Brassica sinapistrum*): Husk.

Characters.—In colour agrees with husk of black mustard; in structure nearer to white mustard husk, but cells of outer or mucilaginous coat smaller and more delicate, though similarly perforated: in addition, however, each is characterized by numerous very delicate and minute reticulations. Both the perforations and reticulations of the mucilage cells are clearly indicated in the figure: also the fence cells, in surface view, and the aleurone layer.

Fig. 155.—**Common Rape Seed** (*Brassica napus*, var. *oleifera*): Husk.

Characters.—Composed of two chief membranes, the outer, somewhat like the middle or palisade layer of mustard husk, but the cells are much larger, hence their cavities appear more or less light, the walls being thick and well defined: near the umbilicus of the seed the cells usually disposed in a linear manner. There is no epidermal mucilage layer, and reticulations or ridges are absent from the surface of the husk. The sub-epidermal cells are indistinct. The inner or aleurone layer, which properly belongs to the endosperm, presents no peculiarity, and the substance of the seed is similar to that of mustard.

Fig. 156.—Seed described as **East Indian Rape**, resembling a species of mustard: probably Pasái, or Palangi (*Brassica rugosa*). The seeds of this variety of rape are reticulated, and of a dark brown colour.[1]

[1] See account of *B. rugosa*, in 'A Note on the Mustards cultivated in Bengal,' by D. Prain; 'The Agricultural Ledger,' 1898, No. 1, pp. 11-13.

[*For figures, see pp.* 168, 169, *and* 170.]

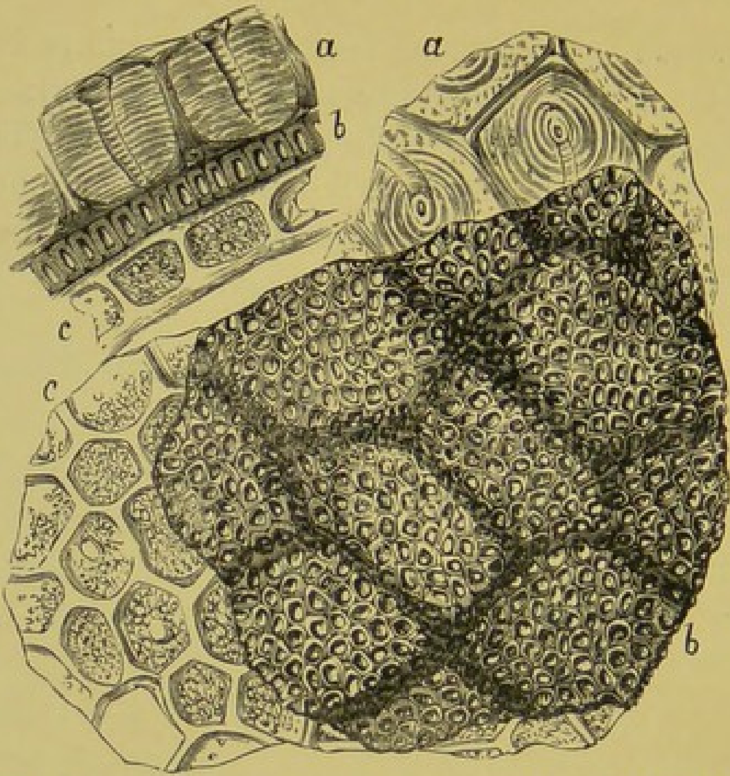


FIG. 153.—HUSK OF SEED, PROBABLY BRASSICA BESSERIANA, FOUND IN IMPORTED RAPE CAKE. × 220.

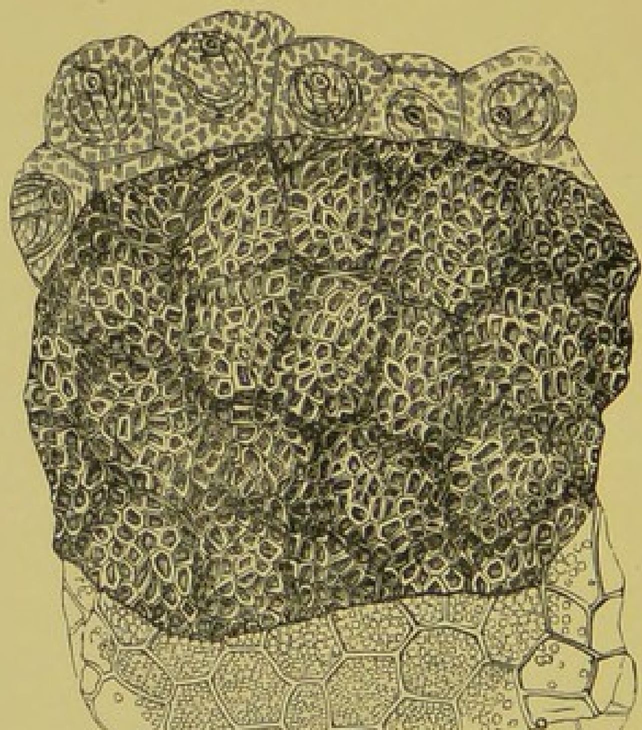


FIG. 154.—CHARLOCK SEED. × 220.

Showing in the upper part the mucilage cells with tubular cavities and minute reticulations ; in the centre the palisade cells ; and beneath, the aleurone layer.

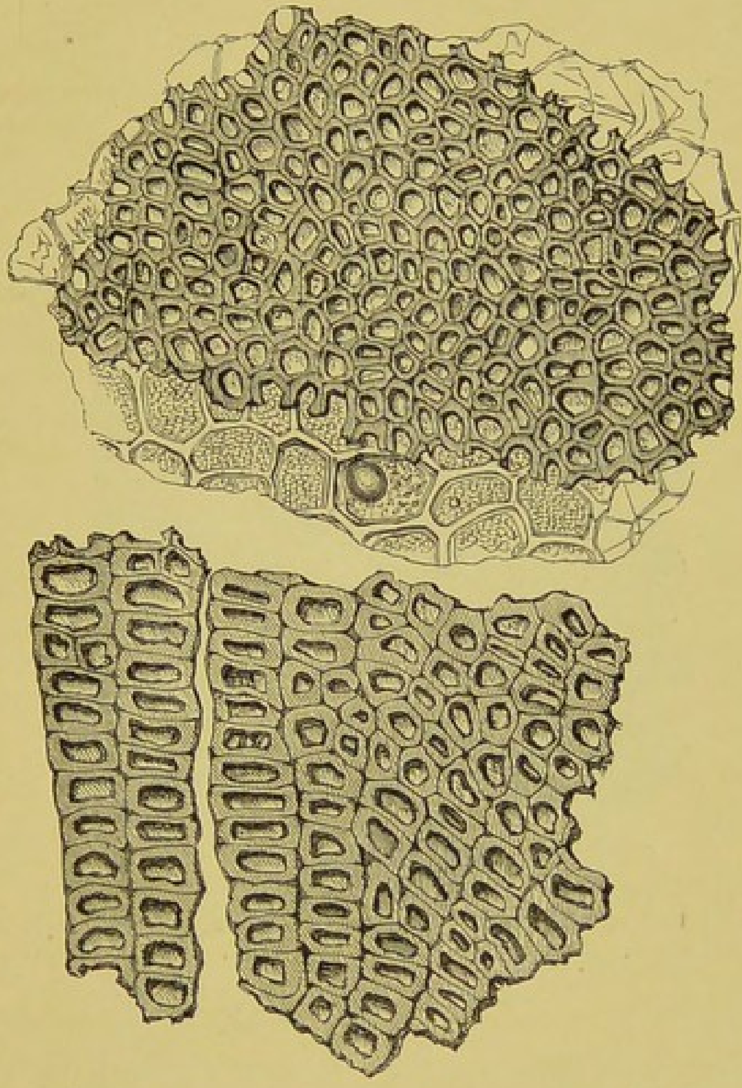


FIG. 155.—COMMON RAPE SEED. × 220 and 325.
Above, palisade and aleurone cells in surface view ; below, the former m highly magnified.

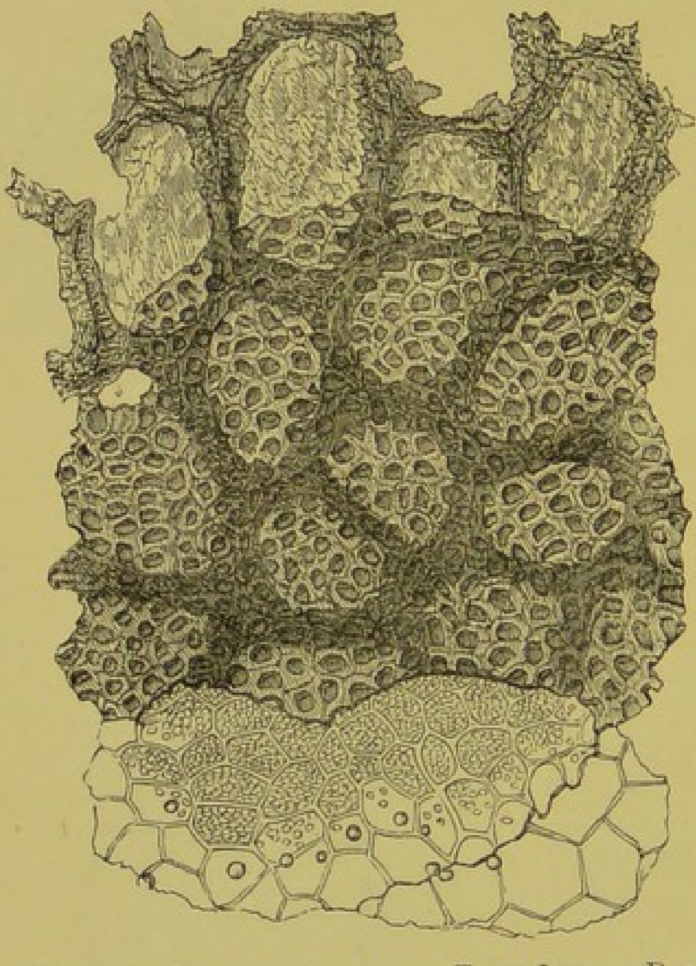


FIG. 156.—HUSK OF SEED DESCRIBED AS EAST INDIAN RAPE, PROBABLY PASÁI, OR PALANGI (BRASSICA RUGOSA). × 220.

[PEPPER.

ORD. POLYGONINÆ, FAM. PIPERACEÆ.

PEPPER.

THE fruit of *Piper Nigrum*, ord. *Polygoninæ*, fam. *Piperaceæ*.

Histology of Berry.—The pepper berry or black peppercorn consists of two parts: the cortex or outer layer (the *pericarp*), and the central or inner portion (chiefly the *perisperm*). The first is black or reddish-black; the second more or less white, also hard and brittle, except in the centre of the seed, where it is often soft and pulverulent.

1. The *cortex* is composed of at least six separate series of cells. Beneath an epicarp of polygonal cells disposed in a single layer, and containing a brown or black substance, is the *hypoderm*. This is composed of yellow-walled stone cells, elongated, vertical, and provided with a central cavity, from which minute canals or channels radiate towards the circumference (Figs. 157, 158, *a*): viewed sideways, they appear rather more than twice as long as broad: seen endways, they are mostly oval in shape, and nearly as broad as long. Somewhat similar cells occur in the epidermis of the sugar-cane (*vide* p. 129, Fig. 116). The cells next in order (Fig. 158, *b*) are of moderate size, angular and somewhat dark coloured; they do not separate readily from, and are probably mere modifications of, the larger cells immediately beneath (Fig. 157, *b*), which form about half the thickness of the cortex (the outer *mesocarp*). Excluding the epicarp, these two strata of cells together constitute the second layer of the cortical portion of the berry. They are all more or less coloured, and the tint deepens as the cells approach the next or third layer. The third stratum is very thin (the *fibro-vascular layer*, Fig. 157, *c*), and is composed of wood

fibre, with bundles of spiral vessels of small size, formed of single threads. The junction of the second with the third layer is marked by a dark line situated about the middle of the cortex (Fig. 157, *c*).

The fourth layer consists of numerous large parenchymatous cells containing a very great abundance of oil globules, and it constitutes the greater part of the rest of the cortex (the *oil cells*, Fig. 157, *d*, and Fig. 159). As the cells approach the base of the cortex they become much modified, two or three times smaller, and very thick-walled, but not equally so on every side (Fig. 157, *e*, and top of Fig. 160). These horseshoe-shaped cells, in fact, form a separate layer, and constitute the innermost or endocarpal element of the pericarp.

The next tissue belongs to the *spermoderm*, and is divisible into two or three layers, the most conspicuous of which is of a deep brownish-red colour (the pigment layer), denoted in Fig. 157 by the sharp line of demarcation just below *e*. This rests upon a colourless, reticulated, and transparent lamina (the hyaline layer), which frequently separates as a distinct tissue (Fig. 157, *f*), and may more accurately be regarded as part of the *perisperm*.

2. The *central* or *inner* part of the berry (chiefly the *perisperm*, but embracing also the *endosperm* and *embryo*) consists of large, angular cells, about twice as long as broad, disposed in a radiate manner: towards the exterior the cells are adherent, starchless, hard, and stonelike (*aleurone* cells), but in the centre they are readily separable, mostly contain extremely minute starch granules, and often form a powder resembling flour (Fig. 157, *g*, and Fig. 160). Certain of these cells, rather larger and of more rounded outlines than the rest, assume a yellowish or canary tint when immersed in water for a short period: they are at tolerably regular distances from each other, and reflect a deep yellow colour. In recent sections which have not been immersed in water, these cells may be distinguished by a darker shading, or sometimes by a faint tint of colour. They contain the resin, frequently also crystals of piperine, and exhibit characteristic

changes of tint under the influence of reagents, such as alcohol, nitric acid, and sulphuric acid. These coloured cells are clearly indicated in Figs. 157 and 160.

In ground *black* pepper all the described structures may be met with in a broken and fragmentary condition (Fig. 161): but in *white* or 'decorticated' pepper, only the central part cf the berry, with portions of the oil-bearing stratum of the *pericarp* and pigment layer of the *spermoderm*, are present. White pepper, indeed, is not entirely denuded of the cortex, nor is its powder white, for some reddish-brown fragments of these two layers are usually visible when some of the crushed pepper is diffused through water on a glass slip.

Preliminary bleaching with chlorine water is, as a rule, necessary before the structure of the dark fragments in black pepper can be made out with the microscope. The large white cells of the central part of the pepper-berry (the *perisperm*) have a strong external resemblance to grains of sand, but when touched with iodine solution they become blue.

Extraneous Substances Detectable by the Microscope.—Sand, linseed meal (see pp. 178, 179, Fig. 162), mustard husk, wood fibre, pepper-dust (sweepings), wheat, pea (see p. 178), and other flours, 'poivrette' (crushed olive-stones), an undue proportion of pepper-husk (in black pepper), etc.

[*For figures, see pp.* 175, 176, 177 *and* (*linseed*), 179.]

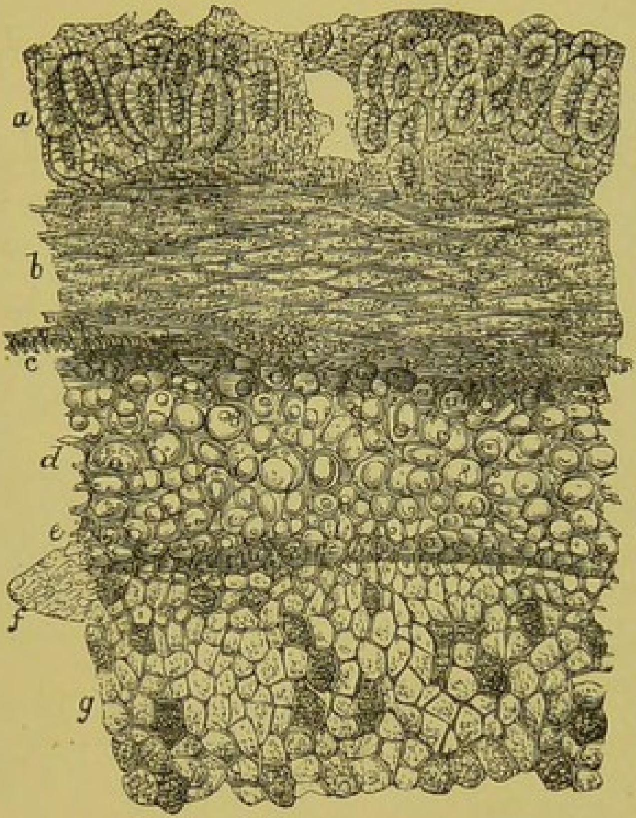


FIG. 157.—PEPPER-BERRY (SECTION). ×80.

a, Layer of stone cells, with epicarp above; *b*, cells of the outer mesocarp; *c*, fibro-vascular zone; *d*, *e*, oil cells, with horseshoe cells and pigment layer at base; *f*, hyaline tissue; *g*, aleurone, starch, and resin cells.

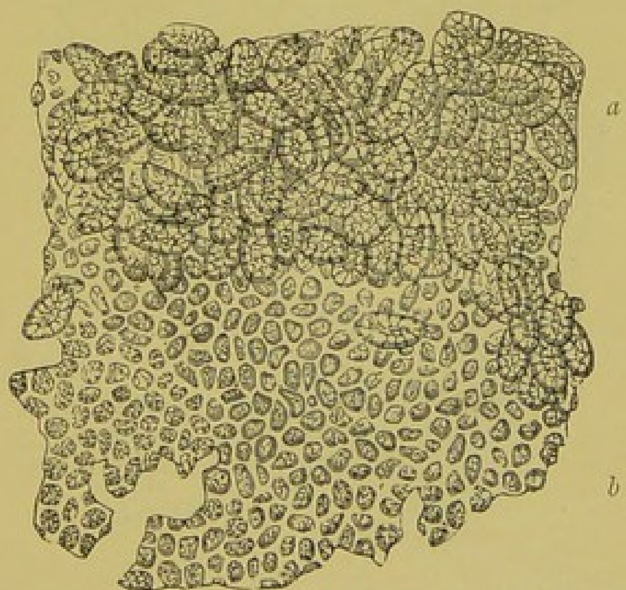


FIG. 158.—PEPPER-BERRY. PART OF CORTEX VIEWED ON SURFACE. ×120.
Above, stone cells (*a*); below, cells of outer mesocarp (*b*).

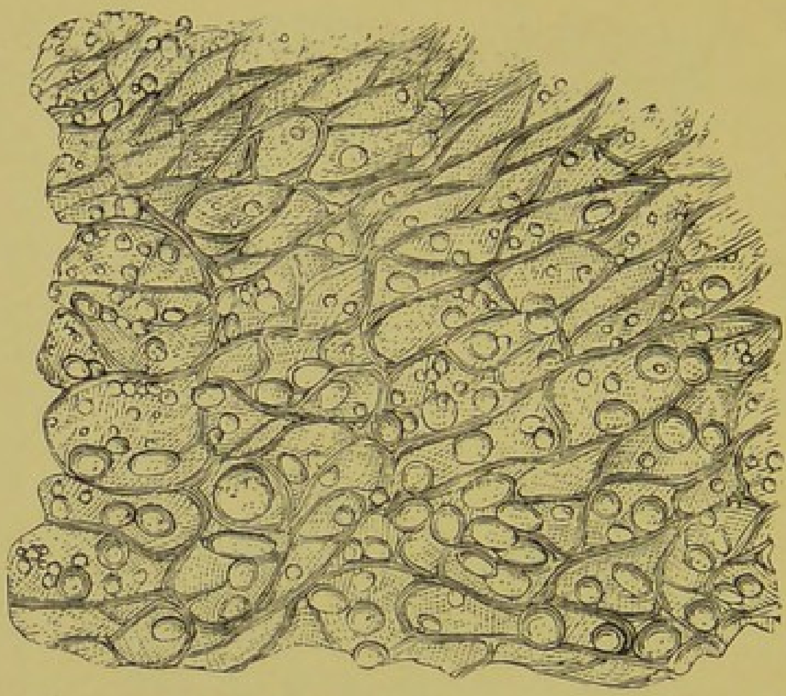


FIG. 159.—CORTEX OF PEPPER-BERRY. PORTION OF OIL-BEARING LAYER OF CELLS, SHOWING THE OIL CONTAINED IN THE CAVITIES. × 120.

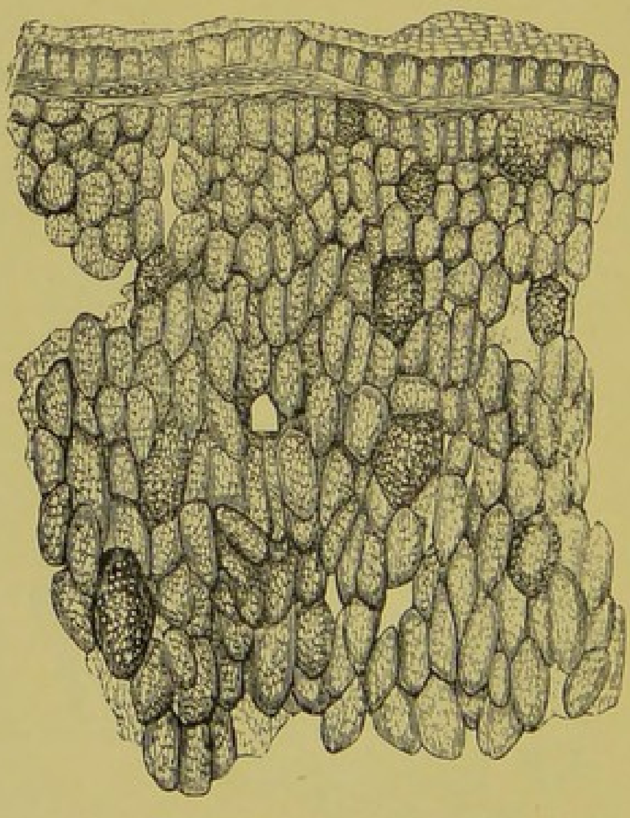


FIG. 160.—PEPPER-BERRY. CENTRAL OR INNER PORTION, SHOWING THE TWO KINDS OF CELLS, COLOURLESS STARCH CELLS AND COLOURED RESIN CELLS; ALSO THE JUNCTION WITH THE CORTEX, WITH THE HORSE-SHOE CELLS, AND PIGMENT LAYER BENEATH THEM. × 120.

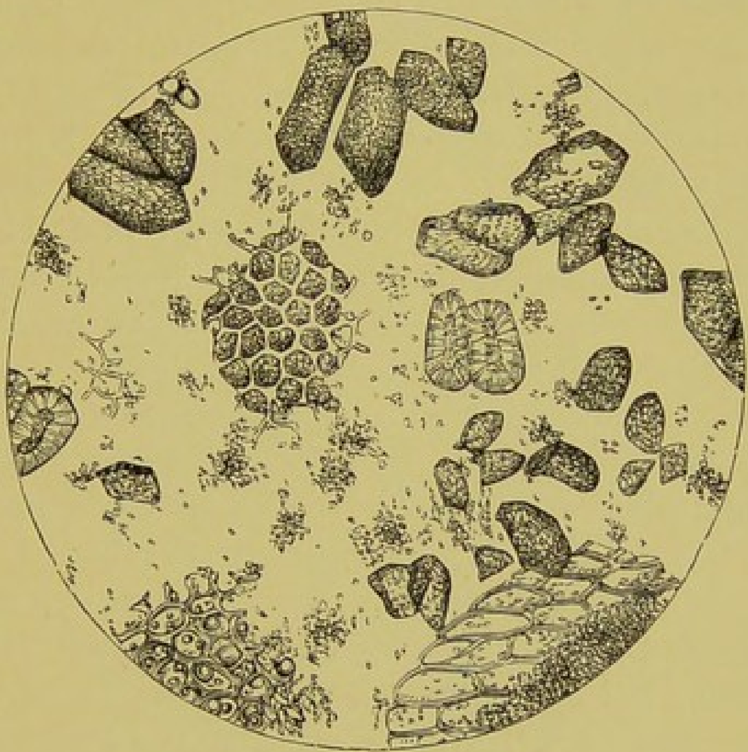


FIG. 161.—BLACK PEPPER, GROUND; SHOWING STONE CELLS, STARCH AND RESIN CELLS, OIL-BEARING LAYERS, STARCH, ETC.

ORD. GRUINALES, FAM. LINACEÆ.

LINSEED.

FIG. 162.—**Linseed**, the seed of the flax plant (*Linum usitatissimum*, ord. *Gruinales*, fam. *Linaceæ*), has occasionally been used as an adulterant of pepper.

Linseed consists of husk and an inner part or kernel.

Histology of Seed.—1. The husk, *testa*, *spermoderm*, or shell, is composed of four layers or coats: the *outer* coat, or *epidermis*, gives lustre to the seed, and is made up of a single stratum of large, colourless, hexagonal cells (the mucilage cells), which yield the mucilage characteristic of linseed. The *second* coat consists of a single layer of thick-walled, round cells, enclosing granular matter. The *third* membrane (fibre cells and cross cells) is composed of narrow, elongated cells, or rather fibres—some longitudinal, others transverse: these impart a striated and very distinctive appearance to the membrane, which, being firm and strong, forms the protecting tunic of the seed. The *fourth* membrane (the pigment layer), often separating with the kernel, is constituted of angular cells, many of which are more or less square, enclosing masses of colouring matter, probably resinous, which readily fall out of the cells, as shown in the figure.

2. The *inner* part, kernel, or substance of the seed (including a thin *endosperm*, two *cotyledons*, and the *embryo*), consists of thin-walled parenchymatous cells, containing oil globules and aleurone grains, but little or no starch. The oil is contained principally in the outer or more superficial cells. All these structures can be detected in linseed meal or powder, the parts most clearly seen being fragments of the fibrous layer, and little masses of the seed substance, from the edges of which portions of the walls of the transparent cells radiate characteristically (Fig. 162).

The microscopical appearance of **pea flour**, mentioned among the adulterants of pepper, is very similar to that of bean flour, already described and figured (p. 88, Fig. 74).

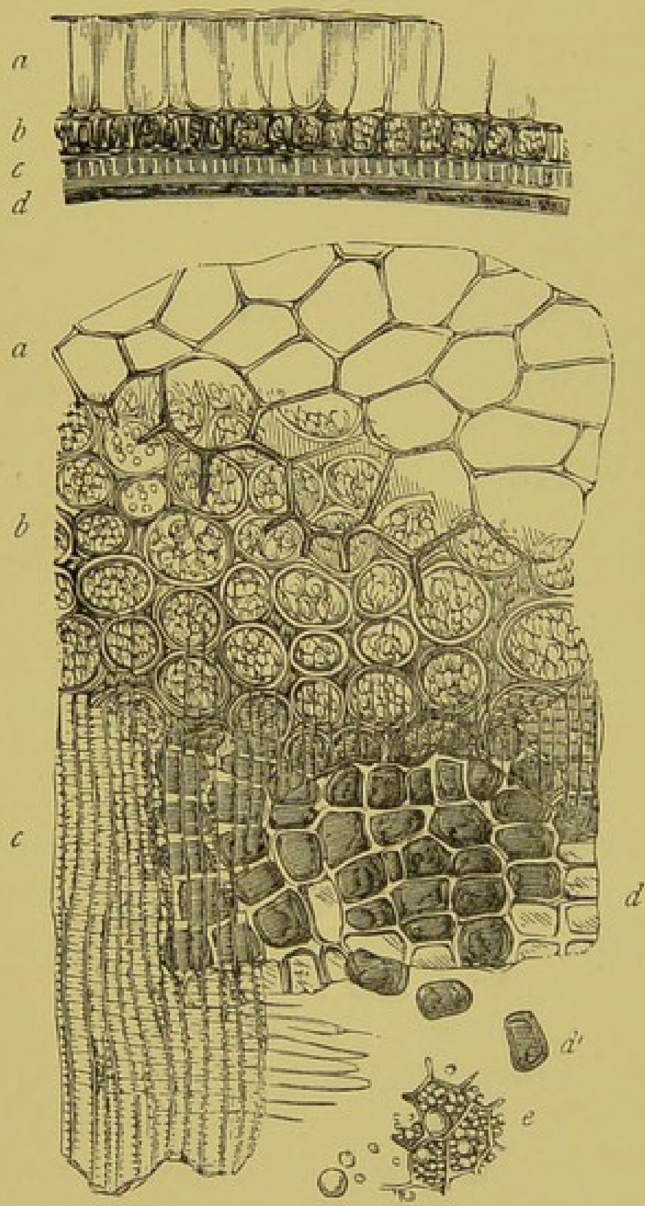


FIG. 162.—LINSEED. SECTION OF HUSK, AND SECTIONAL PLAN.

a, a, Mucilage cells; *b, b,* round cells; *c, c,* longitudinal and transverse fibre cells; *d,* pigment layer; and *d'*, detached fragments of pigment; *e,* cotyledon cells of the seed substance, with oil globules and granular matter.

Ord. PERSONATÆ, Fam. SOLANACEÆ.

CAYENNE PEPPER.

The fruit of *Capsicum frutescens*. Other species are *C. annuum* and *C. minimum*, or *fastigiatum*.

Histology of Fruit.—The capsicum berry or pod is made up of two principal parts: the *pericarp*, including an outer epidermis, with parenchyma tissue within; and the *seeds*.

1. The *epicarp*, or outermost portion of the *pericarp* (Figs. 163, *a*, and 164), consists of flattened cells, angular and tortuous in form. Viewed on the outer or upper surface, the cells are often four-sided, with well-defined borders; and the walls are thick, beaded here and there, the beading of one cell corresponding to that of contiguous cells, while the lines of junction are sometimes faintly indicated. Parenchymatous mesocarpal cells, with fibro-vascular bundles, and numerous oil globules (Figs. 163, *b*, and 166, *a*), follow. The cells of the inner layer, or *endocarp* (Figs. 163, *c*, and 165), appear less angular, but more tortuous: the walls of many are thicker and much more beaded. Many orange-red coloured oil globules are seen when the epidermis is immersed in water: some remain embedded in the cell cavities, most float freely in the surrounding water. The parenchyma tissue, which unites the seeds with each other, and the whole with the epidermis and peduncle, is constituted of rounded or oval cells with thin parietes, containing a very large quantity of oil in the form of innumerable globules, many of considerable size (Fig. 166, *b*, and 167).

2. The *seeds* have two portions to be described; (*a*) the covering, or *spermoderm*, and (*b*) the inner substance, or

endosperm :—(*a*) The *covering* is thick, and of a bright yellow colour. Under the microscope, its outer surface exhibits a cellular texture, the margins of the cells being thick and extremely tortuous, and the cavities dark and depressed, appearing as if they were rather apertures than the hollow interiors of cells. Vertical sections of this covering display toothlike processes, with intervals between, the tapering and divided summits of the 'teeth' ending in two or more spines attached to the thin membrane forming the external coating of the seed. The processes consist of the thickened walls of contiguous sclerenchymatous cells: that this is so, is evident from an examination of the upper of the two sketches on the left of the figure (Fig. 168, *a'*). These cells, beneath which are several layers of parenchyma, are best developed at the extremity of the seed. (*b*) The *substance of the seed* consists of minute angular cells, with thick and colourless parietes: their cavities are filled with oil-globules of various sizes and aleurone grains, but do not contain starch (Fig. 168, *c*).

Extraneous Substances Detectable by the Microscope.—Mustard husk, rice, turmeric, etc.

[*For figures, see pp.* 182, 183, 184, 185, *and* 186.]

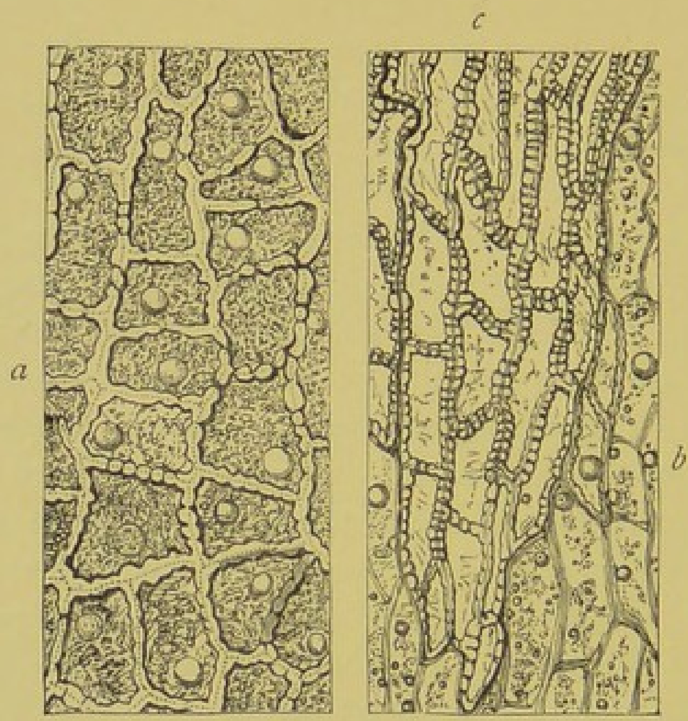


FIG. 163.—PERICARP OF CAPSICUM FRUIT. × 200.
a, Outer surface, with oil drops (epicarp) ; *b*, mesocarpal cells, with oil globules; *c*, cells of inner surface (endocarp).

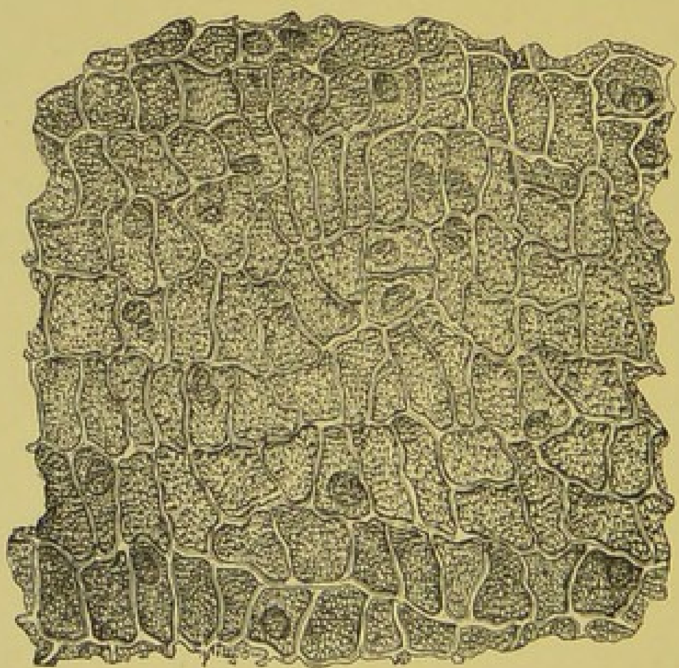


FIG. 164.—EPICARP OF CAPSICUM FRUIT, UNDER A LOWER POWER, AND IN LESS DETAIL. × 100.

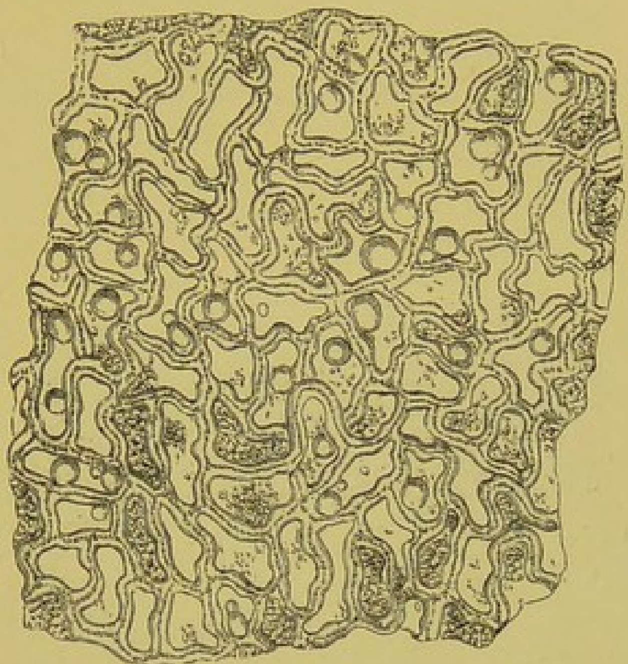


FIG. 165.—PERICARP OF CAPSICUM FRUIT. × 100.
Another portion of the endocarp.

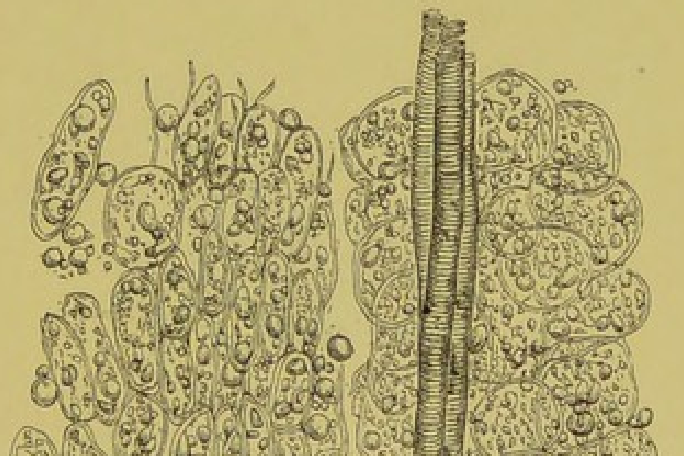


FIG. 166.—CAPSICUM FRUIT. × 200.
a, Parenchyma of mesocarp [cells in this situation traversed by spiral vessels and wood fibre (fibro-vascular bundles)]; *b* parenchyma surrounding the seeds (thin-walled cells, containing much oil).

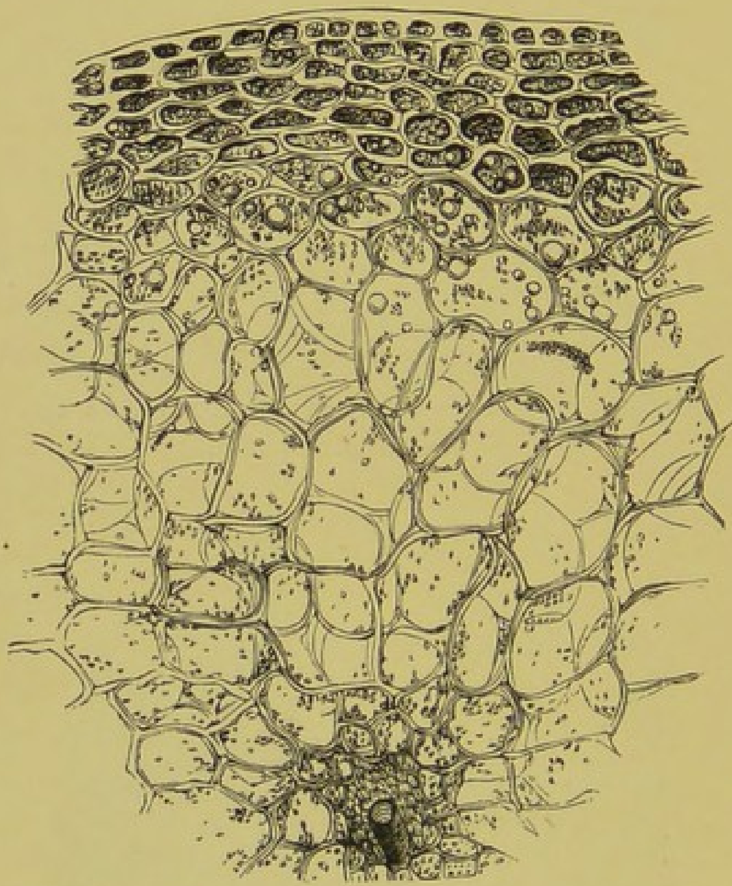


FIG. 167.—CAPSICUM FRUIT. TRANSVERSE SECTION OF THE CORTICAL PORTION OF THE POD. × 100.

Above, cells of epicarp; centre, parenchyma, with oil globules and granular contents; below, *peduncle*, or stalk.

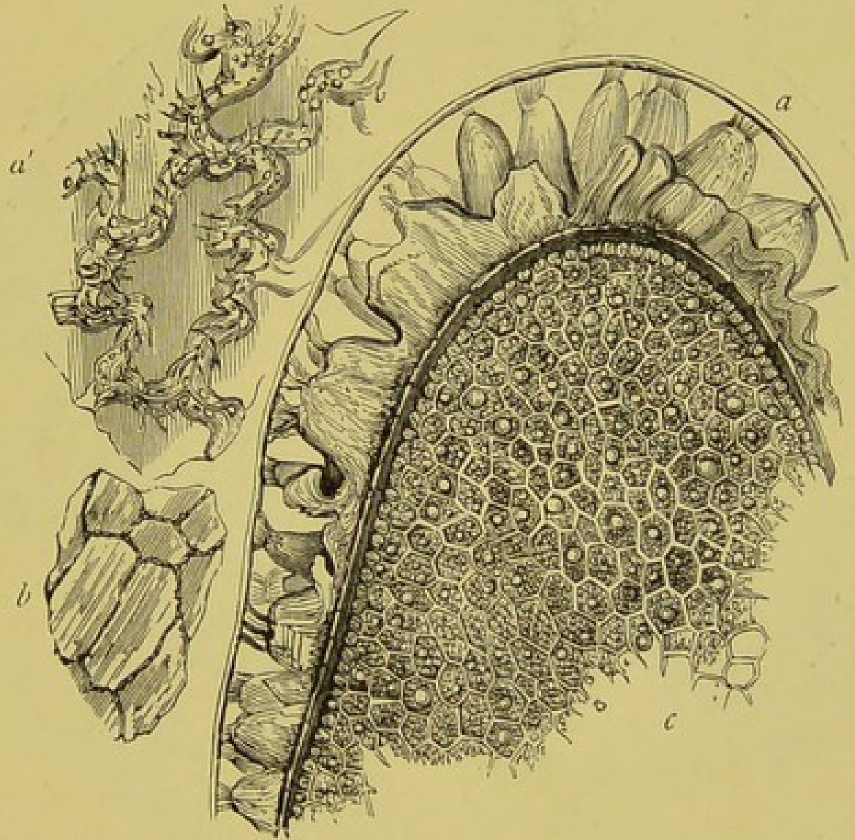


FIG. 168.—SEED OF CAPSICUM FRUIT, VERTICAL SECTION. × 100.

Showing the sclerenchymatous cells of the testa, with tooth-like processes, *a*; also these cells in surface view, *a′*, with parenchyma cells beneath (left of the figure), *b*; and the small angular cells of the seed substance, *c*.

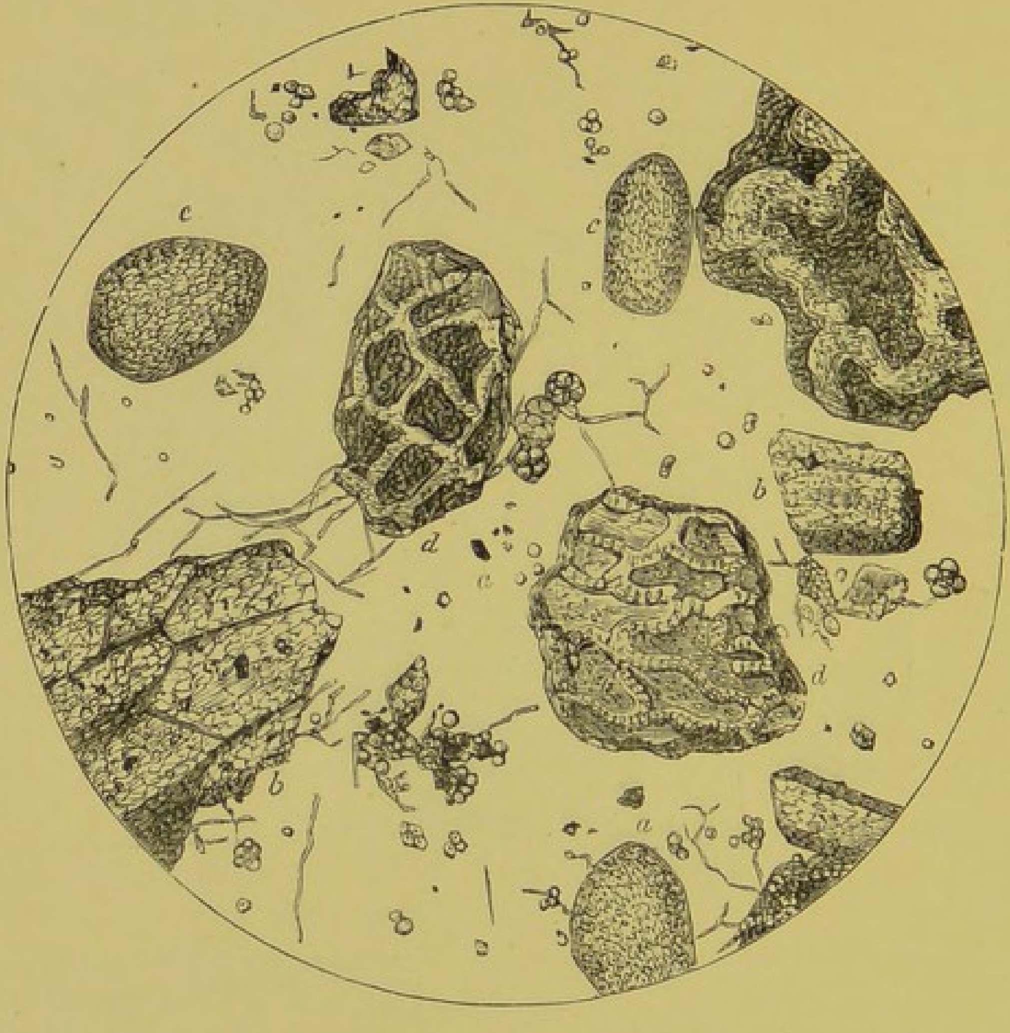


FIG. 169.—CAYENNE PEPPER. × 225.

Admixed with :—*a*, *a*, red lead ; *b*, *b*, ground rice ; and *c*, *c*, turmeric : *d*, *d*, epidermis and seed of capsicum infested with the hyphæ and spores of a *fungus*, to the attacks of which damaged cayenne is subject.

[GINGER.

ORD. SCITAMINEÆ, FAM. ZINGIBERACEÆ.

GINGER.

THE branched *rhizome*, or underground stem, of *Zingiber officinale*, ord. *Scitamineæ*, fam. *Zingiberaceæ*.

Histology.—1. When the rhizome is unscraped,[1] there is an *epidermis* consisting of several layers of large, angular, transparent, brownish cells, firmly adherent to one another, forming a distinct membrane, and when macerated in water becoming soft and somewhat gelatinous. Immediately beneath this membrane are some layers of smaller cells, associated with yellow oil globules of various sizes, as well as a few large oleo-resin cells, of a deep yellow colour, closely resembling in structure and tint those of turmeric. Crystals are sometimes observed lying underneath the epidermis. Fig. 170.

2. The *substance* of the rhizome is a parenchyma composed of cells having delicate transparent walls minutely punctated, and adhering together so as to form a connected tissue. The cells contain numerous starch granules, many of which, as the cell walls are easily broken, are seen in most sections to have become effused. Lying here and there in the midst of the above-described cells are other cells of nearly similar size and form, but of a bright yellow colour, and indistinguishable from the coloured cells of turmeric. To these cells ginger owes its tint, which varies with their number. Bundles of bast fibres, accompanying, sometimes one, but

[1] Much of the ginger of commerce is decorticated: but scraping or cutting off the surface of the rhizome exerts comparatively little influence on the chemical composition of the product.—*Vide* paper 'On some Analyses of Ginger' (E. G. Clayton), *Analyst* (1899), xxiv., pp. 122-126.

occasionally two or even more reticulated vessels, traverse the rhizome in a longitudinal direction. Fig. 171.

3. The elongated and flattened *starch granules* somewhat resemble those of East India arrowroot (*Curcuma angustifolia*), but are smaller and less elongated; also the excentric hilum and ring markings are more obscure. Figs. 171 and 172.

Extraneous Substances Detectable by the Microscope.—Sago, tapioca, potato, wheat, rice, cayenne, turmeric, mustard, husk, etc.

[The addition of *wheat flour* is difficult to detect; hence the structural peculiarities of both the starches should be carefully studied and compared. Turmeric can only be concluded to have been added when the number of large yellow cells is much greater than in genuine ground ginger.]

[*For figures, see pp.* 190, 191, *and* 192.]

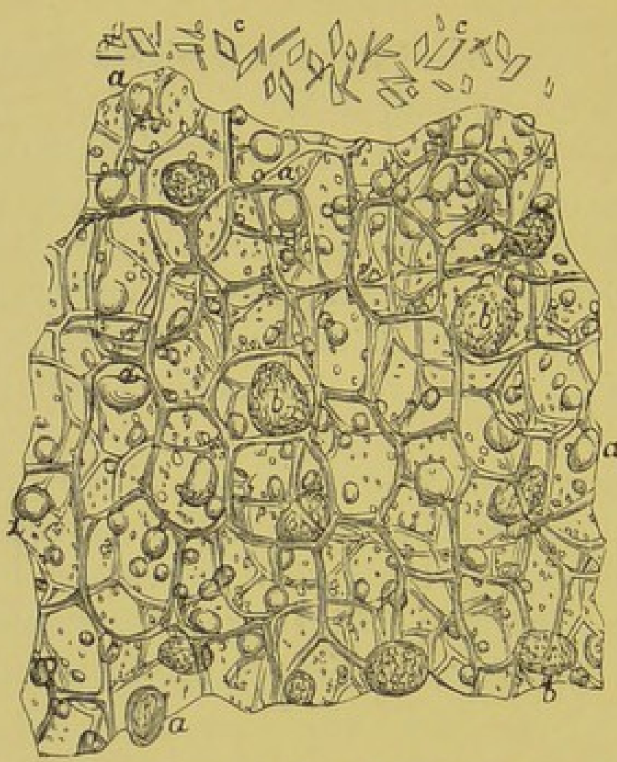


FIG. 170.—EPIDERMIS OF GINGER RHIZOME. × 100.
a, a, Cells and oil globules; *b, b*, turmeric-like cells; *c, c*, crystals frequently observed beneath the epidermis.

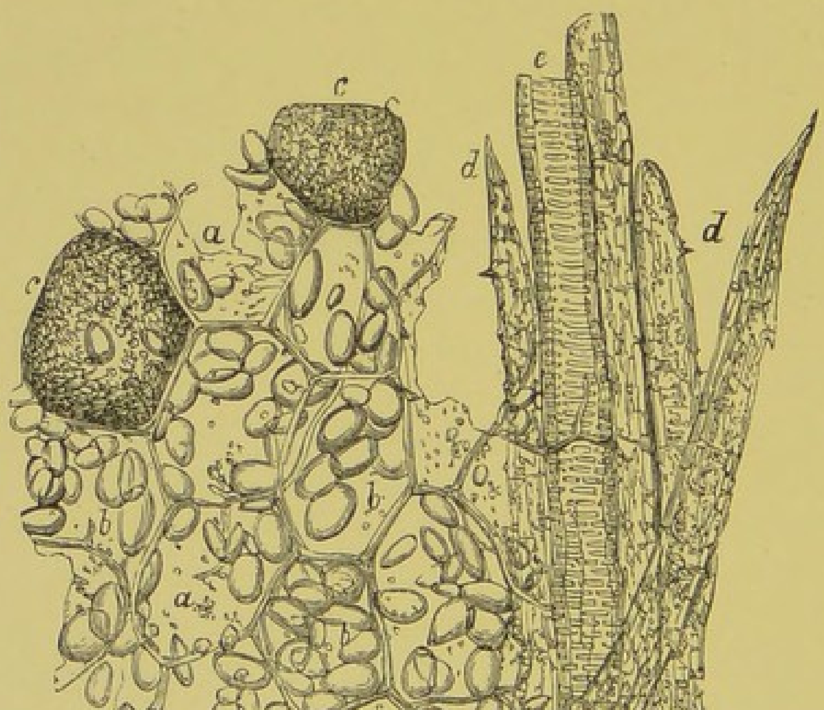


FIG. 171.—SUBSTANCE OF GINGER RHIZOME. × 200.
a, a, Parenchyma cells containing the starch; *b, b*, starch granules; *c, c*, turmeric-like cells; *d, d*, bast fibres; *e*, reticulated vessel.

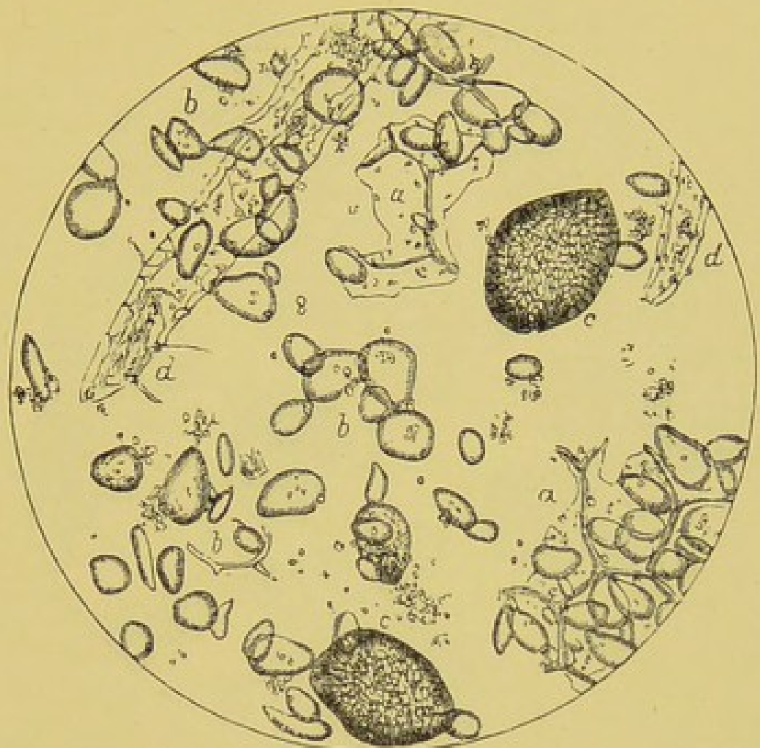


FIG. 172.—PURE GINGER, GROUND. × 200.
a, *a*, Cells containing the starch; *b*, *b*, loose starch granules; *c*, *c*, turmeric-like cells; *d*, *d*, wood fibre.

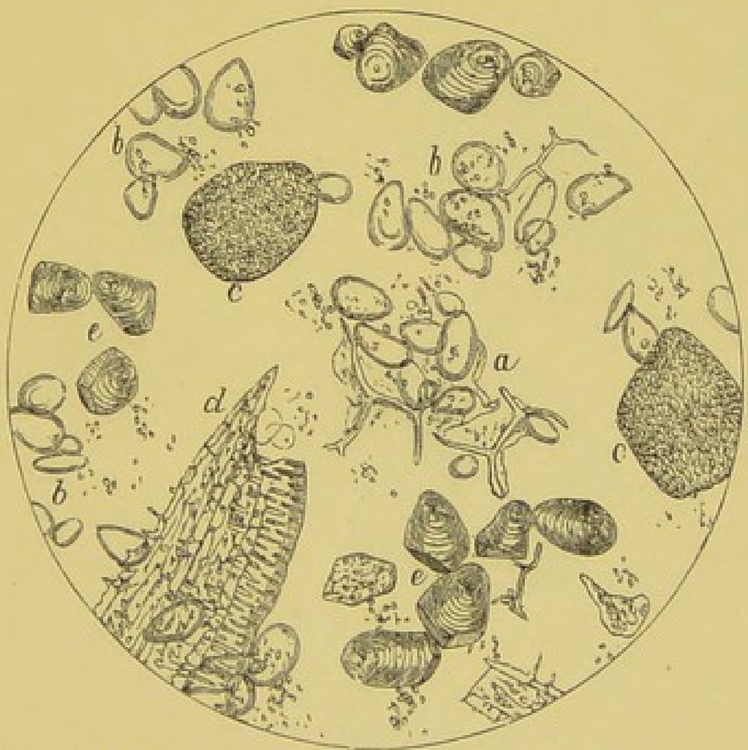


FIG. 173.—GROUND GINGER ADMIXED WITH SAGO STARCH. × 200.
a, *a*, Ginger cells; *b*, *b*, ginger starch; *c*, *c*, turmeric-like cells; *d*, *d*, wood fibres; *e*, *e*, sago starch.

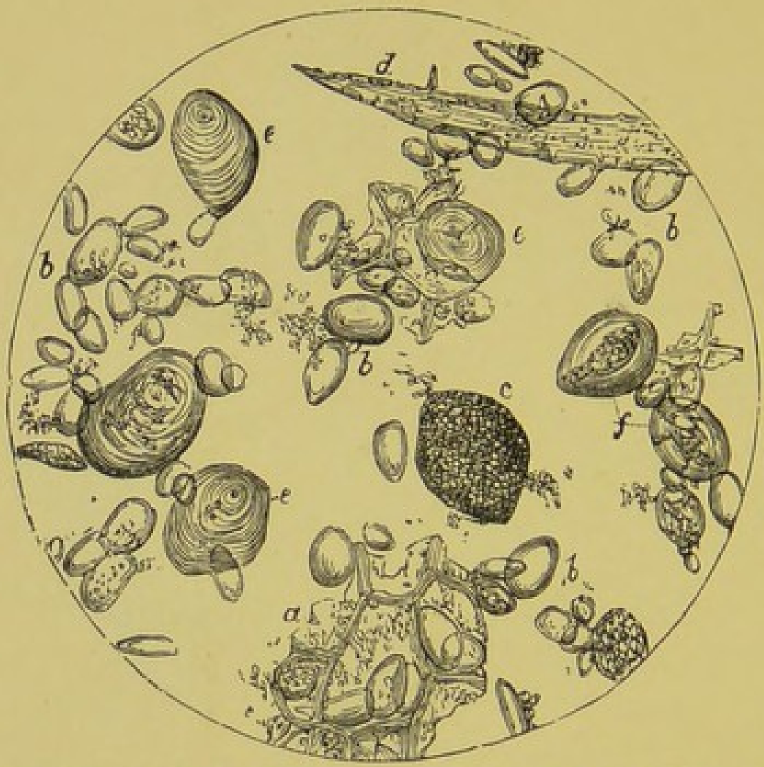


FIG. 174.—GROUND GINGER MIXED WITH POTATO AND SAGO STARCHES. × 200.

a, *a*, Ginger cells ; *b*, *b*, ginger starch ; *c*, turmeric-like cell ; *d*, wood fibre *e*, *e*, potato starch ; *f*, *f*, sago starch altered by heat.

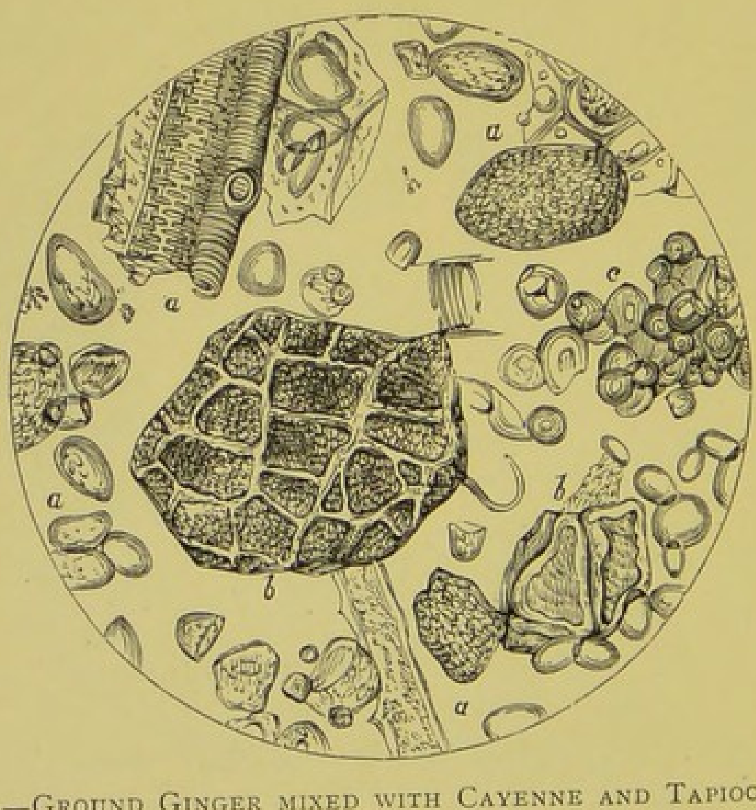


FIG. 175.—GROUND GINGER MIXED WITH CAYENNE AND TAPIOCA. × 200.

a, *a*, Ginger ; *b*, *b*, cayenne ; *c*, *c*, tapioca.

[Cinnamon and Cassia.

13

ORD. POLYCARPICÆ, FAM. LAURACEÆ.

CINNAMON AND CASSIA.

BARKS of *Cinnamomum Zeylanicum* and *C. cassia*, respectively.

Histology.—The scraped, or partly scraped, bark is brownish-red, scarcely thicker than drawing-paper, and breaks with an uneven and fibrous margin. Each stick consists of eight or more pieces or quills of bark, inserted one within the other (Fig. 178, *A*, *a*). A longitudinal section, carried through the thickness of the bark, shows on its external surface numerous 'stellate' cells (stone cells, with very thick walls and radiating pores), readily separable from each other, disposed in several layers, and forming a considerable part of the thickness of the bark. They are situated in the intervals between the bast fibres, and are of an oval form, having the long axes placed usually transversely to the bark, their breadth being greater than their depth. However they are viewed, both the central cavities and the rays proceeding from them are visible. Exceptionally, a few starch granules may be seen imprisoned in the cavities. Proceeding inwards, the stone cells are succeeded by parenchyma cells, distinguished by the absence of rays, by the thinness of the walls, and by the firmness with which they adhere to each other; they generally contain a few starch granules. These cells, which form several series, complete the thickness of the bark. Interspersed between both kinds of cells are numerous *bast fibres*, pointed at each extremity, and furnished with a central canal or *lumen*: these impart the fibrous character to cinnamon, particularly observable in fractures of the bark. The *starch granules* of cinnamon are small, more or less globular, and furnished with a very distinct hilum, having the appearance of a central depression: they usually occur singly, but are sometimes united in pairs or fours. Lastly, lying in the cavities of the most external of the second order of cells are often to be seen *granular masses* of oleoresin of a deep reddish-brown colour (Fig. 176). Other features of cinnamon are mucilage cells and calcium oxalate crystals.

In ground cinnamon most of the above structures occur, disunited and broken (Fig. 177).

Structure of Cassia.—Cassia bark is stouter than cinnamon bark, being often as thick as a shilling (Fig. 178, *B, b*): it is also paler and browner, and has a less delicate and pleasant taste. Under the microscope, sections bear a close general resemblance to those of cinnamon, but differ in their greater width and the relative proportions of the several structures, especially in the size and number of the starch granules (Fig. 179). On the outer surface, as in cinnamon, are *stone cells*, the cavities of which, however, are filled with well-developed starch granules much more commonly than are the corresponding cells of cinnamon. Next to these are the starch-bearing parenchyma cells, quite filled with starch granules, which, while of the same general form as those of cinnamon, are, as a rule, two or three times larger, as well as many times more numerous. The *bast fibres* occur, as in cinnamon, interspersed between both kinds of cells (Fig. 179).

Of the entire thickness of the bark, about one-fourth is formed by the stone cells, the remaining three-fourths consisting of the starch-bearing cells. In ground cassia, therefore, the stone cells and wood fibre are less abundant, while usually the starch granules are larger and more numerous than in powdered cinnamon (Fig. 180).

Extraneous Substances Detectable by the Microscope in Ground Cinnamon and Cassia.—Various baked starches, wheat, potato, sago, etc.

[*For figures, see pp.* 196, 197, 198, *and* 199.]

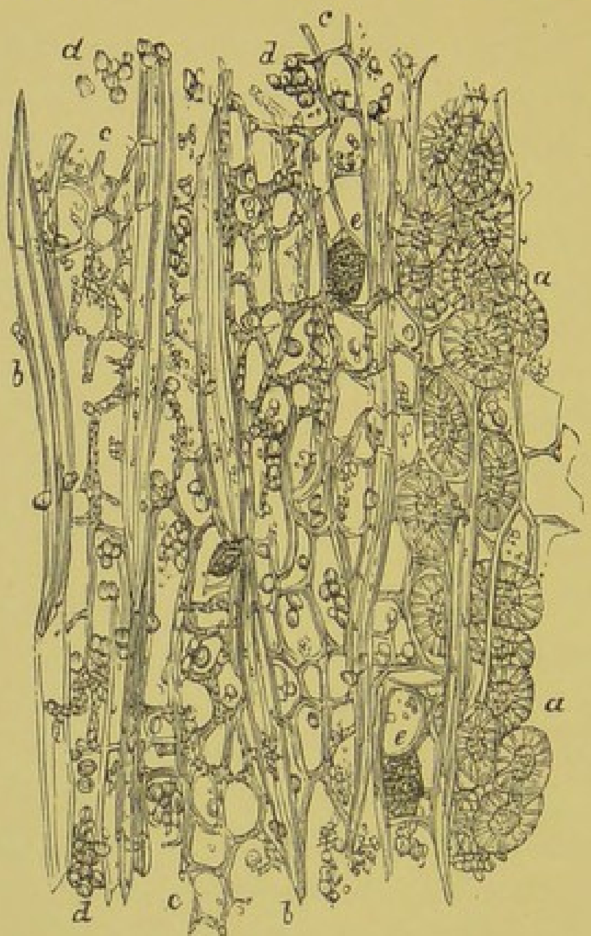


FIG. 176.—CINNAMON: LONGITUDINAL RADIAL SECTION. × 140.
a, *a* Stone cells; *b*, *b*, wood or bast fibres; *c*, *c*, starch-bearing parenchyma; *d*, *d*, starch granules; *e*, *e*, reddish-brown granular oleoresinous masses.

FIG. 177.—GROUND CINNAMON. × 220.
a, *a*, Stone cells; *b*, *b*, bast fibres; *c*, *c*, starch granules.

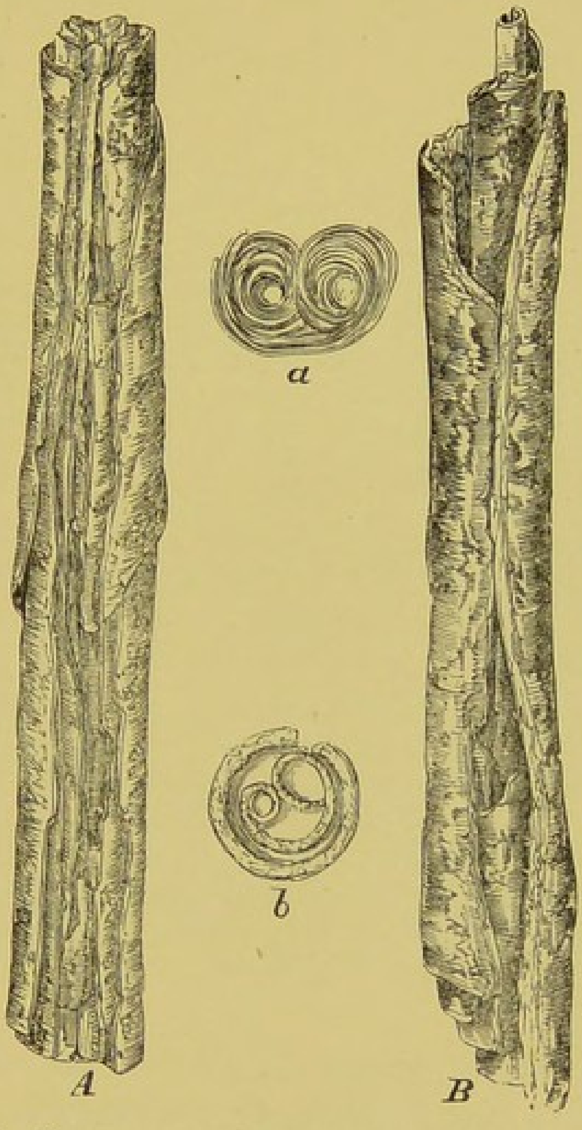


FIG. 178.—CINNAMON AND CASSIA STICKS (NATURAL SIZE).

A, Stick of *cinnamon*, showing the thinness of the bark and the manner in which the layers are enclosed one within the other; *a*, cross-section of the same, exhibiting more completely the number of layers and their disposition. *B*, Stick of *cassia*; and *b*, cross-section of the same, showing corresponding features.

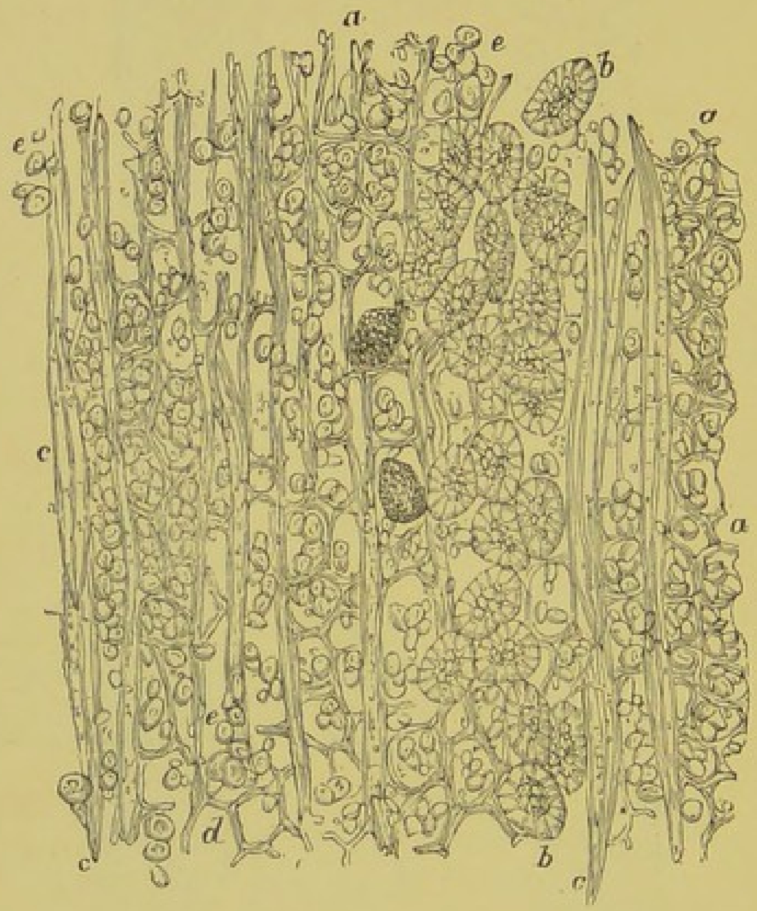


FIG. 179.—CASSIA: LONGITUDINAL RADIAL SECTION. × 140.

a, *a*, and *d*, *d*, Starch-bearing parenchyma; *b*, *b*, stone cells; *c*, *c*, wood fibres; *e*, *e*, starch granules; *f*, *f*, coloured granular oleoresinous masses.

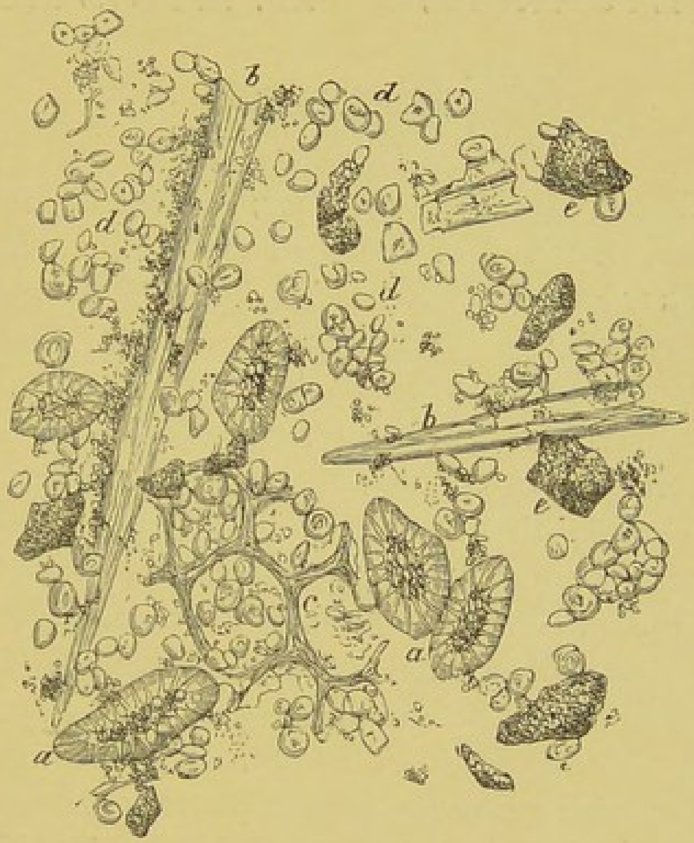


FIG. 180.—GROUND CASSIA. ×220.

a, a, Stone cells ; *b, b,* bast fibres ; *c, c,* starch-bearing cells ; *d, d,* starch granules ; *e, e,* coloured granular masses.

Ord. POLYCARPICÆ, Fam. MYRISTICACEÆ.

NUTMEG.

The seed of *Myristica fragrans*, ord. *Polycarpicæ*, fam. *Myristicaceæ*, deprived of the seed mantle or *arillus* (mace), and of the hard shell or *spermoderm*, beneath the mantle.

Histology of the Decorticated Seed.—The white or *uncoloured* portion is the *endosperm*, and consists of minute angular *cells*, which, previously to the action of water upon them, present an opalescent appearance from the quantity of oil enclosed: the cavities contain aleurone grains and crystals, also numerous small but distinct *starch* granules, mostly rounded, though sometimes angular, often in triplets, and all having well-marked central depressions. The *coloured* veinlike portion of the nut is part of the *perisperm*, and is composed of cells destitute of starch, containing little oil, but charged with much brown pigmentary matter (Fig. 181).

Additions and Substitutes Detectable by the Microscope.—Artificial or factitious nutmegs, linseed, grain, etc.

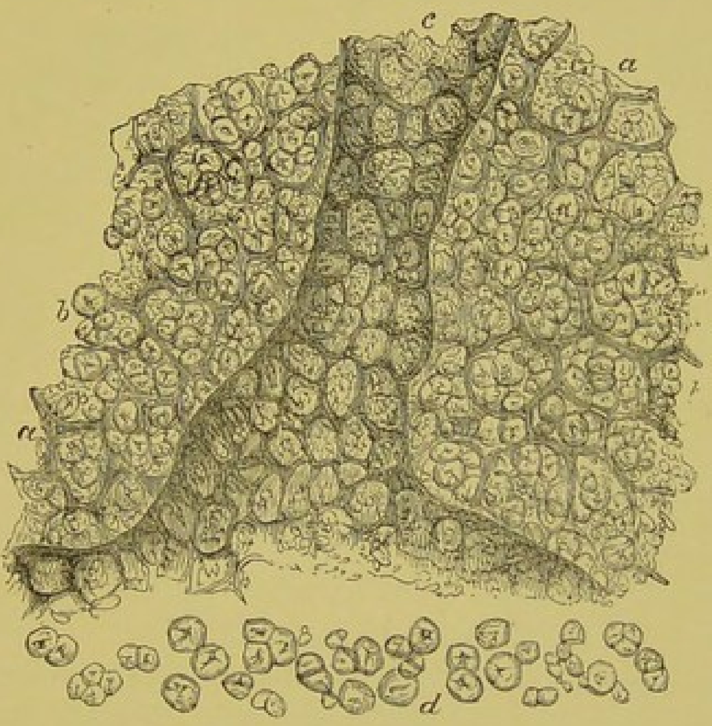


FIG. 181.—NUTMEG (SECTION). ×220.

a, *a*, Starch-bearing cells of the *endosperm*; *b*, *b*, the starch granules; *c*, starchless coloured cells constituting one of the veins formed by the folds of the *perisperm*; *d*, some loose starch granules (×420).

MACE.

THE seed mantle, or *arillus*, of the seed of *Myristica fragrans*.

Histology of Mace.—Covering the surface of the blades is a membrane, or *epidermis*, consisting of a single layer of greatly elongated, very thick-walled, tubular cells, which taper at either end to a point, and resemble in size and form, although not in delicacy of texture, ordinary wood fibre. The long diameters of the cells are disposed vertically on the surface of the mace. But the chief substance is made up of a parenchyma of cells differing in size and form from those already noticed, and containing fixed oil, with much amylodextrin starch—a substance turned reddish-brown by solution of iodine. Imbedded in the midst of these cells are larger spaces or receptacles (the large oil cells), which in thin sections, whether transverse or longitudinal, appear as apertures. These contain the essential oil of mace. Here and there may be perceived, both in longitudinal and transverse sections, small bundles of brownish wood fibre, enclosing one or two spiral vessels. In transverse sections the ordinary cells are seen arranged around the bundles in a radiate manner. Fig. 182.

Sophistication.—Admixture with, or substitution of, Bombay or other inferior mace.

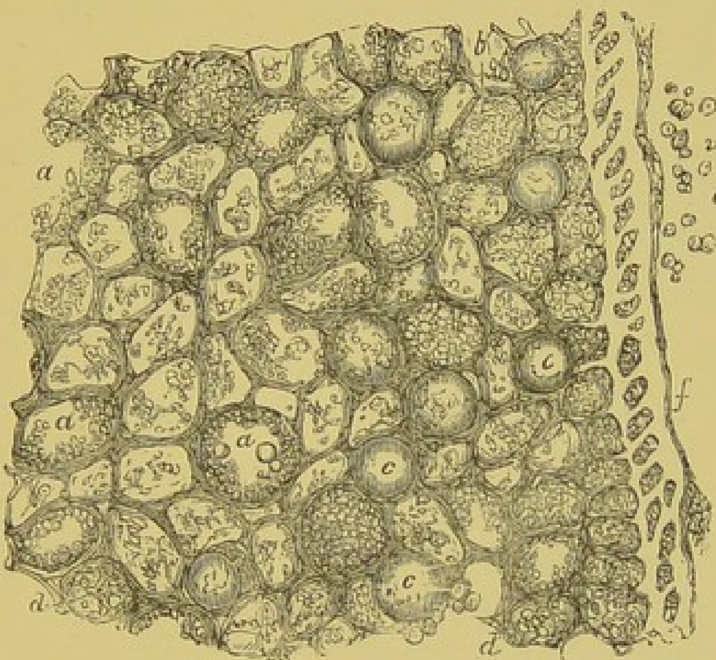


FIG. 182.—MACE (TRANSVERSE SECTION). × 220.

a, a, Large oil cells; many appearing in the section as apertures, and represented as such in the figure; *b, b*, the same, exhibiting the appearance of closed cells, from the circumstance of their not being cut into: the colouring matter of mace is located chiefly in these cells or receptacles; *c, c*, large air bubbles usually observed in sections immersed in water; *d, d*, cells filled with amylodextrin starch granules; *e*, some of these granules loose (× 420); *f, f*, cells of the epidermis.

ORD. MYRTIFLORÆ, FAM. MYRTACEÆ.

CLOVES.

THE unexpanded flower-buds of *Eugenia caryophyllata* = *Caryophyllus aromaticus*, ord. *Myrtifloræ*, fam. *Myrtaceæ*.

Histology.—The structure of the clove is extremely characteristic. The *rounded head* or *bud* consists of four unexpanded petals, and in transverse section is seen to be composed of parenchymatous cellular tissue, in the midst of which are numerous oil cavities, or receptacles for the essential oil: these extend through the whole thickness of the petals, being usually three or four deep, and somewhat smaller near to the inner surface of the leaf. When the petal is viewed on the surface, the oil receptacles are seen indistinctly, being obscured by the epidermal cellular tissue, which, both on the outer and inner surfaces, consists of small, clearly defined polygonal cells (Fig. 183).

In a thin transverse section of the calyx-tube or *flower-stalk*, many large holes are observed in the outer third of the section: these are the oil receptacles, which have been cut through by the razor or knife, in the preparation of the specimen: next to these, passing inwards, are fibro-vascular bundles, with spiral vessels and bast fibres, embedded in parenchymatous tissue, and forming a narrow circle in the interior of the stalk: then come numerous tubular cells with large spaces between them, and extending nearly to the centre of the stalk. The receptacles, tubular cells, and intercellular spaces contain essential oil, visible in sections immersed in water, in the form of innumerable droplets (Fig. 184). Longitudinal sections exhibit a nearly similar structural arrangement (Fig. 185). Cloves contain scarcely any starch.

Clove footstalks present a structure somewhat similar to that of cloves themselves—that is, they consist of parenchymatous cellular tissue, hollowed out here and there into receptacles for essential oil, and traversed by fibro-vascular bundles, including scalariform vessels; but in addition there are small granules of starch, and in the cortical region many 'stellate' or stone cells, distinguished by thick walls penetrated by radial pores.

Sophistication Detectable in Powdered Cloves by the Microscope.—Admixture with ground clove footstalks, foreign vegetable matters, etc. [The presence of the first-named can be discovered by means of the porous stone cells.]

[*For figures, see pp.* 206, 207, *and* 208.]

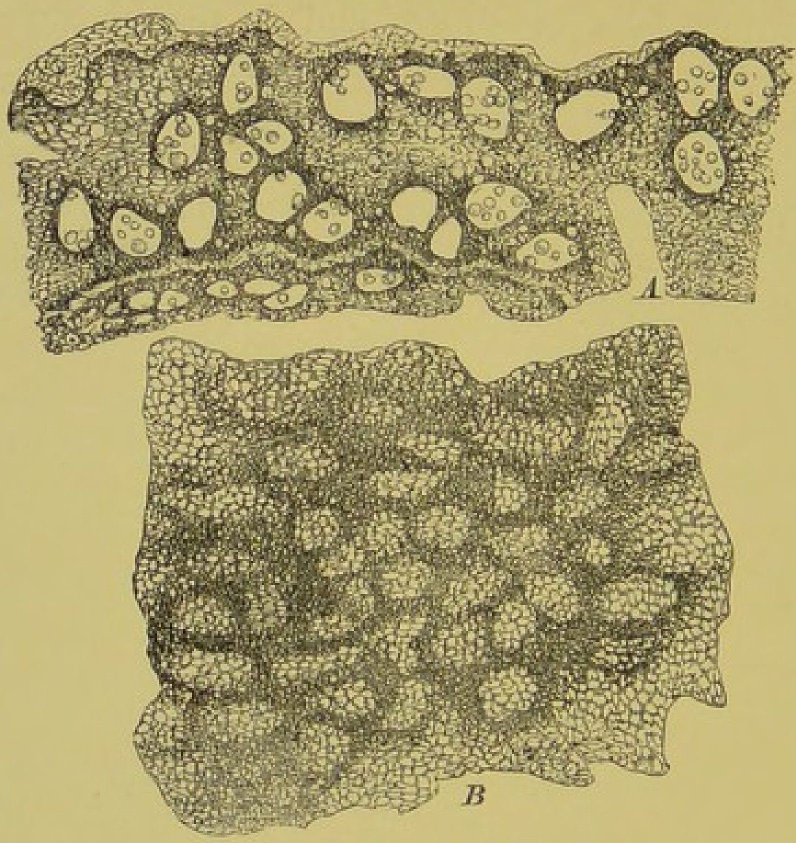


FIG. 183.—PETAL OF CLOVE BUD. × 60.
A, Transverse section, showing oil receptacles; *B*, surface, showing the receptacles indistinctly.

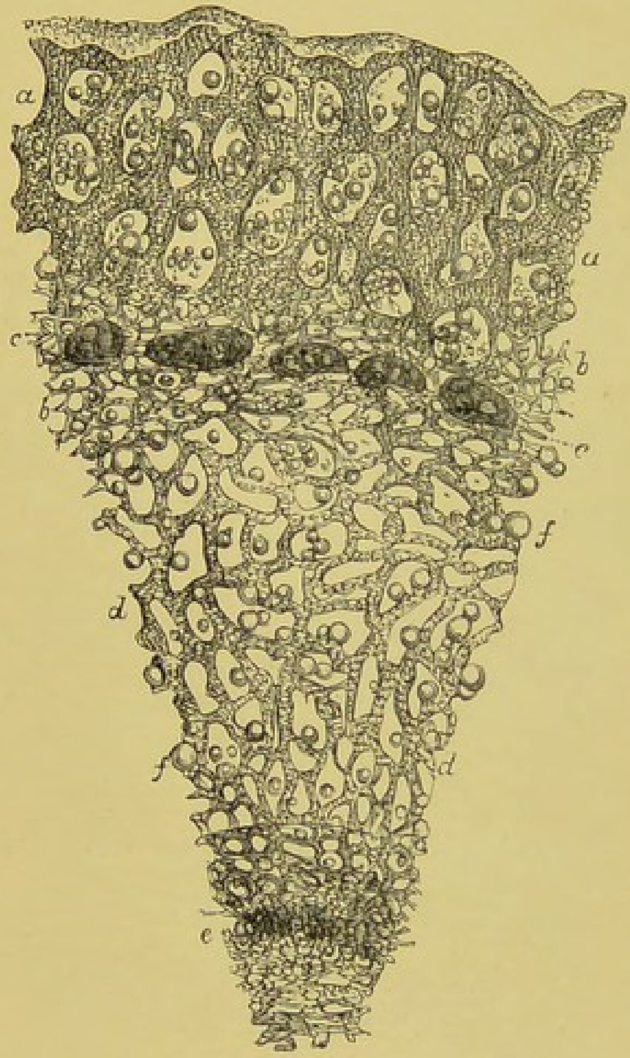


FIG. 184.—CALYX TUBE OR FLOWER-STALK OF CLOVE (TRANSVERSE SECTION). × 60.

a, *a*, Oil receptacles, appearing as apertures, the section being thin; *b*, *b*, cellular tissues surrounding the fibro-vascular bundles; *c*, *c*, bundles of wood fibre; *d*, tubular cells and intercellular spaces forming the internal portion of the stalk; *e*, centre of stalk, appearing dark under the microscope; *f*, *f*, oil droplets.

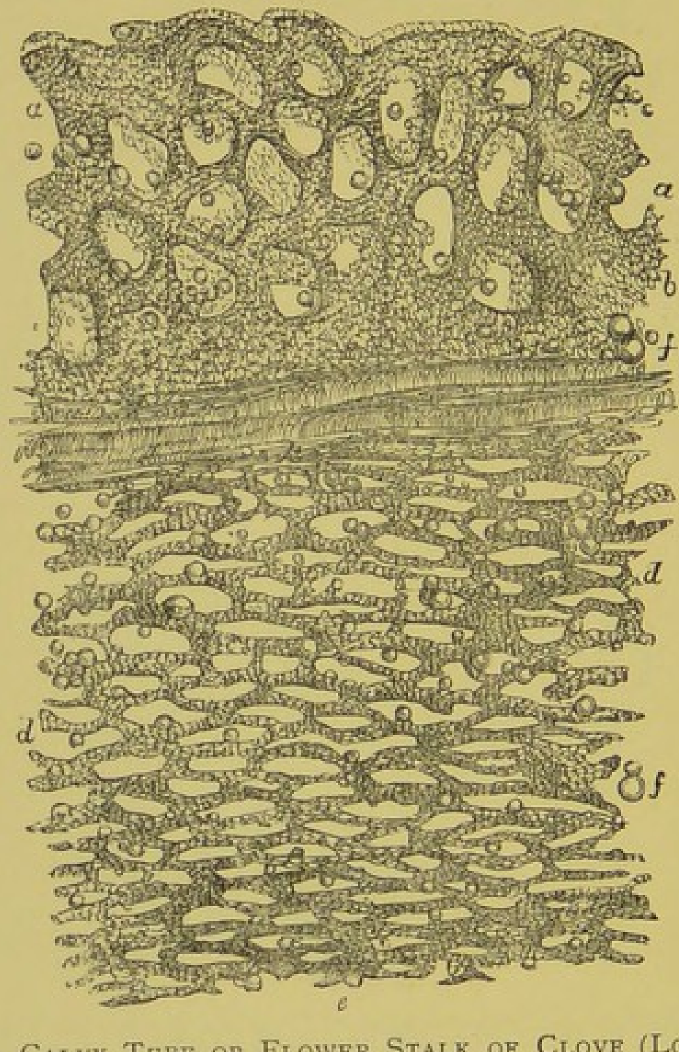


FIG. 185.—CALYX TUBE OR FLOWER STALK OF CLOVE (LONGITUDINAL SECTION). ×60.

a, a, Oil receptacles, appearing as apertures, the section being thin; *b*, cellular tissue; *c*, wood fibre; *d*, tubular cells and interspaces forming the internal part of the stalk; *e*, dark central portion; *f, f*, oil globules.

[PIMENTO OR ALLSPICE.

14

PIMENTO OR ALLSPICE.

THE fruit or berry of *Pimenta officinalis* or *Eugenia pimenta*, ord. *Myrtifloræ*, fam. *Myrtaceæ*.

Histology of the Fruit.—The pimento berry is divisible into the pericarp, or outer husk, and the contained seeds or seed. The pericarp is thick, and when dried soft and brittle: it sends off from its inner surface a prolongation which forms a *septum*, and divides the interior into two parts or cavities. Vertical sections of the outer husk or pericarp, viewed under the microscope, present the following structures: Beneath the *epicarp* of small thick-walled cells are seen, in the outer *mesocarp*, several large receptacles for the essential oil (the oil cavities), sometimes two or three deep: next to these are numerous stone cells attached to and imbedded in the parenchymatous cellular tissue of the inner mesocarp: then come bundles of wood fibre and delicate spiral vessels; and the deepest or innermost part of the section consists of numerous layers of flattened cells (Fig. 186).

Occupying each of the cavities formed by the pericarp is one of the small chocolate-coloured seeds. After maceration two principal membranes (together constituting the spermoderm or testa) are separable, though with some difficulty, from the surface of the seed. The outer membrane or epidermis is thin and delicate, consisting of a single layer of elongated and angular cells. The inner membrane is composed of several layers of large, corrugated, and coloured cells: to these is due the dark colour of the surface of the seed, and they exhibit a characteristic port-wine tint when viewed with the microscope (Fig. 187). A third, or lining membrane, not very distinctive, is sometimes described.

The structure of the *seed*, as seen in vertical sections, is as follows: Running round the outer part of the section, beneath a stratum of coloured epidermal cells, is a single layer of large oil receptacles resembling those of the pericarp; and the remaining thickness is made up of angular, transparent cells, filled with numerous well-defined starch granules (Fig. 188), somewhat like the starch of nutmeg.

Ground pimento berries show all the foregoing structures, broken up and variously intermixed. The port-wine coloured cells are particularly conspicuous, and afford a character by which the nature of the powder may be at once determined (Fig. 189).

Extraneous Substances Detectable by the Microscope.—Mustard husk, etc.

[*For figures, see pp.* 212, 213, 214, *and* 215.]

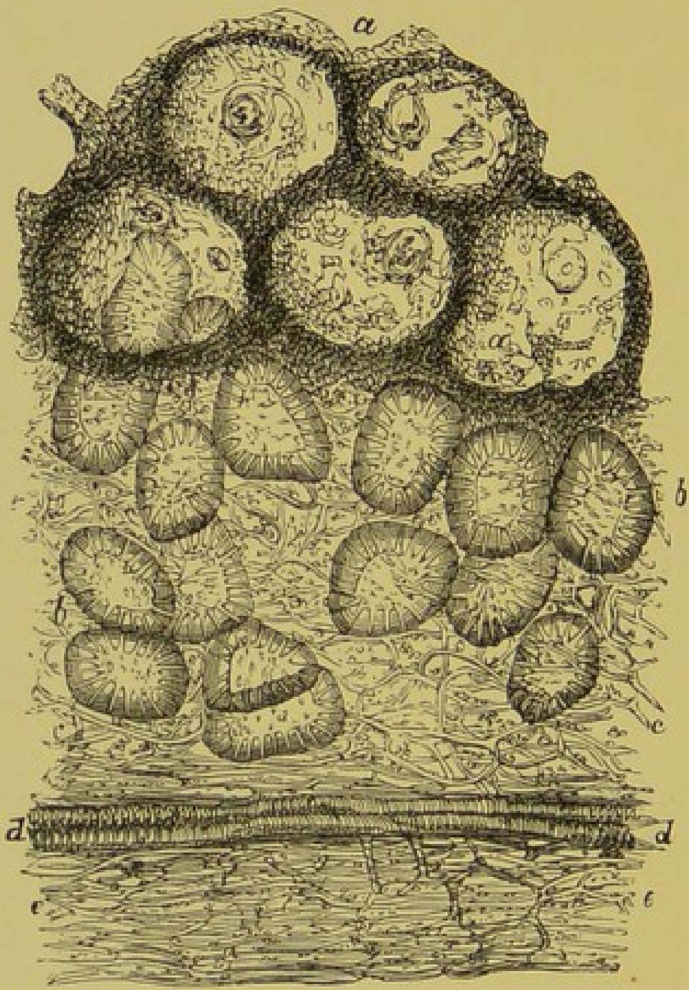


FIG. 186.—HUSK, OR PERICARP, OF PIMENTO FRUIT (VERTICAL SECTION). × 220.

a, Cells or receptacles for the essential oil; *b*, *b*, stone cells; *c*, *c*, parenchymatous cellular tissue surrounding the stone cells; *d*, *d*, wood fibres and spiral vessels; *e*, *e*, layers of flattened cells forming the innermost part of the section.

FIG. 187.—SEED OF PIMENTO FRUIT: MEMBRANES OF THE SPERMODERM, OR TESTA, IN SURFACE VIEW. × 220.

a, a, External membrane, or epidermis, consisting of a single layer of elongated and angular cells; *b, b*, internal membrane, made up of large, port-wine coloured cells.

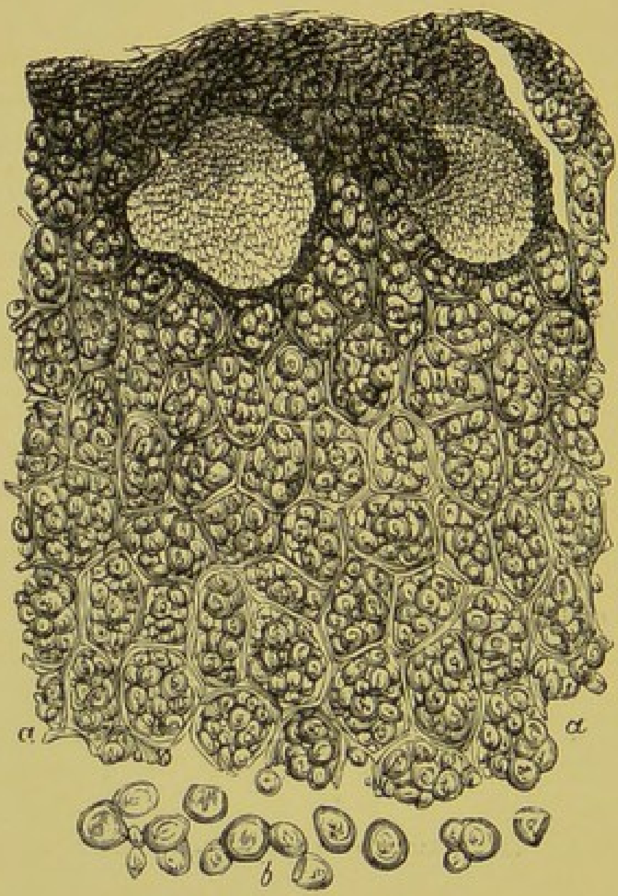


FIG. 188.—SEED OF PIMENTO FRUIT (VERTICAL SECTION). ×220.

In the upper part of the figure, two of the oil receptacles; in the lower part, *a*, *a*, the cells containing the starch granules; *b*, *b*, loose starch granules (×420).

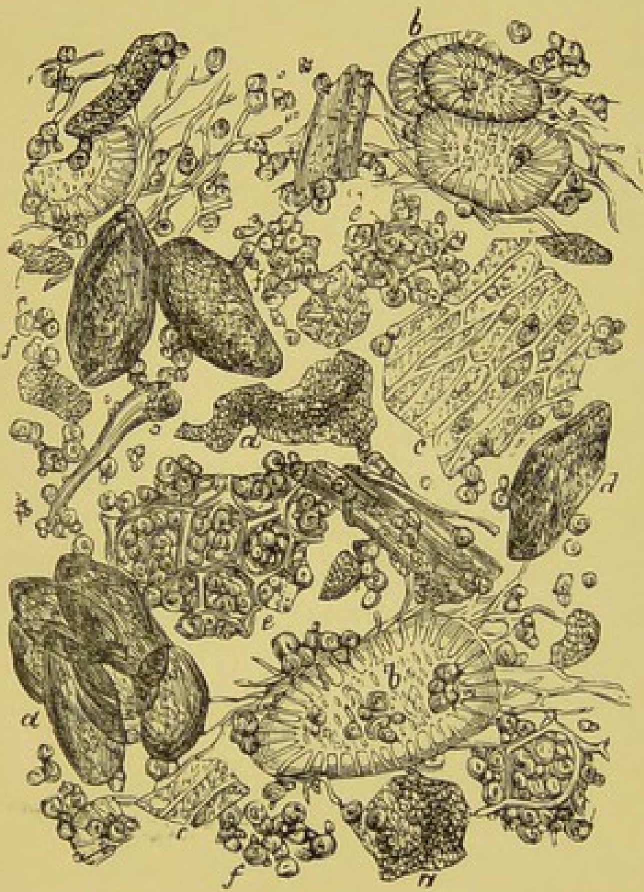


Fig. 189.—Ground Pimento or Allspice. × 220.

a, *a*, Outer husk or pericarp; *b*, *b*, stone cells; *c*, *c*, external membrane, or epidermis, of the seed-coat or testa; *d*, *d*, port-wine coloured cells, forming second membrane of seed; *e*, *e*, cells of the seed, containing starch granules; *f*, *f*, loose starch granules.

MIXED SPICE.

Structure.—Mixed spice, being usually an admixture, in different proportions, of ground ginger, pimento or allspice, and cassia or cinnamon, sometimes with powdered cloves, mace, or nutmeg, exhibits under the microscope the characteristic features of these spices, as shown in Fig. 190.

Extraneous Substances Detectable by the Microscope.—Wheat flour, potato farina, etc.

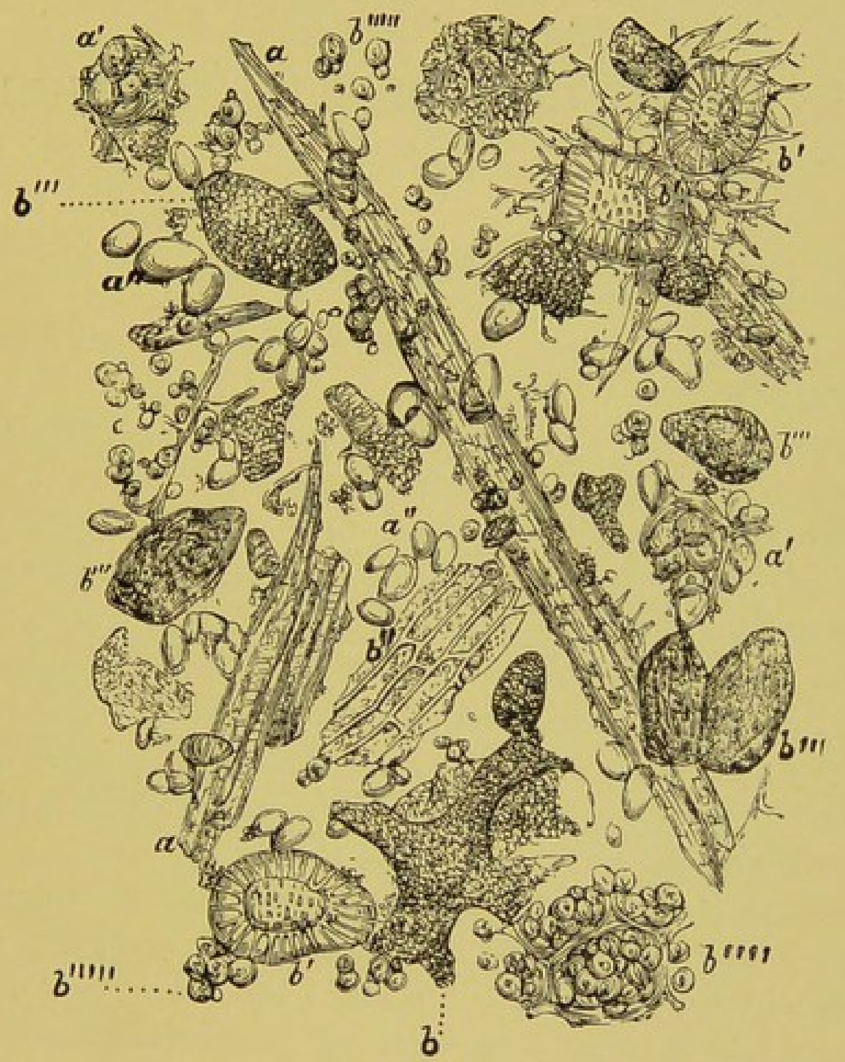


FIG. 190.—MIXED SPICE. ×220.

a, *a*, Wood fibre of *ginger*; *a'*, cells of ginger which contain the starch; *a''*, *a''*, starch granules of ginger; *b*, outer husk of *pimento*; *b'*, *b'*, stone cells of pimento; *b''*, husk of the seed proper of pimento; *b'''*, *b'''*, port-wine coloured cells of pimento; *b''''*, starch-bearing cells; *b'''''*, *b'''''*, starch granules of pimento; *c*, *c*, starch granules and fragments of *cinnamon*.

ORD. UMBELLIFLORÆ, FAM. UMBELLIFERÆ.

CORIANDER.

THE fruit of *Coriandrum sativum*, ord. *Umbelliforæ*, fam. *Umbelliferæ*.

Histology.—*Fruit or seed-vessel*, light brown, globular, and about twice the size of white mustard seed. The fruit consists of two hemispherical portions termed *carpels* or *mericarps*, each of which encloses a seed, and exhibits on its outer surface five primary ridges, depressed and wavy, together with four secondary ridges, more prominent and straight. The dorsal sides are without *vittæ*, or receptacles for the essential oil: but near the commissures in each mericarp there is a small vitta, so that each fruit is provided with four oil-ducts.

Pericarp or husk, thick and brittle: under the microscope, its most characteristic membrane is seen to consist of narrow, sclerenchymatous fibres, crossing each other, and disposed in a waved manner (Fig. 191). Loose cellular, mesocarpal tissue follows, the cavities of the cells being empty. On the removal of the husk, these cells are torn through, some remaining attached to it, and the rest to the surface of the seed. Beneath the loose cells is a delicate fibrous membrane, the endocarp, succeeded by a layer of deeply-coloured cells (the cells of the spermoderm), which merge into the cells forming the endosperm, or *substance of the seed*: these are angular, with well-fined parietes, their cavities enclosing aleurone grains and oil globules. The mature seed does not contain starch.

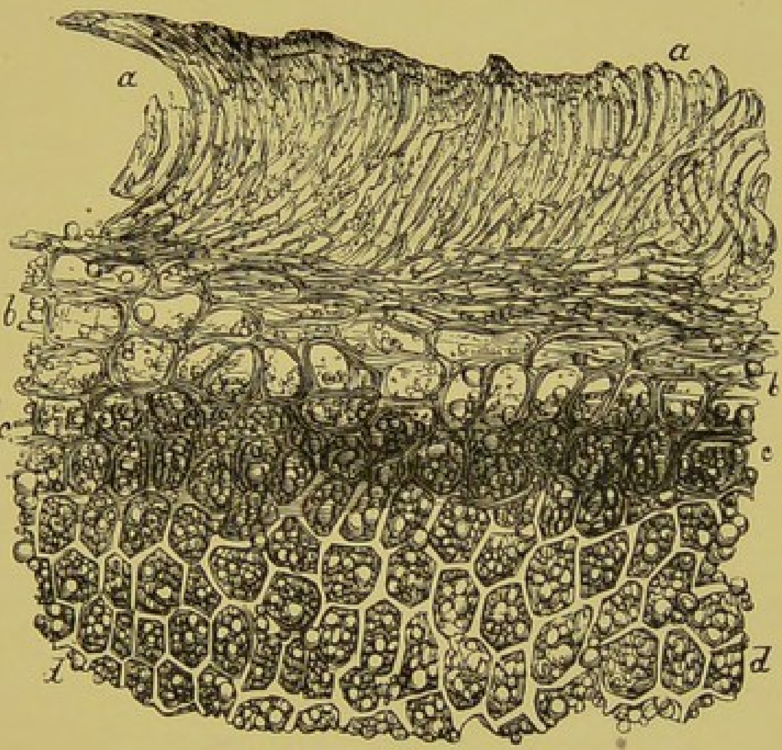


FIG. 191.—CORIANDER (TRANSVERSE SECTION OF CARPEL). ×220.

a, *a*, Sclerenchymatous fibres of the husk; *b*, *b*, loose cells beneath; *c*, *c*, layer of deeply-coloured cells (the spermoderm); *d*, *d*, cells of the endosperm.

ORD. SCITAMINEÆ, FAM. ZINGIBERACEÆ.

CARDAMOM.

THE fruit of *Elettaria cardamomum*, ord. *Scitamineæ*, fam. *Zingiberaceæ*.

Histology.—Seed-vessels or pods, triangular, and consist of three valves, tapering at each extremity to a blunt point. The *membrane*, or pericarp, forming them is thick, tough, and fibrous: it is made up of cellular tissue and bundles of wood fibre, which spread out from the flower-stalk and on the surface of the pod are visible to the naked eye, imparting the striated appearance characteristic of the seed-vessel of cardamom. From its interior the seed-vessel sends off three septa or prolongations, dividing it into many compartments, each containing several hard, reddish-brown seeds, exhibiting peculiar markings on the surface. The *seeds* are enveloped and united together by a gelatinous parenchymatous membrane, or *arillus*, consisting of numerous delicate tubules, filled with granular and oily matter.

The *covering of the seed*, or spermoderm, viewed under the microscope on its surface, is observed to have externally a single layer of coloured cells, much elongated and of uniform diameter, terminating in rounded extremities, and accurately adapted to each other (Fig. 192, *A*). Beneath these are other cells (cross cells), generally resembling those just described, but differing in being more irregular, much more delicate, and in the absence of colour: they are disposed in an opposite direction to those of the outer layer. In transverse sections, the elongated coloured cells appear as small channels, of a rounded form, the cross cells as a thin band just beneath. Below the cross cells is a single row of large oil receptacles. Next is a layer of palisade cells, very thick walled and deeply coloured. These are succeeded by the cells constituting the perisperm, or principal part of the substance of the *seed*, which in the outer stratum contain aleurone grains, but for the rest are very angular, and resemble closely the cells of pepper. They differ, however, in their more delicate and transparent appearance, and in being minutely dotted (Fig. 192, *B*). These cells are completely filled with minute, distinctly-formed starch granules, very much like those of rice.

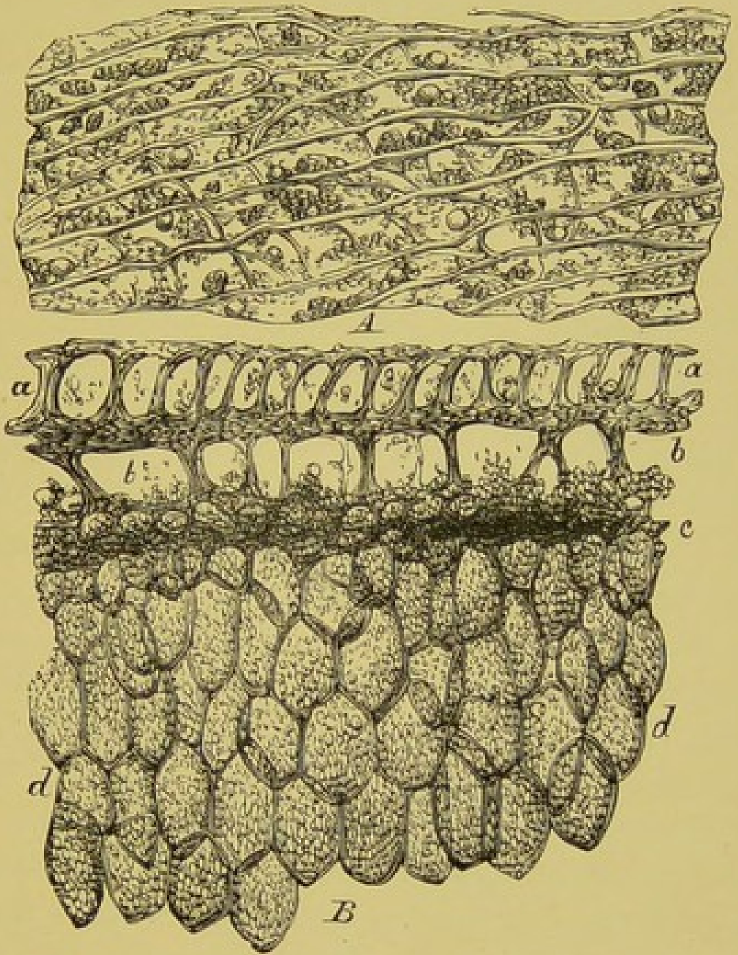


FIG. 192.—CARDAMOM: ELONGATED COLOURED CELLS OF SPERMODERM OR SEED-COVERING, AND TRANSVERSE SECTION OF SEED. ×220.

A, Portion of outer membrane, showing coloured cells on its surface. *B*, transverse section of seed; *a*, *a*, cells forming outer membrane; *b*, *b*, oil receptacles; *c*, layer of deeply coloured fence, or palisade cells; *d*, *d*, transparent and minutely-dotted cells, making up the substance of the seed, and filled with starch granules.

ORD. LEGUMINOSÆ, FAM. PAPILIONACEÆ.

FENUGREEK SEED.

THE seed of *Trigonella Fœnum-Græcum*, ord. *Leguminosæ*, fam. *Papilionaceæ*.

Histology.—*Husk of seed, spermoderm*, or *testa* consists of three membranes, the outer formed of a single layer of curious paling, fence, or palisade cells, resembling from certain points of view short-necked bottles. The long diameter of these cells is disposed vertically, the narrow, neck-like part extending into an external mucilaginous stratum, situated at the surface of the seed-coat. The second membrane consists of a single layer of cells, two or three times larger than the former, very much flattened, and with regularly and beautifully crenate margins. The third and innermost membrane is made up of flattened parenchyma cells. The *endosperm*, which constitutes more than a third of the bulk of the *seed*, is mainly composed of large transparent mucilage cells, which expand enormously when immersed in water (Fig. 193). An aleurone layer is outside the mucilage membrane.

The cotyledons are covered by two epidermal layers of small angular cells, beneath which are several tiers of rounded and polygonal cells with usually three layers of elongated or paling cells, the long axes being placed transversely in each lobe, and numerous aleurone grains being present. Fenugreek seed contains no starch.

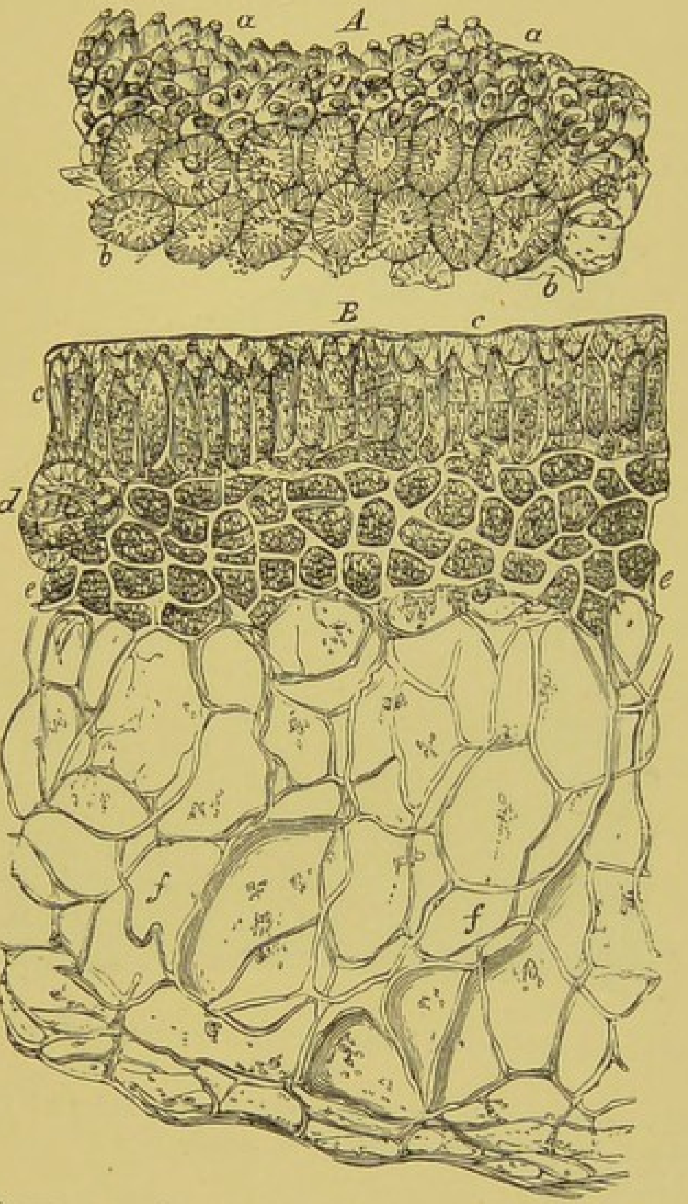


FIG. 193.—FENUGREEK SEED: TESTA, SPERMODERM, OR OUTER COAT. × 220.

A, Portion of the outer and second membrane stripped off; *a*, *a*, paling, or bottle-like cells; *b*, *b*, crenated cells; *B*, transverse section through husk, and endosperm beneath; *c*, *c*, paling or bottle-like cells; *d*, position of crenated cells; *e*, *e*. layer of coloured cells (the aleurone layer) merging into *f*, *f*, the large transparent mucilage cells.

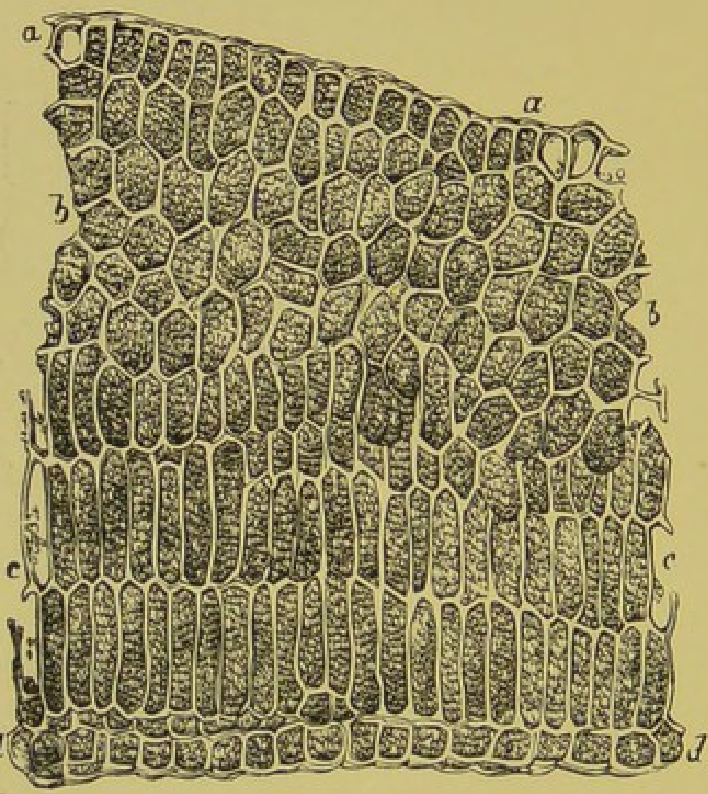


FIG. 194.—FENUGREEK SEED: TRANSVERSE SECTION OF COTYLEDON OR LOBE. × 220.

a, a, Small angular cells on surface; *b, b*, rounded and polygonal cells; *c, c*, elongated or palisade cells; *d, d*, single row of cells forming inner epidermis of lobe.

[Cumin or Cummin.

ORD. UMBELLIFLORÆ, FAM. UMBELLIFERÆ.

CUMIN OR CUMMIN.

THE fruit of *Cuminum cyminum*, ord. *Umbelliflorœ*, fam. *Umbelliferœ*.

Histology.—The fruit resembles that of the caraway, but is larger, straighter, of a lighter colour, and possessed of a characteristic odour and taste. Fruit double, like that of coriander and other umbelliferæ, consisting of two carpels or mericarps. Each mericarp has five primary filiform ridges and four prominent secondary ridges: both furnished with very fine hairs or prickles, and under each secondary ridge is a receptacle, *vitta*, or oil-duct. Transverse sections of cumin show the following characters: the hairs or prickles are composed of cells, the long diameters of which are arranged in the long axes of the hairs. The pericarp, or outer covering of the fruit, consists of numerous rounded or angular cells, in the midst of which the large triangular vittæ are situated; and within the pericarp there is usually a small space, which is formed by the contraction of the seed after it has arrived at maturity. Superficially, the kernel is of a pale-brown colour: internally, it is whitish and translucent. The exterior (the *spermoderm* or seed-coat) is constituted of elongated and flattened brownish cells, while the interior and chief substance of the seed (the *endosperm*) is made up of numerous distinct angular cells with thick and perfectly transparent walls: the contents consist principally of aleurone grains, calcium oxalate crystals, and oil. The seeds do not contain starch (Fig. 195).

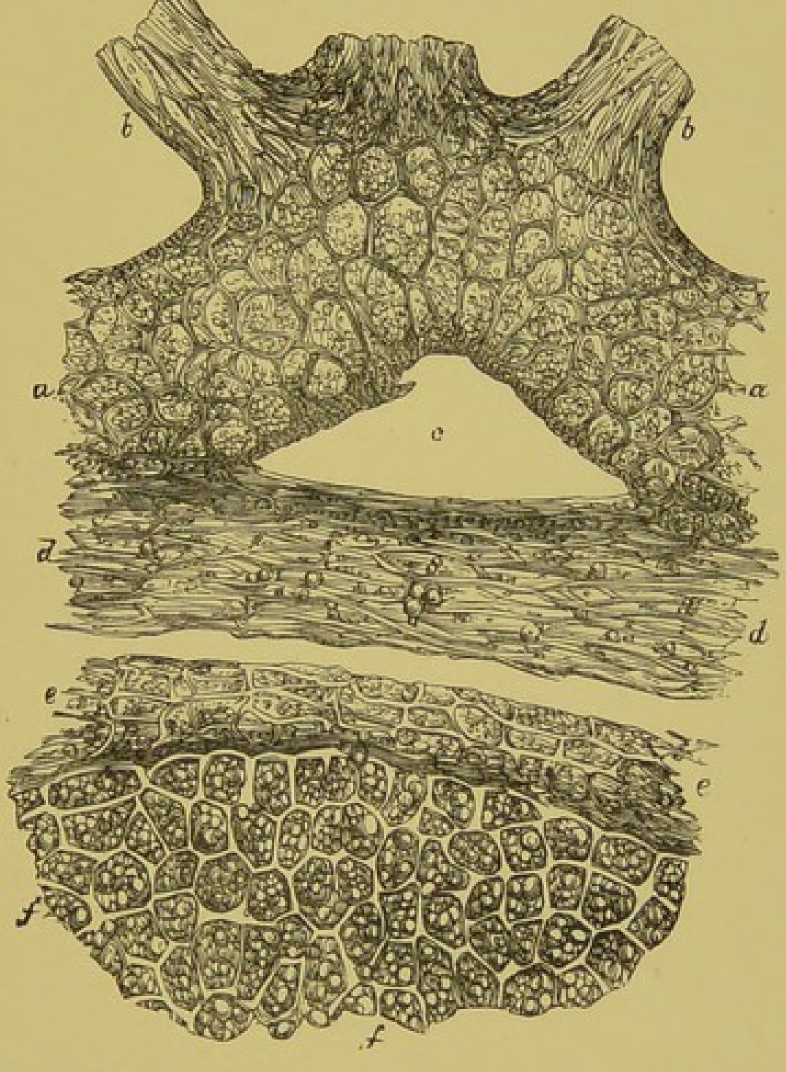


FIG. 195.—CUMIN: TRANSVERSE SECTION OF MERICARP. ×220.

a, a, Cells forming the outer husk or pericarp; *b, b,* beginnings of two hairs or prickles: *c,* oil-duct or *vitta; d, d,* elongated cells composing innermost layer of husk; *e, e,* cells and fibres forming the spermoderm or external surface of seed; *f, f,* cells of the endosperm or interior substance of the seed, containing aleurone grains, oil, etc.

SECTION II.

FOODS DERIVED FROM ANIMAL SOURCES.

FLESH.

THE flesh of meat consists in great part of the *voluntary* muscles, which have been controlled by the will and concerned in the movements of the oxen, sheep, and other animals killed and eaten by man. The distinctive microscopical feature of this variety of muscle is the cross-striated or striped appearance of the cylindrical fibres, which are about $\frac{1}{500}$th inch in diameter and sometimes upwards of an inch long. Each fibre is encased in a sheath of elastic substance, the *sarcolemma*, and is composed of a number of parallel contractile *fibrils*, across all of which run alternate dark and light bands or striations. Oval *nuclei* also are visible, under or adherent to the sarcolemma (Fig. 196).

The *involuntary* muscles, present in the walls of hollow organs, such as the intestines, stomach, bladder, and trachea, are composed of flat, elongated, fusiform cells, each made up of unstriped fibrils and possessed of an elliptical nucleus, exhibiting intra-nuclear network, with usually *nucleoli*. This kind of muscular fibre is described as plain, non-striated, or smooth (Fig. 197, *A* and *B*).

The hollow viscera are mostly excluded from the better classes of animal food : the involuntary muscles are therefore of less moment than striped muscle, or at all events should be far seldomer met with by the food-microscopist. Nevertheless, when examining sausages (especially such as are of exotic origin), cheap brawns, flesh pastes, and other minced or comminuted preparations of meat, packed in cans, jars, or otherwise, he will do well to let his 'sense of mystery' be ever present. He should have read his Upton Sinclair, and be doubly careful.

Cardiac muscle-fibres are striated, but less distinctly and regularly than the fibres of voluntary muscle. They differ in outward form from both species of muscle-fibre previously described, being quadrangular cells, usually with a side branch near one end, by which, as well as by the ends, they are attached to adjacent cells. Large central nuclei are present (Fig. 197, *C*).

Microscopically, to distinguish one sort of flesh from another, as horse from beef, cat from sucking pig, or rat from rabbit, unfortunately at present is scarcely possible.

A megascopic investigation of flesh is quite as important as the microscopical examination, but an account of it is beyond the province of the present volume.

Extraneous Matters Detectable by the Microscope.—Flesh-parasites (described in the next sub-section): tubercle: crystals of salt, nitre, and other mineral adjuncts used for preservative purposes: also bread and other vegetable additions, such as starch, bran, spices, and *je ne sais quoi*, in sausage-meat, or the like. The ingenious fabricator of the inexpensive sausage is sometimes a past-master in the craft of making the worse appear the better product. A skilful *user* of antiseptics and dyestuffs, superadded to the judicious compounding of a maximum of old bread with a minimum of indefinable animal-flesh, enables him to produce marketable and, to appearance, inoffensive *delicatessen*. He is, in fact, a synthetic chemist. But *all* sausage-makers are not so clever; and this is as well.

[*For figures, see pp.* 235, 236.]

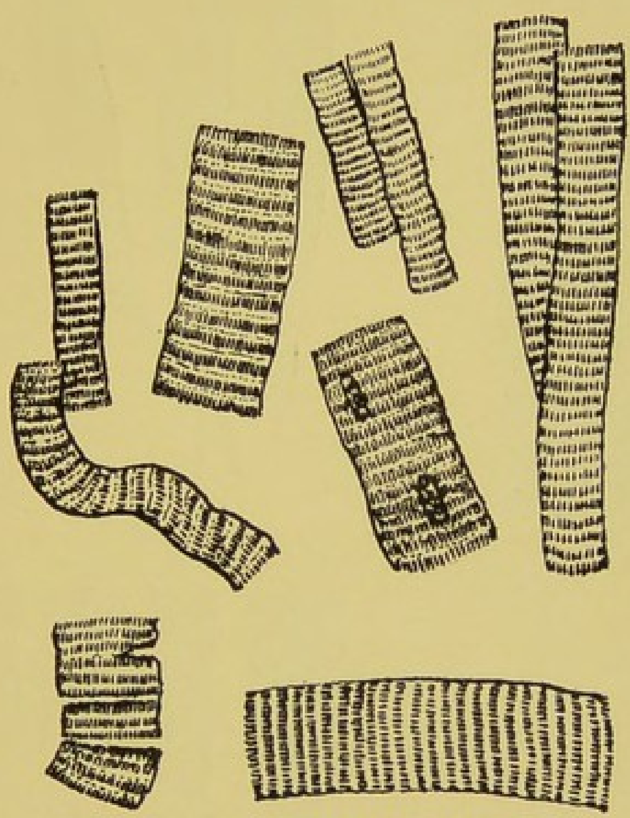


FIG. 196.—VOLUNTARY MUSCLE. × 220 and 350.

[E. G. Clayton.]

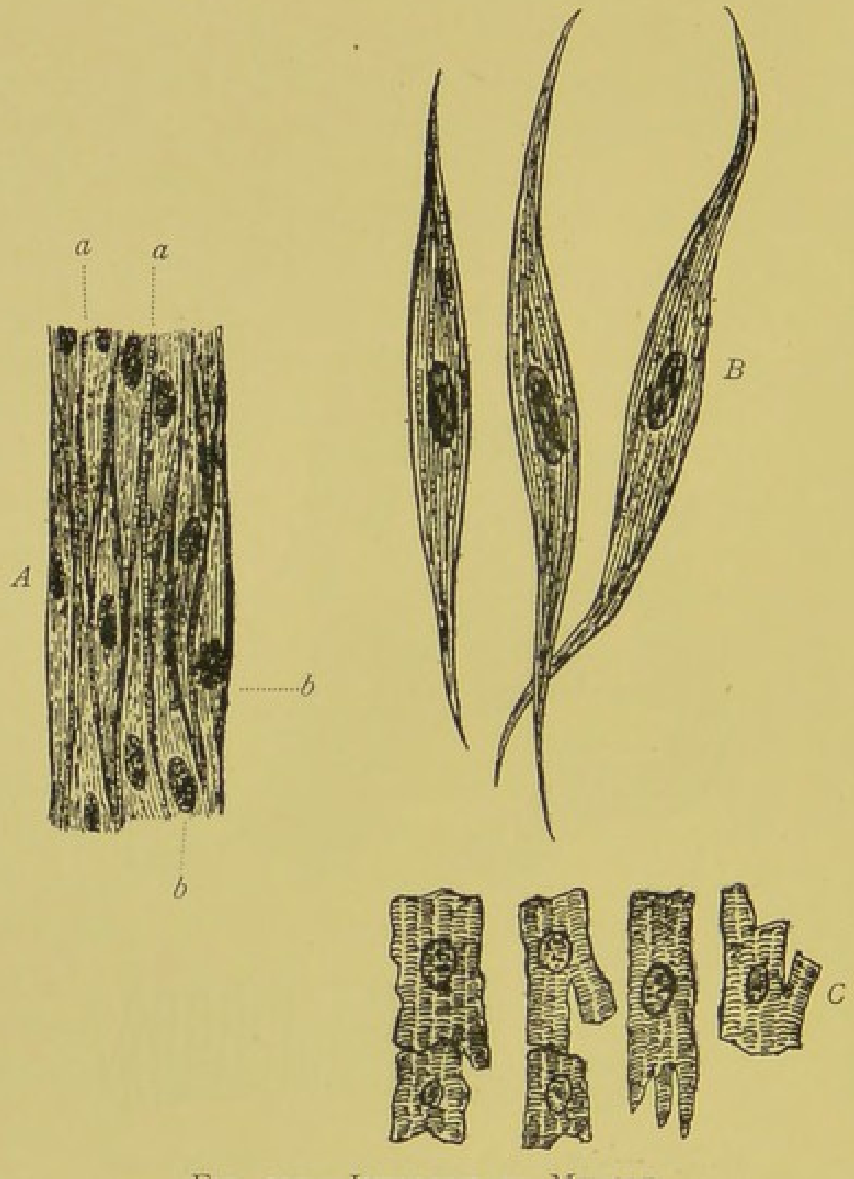


FIG. 197.—INVOLUNTARY MUSCLE.

A, Longitudinal section of non-striated muscular tissue from intestine, showing (*a*, *a*) 'cell-bridges' crossing the interstices and connecting the fibres; and (*b*, *b*) the nuclei. × *c*. 300.

[E. G. C., *del.*, after Schäfer, and Szymonowicz.]

B, Three isolated unstriped muscle-fibre cells, more highly magnified, showing longitudinal fibrillation: no cross-stripes such as are seen in voluntary muscle. [E. G. C.]

C, Cardiac muscle-fibre cells, showing quadrangular forms, branches, and nuclei. × *c*. 400. [E. G. C.]

[Animal Parasites which Infest Flesh.

ANIMAL PARASITES WHICH INFEST FLESH.

ANIMALS (not excepting man) are the prey of innumerable external and internal parasites (*epizoa* and *entozoa*). A large measure of scientific truth was wittily conveyed by the late Professor Augustus de Morgan, when, imitating and improving upon Jonathan Swift, he wrote:

'Great fleas have little fleas upon their backs to bite 'em,
And little fleas have lesser fleas, and so *ad infinitum*.
And the great fleas themselves, in turn, have greater fleas to go on;
While these again have greater still, and greater still, and so on.'[1]

The original form of this aphorism, composed 130 years before by the Dean of St. Patrick's, is worth quoting. Clearly the Very Reverend satirist was scientifically inspired at the time:

'So, naturalists observe, a flea
Has smaller fleas that on him prey;
And these have smaller still to bite 'em,
And so proceed *ad infinitum*.'[2]

As the inner portions of beasts in general are alone used for the food of man, so it is the internal parasites only with which we are now concerned. And the present work deals not with bacteria, pathogenic or other: therefore, any detailed consideration of the microscopic flora to which tuberculosis, anthrax, pleuro-pneumonia, glanders, and other microbic diseases are due, although these distempers present some of the most serious problems confronting the student of dietetics, must be omitted from this book. But the effects of entozoa, which are mostly intestinal worms, belonging to the sub-kingdom *Vermes*, may be sufficiently serious. For a long

[1] 'A Budget of Paradoxes' ('Are Atoms Worlds?' 1863), 1871.
[2] 'On Poetry: A Rhapsody,' 1733.

period these organisims were believed to be of small importance, if not innocuous. It is now realized that this was an erroneous view. Rudolf Leuckart in 1886 pointed out that 'worms by their movements frequently cause disturbance, and often very serious disturbance, in the intestinal and other viscera. They excite irritation, which in delicate lining-membranes naturally leads to catarrhal and inflammatory states proportionate in intensity to the number and activity of the parasites.'[1]

It is at the present time recognized that so-called malarial diseases arise from the punctures caused by mosquitoes, flies, rat-borne fleas, and other external pests. Similarly, wounds of the intestine, caused by worms, can give rise to grave bodily conditions. Il'ya Mechnikov considers that many cases of appendicitis are traceable to inoculation of microbes through injuries to the walls of the bowels caused by intestinal worms. He has called attention to the numerous cases of this serious disease, in which *Nematoda*, or round worms, in particular *Oxyures*, *Trichocephali*, and *Ascarides*, are discovered in the inflamed appendix. He remarks:

'The bites of intestinal worms may cause just as much evil as the pricks of Arthrópoda carrying pathogenic microbes. . . . These parasites injure the walls of the bowels and there inoculate microbes, causing an inflammatory reaction. The number of appendicitis cases in which entozoa, especially Nematodes, are found would appear to be considerable, so far as one can judge from the literature upon this subject.'[2] One of the instances quoted was that of a boy brought to the Pasteur Institute. The illness ended fatally. In the ulcerated mucous membrane of the vermiform appendix was discovered an *Oxyuris*, 'surrounded by a zone of inflammation, in which was recognized a quantity of white blood-cells and a certain number of large Gram-positive bacilli.' The worm had "penetrated into the appendix, attacked the mucous membrane, and there inoculated a microbe which produced a fatal affection. The rôle of the

[1] Rudolf Leuckart, 'The Parasites of Man,' translated by W. E. Hoyle, 1886.
[2] Harben lecture, 'The Hygiene of the Alimentary Canal,' 1906.

parasite was, therefore, quite similar to that of a flea which inoculates the plague bacillus to man, and thus causes his death.'[1]

Mechnikov, after mentioning Dr. Guiard's belief that intestinal worms may not only inoculate the microbes of appendicitis, but be capable also of transferring typhoid bacilli to the mucous membrane, and so cause enteric fever, proceeds:

'The whole of these data . . . indicate that it is high time to undertake a campaign against the entozoa, which would have to be conducted on similar lines to the war now waged against the mosquitoes and other microbe-carrying *Arthropoda*. The difference would be that measures directed against the intestinal worms are far more easily carried out in practice.'[2] He is very emphatic as to the advisability of taking no raw food: especially such as may introduce ova or parasites into the alimentary and intestinal canals. Water and milk must be boiled. Flesh, eggs, and fish are to be thoroughly cooked. Vegetables, salads, and even fruits, should be boiled, or at least scalded: this applies in a special degree to radishes and strawberries. The last named, and cherries, which are often pecked at by birds, are among the most likely fruits to convey ova, infectious germs, and parasites. 'It is as a rule wiser to eat fruits, so far as possible, in the form of jams or compôtes."[3] But it has already been shown that jams, in these competitive days, are sometimes made from very questionable materials and amid repulsive surroundings. Fortunately the temperature is high at which the chief operations are conducted: there rests the hope of safety.

The following are some of the more important parasites of flesh:

Cysticercus cellulosæ most often infests the flesh of swine, rendering the muscles flabby, soft, and pale, and producing the appearance described as 'measly.' The small round or

[1] Harben lecture, 'The Hygiene of the Alimentary Canal,' 1906.

[2] *Ibid.*

[3] *Loc. cit.*

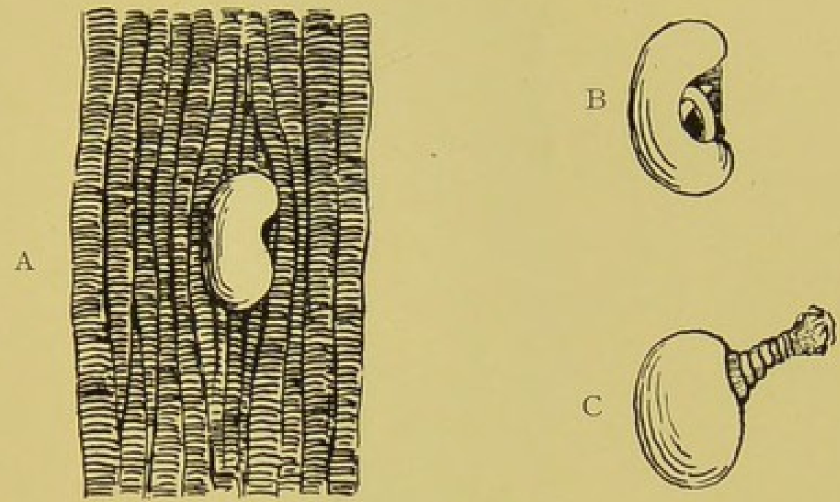


FIG. 198.—CYSTICERCUS CELLULOSÆ.

A, Encapsulated *Cysticercus*, or 'bladder-worm,' in muscle-fibre (× 6); B, bladder-worm, with head withdrawn (× 12); C, the same, with head extended (× 12).

[Faith Clayton, *del.*]

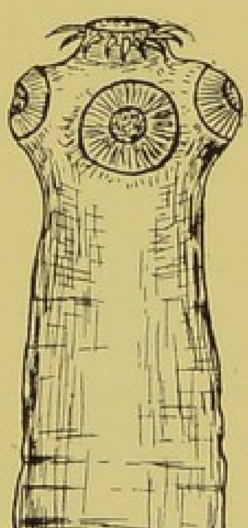


FIG. 199.—TÆNIA SOLIUM.

The common tape-worm. Cephalic and cervical portion, showing circlet of hooks (× 30). (After Rudolf Leuckart.)

[E. G. C., *del.*]

FIG. 200.—TÆNIA SAGINATA, Göze (= *T. mediocanellata*, Küchenmeister).

A cystic tape-worm without a circlet of hooks (R. Leuckart). Cephalic portion showing suckers. × *c.* 50.

[E. G. C., *del.*, after L. Landois.]

FIG. 201.—TÆNIA ECHINOCOCCUS. × *c.* 12.

The hydatid-forming tape-worm.

[Faith Clayton, *del.*, after R. Leuckart.]

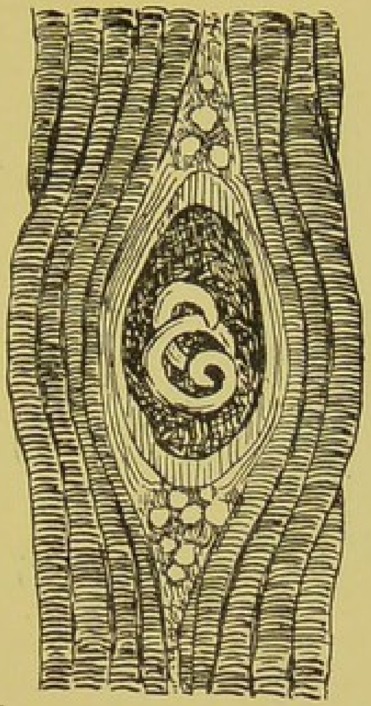


FIG. 202.—TRICHINA SPIRALIS. × *c.* 100.
Worm encysted in muscle.

[Faith Clayton, *del.*]

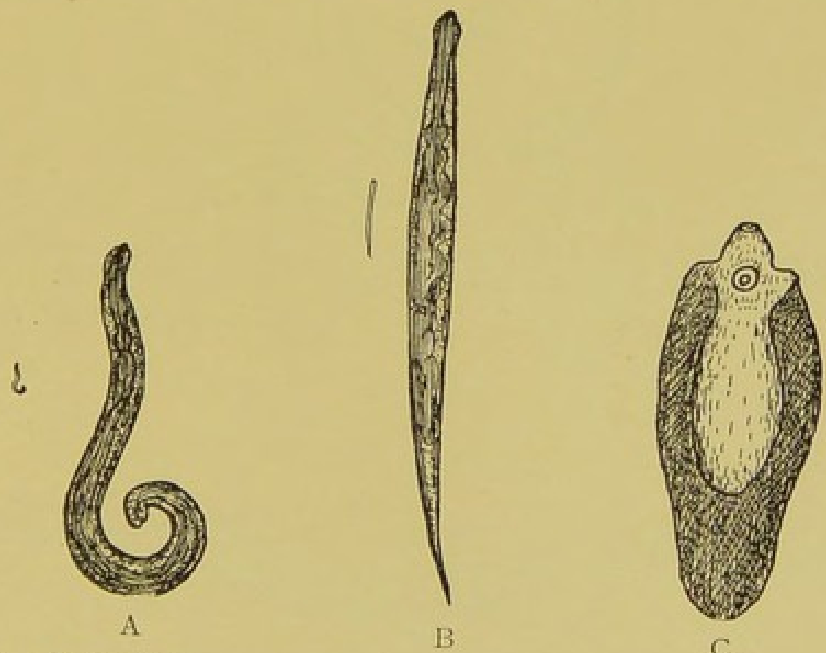


FIG. 203.—A and B, OXYURIS VERMICULARIS. The maw-worm or thread-worm.
A, Male; B, female (natural size, and greatly magnified).
C, DISTOMUM HEPATICUM. The liver-fluke. Natural size.

[E. G. C., after R. Leuckart.]

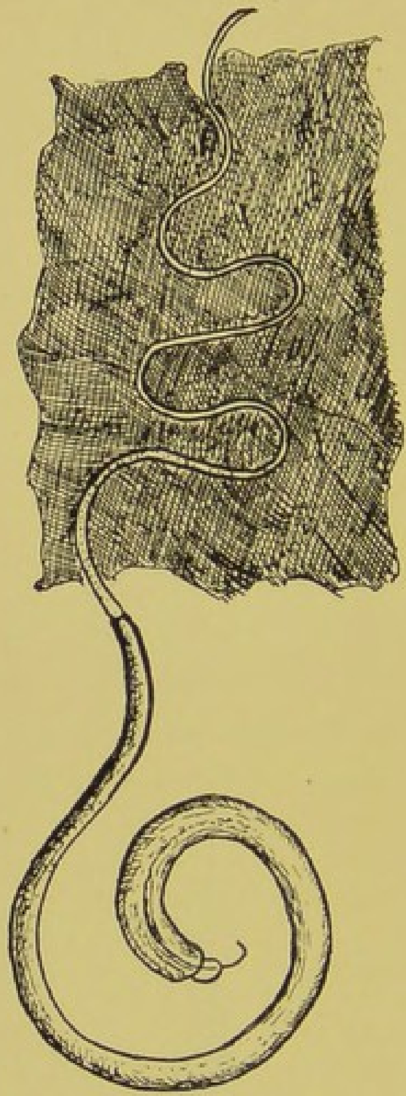


FIG. 204.—TRICHOCEPHALUS DISPAR.

The whip-worm. The anterior portion of the parasite is shown embedded in the intestinal membrane of the host. Greatly magnified.

[E. G Clayton, after R. Leuckart.]

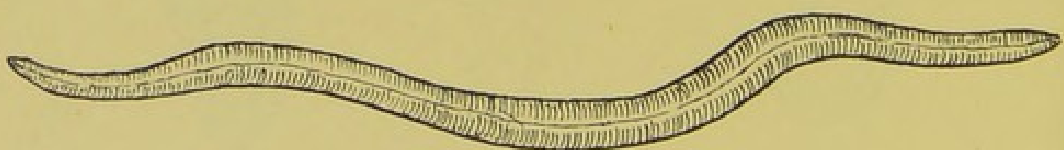


FIG. 205.—ASCARIS LUMBRICOIDES.

The parasitic round-worm. Natural size. [E. G. Clayton.]

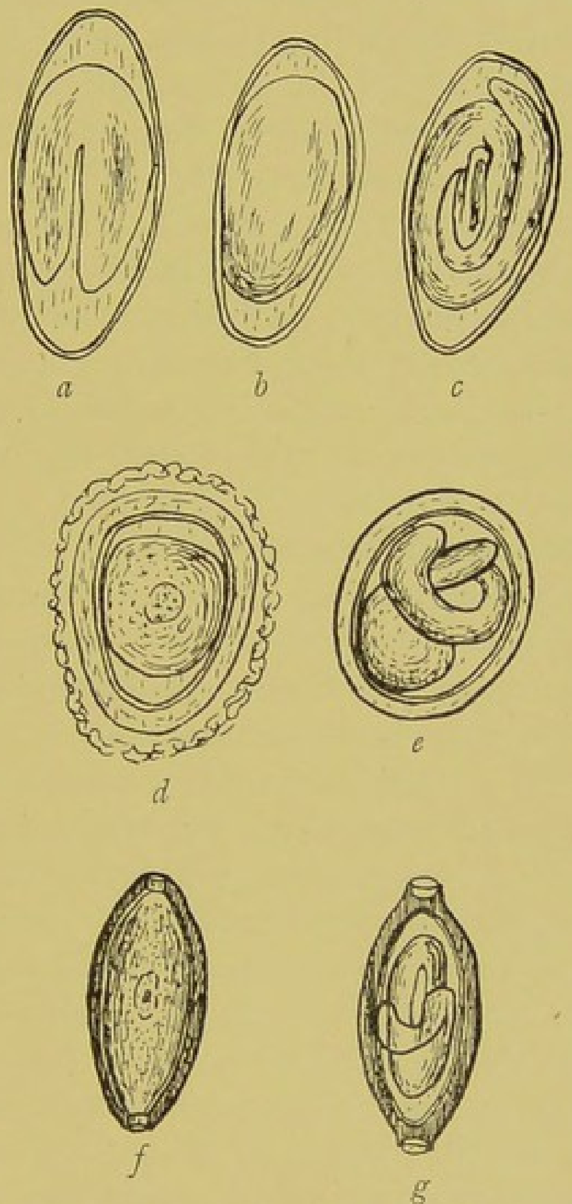


FIG. 206.—OVA OF SOME INTERNAL PARASITES. × *c.* 500.

a, *b*, *Oxyuris vermicularis*, freshly laid; *c*, *Oxyuris vermicularis*, with developed embryo; *d*, *Ascaris lumbricoides*, fresh from dejecta; *e*, *Ascaris lumbricoides*, after exposure to the atmosphere; *f*, *Trichocephalus dispar*, fresh from dejecta; *g*, *Trichocephalus dispar*, after long exposure.

[E. G. Clayton, *del.*, after Leuckart.]

oval cysts, which may attain the size of a pea, are easily visible, embedded in the muscular tissue (Fig. 198).

Tænia solium.—The consumption of such meat gives rise in man to the common tape-worm, *Tænia solium*, the cephalic portion of which is shown in Fig. 199.

Cysticercus bovis is an allied organism, occurring in beef, more commonly abroad than in Britain. It develops into another species of tape-worm,—

Tænia saginata (= *T. dentata*, = *T. mediocanellata*).—The head of this parasite is represented in Fig. 200.

Tænia echinococcus.—The hydatid-forming tape-worm. This organism affects cattle and sheep. The fully developed worm is eaten by the dog, whose distribution of the ova, and close association with man and cattle, have been known to give rise in the latter to hydatids (Fig. 201).

Trichina spiralis also infests the flesh of the pig, producing the serious and sometimes fatal disease known as *trichinosis*, which fortunately is comparatively rare in this country. Fig. 202 shows an encysted worm embedded in muscle.

Oxyuris vermicularis.—The maw-worm or thread-worm: one of the commonest nematode parasites. It is only necessary that the ova, which exhibit already a partially developed embryo, be swallowed. When in the stomach the shells dissolve, and the larvæ, tadpole-shaped in the egg at an early stage, under favourable conditions of temperature and humidity soon become characteristically vermiform. The male and female of *Oxyuris vermicularis* are shown in Fig. 203, A, B; and in Fig. 206 are several representations of ova of this parasite.

Distomum hepaticum.—The liver-fluke (a Trematode parasite).[1] This is a flat organism, from a quarter to three-quarters of an inch in length,[2] finding its habitat mostly in the liver of the sheep. The ova are much larger than those of the creatures last described, or of the two following parasites. Fig. 203 includes a representation of *Distomum hepaticum*.

[1] For a fuller account of this and other internal parasites, see 'Die Parasiten des Menschen und die von Ihnen Herrührenden Krankheiten,' R. Leuckart, continued by G. Brandes, 1886-1901.

[2] Occasionally of a still more considerable size.

Trichocephalus dispar = Ascaris trichiura, Linn.—The whip-worm. The anterior part of this organism is slender, resembles a whip-lash, and becomes imbedded in the mucous membrane of the intestine of the host (Fig. 204). T. S. Cobbold quotes an earlier observer, Bellingham, as having found the parasite in eighty-one out of ninety autopsies. The ova of Trichocephalus have at the extremities perforations provided with albuminous plugs: the characters are indicated in Fig. 206, *f*, *g*.

Ascaris lumbricoides.—The parasitic round-worm (Ger., *Spulwurm*) (Fig. 205). An organism which, because of its similar appearance, is sometimes confused with the earthworm, to which it is not related. The ova of *Ascaris* are thick-walled, and enclosed in an albuminous envelope, coloured with bile-pigment (Fig. 206, *d*, *e*). The worm varies in length from half an inch or less, when immature, to four inches or more, when full grown. Swine are particularly liable to become infested with this parasite, by swallowing polluted water containing the eggs. It follows that for dietetic and most other household purposes water from wells near pigsties should be most carefully avoided.

Man and his domestic pets are hosts of *Ascaris lumbricoides* and its congeners. Some years ago, the present writer found a specimen, an inch long, of an allied organism, *Ascaris mystax*, in the viscera of a cat, submitted to him for analysis. The animal was suspected to have been poisoned, but a laborious and minute analysis revealed no definite toxic substance. It is probable that the worm had originated a lesion in the intestinal wall, so facilitating the entrance into the body-cavity of putrefactive microbes, and indirectly causing Malkin's death. Mention already has been made of Mechnikov's views concerning the maleficent functions exercised in man by intestinal worms; and this case, which came under the author's personal observation, would seem to be an illustration of the same influence in a domesticated animal.

This brief review of an unpleasant, but highly important subject may fittingly end with some warnings regarding the use of raw foods. Whether from animal or vegetable sources, these should be minutely inspected before they are eaten. The imperative necessity of taking this precaution should be impressed upon every person engaged in the preparation of food for the table; and instruction should be conveyed in simple means of recognizing the presence of parasites, or their ova. Mechnikov, we have seen, is even of the opinion that food in an uncooked condition should be avoided altogether. It has been stated on a previous page that certain fruits and vegetables are especially unsafe. Water-cress, celery, salads, etc., should be cleansed with the utmost care. Drinking water should be clean and pure. Dirty or organically contaminated water is not infrequently the medium of infection.[1] Flesh-foods, in which on the whole there is the greater risk of parasitic contamination, should be kept apart from other kinds of food, such as vegetables, cereals, bread, and the like. Domestic animals, especially dogs—for they are the most likely of the class to be infested with internal parasites—ought to be banished from rooms in which food is stored, prepared, and consumed. Their own food should be cooked, and must *not* consist of raw, or semi-raw viscera and offal of diseased or slaughtered beasts. At least as much care should be bestowed upon the feeding and housing of the animals which we design to kill and eat. Lastly, our pets must be fondled and caressed as little as possible.

For some decades much has been written on public hygiene; but in certain matters we seem not to be much more enlightened than were our forefathers in the thirteenth century. Writing before the year 1292, Roger Bacon, philosopher and Franciscan friar, laid the greatest stress on the need that creatures to be used for human food should be properly kept and cleanly fed. The passages are too long to quote in their entirety: but the following excerpts from a tract by Bacon might yesterday have been committed to paper by a twentieth-century sanitary expert:

'. . . . : multũ eſt ſi bona fuerit illorũ viventiũ paſtinatio, sicut in piſcibus, & reliquis animalibus. . . ., & ideò meliorem generant cibum, quę melius nutriuntur. Et non

1 *Vide* Section IV., 'Water.'

ſolum paſtus eſt conſiderandus, ſed locus in quo nutriuntur : ſic vidimus piſces in aquâ fęculentâ & turpi degentes, qui ſuâ naturâ bonum cibum generare ſolebant, tamen malum pepererunt : & ē contra.'—'It is of great moment that the Feeding[1] of these living Creatures be good, as in Fish and the rest of Animals. . . ., and therefore these breed better food, which are themselves better fed. And not only their Food is to be considered, but the Place wherein they are brought up. So we have seen Fish living in a muddy and foul Water, which of their own Nature use to breed good Food, have notwithstanding produced very bad ; and on the contrary.'[2]

It cannot too emphatically be urged, in these careless, competitive, hasty, and avaricious days, that on the quality of the national food largely depends the future of the race. No pains should be spared to ensure the purity and wholesomeness of one of the prime factors of existence.

> 'I go not your way, ye despisers of the body ! Ye are no bridges for me to the superman ! . . . More uprightly and purely speaketh the healthy body, perfect and square-built ; and it speaketh of the meaning of the earth.'[3]

A Recruiting Return,[4] supplied early in the present year (1908), in reply to a question in the House of Commons, showed that one-half of the young men offering themselves were unfit for military service. In view of the disgraceful facts which of late years have come to light, concerning the nature, origin, and preparation of the foods—especially the flesh-foods—mostly, but by no means exclusively consumed by the working-classes, the inference is irresistible that bad food, much of it doubtless derived from diseased animals, was at least in part responsible for so grave

[1] The word in the Latin edition consulted (1590) is *pastinatio*=digging or trenching the ground of a vineyard. The sixteenth century copyist probably incorrectly expanded an abbreviation in the original MS. The writer ventures to suggest that the word used by Bacon was *pastio*=grazing, pasturing, feeding. And it is noteworthy that Browne thus rendered it into English.

[2] 'Libellus De retardandis Senectutis accidentibus & de Sensibus conservandis,' by Roger Bacon [1214(?)–1294]. Published at Oxford in 1590 ; translation by Richard Browne, 1683. Chap. vii.

[3] F. Nietzche.

[4] This Return, for the details of which the author is indebted to Colonel Sir E. W. D. Ward, K.C.B., K.C.V.O., Secretary of the War Office, and

a state of affairs. I have tried herein to show that while caution is pre-eminently needed with regard to flesh-floods, in which the risks to be run are perhaps more numerous and varied, not much less care is wanted on the part of him whose staple fare is vegetable—if he dare, that is, to eat it raw.

Permanent Under-Secretary of State for War, gave the numbers of men who offered themselves for enlistment into the Regular Army, in the ten large towns named below, during the twelve months ended September 30, 1907, and the numbers of such men who were rejected for physical reasons. Here are the figures :

Town.	Offered for Enlistment.	Rejected for Physical Reasons.	Percentage of Rejections.
London	20,975	8,806	42
Birmingham ...	1,858	1,084	58
Manchester ...	2,523	1,821	72
Sheffield	1,031	363	35
Leeds	791	452	57
Newcastle	1,493	1,046	70
Sunderland ...	776	282	36
Glasgow	2,905	1,135	39
Dundee	956	680	71
Edinburgh... ...	1,500	628	41

[Average for the ten towns, 52·1 per cent.—E. G. C.]

The numbers for the United Kingdom, rejected for physical reasons during the twelve months above named, and the previous twelve months, were :

	Offered for Enlistment.	Rejected for Physical Reasons.	Percentage of Rejections.
1906...	107,668	56,509	52·48
1907...	89,893	40,258	44·78

It should be added that the author is informed by Colonel Ward that for this last year (ended September 30, 1908), the recruiting department has eliminated from its returns the numbers of men who were rejected by recruiters, and thus never actually submitted to a *medical* examination. 'This change has been made, as it was not considered that the figures given by recruiters were thoroughly reliable, and as it was impossible to check them.'

The numbers of men rejected out of those submitted to a medical examination are no doubt considerably smaller (30·09 per cent., for the United Kingdom, for the year ended September 30, 1907): but after making every allowance, the above figures are very startling.

If even recruiting officers—a class of men who are not, as a rule, deficient in zeal—are obliged to reject applicants without venturing to send them on to the medical officer, the physical condition of the poor fellows who apply must be bad indeed.

[*For figures, see pp.* 241, 242, 243, 244, *and* 245.]

FISH.

MANY of the concluding remarks in the preceding sub-section apply to fish. Equally with flesh and fowl, fish are victims to attack by *parasites*. All adult fish are apt to harbour entozoa and other organisms. In some regions near the Baltic Sea, and in French Switzerland, the prevalence of *Bothriocephalus latus* is due to the consumption of fresh-water fish (pike), which there contain the larvæ of this noisome cestode worm. Mackerel are infested by fourteen species of parasites, twelve internal, and two which attach themselves to the gills.[1] A high temperature destroys the parasites and ova: hence, thorough cooking of fish is highly desirable.

The value of the microscope, in searching for, and identifying encapsulated and other parasitic organisms, has been already indicated.

In fresh fish, fish preserved in oil, and to a smaller extent in imperfectly salt-cured fish, various species of bacteria and allied micro-organisms, some extremely deleterious, are prone to develop. In 1893, Du Bois de Saint Sévrin observed on the fish exposed in a factory where sardines were prepared for the market, a copious growth of chromogenic *micrococci*, and in some of the tins numerous very minute *cocci*, which were shown by his experiments to be associated with the occurrence of an outbreak of whitlows among the workers.[2] It has been suggested by Sir Jonathan Hutchinson[3] that leprosy is caused by eating fish in a state of incipient decomposition: fish, that is to say, specifically

[1] T. S. Cobbold, lecture, 'Parasites of Meat and Prepared Flesh Food,' 1884.

[2] A. Villiers et E. Collin, 'Traité des Altérations et Falsifications des Substances Alimentaires,' 1900, pp. 538-539.

[3] 'On Leprosy and Fish-Eating,' J. Hutchinson, F.R.S., F.R.C.S., 1906.

tainted, and badly cured, or not cured at all. He has accumulated a number of striking arguments in support of his hypothesis.

Though alluded to in this place, the bacterial contamination of fish, the possible infection of oysters and other molluscs by typhoid germs, and the occasional development of toxic substances in mussels, and similar articles of food, are subjects which cannot adequately be discussed in the present work.

Many ingredients which have never been near a river or the sea are used in the compounding of fish-pastes, potted fish, and the like. This is said to be the case, also, with the eel-pies obtainable at many of the humbler restaurants in Paris. Some fish-pastes are composed chiefly of a basis of fat bacon, associated with flour or bread, and a flavouring of bloater, shrimp, etc. In fact, 'it's the seasonin' as does it.'[1] In the detection of the components of such mixtures, which have generally been finely minced or reduced to a pulp, the microscope is, of course, exceedingly useful.

A curious phenomenon is observed in very intimate admixtures of fish-oils, such as cod-liver oil, with liquid extract of malt, of which the index of refraction is near to that of the oils. Under the microscope, these mixtures appear quite homogeneous, not exhibiting a trace of the presence of oil-globules, until a droplet of water is passed under the cover-glass. Myriads of oil-drops then at once appear. The globules are quite invisible until the water is added.[2]

On a gross scale, there is much substitution of one variety of fish for another. Remarkable changes are rung among different members of the great Herring family, or *Clupeidæ*. The young of the twaite or thwaite-shad, *Alosa finta*; of the

[1] Mr. Brooks, the pieman, quoted by Mr. Samuel Weller ('The Pickwick Papers,' chap. xix.): '"They're all made o' them noble animals," says he, a pointin' to a wery nice little tabby kitten, "and I seasons 'em for beef-steak, weal, or kidney, 'cordin' to the demand. And more than that," says he, "I can make a weal a beef-steak, or a beef-steak a kidney, or any one on 'em a mutton, at a minute's notice, just as the market changes, and appetites wary!"'

[2] See a paper by the present writer, published in the *Analyst*, 1885 (x.), 140.

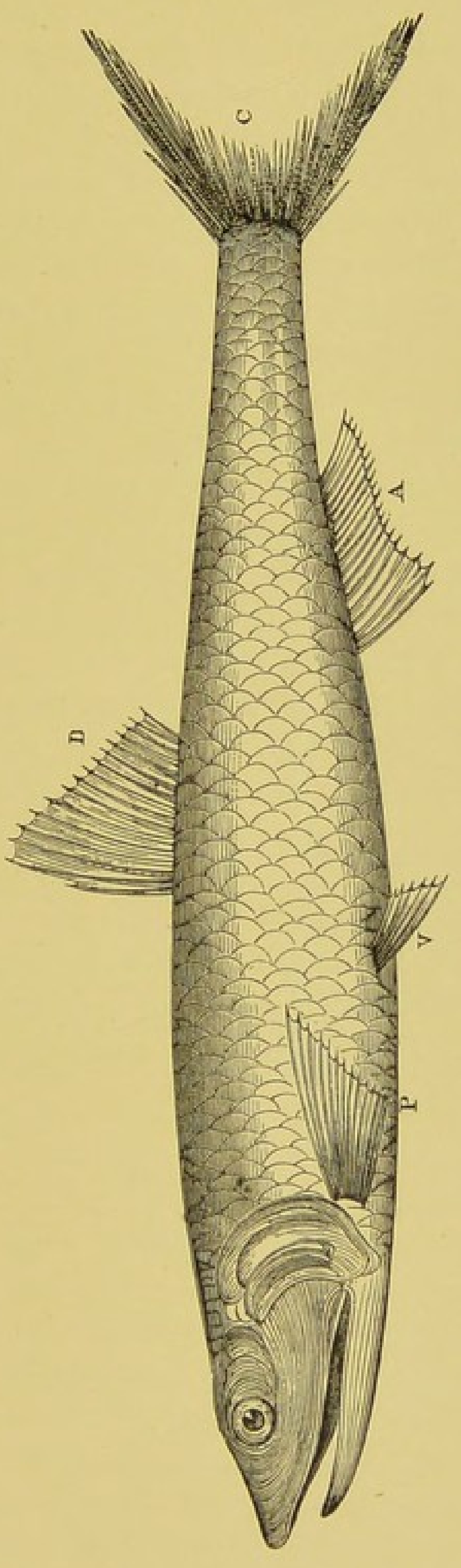


Fig. 207.—The Anchovy.

D, Dorsal fin; P, pectoral fin; V, ventral fin; A, anal fin; C, caudal fin.

menhaden, *Brevoortia tyrannus* or *Alosa menhaden;* also of the herring, *Clupea harengus;* the sprat, *Pomolobus sprattus;* and the pilchard, or Cornish sardine (*Sardinella pilchardus* = *Clupea pilcardus*, Flem. = *Alausa pilchardus*, Valenciennes), are all packed in oil and sold instead of the true sardine, *Clupea sardina*, a fish, smaller than the pilchard, coming from the Atlantic, Mediterranean, and Levant. The Californian sardine is *Sardinella cærulea.* The Cuban 'Sardina de España' is *S. pseudohispanica.* The sprat and the sardine have been known to masquerade as the anchovy (*Engraulis encrasicholus*, Flem. = *Clupea encrasicholus*, Linn.). The discovery of this kind of falsification requires macroscopic rather than microscopical investigation; and to detect the substitution of inferior varieties of the anchovies from Holland and France, for the Levantine fish or that from the Island of Gorgona, necessitates the experience of an expert in the trade. Fig. 207 is a representative of the anchovy, which is distinguished from its kindred by the sharply pointed head and projecting upper jaw.

Whitebait, at one time regarded as a distinct genus, are the nondescripts of the fish-kind. They have no race. London whitebait are believed now to be youthful herrings and sprats of various species. A 'small and feeble [smelt], *Osmerus thaleichthys*, mixed with other small or delicate fishes, is the whitebait of the San Francisco restaurants.'[1]

[1] D. S. Jordan, 'A Guide to the Study of Fishes,' 1905, vol. ii., p. 123.

[*For figure, see p.* 253.]

MILK.

THE lacteal secretion of female mammals. An opaque or translucent fluid, of complex constitution, and containing in suspension myriads of fat-globules. There has been much discussion whether the fat-globules in milk are, or are not, individually surrounded by a gelatinous or other proteid membrane. The question is not yet settled; but the balance of opinion at present appears to be against the existence of a definitely membranous layer. Milk is probably a true emulsion of fat in an aqueous medium containing sugar of milk, casein, lactalbumin, and other substances.

The microscopic appearances of good and poor milk, respectively, are shown in Figs. 208 and 209, in which the fat-globules are clearly seen. Cream contains a large proportion of fat-globules, some of which are of very considerable size (Fig. 210). The casein or curd of milk is represented in Fig. 211; and *colostrum*, or the first milk yielded by the cow after calving, is depicted in Fig. 212, which well shows the numerous characteristic corpuscles of large size and granular appearance.

Extraneous Substances Detectable by the Microscope (most conveniently sought, after the milk has been allowed to stand for some hours, or better, centrifuged).—Particles of sand, hairs, cotton- and wool-fibres, showing dust: starch grains and vegetable cellular tissue, indicating cattle-food; similar vegetable tissues stained yellow, = excretal matters, farm-refuse, and the like. Starch, chalk, brains, etc., have been mentioned among additions to milk in the past. Chalk, for obvious reasons, nowadays would scarcely be used by any sane adulterator. The alleged addition of cerebral matter,[1]

[1] Fig. 213 depicts milk containing cerebral matter.

many years ago, chiefly rests, it is believed, on the questionable authority of an anonymous contributor to *La Gazette des Hôpitaux* of 1841. The subject was investigated separately by MM. Quevenne and G. de Claubry, whose results left grave doubts whether such a form of adulteration had ever been practised: it was discussed at some length in Jean J. J. Garnier and Charles Harel's 'Des Falsifications des Substances Alimentaires,' published in 1844; and mentioned by various other writers, among them A. Normandy (1850), whose somewhat sceptical reference was quoted in Hassall's 'Food and Its Adulterations' (1855). Professor J. T. Quekett is said to have shown drawings prepared by himself from specimens of adulterated milk containing both starch and brain elements. There I must leave the matter, which is not set forth in this book as 'historic fact.' Indeed, it has been characterized as fable. Perhaps it may suitably be put into the category of 'facts for faith': remembering that there is a variety of blind, unquestioning 'faith' somewhere defined as 'that which makes you believe what you know to be untrue.'[1] Possibly once upon a time an ingenious person did experimentally prepare such a *mélange:* but as for the statements of the earlier French writers on food, that adulteration of milk with sheep's brains frequently prevailed —*Credat Judæus Apella!*

[1] An attitude of mind, by the way, which recalls, and indeed differs little from, that reflected in Tertullian's sometimes applauded dictum, 'Certum est, quia impossibile' ('De Carne Christi,' chap. v.), often, but with doubtful accuracy, quoted, 'Credo quia absurdum est.' Such 'faith' is hopelessly out of correspondence with the scientific and inquiring spirit of the twentieth century.

[*For figures, see pp.* 257-259.]

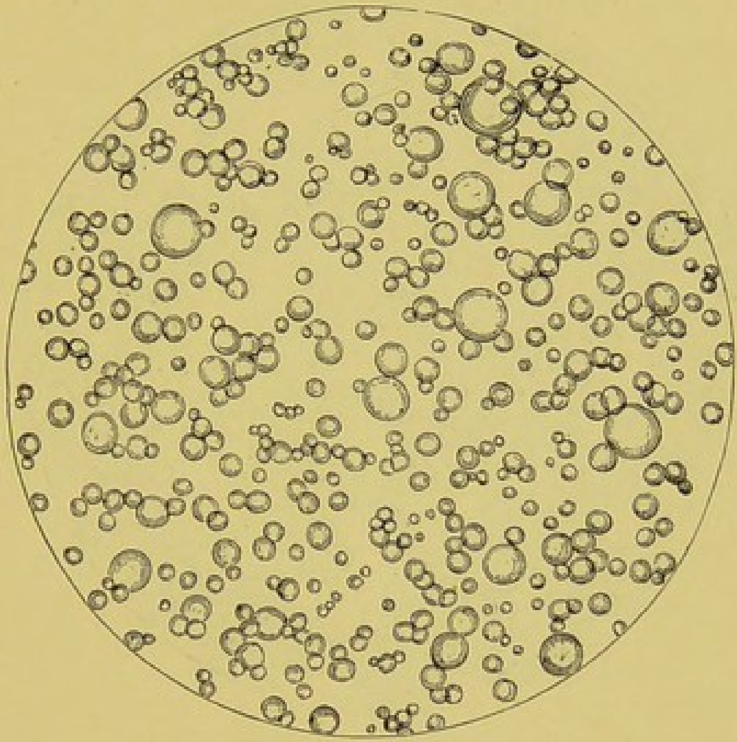


Fig. 208.—Milk: of Average Quality. × 630.

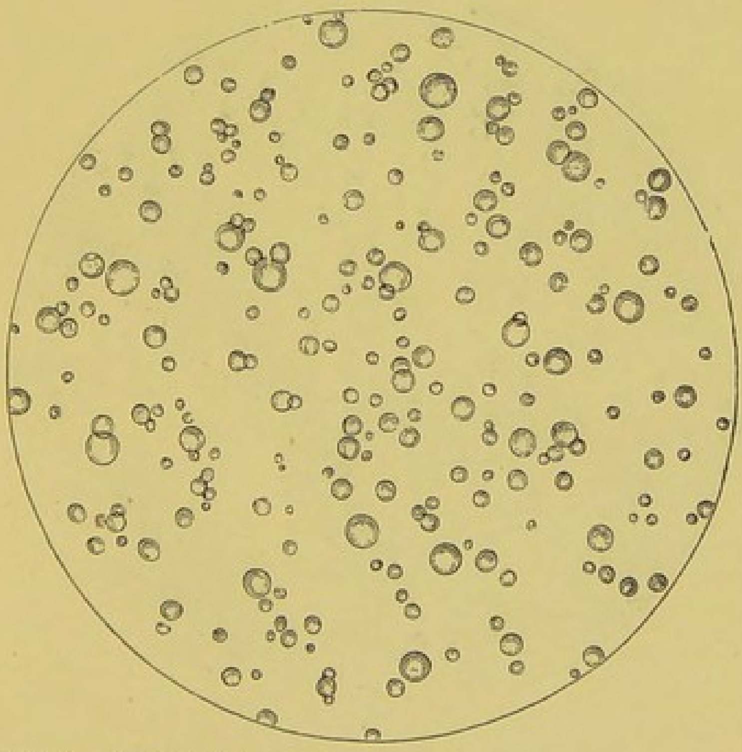


Fig. 209.—Milk: Diluted, or of Poor Quality. × 630.

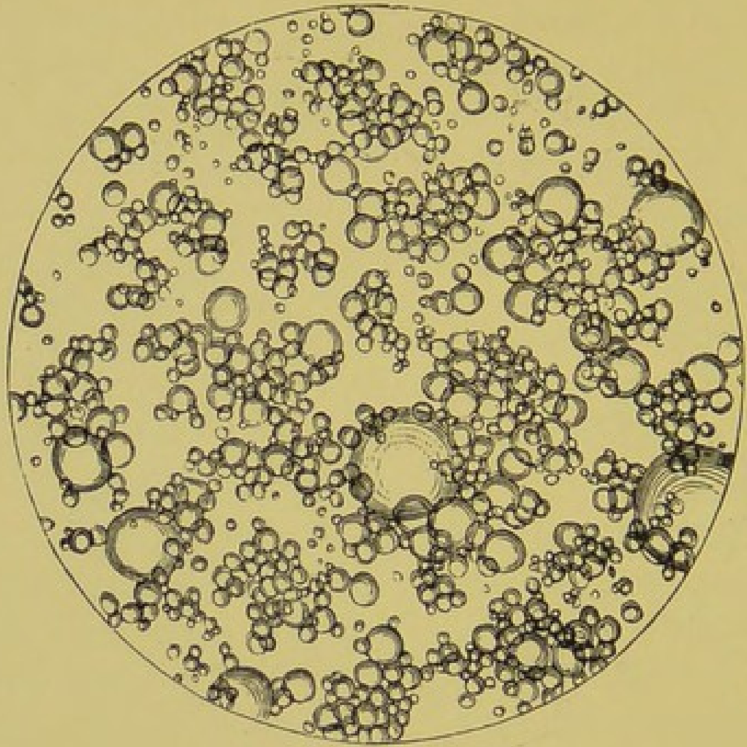


FIG. 210.—CREAM. × 630.

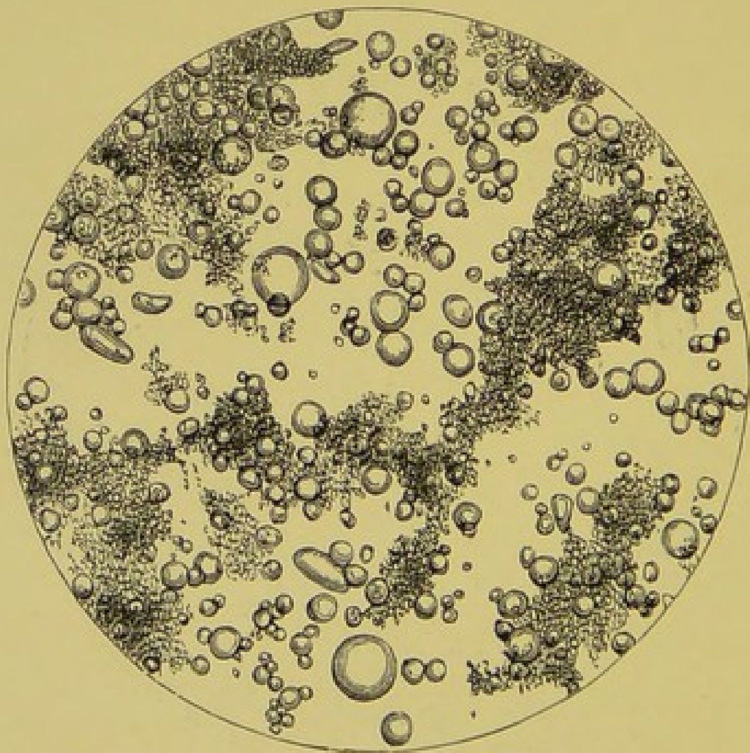


FIG. 211.—CASEIN OF MILK. × 630.

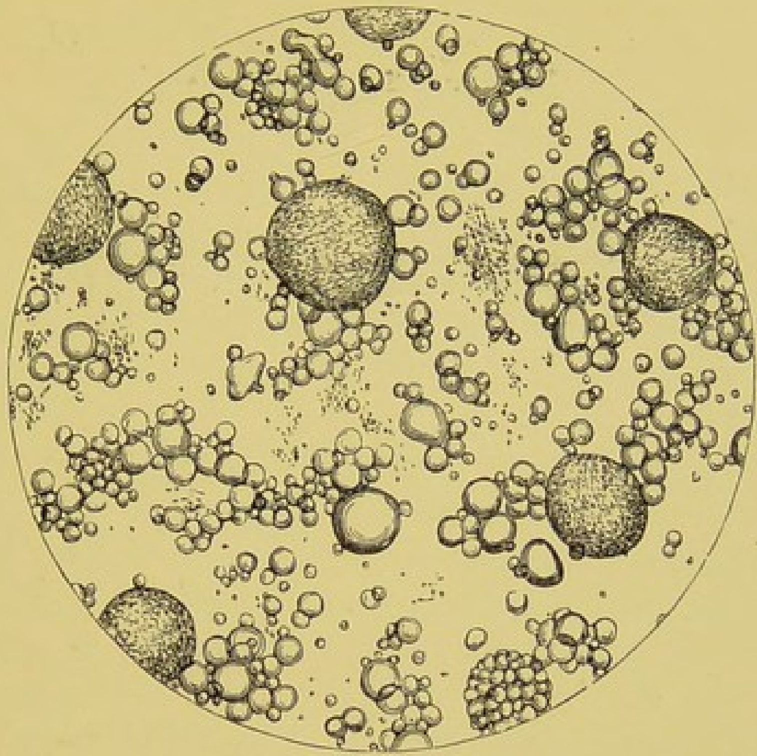


FIG. 212.—COLOSTRUM. × 630.
Showing the 'corps granuleux' of Donné.

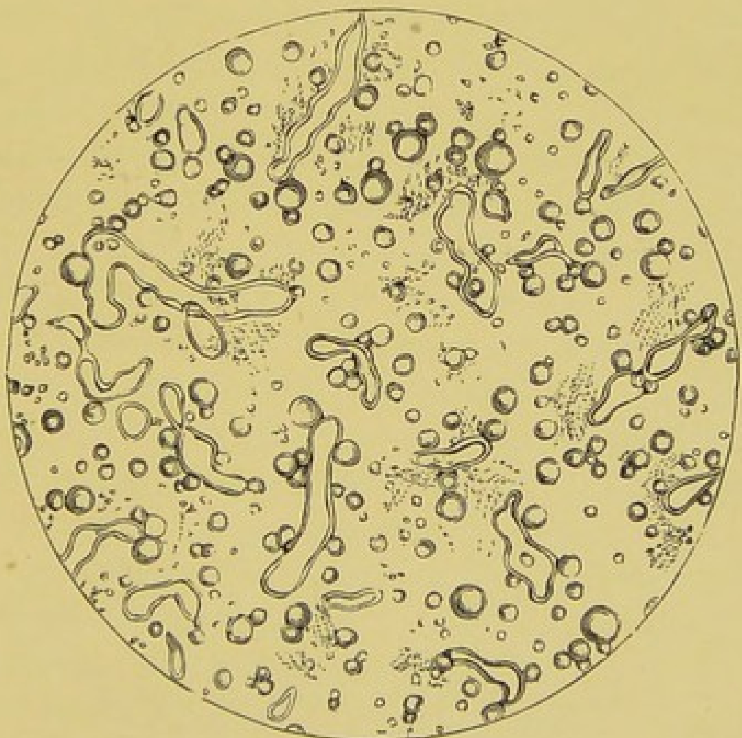


FIG. 213.—MILK, TO WHICH CEREBRAL MATTER HAD BEEN ADDED. × 630.

BUTTER.

UNDER the microscope, in ordinary light, normal butter exhibits a background indistinctly defined, with numerous irregularly-shaped globules of water or whey, often tinted yellow by annatto or other 'butter-colouring' used; and there are visible also fragments of granular caseinous matter: but no crystalline particles are to be seen, other than of salt, or of other added solid preservatives, if these be present. In polarized light, the field appears almost uniformly dark when the nicols are crossed. At the most, faintly illuminated dots or specks may be seen here and there. Fig. 214, *A*, gives some idea of the microscopical appearance of butter in ordinary light.

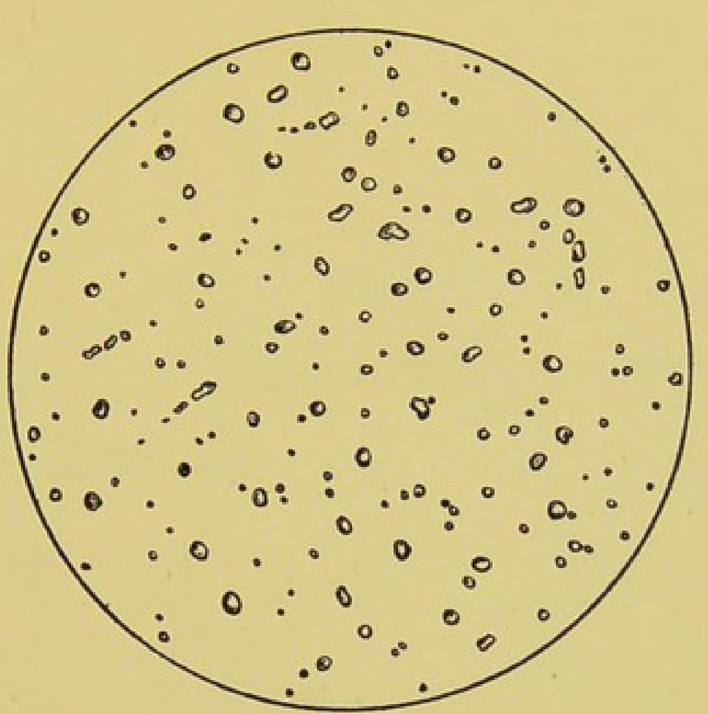
After fusion followed by slow cooling, butter and other fats partially crystallize, showing under the microscope circular, stellate, fan-shaped or fern-like aggregations of acicular crystals, which, when the polarizer and analyzer are at right angles, present a brilliant appearance upon a dim background, a dark cross often subdividing the bright patches. If a selenite plate be used, on a green background the crystalline patches will appear red. E. Collin, C. Girard, and others have shown that after some time the phenomena cease to be visible. As showing that the fat had been melted and cooled, the presence of such crystalline aggregates at one period was considered a 'sure and certain' indication that a sample of butter had suffered uncanny treatment, in which fusion with a foreign fat, or mixing with such fat, previously melted and cooled, had been an important stage of the proceedings. And it has even been affirmed, comparatively recently, that the appearance and reactions of the crystal-groups may be clues to the origin of the fat. In the examination of butter, according to the author's experience, it would be most unwise to base conclusions on any such data. The presence of crystalline patches must be regarded as suspicious, but as nothing more than an indication that the fat, or some of it, has been heated and afterwards slowly cooled. As for the appearances assumed by the crystals, these in general are not nearly distinctive enough to furnish diagnostic assistance. Fig. 214, *B*, shows the microscopic characters of butter which has been fused and slowly cooled. In Fig. 217 (under 'Lard') the appearance of beef-stearin is shown; and it will be observed that the forms of the crystal-aggregates are very similar.

It is awkward, on the one hand, that undoubtedly genuine butter—that, for instance, which has been treated with hot water and re-churned, or butter which has quickly become rancid—may exert a depolarizing effect: on the other, that mixtures of butter with margarine (such mixtures are now, legally, 'margarine') can be so manufactured as to exhibit no optico-crystalline characters. A fat *rapidly* cooled from a state of fusion may show no crystals. Also, very old butter undergoes chemical changes, accompanied by physical alterations, among the latter being frequently the assumption of a crystalline texture. Some years since, the author had an opportunity of examining a specimen of butter, known to be genuine, which had been preserved for eighteen years in a loosely stoppered bottle.[1] This butter, which had become granular, and had undergone considerable chemical metamorphosis, showed under the microscope very many crystalline patches.

In short, the microscopical examination of butter is a useful preliminary test, which should never be omitted, and may rapidly lead the chemist to suspect that a sample has been falsified. It will readily disclose grosser adulterations, such as starch, flour, mashed potatoes, and the like, which, though now extremely rare, have been discovered occasionally. But one must by no means infer from a negative result with the microscope that a specimen is immaculate: nine-tenths of it may be coco-nut oil. Chemical tests are essential and paramount in the examination of all fats.

Margarine alone under the microscope is more granular in appearance than butter, and in polarized light frequently exhibits bright areas and spots scattered over the field.

1 'A Butter Eighteen Years Old'; paper by the present writer in the *Analyst*, 1898, xxiii., 36.



A

B

FIG. 214.—BUTTER.

A, Normal appearance; *B*, aspect after fusion, followed by slow cooling. × 300.

[E. G. Clayton, *del.*]

CHEESE.

THE product of the action of the enzyme of rennet on new milk-casein.

New cheese is not very distinctive microscopically: but decayed cheese is well known to become the prey of innumerable minute, greyish-white, apterous insects or 'mites.' These are different species of the genus *Tyroglyphus*. The commonest is *T. siro* or *domesticus*, which is identical with the wheat mite, *Tyroglyphus* or *Acarus farinæ*.

Extraneous Substances Detectable by the Microscope.—Starch and flour are sometimes added to cheese. A particular brand of cream cheese, served to the present writer some years ago in one of the best-known restaurants in London, was so 'gritty' on the palate that his suspicions were aroused. He abstracted a fragment from his plate for microscopical and chemical tests in the laboratory. A huge quantity of starch was present: the precise amount was not determined, but it constituted probably more than a quarter of the cheese.

[*For figures, see pp.* 265, 266.]

FIG. 215.—THE DUST OF OLD CHEESE, consisting almost entirely of the CHEESE MITE (*Tyroglyphus domesticus* or *T. siro* = *Acarus domesticus*, or *A. siro*, Linnæus), in all conditions of development from the ova upwards. × 40.

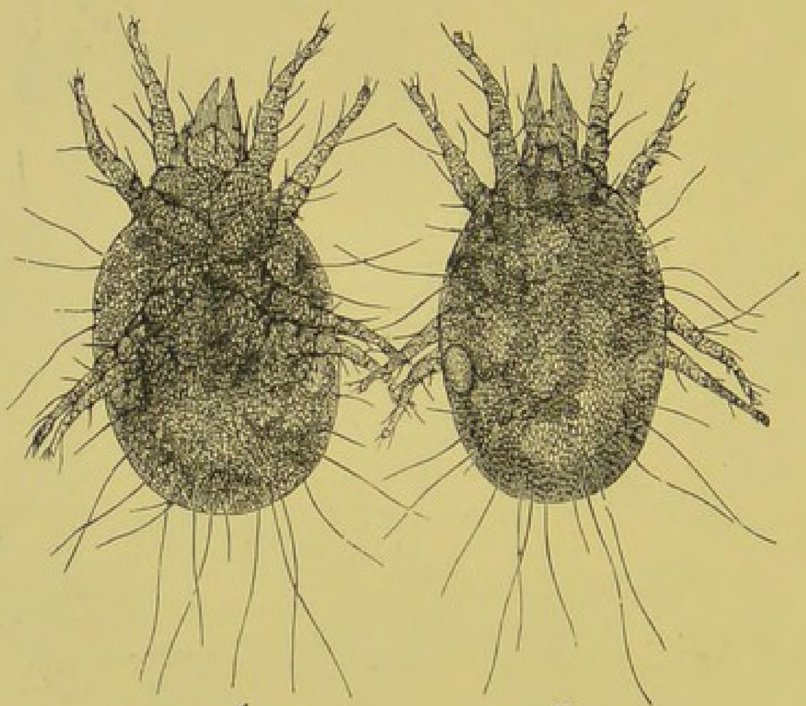


FIG. 216.—THE CHEESE MITE (*Tyroglyphus domesticus*).

Anterior (*A*) and posterior (*B*) views. × 100.

LARD.

THE fat of the pig rendered and clarified.

Under the microscope, pure lard shows, on a granular background, small, circular, isolated patches of radiating acicular crystals (sphæro-crystals). In polarized light, with a selenite plate, if the field be green, these little patches appear orange-red, and bear some resemblance to those seen in butter, very slowly cooled after previous fusion (see *ante*, Fig. 214, *B*).

At the present time the main adulterants of lard are beef-stearin and several vegetable oils, only discoverable by chemico-physical tests. Though useful as a preliminary test, the microscope alone cannot be considered a certain guide in the detection of beef-fat. An ethereal solution of pure lard, allowed to evaporate, generally yields elongated, tabular crystals, obliquely terminated, and sometimes disposed in radiated, though not usually stellate, aggregates: but if the lard contain a high percentage of stearic acid, the crystals deposited closely resemble those which are always yielded by beef-stearin—namely, stellate or radiating groups of fine, short, occasionally curved, acicular crystals, such as are faithfully indicated in the figure on the opposite page. Here again, as in the case of butter, ample corroboration must be yielded by a series of chemical tests, before one can venture to pronounce that there has been adulteration. Formerly, lard was not infrequently admixed with potato-flour and the like. These cruder forms of adulteration are readily seen with the microscope.

Fig. 217.—Lard containing Potato-Starch, and probably Beef-Stearin: showing fat-crystals and starch-granules.

ISINGLASS AND GELATIN.

THE air-bag, swimming-bladder, or sound, of various fish, chiefly of the sturgeon tribe. *Gelatin* is much used as a substitute: 'patent isinglass' is, in fact, gelatin. The microscope shows some differences between the natural product and the substitute: but other tests are better.

Fig. 218 shows the appearance of *sections of shreds of gelatin and isinglass*, softened in cold water and examined under the microscope. (Shreds of gelatin, placed in cold water, acquire increased transparency, and show no structure. Shreds of isinglass, similarly treated, become white and opaque, and possess a fibrous structure; a few vessels, granular cells, and nuclei being scattered here and there.)

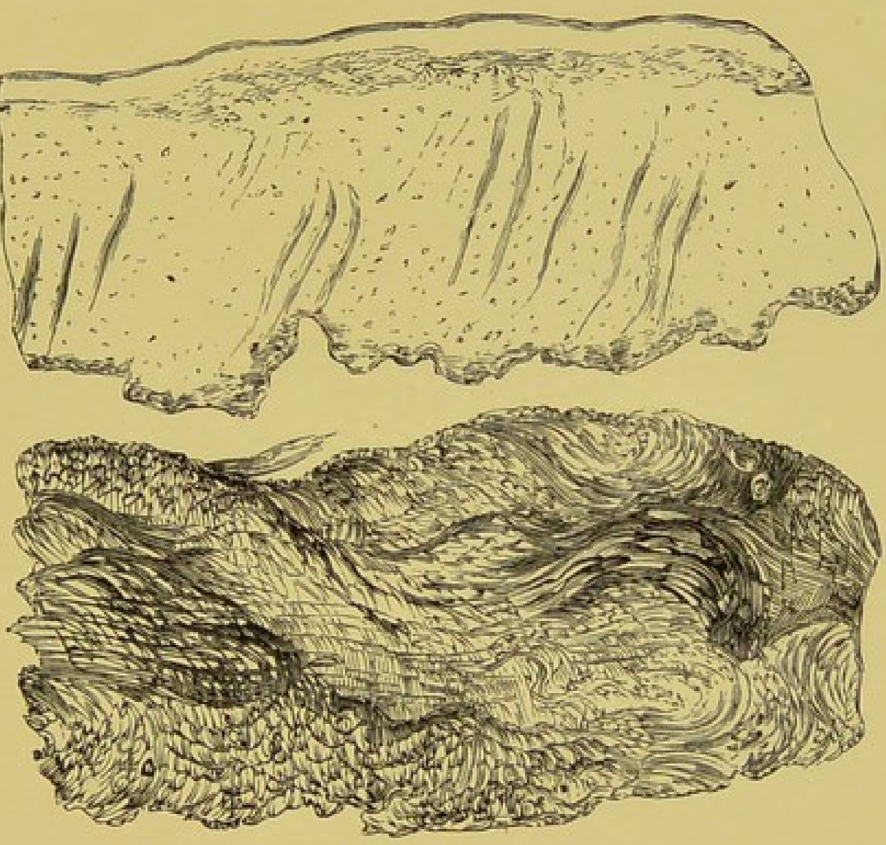


FIG. 218.—GELATIN (above) and ISINGLASS (below). ×75.

SECTION III.

TOBACCO, DRUGS, BITTERS, AND COLOURING MATTERS.

Ord. PERSONATÆ, Fam. SOLANACEÆ.

TOBACCO.

The dried and cured leaves of *Nicotiana tabacum* and *N. rustica*, ord. *Personatæ*, fam. *Solanaceæ*.

Histology.—The leaves may be divided into two parts: the broad expanded part, or lamina, and the midrib, or stalk, and 'veins,' which traverse this, imparting strength and solidity. The lamina is composed chiefly of cellular tissue, and the veins mostly consist of wood-fibre and vessels. A fragment of tobacco leaf, viewed on its *upper* surface with a half- or quarter-inch object-glass, is seen[1] to possess an epidermal covering of cells having smooth and waved borders, with here and there stomata and numerous hairs. The hairs are pluricellular, mostly glandular—terminating in a roundish swelling or enlargement, very clearly seen even in the dried leaf—and vary greatly in size. Occasionally they are divided or compound (Fig. 219). The *mesophyll*, or middle stratum of the leaf, consists of parenchyma cells containing chlorophyll grains.

The structure of the *under* surface of the leaf is nearly similar to that of the upper surface, but the stomata are much more numerous, and the hairs fewer (Fig. 220).

The *veins* and *midribs*, viewed in transverse sections, are frequently of a crescentic or horseshoe shape. This is somewhat characteristic of tobacco: but sections of Stramonium and Hyoscyamus stalks present a closely similar outline. Transverse sections of the smaller veins of tobacco, under a low power, present the appearances shown in Fig. 221: on the outside, running all round the section, is a layer of cells similar to the epidermal cellular tissue, with which the lamina of the leaf is itself mainly covered, bearing on its outer surface the glandular hairs: beneath are elongated cells, and collenchymatous tissue; and in the centre of the section the cut extremities of fibre-cells and pitted vessels, bundles of which chiefly make up the stalks, are seen, having a somewhat radiated disposition. These structures are more clearly pictured in Fig. 222. A longitudinal section of one of the smaller midribs, in which the hairs, cells, fibres, and spiral vessels are still better seen, is represented in Fig. 223. The quantity of wood-fibre in the central part of the midrib is by no means considerable, the bundle being made up to a great extent of the spiral ducts. The fibres usually are more like elongated cells than ordinary wood-fibres; nevertheless, bundles of undoubted wood-fibre do occur. The fibres are short, the borders striated, and the extremities truncate.

In the leaf of tobacco reduced to powder, all the above structures may be readily detected—of course much broken up:—the hairs, cells of the lamina, the stomata, elongated cells, wood-fibre, together with portions and fragments of the spiral ducts (Fig. 224).

Substitutes and Additions Detectable by the Microscope.—The leaves of the foxglove (*Digitalis purpurea*), dock, rhubarb, chicory, burdock (*Arctium lappa*), coltsfoot, cabbage, and many other plants, are stated to have been used as substitutes for tobacco, to act as "fillers" of cheap cigars, and so forth. Some of these are described and figured in the following pages, but their employment at the present time probably is rare. They have mostly been dismissed to the limbo of discarded adulterants. Water, and mucilaginous or saccharine solutions, are more commonly added to tobacco: but for the detection of these, the microscope, of course, gives place to the chemist's beaker and the polarimeter.

[*For figures, see pp.* 277, 278, 279, 280, *and* 281.]

FIG. 219.—TOBACCO LEAF: upper surface, showing epidermal cells, stomata, and glandular hairs. × 220.

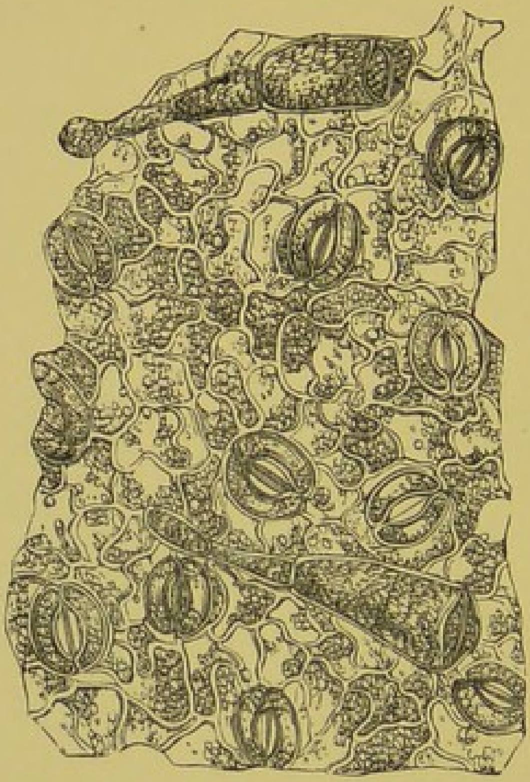


FIG. 220.—TOBACCO LEAF: under surface, showing epidermis, with more stomata and fewer hairs. × 220.

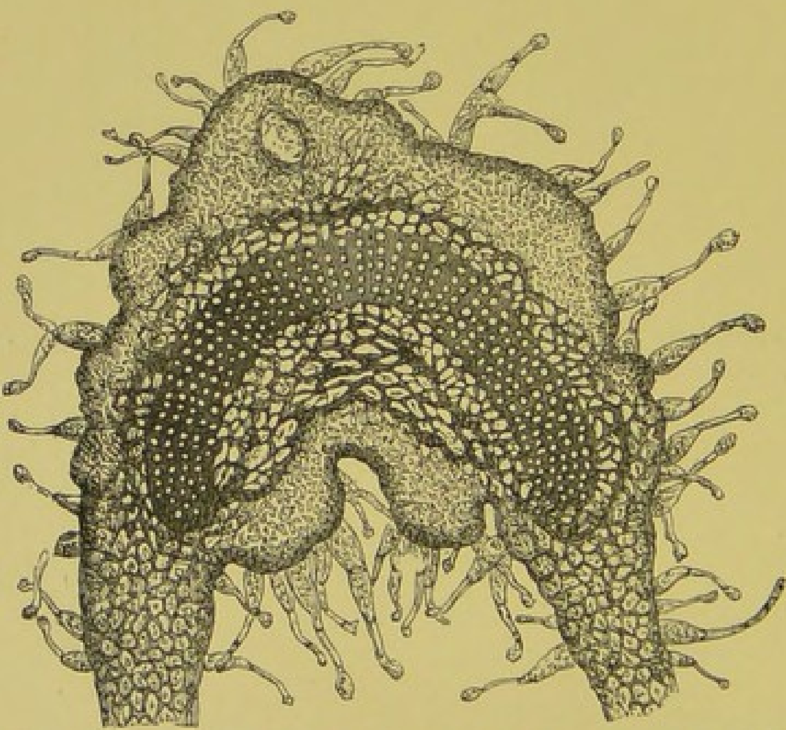


FIG. 221.—TOBACCO LEAF: transverse section of crescentic midrib, showing glandular hairs, cellular tissue, and fibro-vascular bundle. × 40.

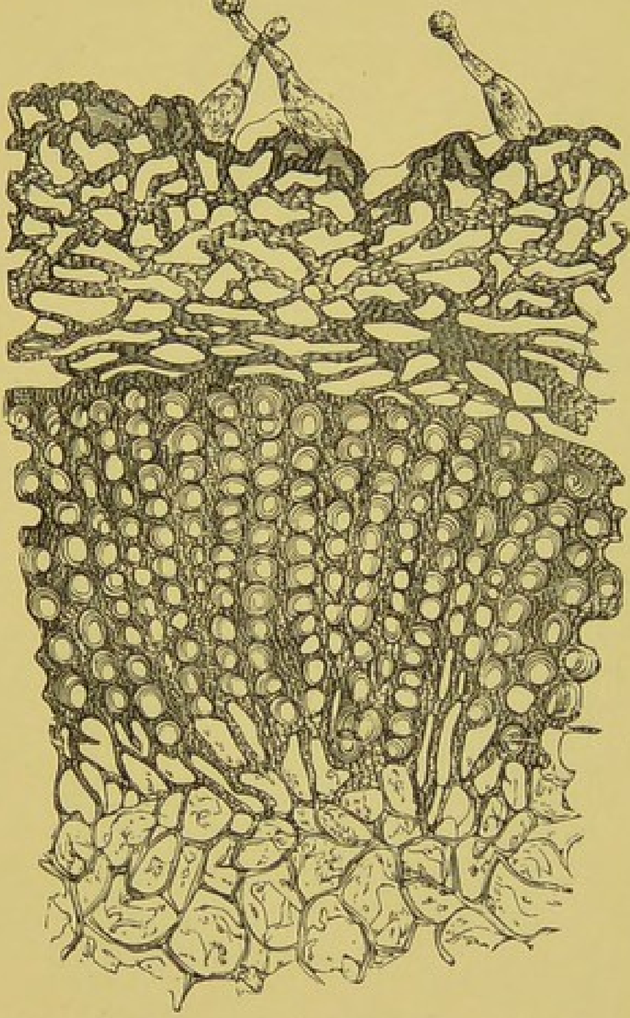


FIG 222.—TOBACCO LEAF: portion of transverse section of midrib, more highly magnified. ×90.

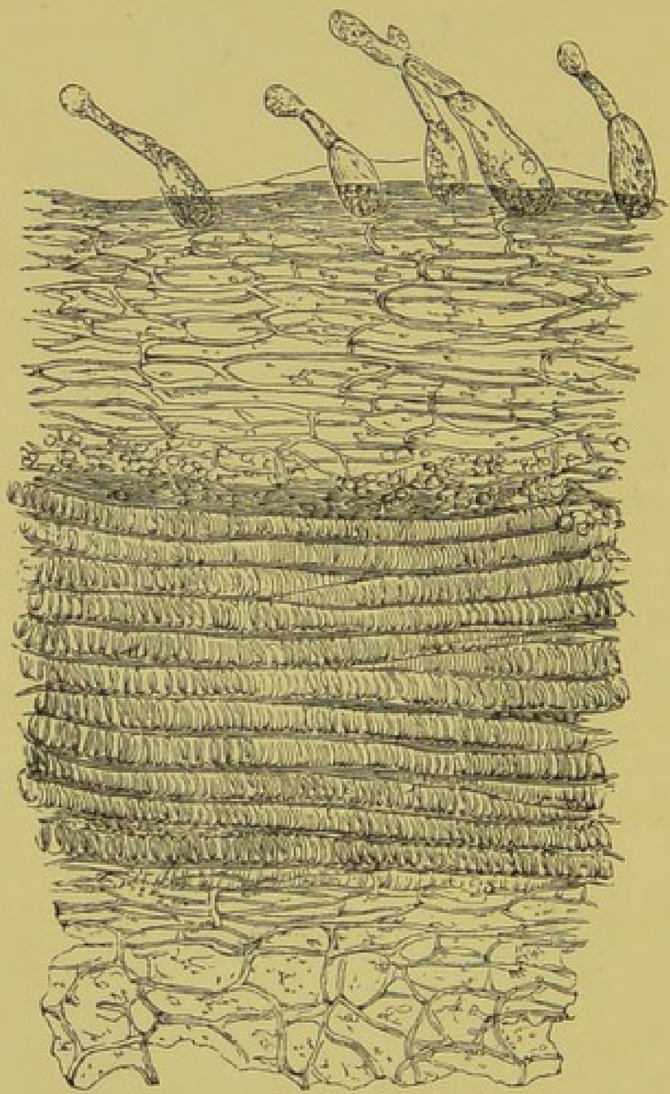


FIG. 223.—TOBACCO LEAF: longitudinal section of midrib, showing hairs, cells, fibres, and spiral vessels. ×90.

FIG. 224.—TOBACCO REDUCED TO POWDER: showing most of the structures previously described. × 40.

LEAVES WHICH HAVE BEEN USED AS SUBSTITUTES FOR TOBACCO: DOCK, RHUBARB, COLTSFOOT, ETC.

I. Dock Leaf (*Rumex*, sp., ord. *Polygoninæ*, fam. *Polygonaceæ*).

Histology.—The cells of the *lamina* and stomata do not differ materially from those of tobacco leaf. As in tobacco, the stomata occur on both surfaces of the leaves, and are more numerous on the under surface. Unlike tobacco, however, the cellular part of the lamina is wholly destitute of hairs (Fig. 225). The *midrib* and *veins* differ very greatly from those of tobacco—in shape, in the form and nature of the spines or hairs which arise from them, and in the arrangement of the vessels and wood-fibre. Transverse sections of the midrib are roughly triangular, the base of the triangle being smaller than the sides: one of these sections viewed with an inch object-glass presents six prominences, indicating the number of ridges by which the midrib is traversed longitudinally. One ridge is situated on the upper surface of the midrib (the base of the triangle), between the origins of the lamina of the leaf; the other five ridges are below, one in the centre, large and prominent, forming the lower surface of the midrib (apex of the triangle), and two on each side.

The *hairs*, or rather spines, spring from the surface of the midribs and veins, and principally from the ridges; they are thick, short, hollow, striated, of considerable diameter, and terminate in obtuse rounded extremities: these spines impart a feeling of roughness to the finger passed along the midrib.

The *wood-fibre* and *vessels* traverse the midrib in bundles, the number of bundles being greatest in sections of the larger midribs: in those of small and medium size there are usually six or eight *fasciculi* (Fig. 226).

The *cells* forming the ridges are very characteristic, being small and angular: those composing the internal part of the midrib, which are traversed by the vascular and woody tissue, are larger, parenchymatous, and more wavy-walled, as seen in transverse section (Figs. 227 and 228).

[*For figures, see pp.* 285, 286, *and* 287.]

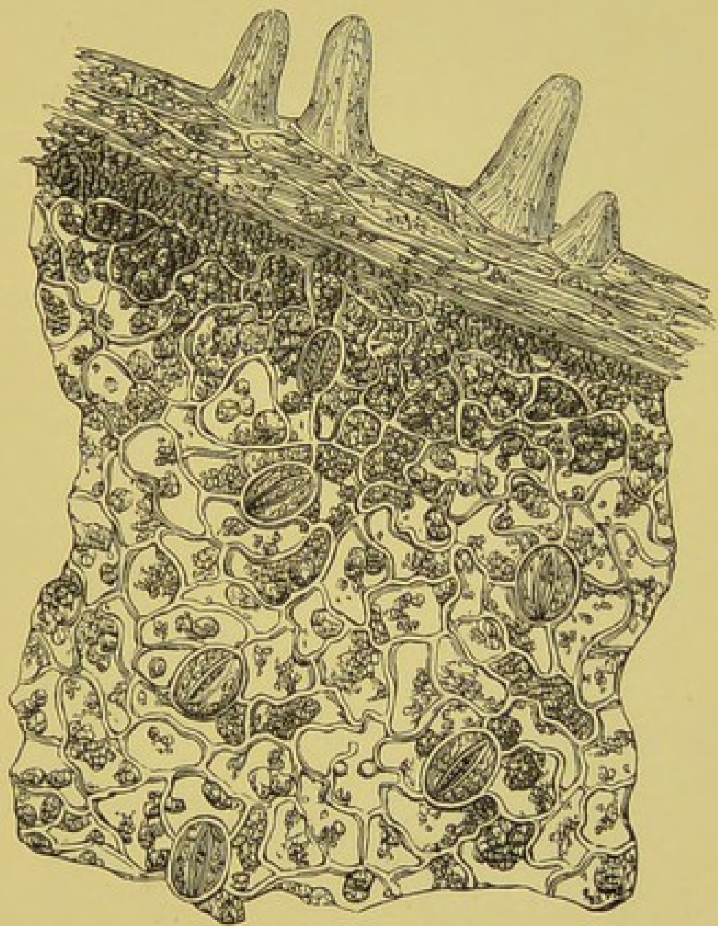


FIG. 225.—DOCK LEAF: portion of under surface, showing cells, stomata, and junction of the lamina with one of the smaller veins. × 220.

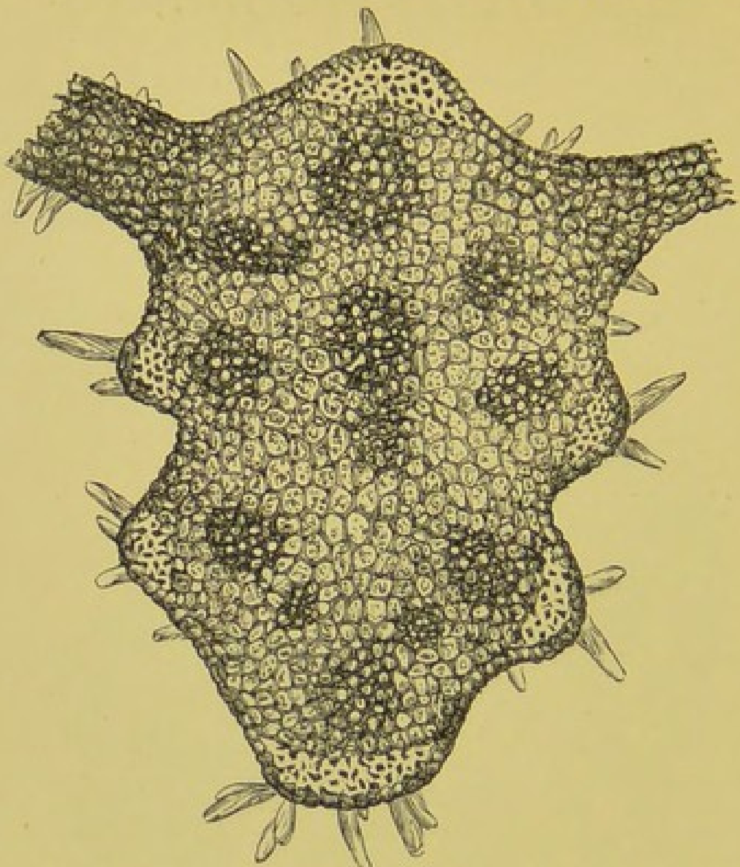


FIG. 226.—DOCK LEAF: transverse section of midrib, showing ridges, hairs, and bundles, or fasciculi. ×40.

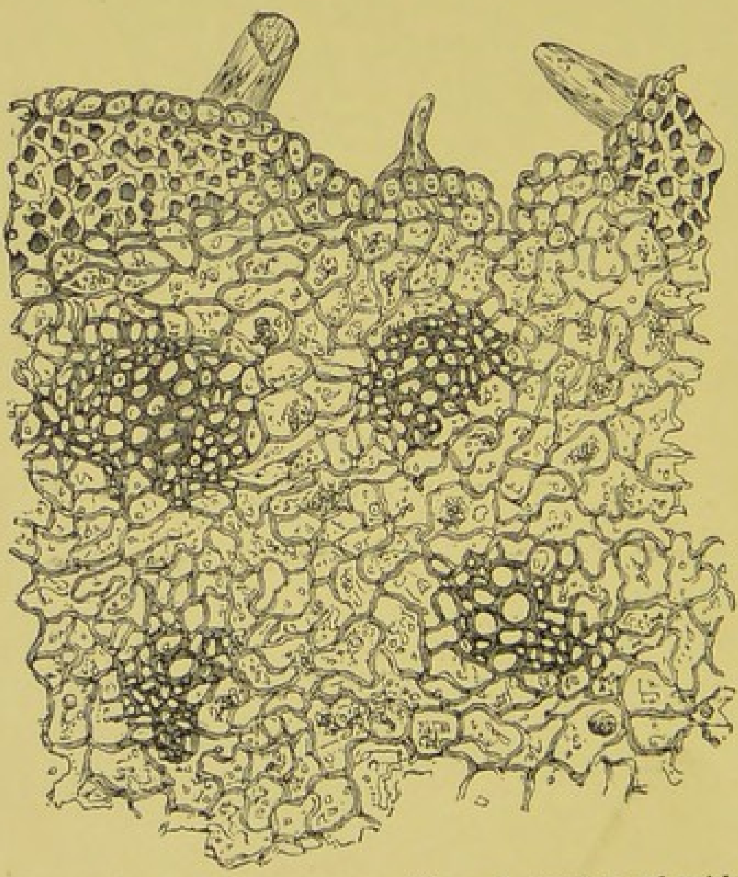


FIG. 227.—DOCK LEAF: transverse section of portion of midrib, showing the different forms of cells, and several fibro-vascular bundles. ×90.

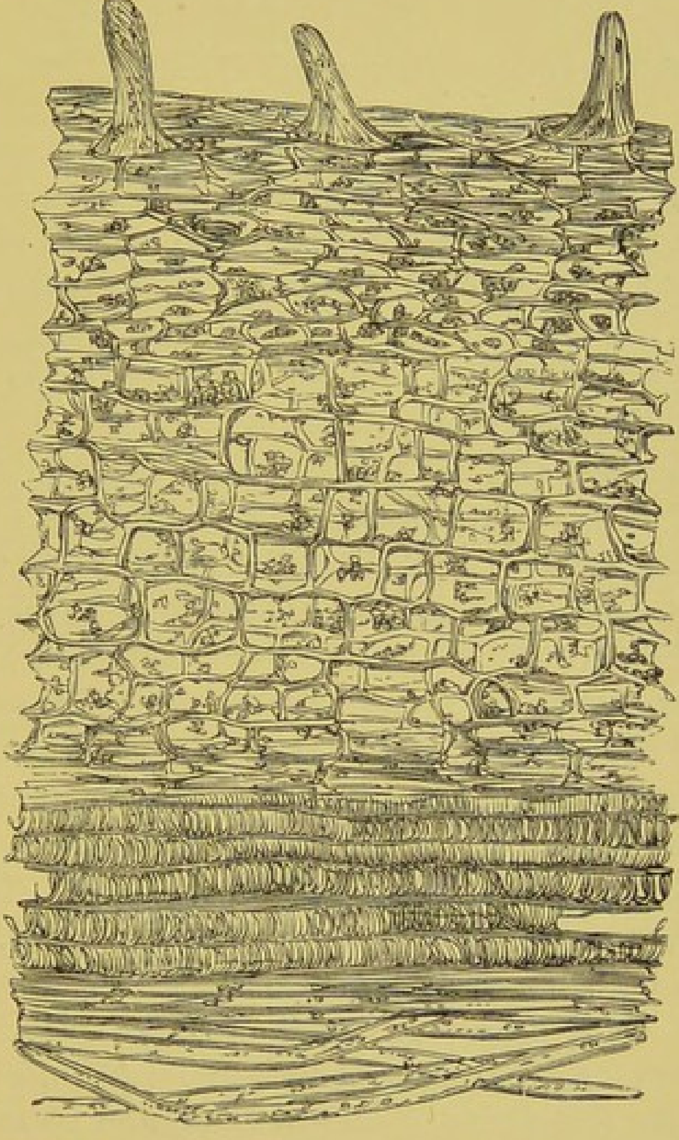


FIG. 228.—DOCK LEAF: longitudinal section of portion of midrib. ×90.

II. RHUBARB LEAF (*Rheum hybridum*, ord. *Polygoninæ*, fam. *Polygonaceæ*).

Histology.—Slight differences only are observable in the stomata, and in the form and size of the cells of the rhubarb leaf: but the walls of the cells are finely striated (Fig. 229); and this is a character by which rhubarb leaf may at once be known from tobacco. Other differences are found in the characters of the short spines or hairs, in the form of the *midrib and veins*, and in the presence of annular, quadripartite glands, scattered throughout the lamina of the leaf. The *hairs or spines* are short, thick, hollow, striated, and terminate in obtuse, rounded extremities. They resemble closely in form those of the dock, but differ in being several times larger, in the character and fineness of the striæ with which they are marked, and in their distribution: for, while in the dock leaf the hairs spring only from the midrib and veins, in the rhubarb leaf they arise from all parts of the leaf, the lamina as well as midrib and veins. The *midrib* and branches, as in the dock, consist on the outside of small angular cells, succeeded by a network of large, parenchymatous cells, traversed by bundles of wood-fibre and spiral vessels: the differences between the midribs of the leaves of the two plants being in form, and in the absence of distinct ridges on the midrib of the rhubarb leaf (Fig. 230).

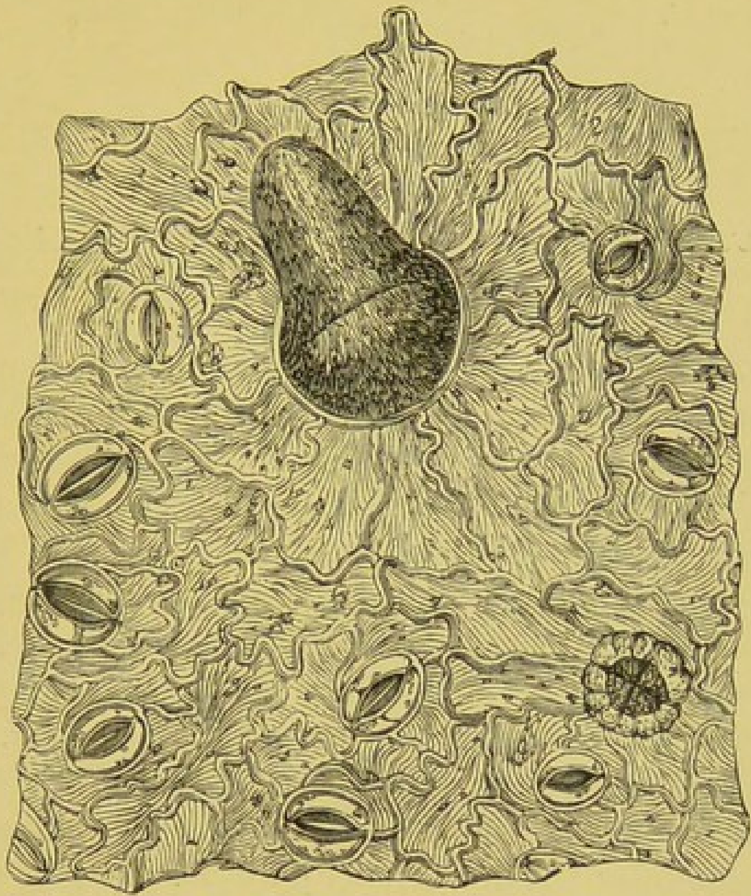


FIG. 229.—RHUBARB LEAF: portion of under surface, showing the striation of the cells, a spine or hair, and one of the quadripartite glands. × 220.

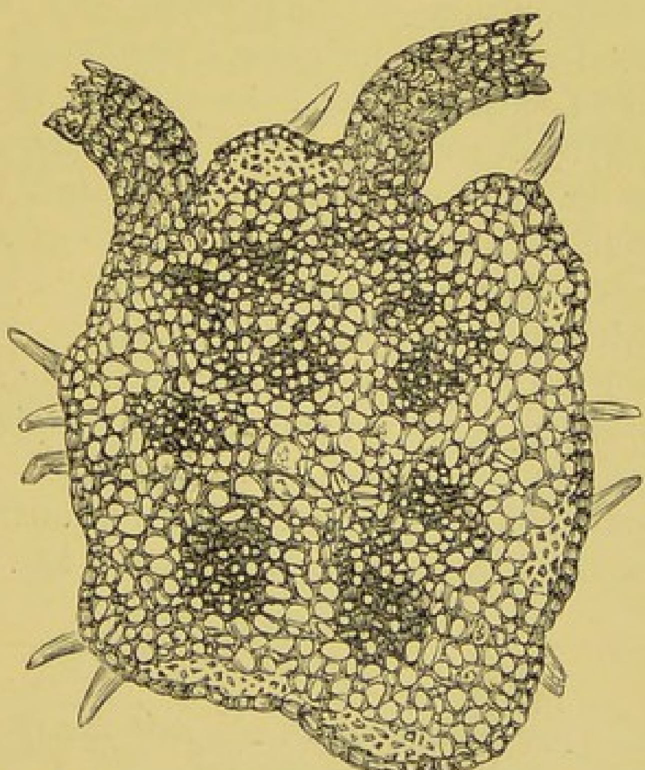


FIG. 230.—RHUBARB LEAF: transverse section of midrib, showing angular epidermal cells, parenchyma cells, and fibro-vascular bundles. × 40.

III. Coltsfoot Leaf (*Tussilago farfara*, ord. *Aggregatæ*, fam. *Compositæ*).

Histology.—The epidermal *cells* forming the *upper* surface of the leaf of coltsfoot or tussilage are small, angular, and faintly striated: there are few stomata, and no hairs, except on the midrib and principal veins (Fig. 231). The structure of the *under* surface of the leaf is entirely different; the cells are also small, but their margins are waved, and the walls are not striated. The stomata are exceedingly numerous, and the whole surface is clothed with delicate filamentous hairs, which impart the downy character to the leaf. Intermixed with these are other much larger hairs, which, being jointed, somewhat resemble those of tobacco, but want the distinct glandular terminations (Fig. 232).

Transverse sections of the large *leaf-stalk* have externally a well-defined border of distinctly angular, thick-walled cells, from the outside of which spring the two kinds of hairs described above. The central portion of the section is composed of loose cellular tissue, similar to that of the midribs of many other leaves; and it is traversed by from six to eight bundles of fibro-vascular tissue, the number usually varying with the size. [The large *leaf-stalks* of coltsfoot, however, would scarcely be used in any case for admixture with cut tobacco.]

Sections of the branches or veins are nearly similar: the principal difference is in the number of the bundles traversing them, there being almost invariably but three such bundles. By this character the veins of the leaf of coltsfoot are distinguished at once from those of the other leaves described (Fig. 233).

[*For figures, see pp.* 291 *and* 292.]

FIG. 231.—COLTSFOOT LEAF: upper epidermis, showing striated cells, stomata, no hairs. × 220.

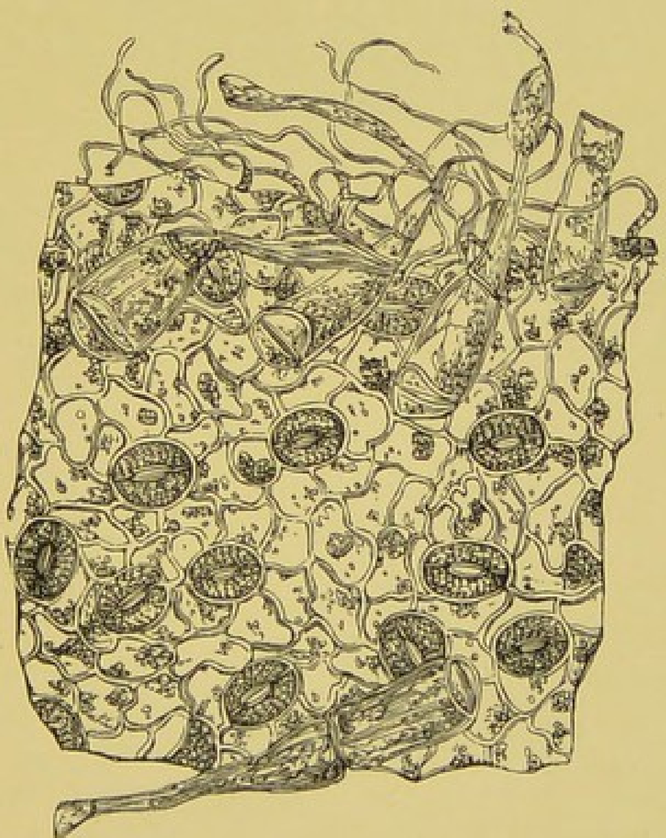


FIG. 232.—COLTSFOOT LEAF: under epidermis, showing wavy-walled unstriated cells, with many hairs and stomata. × 220.

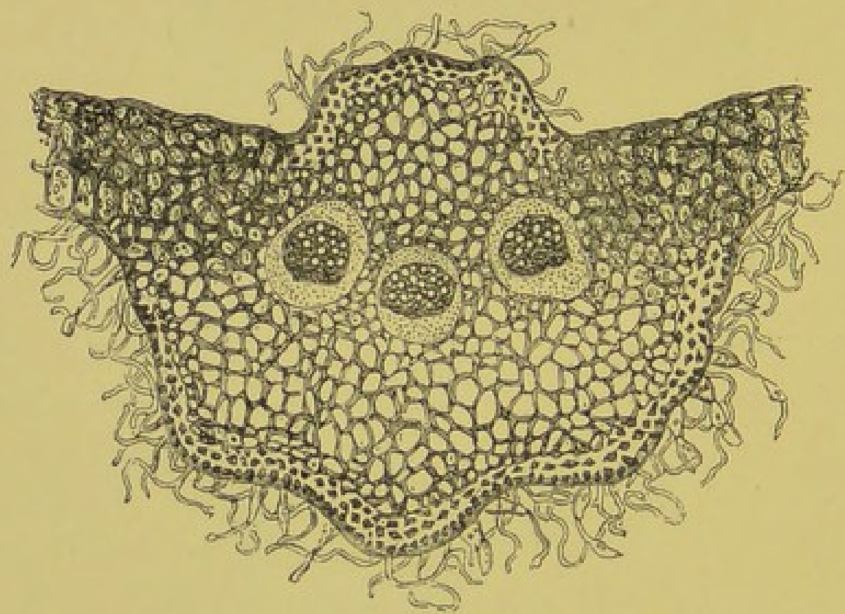


FIG. 233.—COLTSFOOT LEAF: transverse section of one of the veins, showing hairs, angular surface-cells, loose parenchymatous tissue, and *three* fibro-vascular bundles. × 40.

[Hops.

Ord. URTICINÆ, Fam. CANNABINACEÆ.

HOPS.

The imbricated scaly inflorescences, or *strobili*, of *Humulus lupulus*, ord. *Urticinæ*, fam. *Cannabinaceæ*, used to impart an aromatic and bitter taste to beer.

Histology.—The epidermal cells of the *bracts* and *bractioles*, or scale-like hop-leaves, possess extremely sinuous outlines; and attached to the surface are numerous spherical glandular hairs, in appearance not unlike pollen-grains. These secrete the *lupulin*, to which the properties of the hop most valuable to the brewer are mainly due. The microscopical characters of the lupulin-glands are indicated in the figure on the opposite page.

The *seed* is enclosed within an outer covering, consisting of several layers, of which the corrugated and tortuous aspect of the cells composing the second layer is perhaps the most distinctive feature. Fig. 235 shows the covering in surface view, and in section, together with the inner portion of the seed.

Substitutes for, and Additions to, the Hop, Detectable by the Microscope.—Preparations, more beloved by the brewer than the farmer, and compounded of quassia, gentian, chiretta, calumba, or the like—particles of which, by careful examination, can often be detected in the dregs of a beer-vessel—are at the present time to be found on the market. Though permissible by law, and probably as a rule innoxious, these 'hop-substitutes' yield products far less satisfactory to connoisseurs than beer brewed from *Humulus lupulus;* and their extending use, from several points of view, is highly regrettable.

Fragments of hop can even now be discerned within the precincts of some of our breweries; usually those of a better class.

[*For figures, see pp.* 295 *and* 296.]

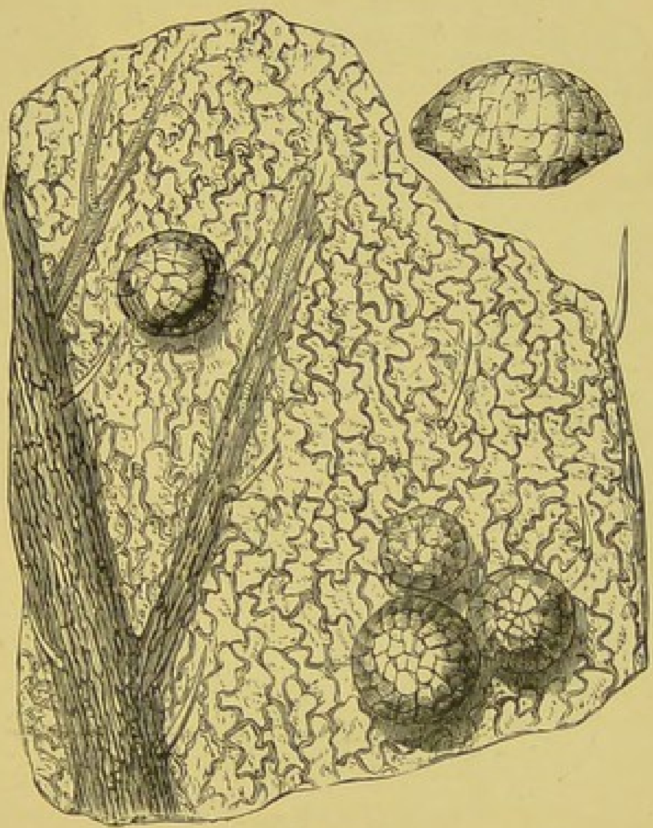


FIG. 234.—HOP LEAF: portion of, with lupulin-glands × 100

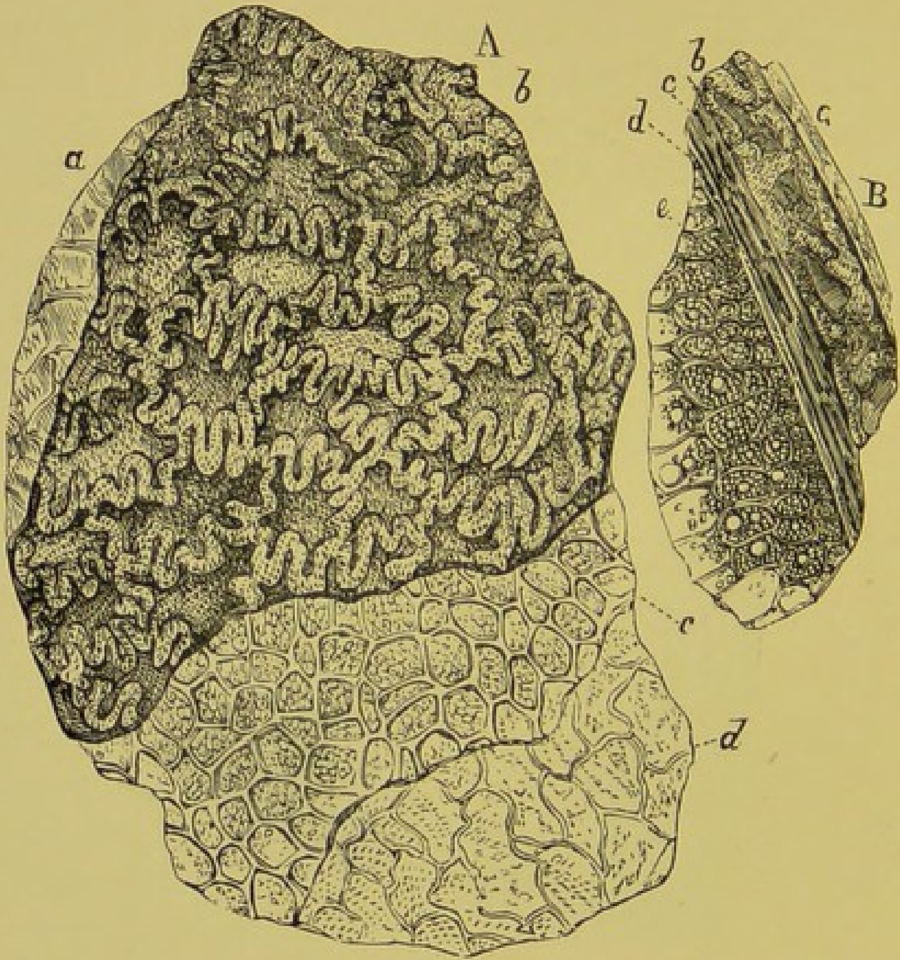


FIG. 235.—HOP SEED. × 200.

A, *Outer covering*, showing the four coats of which it is formed, the second, marked *b*, being the most characteristic; B, *vertical section of seed*, exhibiting the four membranes, and the substance of the seed, *e*.

[THE POPPY.

ORD. RHOEADINÆ, FAM. PAPAVERACEÆ.

THE POPPY.

THE poppy head, or poppy capsule, is the dried fruit of *Papaver somniferum*, ord. *Rhoeadinæ*, fam. *Papaveraceæ*. It is used for the preparation of opium, as a source of the alkaloid morphine, and for other purposes.

Histology of the Poppy Capsule.—The fruit is globose or ovate-globose, varies in size from a hen's egg to an orange, and is of a light, spongy, and papyraceous texture. It is one-celled, consisting of numerous carpels enclosed in a membranous production of the *thalamus*, or receptacle of the flower, and is furnished with *placentæ*, forming dissepiments in the interior of the capsule, the number and position of which correspond with the carpels.

Thin sections of the *external* surface of the capsule, or *epicarp*, examined under the microscope, are seen to be composed of small, angular cells, having exceedingly well-marked, broad walls or parietes, with here and there a few rounded stomata. It is necessary to be thoroughly well acquainted with this structure, because it is chiefly the external part of the capsule which enters into the adulteration of opium. There is some slight resemblance between the membrane in question and that forming the surface of the grain of wheat (Fig. 236).

The endocarp, or membrane which lines the *interior* of the capsule, and is situated between the dissepiments, is very different: it consists of very large elongated and irregular cells, mostly becoming narrow towards each extremity. The walls are very thick and beaded: there are also a few angular stomata (Fig. 237).

In longitudinal sections, passing through the entire thickness of the capsule, a side view is obtained of the cells forming the outer and inner portions, the space between the two consisting of a loose and open cellular tissue, the mesocarp, which imparts sponginess to the poppy head, and is traversed here and there by bundles of reticulated ducts, spiral vessels, and wood-fibre (fibro-vascular bundles).

The structure of the dissepiments, or *placentæ*, is entirely different from that of the internal wall of the capsule. The surface of each dissepiment on both sides presents numerous dark points or specks: these consist of short, raised projections, or spermophores, each of which originally gave support to a distinct seed, which in the ripe capsule is found usually to be detached. The portions of the surface of the dissepiment lying between the spermophores are composed of cells which, though rather large, are much smaller than those forming the internal surface of the capsule: they are somewhat elongated, become narrow at each end, have dotted margins, and there are no stomata. The spermophores, or projections supporting the seeds, consist of similar cells (Fig. 238). In transverse sections of the dissepiment, viewed with a very low power, the spermophores are well seen, as also the manner in which the seeds are supported and distributed (Fig. 239). With a half-inch object-glass the intimate structure of the dissepiment may be followed out. The central, or spongy part, which swells greatly when immersed in water, consists of tubular cells running in every direction, with considerable interstices, or *areolæ*, between them, together with bundles of wood-fibre and vessels, one of which bundles passes up through the centre of each spermophore (Fig. 240).

The poppy seed is very characteristic in appearance. The surface of the *testa* is finely reticulated, the ridges coinciding with the walls of the exceedingly large cells of the epidermis (Fig. 241, *a*, *a*). Beneath this membrane are several others, together making up the thickness of the spermoderm. The two more prominent are shown in the figure: the cross cells (*b*, *b*), and the fibre cells (*c*, *c*). The seed substance is made up of small, angular cells (*d*, *d*), containing aleurone grains and globules of oil. The several characteristic features of the seed are shown in Figs. 240 and 241.

Opium is the inspissated juice obtained from the unripe capsules.

Extraneous Substances Detectable in Opium by the Microscope.—Pounded poppy capsule and petals, flour, wood-fibre, turmeric, etc.

[*For figures, see pp.* 301, 302, 303, 304, *and* 305.]

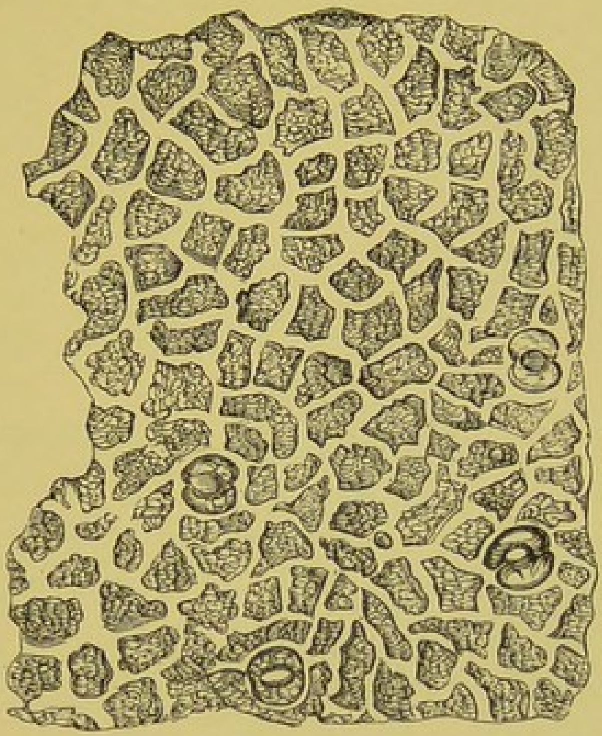


FIG. 236.—POPPY CAPSULE : portion of external surface, or epicarp. × 220.

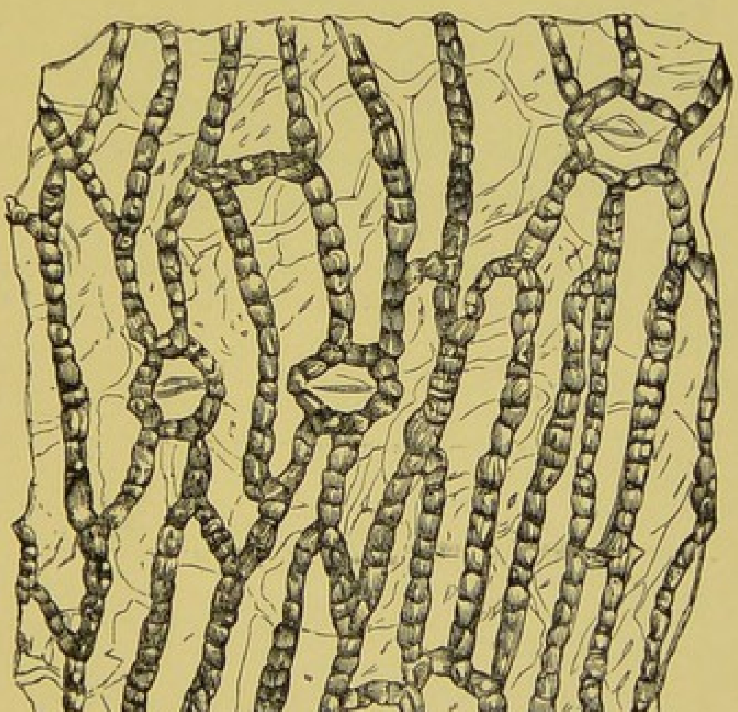


FIG. 237.—POPPY CAPSULE : part of internal surface, or endocarp. × 220.

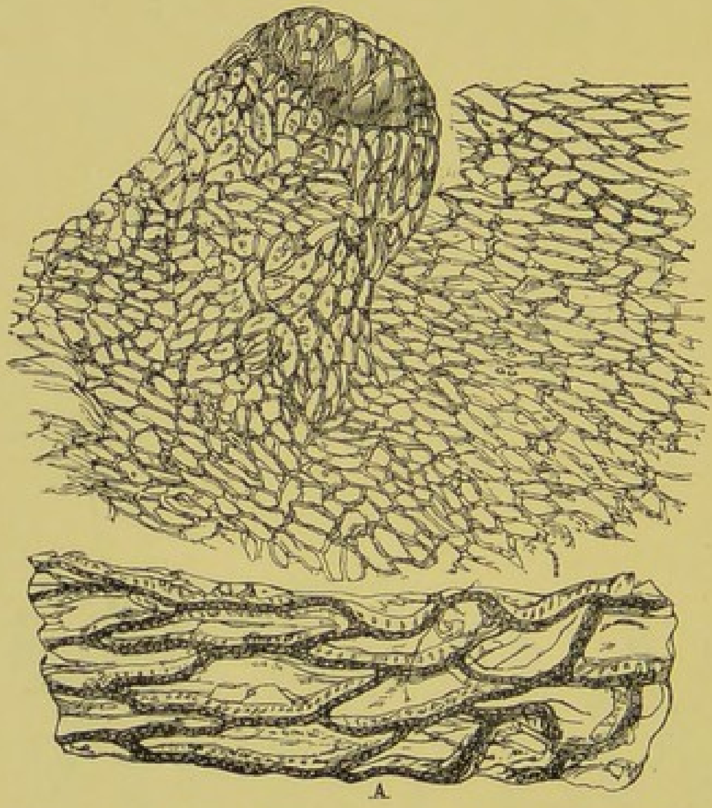


FIG. 238.—POPPY CAPSULE: (above) surface of one of the *placentæ*, or dissepiments, showing a spermophore ($\times 60$); also (A) a fragment of cellular tissue enlarged. $\times 220$.

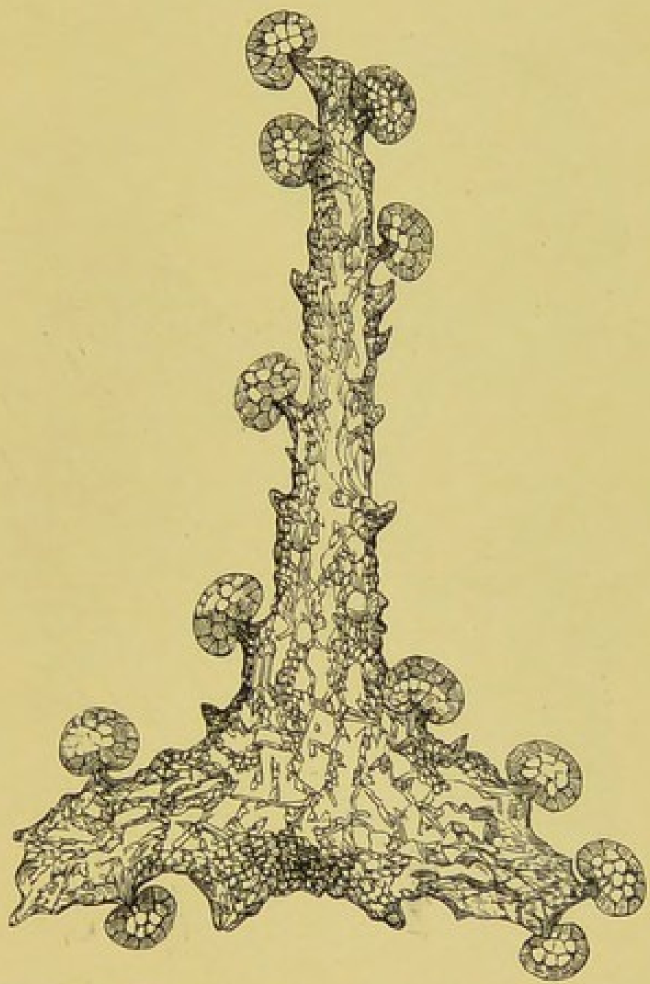


FIG. 239.—POPPY CAPSULE: transverse section through the thickness of a dissepiment, showing spermophores with seeds attached. × 10.

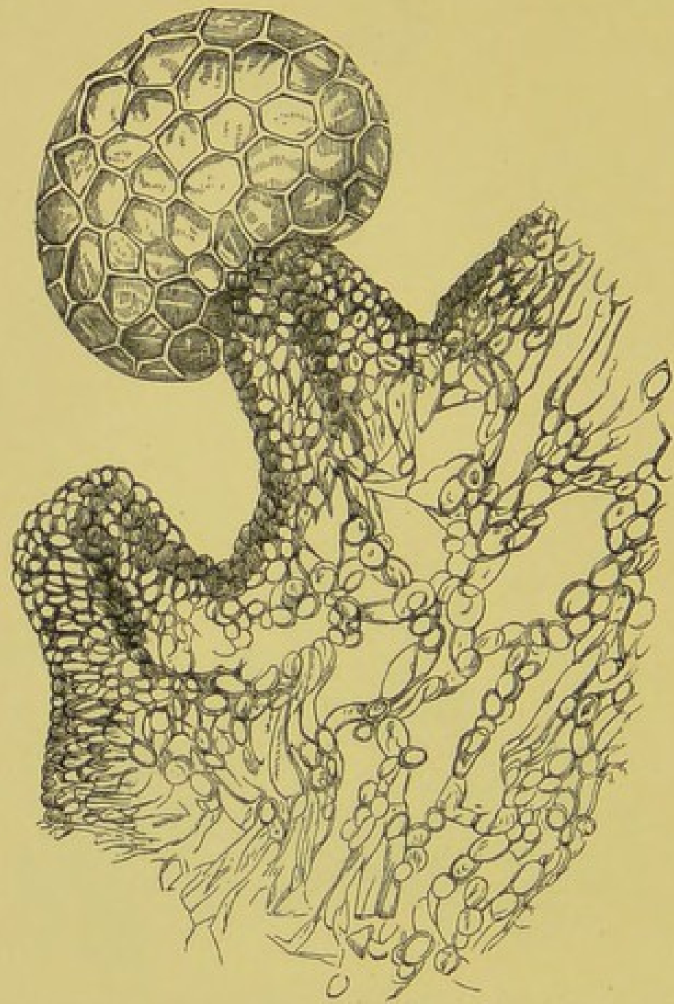


FIG. 240.—POPPY CAPSULE AND SEED: transverse section of a dissepiment, showing two spermophores, and one seed attached. × 100.

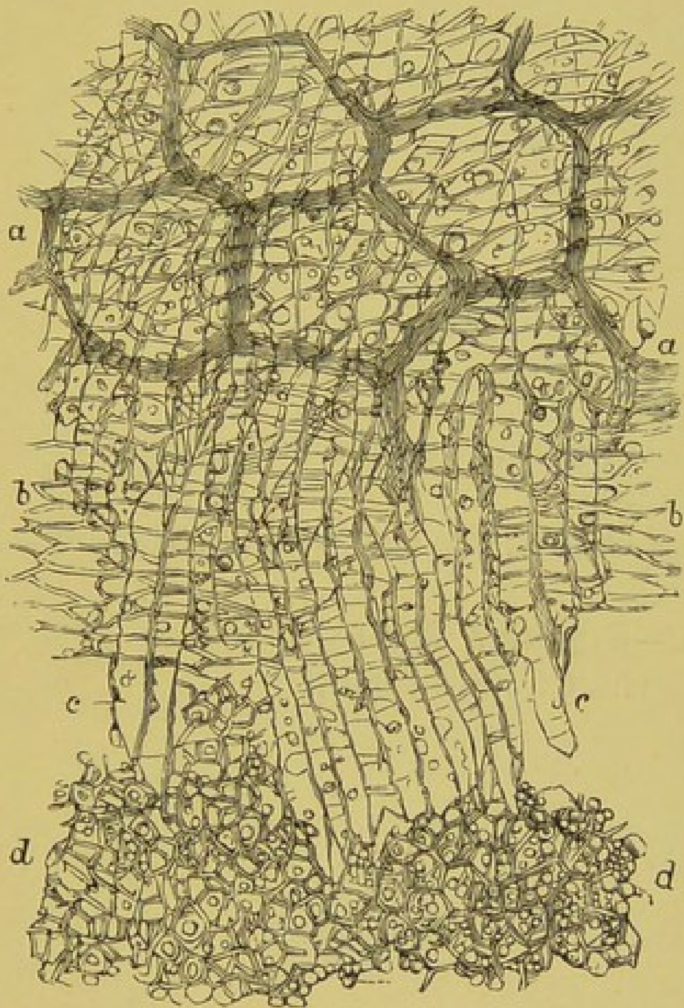


FIG. 241.—POPPY SEED: showing the membranes composing the husk, and the cells forming the substance of the seed.

a, *a*, Very large epidermal cells, the walls coinciding with the superficial ridges; *b*, *b*, cross cells; *c*, *c*, fibre cells; *d*, *d*, substance of seed—cells with aleurone grains and oil globules. × 100.

OPIUM.

Fig. 242.—**Opium**, containing an admixture of poppy capsule. [100.]

Fig. 243.—**Opium**, admixed with poppy capsule and wheat flour. [220.]

Fig. 244.—**Egyptian Opium**, containing gum, woody fibre, and a little wheat flour. [100.]

[*For figures, see pp.* 307 *and* 308.]

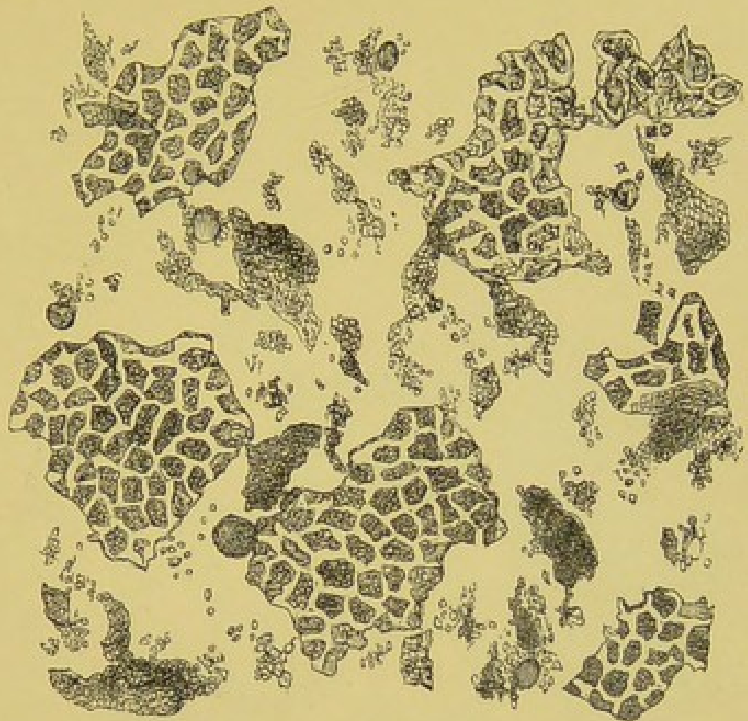


FIG. 242.—OPIUM, containing an admixture of *poppy capsule*. × 100.

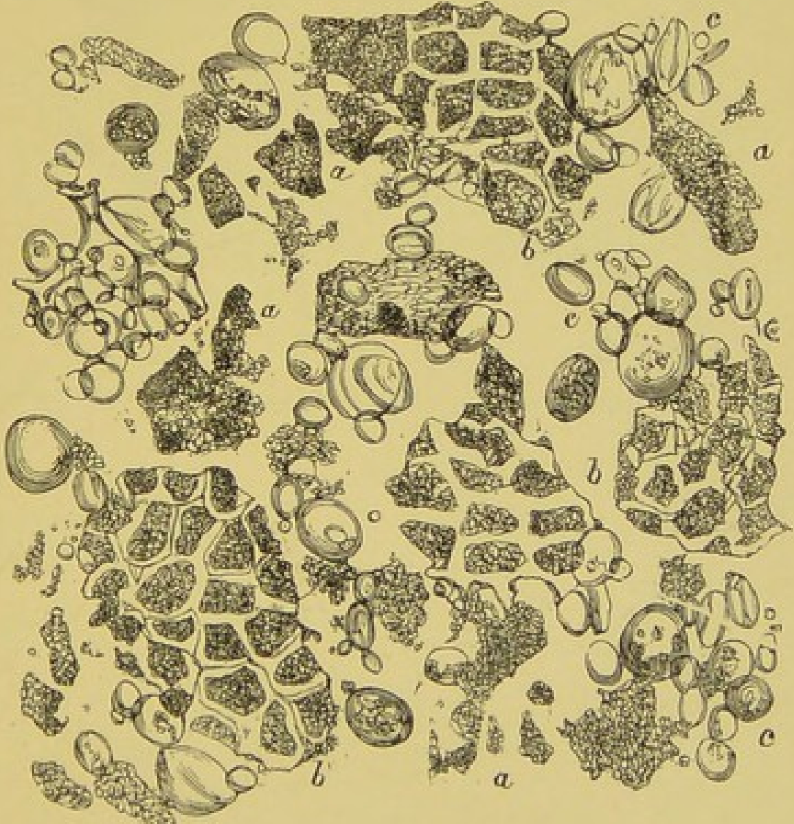


FIG. 243.—OPIUM, admixed with *poppy capsule* and *wheat flour*. × 220.

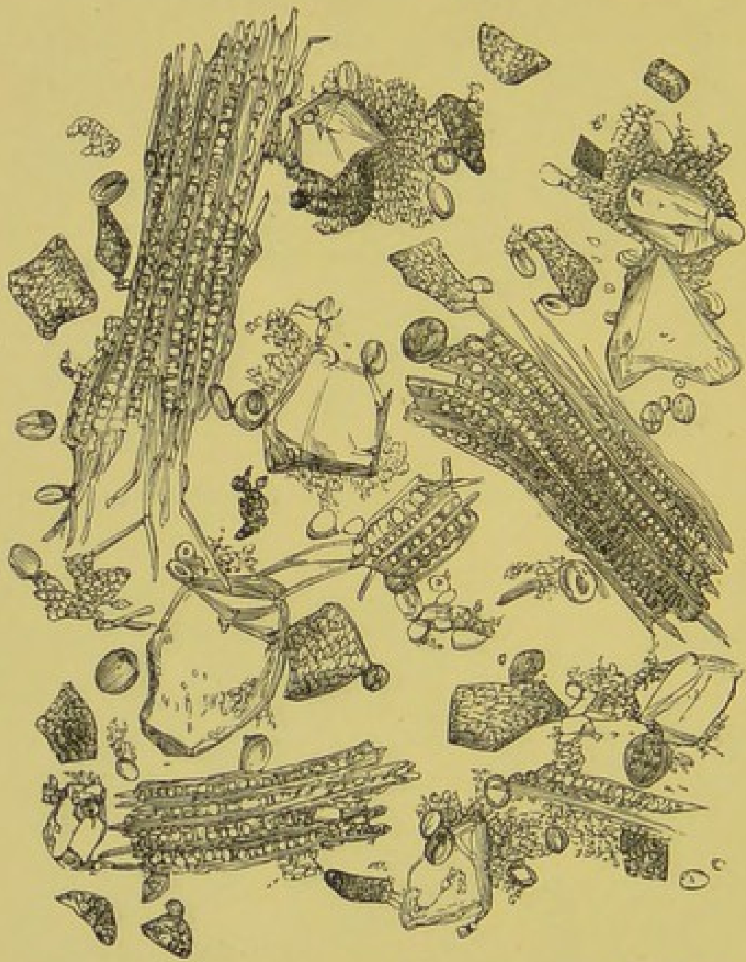


FIG. 244.—EGYPTIAN OPIUM, containing *gum*, *wood-fibre*, and a little *wheat flour*. × 100.

[TURMERIC.

ORD. SCITAMINEÆ, FAM. ZINGIBERACEÆ.

TURMERIC.

THE rhizome, or *rootstock*, of *Curcuma longa*, ord. *Scitamineæ*, fam. *Zingiberaceæ*.

Histology.—The ground rhizome consists of large, yellow-tinted, parenchymatous cells, containing, besides starch-granules, masses of starch-paste coloured yellow by curcumin. Many of these masses are to be seen liberated from the cells, the shapes of which they have retained: they may be recognized under the microscope by their size and bright yellow colour (Fig. 245); and when crushed, they are found to contain many starch-granules, resembling closely those of curcuma arrowroot, already described and illustrated (Fig. 246: see also Fig. 49, p. 63).

Turmeric exhibits appearances somewhat akin to those of ginger, but the characteristics of the starch-granules and elongated cells are notably different.

Extraneous Substances Detectable by the Microscope.—Barley and other flours, cheap starches, wood-fibre, etc.

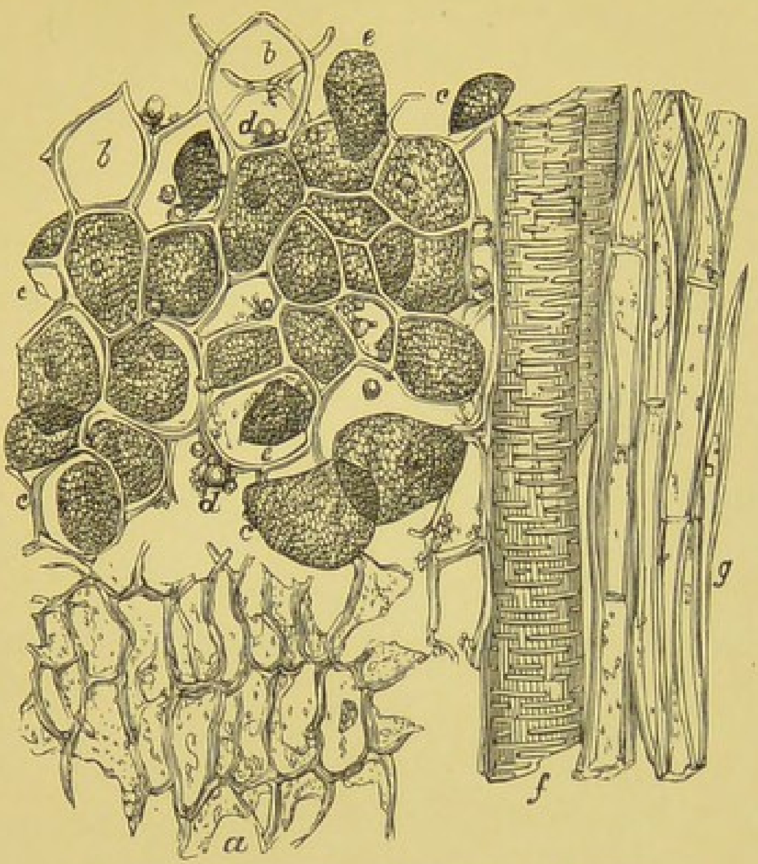


FIG. 245.—TURMERIC: SECTION OF RHIZOME.

a, Epidermis; *b*, *b*, transparent empty cells; *c*, *c*, and *e*, *e*, yellow masses; *d*, *d*, oil globules; *f*, reticulated duct; *g*, elongated cells lying by the side of the duct. × 220.

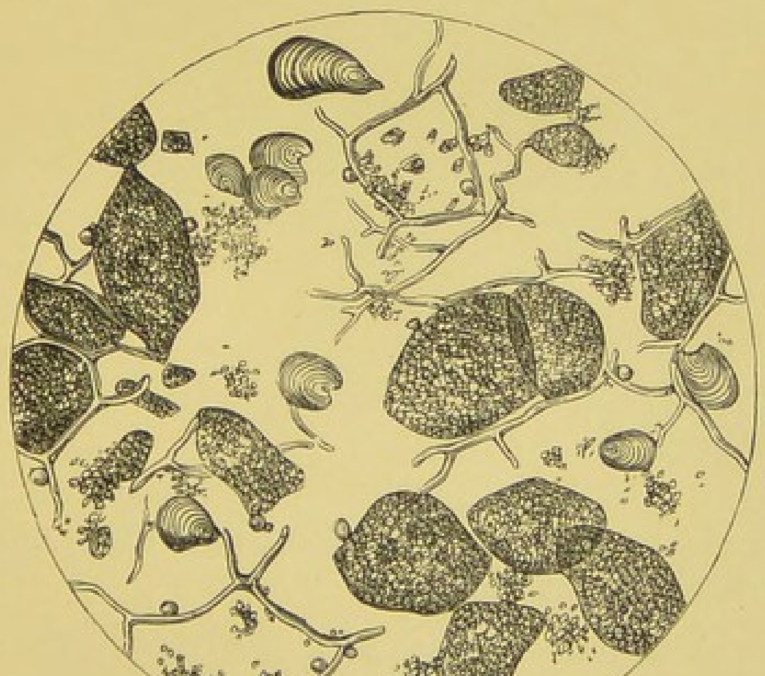


FIG. 246.—GROUND TURMERIC, showing starch-granules, parenchyma, and large yellow masses. × 220.

Ord. BIXINEÆ, Fam. BIXACEÆ.

ANNATTO.

The orange-hued pulp, obtained from the fruit of *Bixa orellana*, ord. *Bixineæ*, fam. *Bixaceæ*: used for colouring butter, cheese, and other articles of food.

Histology.—The cells of the outer or red portion of the fruit are closely compacted, but there is no especially definite characteristic. The surface of the seed-coat mainly consists of elongated palisade or fence cells, vertically arranged, beneath these being a layer of thick-walled cells containing granular matter. The endosperm, or inner white part of the seed, is made up of large cells filled with numerous starch-corpuscles, well defined, of medium size, and resembling in form, also in the long and sometimes stellate hilum, the starch-granules of the bean (Fig. 247: see also Fig. 16, p. 31).

Extraneous Substances Detectable by the Microscope.—Wheat, rye, and barley flours, turmeric, and mineral matter (Figs. 248 and 249, p. 314). Annatto has for many years been one of the most considerably adulterated commodities. Dr. A. H. Hassall half a century ago[1] first called attention to the impurity of commercial annatto, which still maintains an undesirable distinction in this respect. The unacknowledged substitution of coal-tar colours for annatto is now common, especially in the liquid preparations, or so-called 'annatto colourings.' In such cases chemical tests must supplement the microscopical examination.

1 'On the Adulteration of Annatto' (paper read before the Pharmaceutical Society, 1855).

[*For figures, see pp.* 313 *and* 314.]

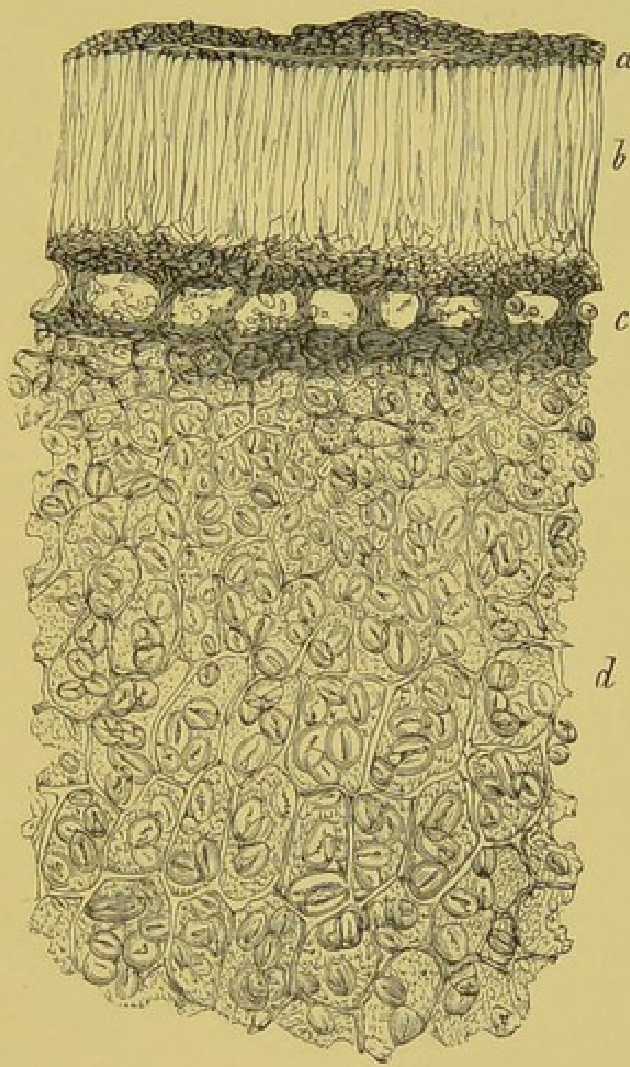


Fig. 247.—Annatto Seed, Section of.

a, Coloured pulp; *b*, fence cells of seed-coat; *c*, layers of thick-walled cells containing granular matter; *d*, cells of the endosperm, containing starch-granules. × 220.

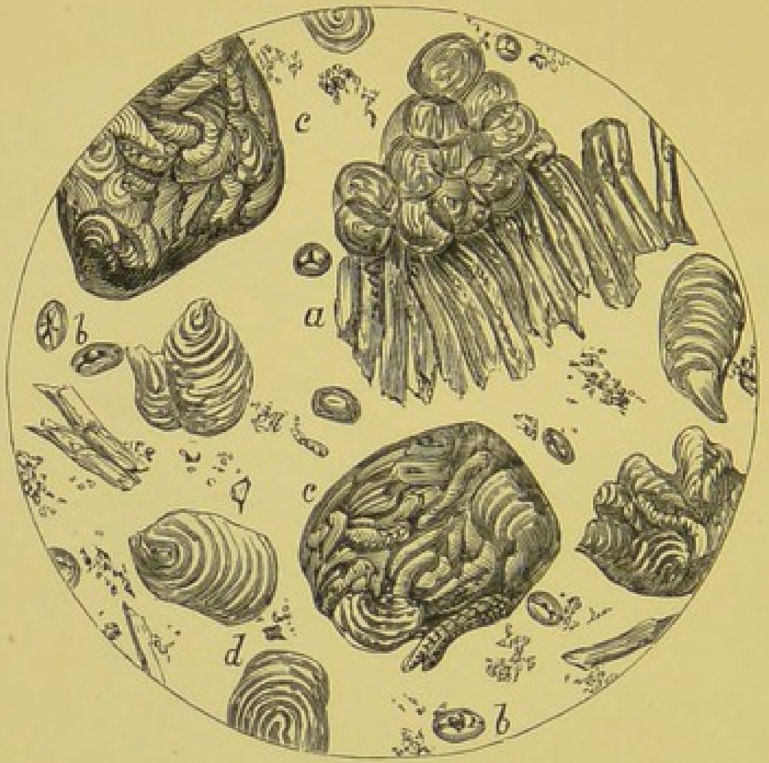


FIG. 248.—ANNATTO, MIXED WITH TURMERIC.

a, Outer part of seed; *b*, starch-granules; *c*, *c*, cells of turmeric; *d*, *d*, free starch-granules of turmeric, much altered by the action of alkali. × 225.

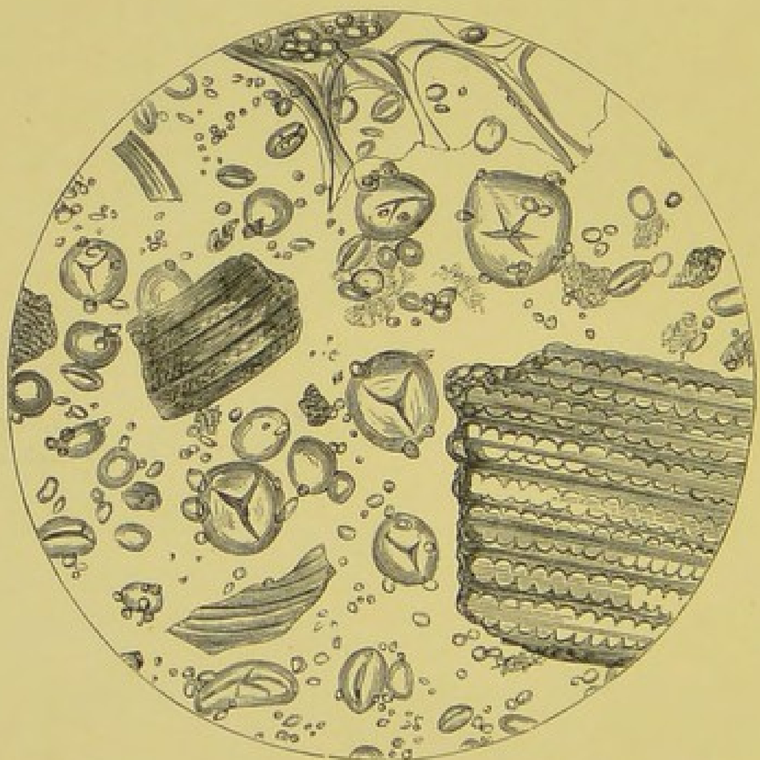


FIG. 249.—ANNATTO, MIXED WITH RYE FLOUR. × 225.

[SCAMMONY.

Ord. TUBIFLORÆ, Fam. CONVOLVULACEÆ.

SCAMMONY.

A gum-resin obtained from the root of *Convolvulus scammonia*, ord. *Tubifloræ*, fam. *Convolvulaceæ*. The best qualities of the commercial product are known as virgin scammony.

Microscopic Appearance of Virgin Scammony.—Angular and resinous fragments or splinters, of a greyish-brown colour and variable size, are seen (Fig. 250): intermixed with these other fragments sometimes occur, which are blackish or quite black, and are best seen when the powdered scammony is viewed as an opaque object. They are broken masses of vegetable tissue, and are occasionally found in small numbers even in the best scammony, but are most abundant in specimens of inferior quality. If the scammony be dissolved out with ether, considerable quantities of vegetable cellular tissue, woody fibre, fragments of spiral vessels, and stellate cells may frequently be discovered in the residue.

Extraneous Substances Detectable by the Microscope.—Starches, flour, vegetable fibre, etc. (Fig. 251). Chemical tests should supplement the use of the microscope.

FIG 250.—VIRGIN SCAMMONY (POWDERED). × 100.

FIG. 251.—SCAMMONY, MIXED WITH WHEAT AND LENTIL FLOURS. *a*, *a*, Scammony; *b*, *b*, wheat starch; *c*, *c*, black fragments of cellular tissue. × 220.

FAM. CONVOLVULACEÆ.

JALAP.

THE dried root tubercles of *Ipomœa purga*, ord. *Tubifloræ*, fam. *Convolvulaceæ*.

Histology.—The epidermis, *suber*, or cork layer, consists of dark-coloured, flat polygonal cells. Beneath is the cortex, consisting of rounded cells, many of which contain starch-grains: also there are elongated, sclerenchymatous, stellate cells, which, however, are not easily discoverable; lastly, there are very many resin cells. These appear as well-defined, dark, and somewhat angular cells, lying here and there in the midst of the other cells (Fig. 252). They appear to contain resin; but they are slowly acted upon by water, and from being dark and opaque become clear and transparent, evidently, therefore, containing some soluble substance. Of the remaining cells, many are apparently empty: these constitute chiefly the outer lamellæ of the jalap tuber (Fig. 252). The inner layers of the tuber are chiefly composed of starch-bearing cells (Figs. 252 and 253): but the *resin cells* are scattered throughout the whole of the root, occurring indifferently in the midst of either the apparently empty cells or those filled with starch. Other features of the inner portion of the root are calcium oxalate crystals, and wood-bundles with pitted vessels.

The *starch-granules* are of considerable size, and possess well-marked characters. Some are circular, but somewhat flattened, while others are muller-shaped. These last are occasionally united in twos, threes, and fours. Whenever muller-shaped starch-granules are met with in any vegetable tissue, it is clear that they were all originally united in this manner, and it is to such union that their form is chiefly due. They all possess a distinct hilum, around which one or two concentric rings may sometimes be seen (Figs. 253 and 254). Many of the granules in every root have become expanded and misshapen from the heat employed in the process of drying.

In genuine powdered jalap all the structures above described may be detected: cork, sclerous cells, resin cells, empty cells, starch-bearing cells, numerous free starch-granules, and occasional fragments of pitted vessels and wood-fibres. The occurrence of single cells completely filled with starch-granules is very characteristic of powdered jalap: and it should be noted that this tuber is made up almost entirely of cellular tissue. There are but few reticulated vessels, and extremely little wood-fibre, the fibres being large, coarse, and dotted, closely resembling, except in size, the vessels themselves.

Extraneous Substances Detectable by the Microscope.—Wood-fibre; foreign starches; mineral matter (Fig. 255).

[*For figures, see pp.* 321, 322, *and* 323.]

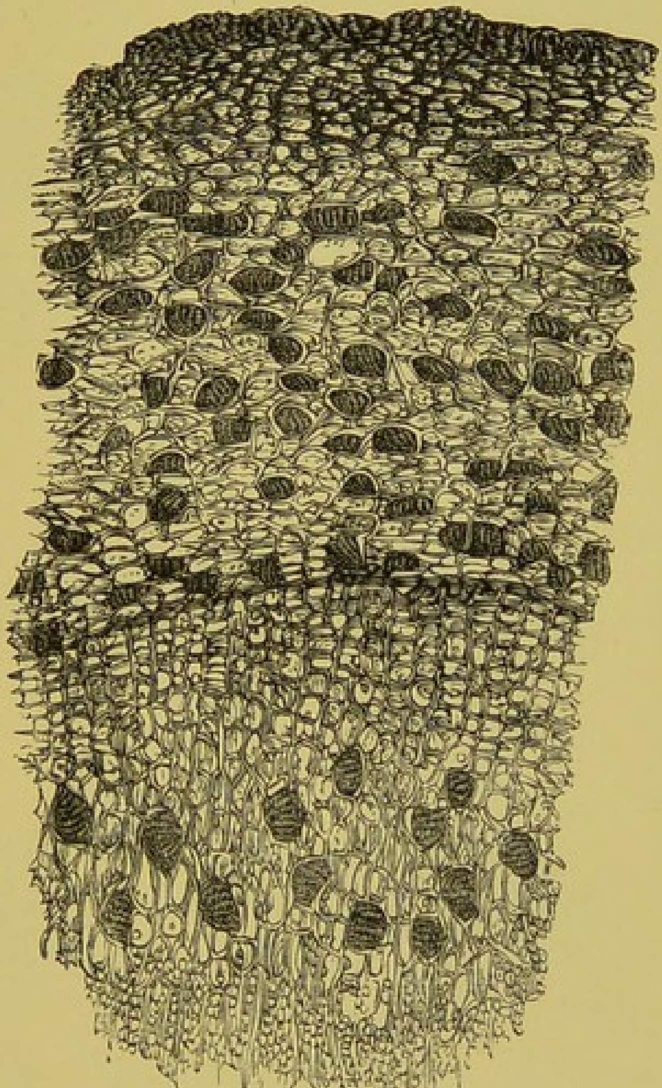


FIG. 252.—JALAP ROOT. × 30.

Transverse section, showing epidermis, cortex with resin cells, empty cells and starch-bearing cells.

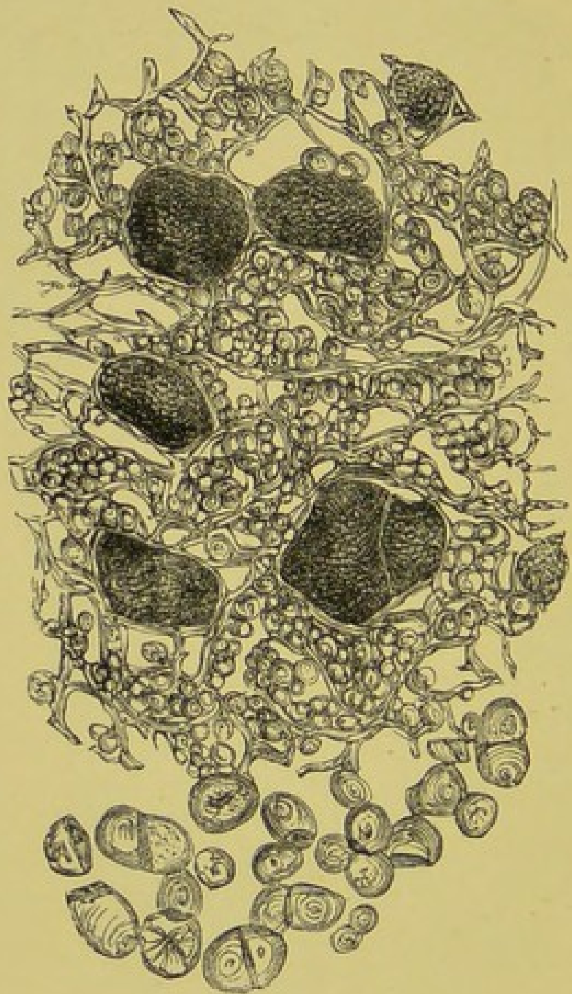


FIG. 253.—JALAP ROOT.

Transverse section of inner portion of root (× 100) ; and starch-grains (× 220).

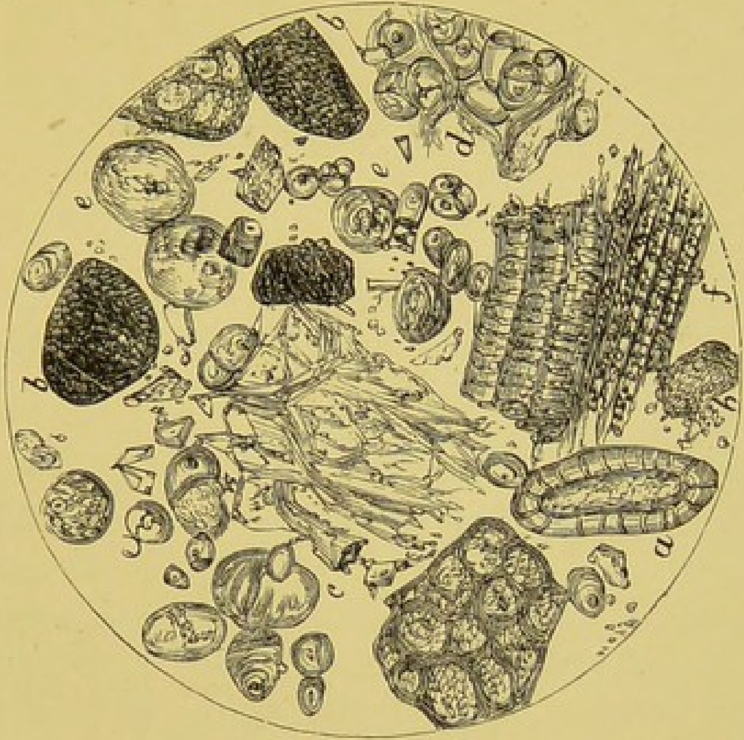


FIG. 254.—POWDERED JALAP. ×220.
a, Sclerotic or stone cell; *b*, *b*, resin cells; *c*, parenchyma; *d*, starch cells; *e*, starch; *f*, fibres.

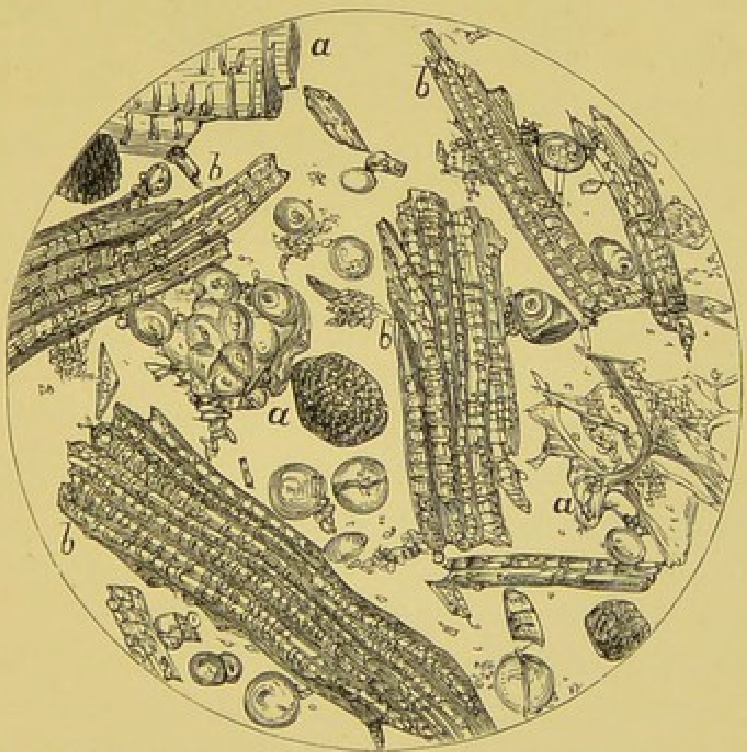


FIG. 255.—POWDERED JALAP, MIXED WITH WOOD-DUST (*Lignum vitæ*, or *guaiacum*). ×220.
a, *a*, *a*, Jalap; *b*, *b*, *b*, wood-dust.

Ord. RUBIINÆ, Fam. RUBIACEÆ.

IPECACUANHA.

The dried root of *Psychotria ipecacuanha*, ord. *Rubiinæ*, fam. *Rubiaceæ*.

Histology.—The substance of the root of ipecacuanha is divisible into two main parts: a thick, outer, *cortical* portion (with some external cork layers), and an inner, fibrous, and *woody* part, constituting the dense centre of the root. These, when dry, separate very easily from one another, and their intimate structure may be determined with facility from transverse sections.

Under the microscope the suberised layers are seen to consist externally of deep brown polygonal cells, the parietes of which are indistinctly visible; these form the epidermis: the rest of the cortex is made up of large colourless cells, the cavities of most of which are filled with minute but exceedingly distinct starch-granules, many being united in twos, threes, and even fours, and consequently rather muller-shaped. All possess a well-marked hilum (Fig. 256). Single acicular crystals of calcium oxalate also are present.

In transverse sections the central part, or wood (Fig. 257), presents the appearance of a number of slightly angular cells, of different sizes, having a radiated arrangement: those forming the outer border and the centre are very much smaller than the intermediate cells. The last are distinguished not only by larger size, but their cavities are, for the most part, filled with starch-granules resembling closely those of the cortex. In longitudinal sections it becomes evident that these cells are wood-fibres and tracheides cut across

(Figs. 257, B, and 258). The walls of all have pores arranged in a spiral manner; and the fibres are remarkable for containing in their cavities an abundance of starch-granules. It is a somewhat unusual circumstance for undoubted wood-fibres to contain starch. There are no reticulated vessels in pecacuanha.

Extraneous Substances Detectable by the Microscope.—Wheat flour; foreign wood-fibre.

[*For figures, see pp.* 327, 328, *and* 329.]

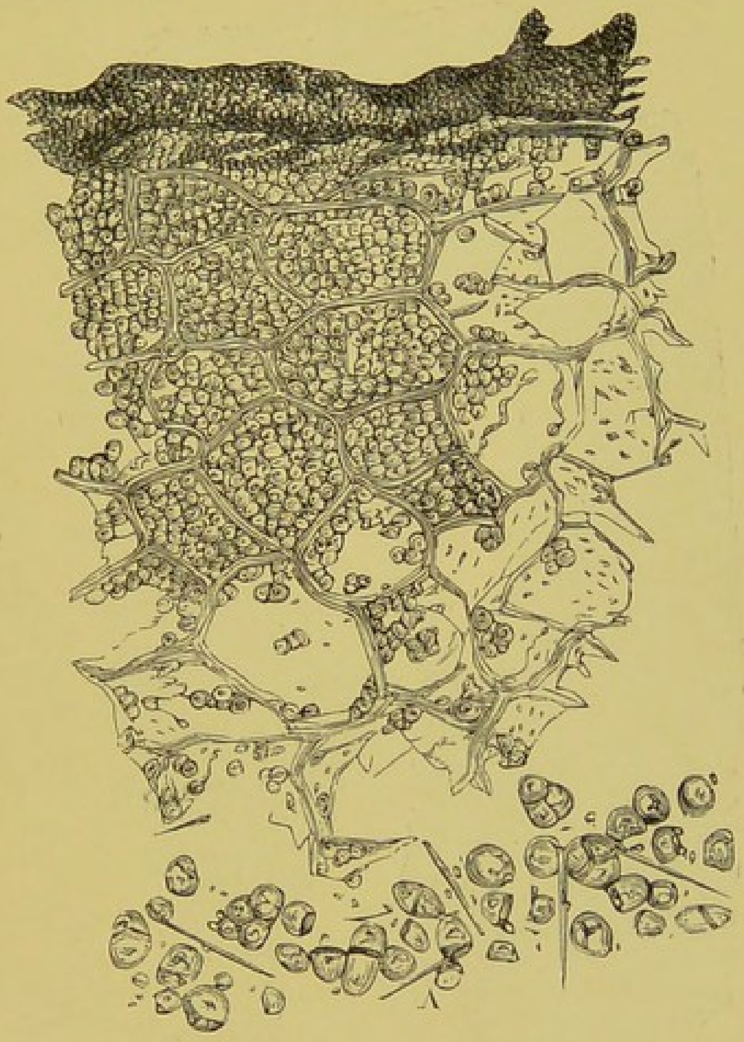


FIG. 256.—IPECACUANHA ROOT.

Transverse section of cortex, showing (above) epidermal cork layers and starch cells (×220); below (A), starch-granules and acicular crystals (×420).

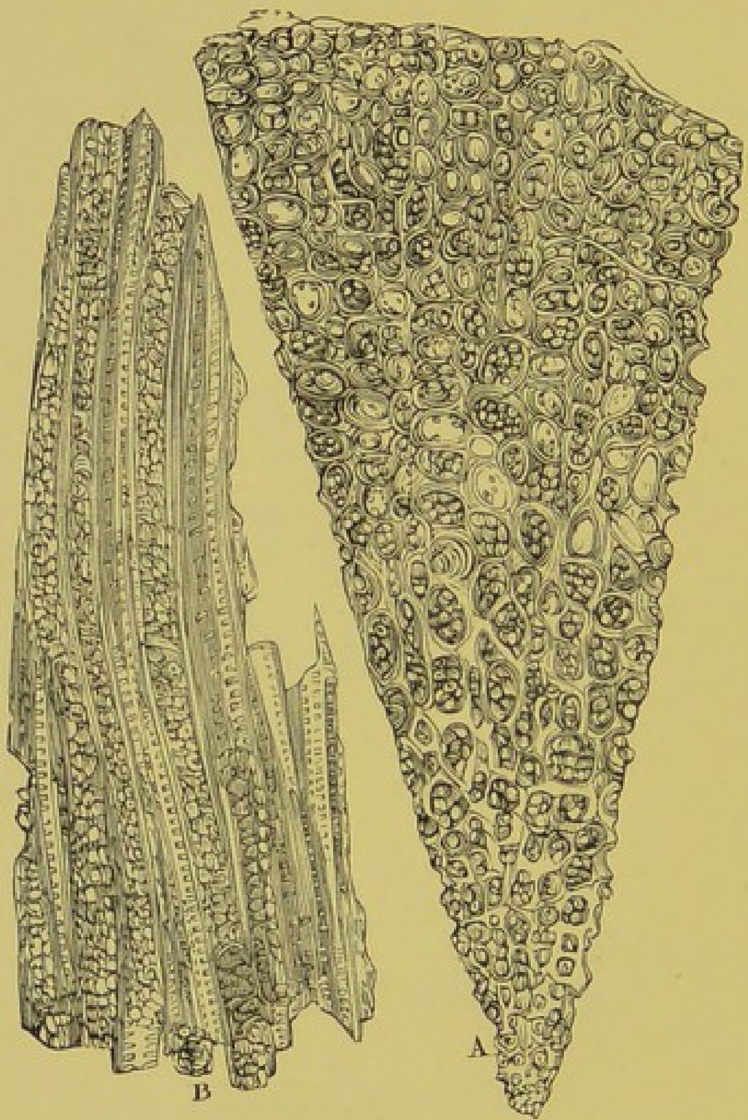


FIG. 257.—IPECACUANHA ROOT: CENTRAL OR WOODY PORTION. ×220.

A, Transverse section, showing ends of fibres, with contained starch; B, longitudinal section, showing pores in walls of tracheides and wood-fibres.

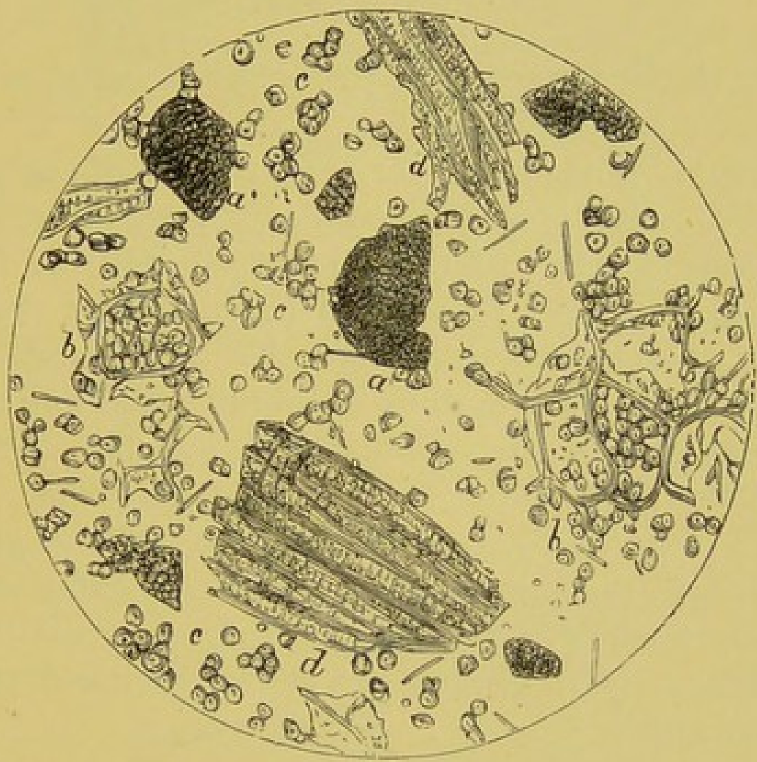


FIG. 258.—GROUND IPECACUANHA. ×420.

a, *a*, Fragments of brown epidermis ; *b*, *b*, cells of cortex, containing starch ; *c*, *c*, loose starch-granules and crystals ; *d*, *d*, wood-fibres of central part of root.

Ord. CAMPANULINÆ, Fam. CUCURBITACEÆ.

COLOCYNTH.

The fruit of the bitter apple, *Citrullus colocynthis*, ord. *Campanulinæ*, fam. *Cucurbitaceæ*.

Histology.—The epicarp, or outer portion of the pericarp, consists of a layer of thick-walled polygonal cells, with stomata visible here and there. Several strata of flattened parenchymatous cells follow, and beneath these are five or six tiers of sclerous, or stone cells with thick, radially perforated walls. These three membranes make up the rind, or external part of the gourd (Figs. 259, 260). Within is the *pulp*, the part of the fruit used in medicine. This is composed of thin-walled, parenchymatous cells, of great size near the central portions of the gourd, but smaller and more elongated towards the exterior. Fibro-vascular bundles, with delicate spiral vessels, are numerous; and there are large intercellular spaces.

Powdered colocynth should never contain any of the *seeds*: the structure of these is shown in Fig. 261. Beneath a transparent hyaline membrane, forming the surface of the seed-coat, is a stratum of fence cells: these are succeeded by many layers of extremely thick-walled sclerenchymatous cells (stellate or stone cells), and these again by a single layer of small cells with rounded outlines. Lastly follows the substance of the seed, which is made up of moderately large starchless cells, charged with aleurone grains.

Extraneous Substances Detectable in Powdered Colocynth by the Microscope.—Wheat flour; colocynth *seeds*.

[*For figures, see pp.* 331 *and* 332.]

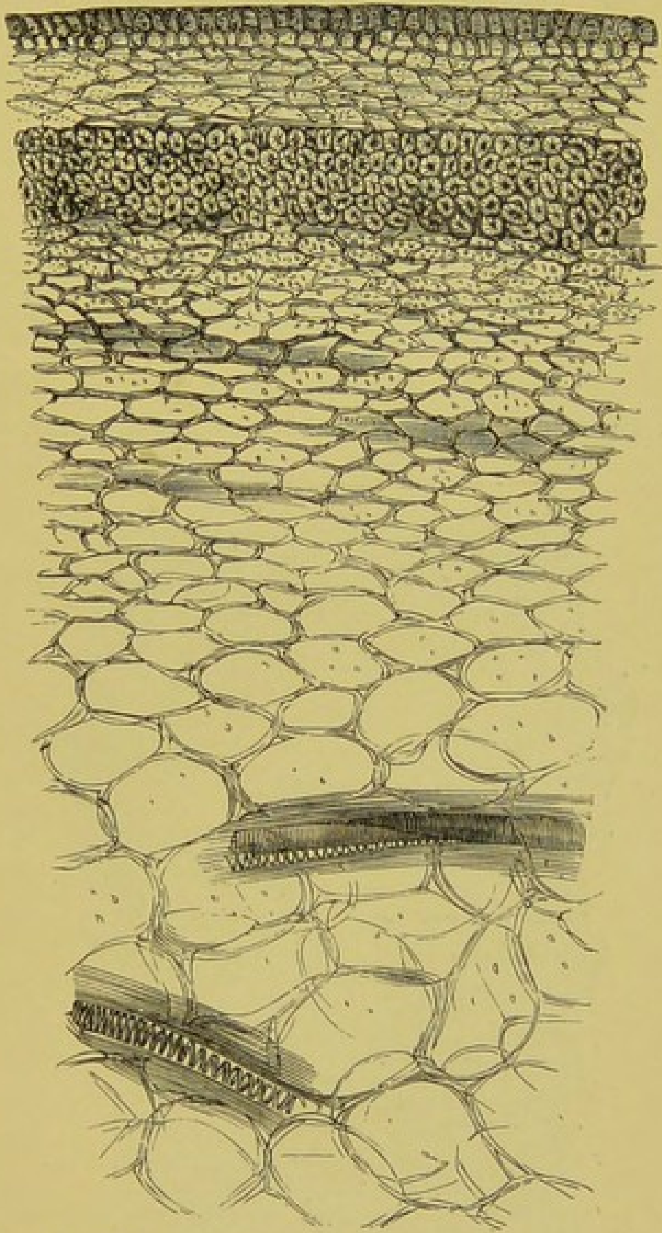


FIG. 259.—COLOCYNTH FRUIT. × 100.

Transverse section through rind and part of pulp, showing thick-walled cells of epicarp, flattened cells, sclerous layers, and large cells of pulp, with fibro-vascular bundles.

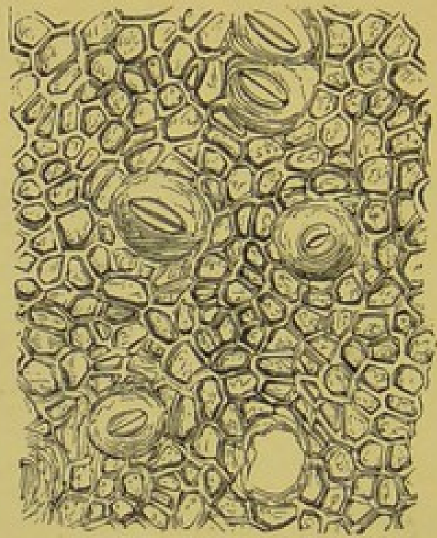


FIG. 260.—COLOCYNTH FRUIT. × 120.
Surface view, showing thick-walled cells of epicarp, with stomata.

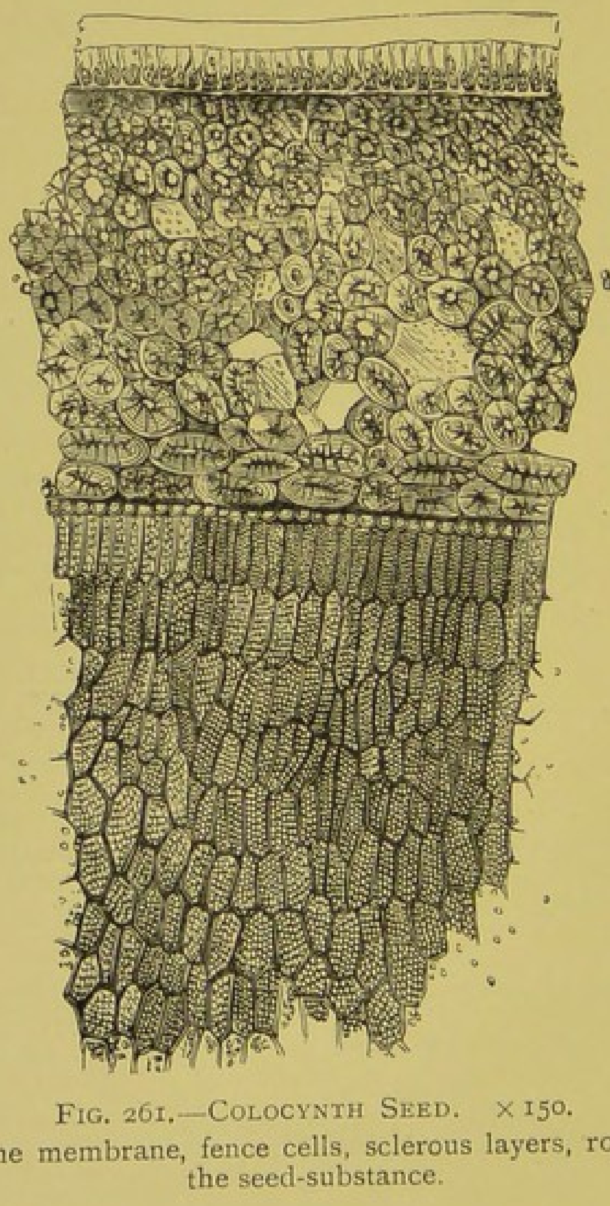


FIG. 261.—COLOCYNTH SEED. × 150.
Showing hyaline membrane, fence cells, sclerous layers, rounded cells, and the seed-substance.

[RHUBARB.

Ord. POLYGONINÆ, Fam. POLYGONACEÆ.

RHUBARB.

The dried and partly decorticated rhizome of *Rheum palmatum*, *R. officinale*, and other species, ord. *Polygoninæ*, fam. *Polygonaceæ*.

Histology.—The leading features are nodular aggregations of crystals, or crystal clusters, consisting of calcium oxalate: small starch-granules somewhat like those of the pea or bean: large reticulated vessels; and the thin, parenchymatous, cellular tissue of the bast ring, carrying a few starch-granules.

Extraneous Substances Detectable by the Microscope.—Turmeric, wheat flour, etc.

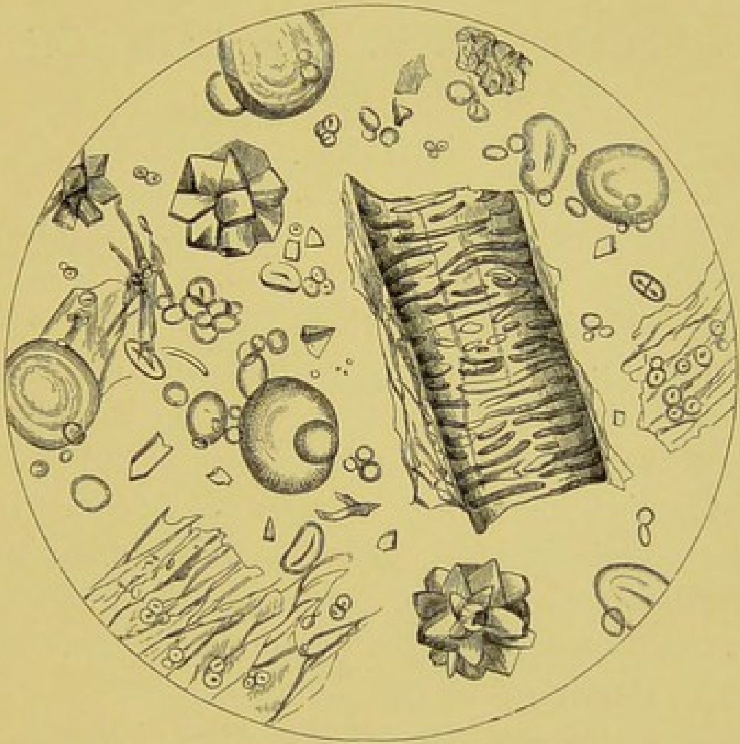


FIG. 262.—RHUBARB, MIXED WITH WHEAT FLOUR. × 220.

The figure shows the oxalate crystals; part of a reticulated vessel; bast tissue; and the small starch-granules of rhubarb, each with a strongly marked hilum: as well as the much larger starch-grains of wheat.

Ord. LILIIFLORÆ, Fam. LILIACEÆ.

SQUILL.

The dried bulb of *Urginea scilla*, ord. *Liliifloræ*, fam. *Liliaceæ*, with the outer scales removed.

Histology.—The bulb is chiefly made up of large polygonal, parenchymatous cells, with much mucilage; and spiral vessels also are present. The most characteristic feature, however, is the abundance of crystals of calcium oxalate, of which there are two modes of occurrence: in isolated rectangular prisms of very considerable dimensions, and in bundles or raphides, composed of minute acicular crystals, sometimes crossing one another. These characters are shown in the figure on the opposite page.

Extraneous Substances Detectable by the Microscope.—Flour; starches; wood-dust.

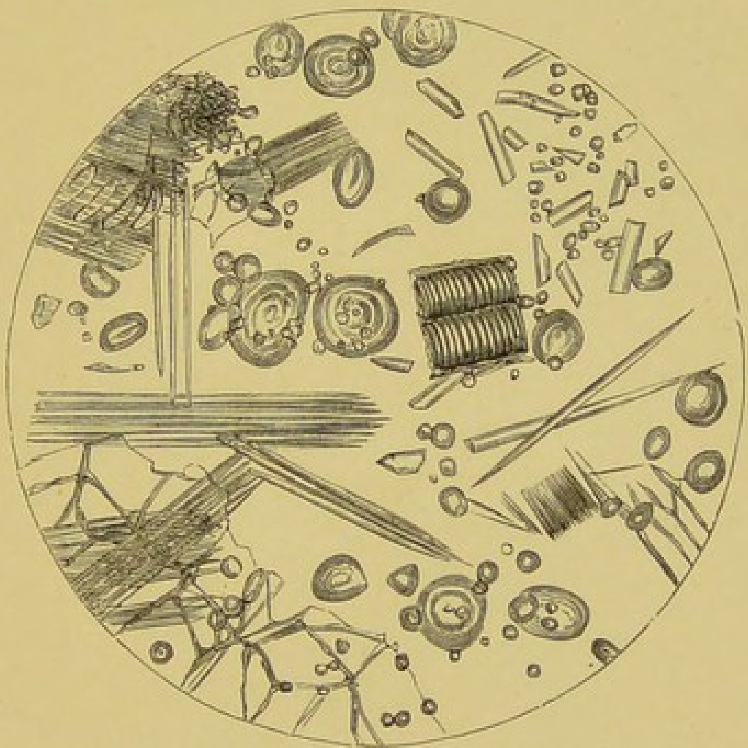


FIG. 263.—POWDERED SQUILL, MIXED WITH WHEAT FLOUR. × 220.

ORD. LEGUMINOSÆ, FAM. PAPILIONACEÆ.

LIQUORICE.

THE dried root and underground stem of *Glycyrrhiza glabra*, *G. glandulifera*, and other species, ord. *Leguminosæ*, fam. *Papilionaceæ*.

Histology.—In transverse sections of the root, a linear zone is observed, usually distant from the circumference about a third of the thickness of the root. The part beneath the cork cells and *without* the zone is traversed by bundles of thick-walled bast-fibres, surrounded by cellular tissue, calcium oxalate crystals being present in many of the cells; that *within* by numerous pitted ducts or vessels, some very large, as well as by bundles of wood-fibre (Figs. 264, 265, and 266). The cells of the cellular tissue, the basis of the root, are mostly filled with *starch-granules*, which are very characteristic: they are small, oval, and generally show an elongated central cavity (Fig. 266). The structure of the wood-fibre is not remarkable: the central cavity is well marked. Medullary rays, separating the bundles of wood-fibre, may be seen in sections of the older roots, and are composed for the most part of cells with rectangular outlines. The yellow colouring-matter of the root is situated chiefly in the wood-fibre, in the walls of the vessels, and in the bast-fibres.

Extraneous Substances Detectable by the Microscope.—Wheat; potato, rice, rye, and other starches; turmeric; excess of mineral matter. Liquorice was adulterated formerly to a much greater extent than now.[1]

[1] See paper 'On the Adulteration of Liquorice,' read by Dr. A. H. Hassall before the Medical Society of London, 1856.

[*For figures, see pp.* 339, 340, 341, *and* 342.]

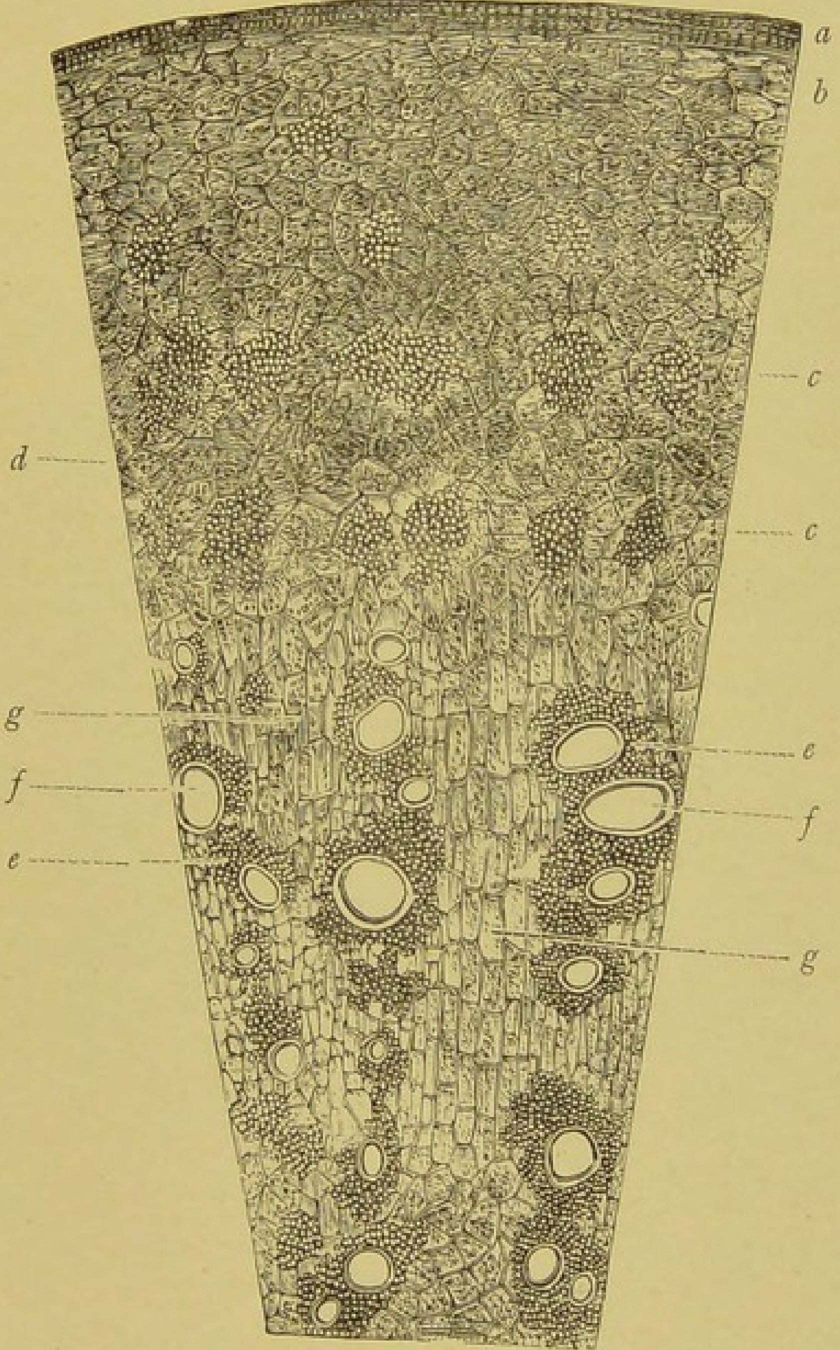


FIG. 264.—LIQUORICE ROOT: transverse section, showing (*a*) *cork*, (*b*) *cortex*, (*c, c*) bundles of *bast-fibres*, (*d*) connecting cellular tissue, (*e, e*) bundles of wood-fibre, with (*f, f*) vessels cut through, and (*g, g*) medullary rays. × 40.

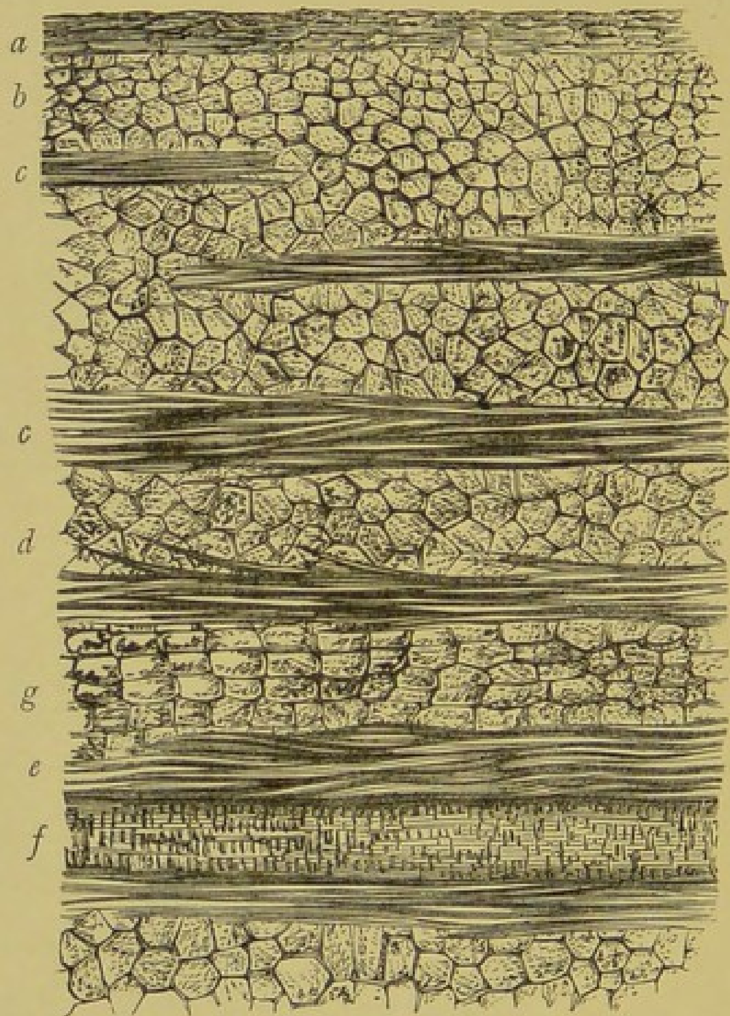


FIG. 265.—LIQUORICE ROOT: longitudinal (radial) section, showing most of the foregoing structures: (*a*) cork, (*b*) cortex, (*c*, *c*) bast-fibres, (*d*) connecting cellular tissue, (*e*) wood-fibres, (*f*) vessel, and (*g*) medullary ray. × 40.

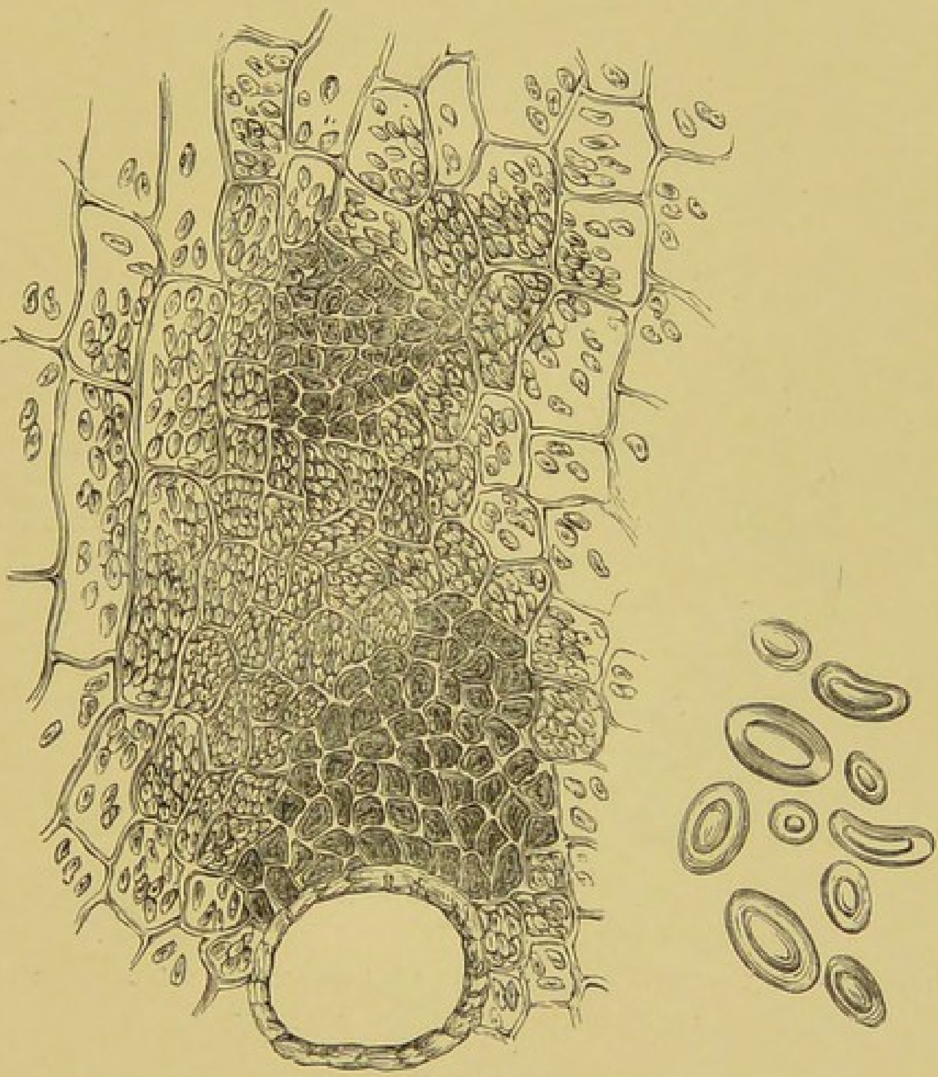


FIG. 266.—LIQUORICE ROOT: transverse section, exhibiting a vessel cut through; two wood-bundles; parenchyma, and part of a medullary ray (× 220); also the starch-granules, separately (× 400).

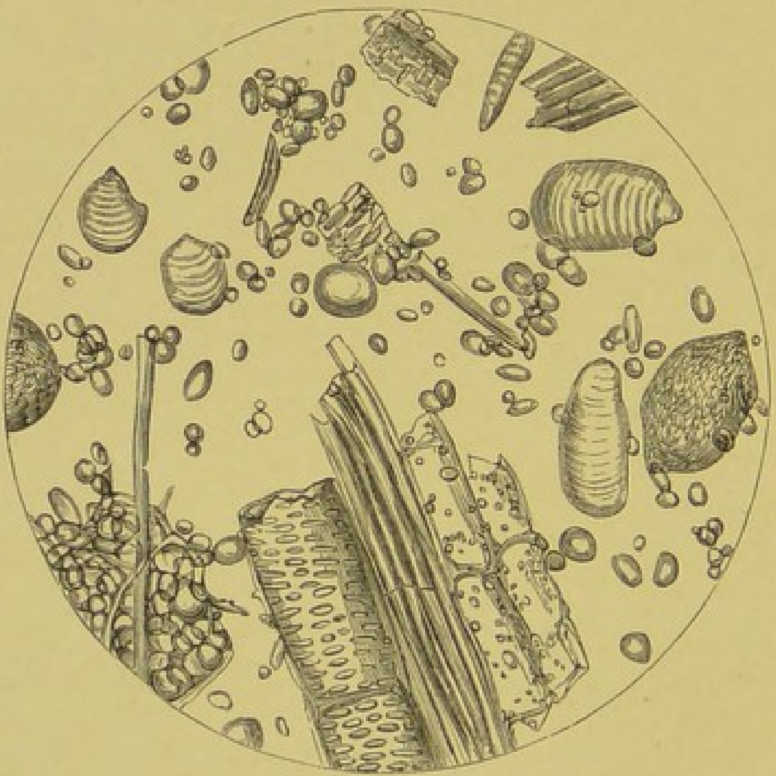


FIG. 267.—LIQUORICE POWDER, WITH AN ADMIXTURE OF TURMERIC AND EAST INDIAN ARROWROOT. × 220.

SECTION IV.

WATER.

WATER.

THOUGH producible by tedious operations in the laboratory, chemically pure water does not naturally occur. It is a sanitarian's ideal. Even when from unquestionable sources of supply, fresh water, with which alone this section is concerned, invariably contains in solution mineral salts and other substances derived from the inorganic world. Usually, in addition, various matters are held in suspension, and eventually deposited as sediment. In these last the microscopist is chiefly interested: but he can derive useful information, also, from an examination of the soluble salts, left as a residue when water is evaporated to dryness.

Extraneous Matters Detectable in Water by the Microscope.—Investigations of the objects carried in suspension, or deposited on standing, show that the unfiltered water of a pond or river is a microcosm, with a varied, living, and fecund population. It exhibits a characteristic vegetation and fauna, and there are present many other bodies, inanimate, but equally worthy of careful study; some of them mineral, others of organic origin. The living, as well as the dead matters, which the microscope reveals, are frequently of great significance as indicating the origin, nature, condition, and dietetic suitability or unsuitability of a particular sample of water. The purer sources of supply, such as deep wells and hill-side springs, yield a product as a rule exhibiting a sparse fauna and flora, comprising few genera and species: but water contaminated with decaying organic matter, as, for instance, with vegetable or animal remains, mill-refuse, or sewage, often teems with microscopic plant and animal life; because the requisite materials for sustenance and growth are there. Of certain organisms in particular, it can be affirmed that their occurrence is a sinister indication. Though not in themselves harmful, they show by their presence that the water is impure. And the greater the number, the higher is the probable degree of pollution. Some organisms there are, whose own life functions, though not hurtful, are productive of inconvenience to water consumers. A third class of organisms, the specific microbes of disease, or pathogenic bacteria, must be regarded as the most fearsome and dangerous of all. Water containing these must for all purposes even remotely associated with dietetics be rejected. Other plants, belonging to the same, or microbic family—certain common water-bacteria—may be dismissed as inoffensive, saprophytic forms: they are probably helpful scavengers, and in no way objectionable. In a like harmless fascicle, it is generally agreed, can be placed most of the group of diatoms.

The late Dr. Arthur Hill Hassall was the first to use the microscope systematically to ascertain the nature of the organic matter suspended in drinking water, and to show the practical and sanitary importance of a study of the microscopical fauna and flora observed.[1] His book, *A Microscopical Examination of the Water Supplied to the Inhabitants of London*[2] *and the Suburban Districts*, published in 1850, following a preliminary article by himself on the same subject in the *Lancet*, produced a sensation. It was shown that the water then supplied by the metropolitan water companies was impure to a degree which at the present time is with difficulty credible. The water of the River Thames, from which at Brentford, Barnes, Battersea, Vauxhall, and Lambeth six of the companies took their supplies, for delivery—unfiltered, or

1 'It was not until 1850 that the study of the organisms in drinking water was recognized as having a practical sanitary value. Dr. Hassal[l], of London, was the first to call attention to it.'—G. C. Whipple, 'The Microscopy of Drinking Water,' 1899, p. 1.

'The fact of the existence in large quantities of living productions belonging to several distinct divisions of the organic world, and for the most part entirely invisible to the common eye, in the waters in general use, was not, I believe, generally known until announced by myself in the pages of the *Lancet*, some weeks since.'—Evidence by Dr. Hassall before the General Board of Health. Report of the Board on the Supply of Water to the Metropolis, 1850, Appendix III., p. 57.

2 Samuel Highley, 32, Fleet Street.

most defectively filtered—to the public, was scarcely in a worse condition. Indeed, the water supplied by two of the companies actually exceeded, in animalcular contents, the unfiltered water of the Thames. In 1854 Dr. Hassall again examined the water supplied to the metropolis, and the results—which still were extremely unsatisfactory—were embodied in an elaborate monograph, with many fine plates, appended to the Report of the Committee for Scientific Inquiries in relation to the Cholera Epidemic of that year.[1] These disclosures powerfully operated in hastening on the adoption of remedial measures. In 1857, after the new Metropolis Water Act had come into operation, Dr. Hassall once more subjected to microscopical examination samples of water supplied from the service pipes of the water companies; and he reported thereon to the President of the General Board of Health.[2] A great improvement was manifest. The agitation, and subsequent legislation, had already done good. Immense progress has since been made. Half-a-century has passed; and it may be accepted as a statement of general accuracy that the quality of the water supplied to London has steadily improved. The difficulty now is connected with quantity rather than quality; not, of course, that the latter is incapable of considerable further improvement.

Of the Methods of Examining Water Microscopically.—(1) A process adopted by *Dr. Hassall*, still very generally used, and, with careful working, roughly quantitative, is to leave from 1 to 2 litres of the water under examination to stand overnight, and to decant all but about 200 c.c. The whole of this, with any sediment, is poured into a conical test-glass with a rounded bottom; and the vessel, lightly covered, is left for six hours. The supernatant liquid is now decanted, and the residual drops are transferred by a pipette to the slide for microscopical examination.—(2) *Dr. J. D. MacDonald* proposed to let down a circular disc of glass, or

[1] General Board of Health, Reports of Commissioners, 1854-55, xxi.

[2] Report to the Right Hon. W. Cowper, M.P., 'On the Microscopical Examination of the Metropolitan Water Supply, under the Provisions of the Metropolis Water Act.'—Accounts and Papers, 1857, xiii 149.

small watch-glass, into a litre of the water. After twenty-four hours the water is removed with a siphon, the disc or watch-glass is lifted out of the vessel, placed on filter-paper (to dry the under-surface), covered with a cover-glass, and forthwith microscopically examined. This method answers most satisfactorily when the amount of deposit is small.—(3) *A. L. Kean* recommended the approximately quantitative 'sand method': the filtration of 100 c.c. through clean sand, placed in a glass funnel plugged in the stem with wire gauze. After filtration, the sand, carrying any deposit, is washed with 1 c.c. of water into a watch-glass; and, after stirring, a part of the liquid decanted from the sand is transferred to a cell holding 1 cubic millimetre.—(4) *W. T. Sedgwick, G. W. Rafter, G. C. Whipple*, and others advise methods in principle based on Kean's. Half-a-litre of the water under investigation is filtered through a stratum, $\frac{3}{4}$ inch thick, of white sand or ground quartz, resting on a perforated caoutchouc stopper, provided with a cap of silk bolting cloth, at the bottom of a graduated cylindrical funnel holding 500 c.c. The stopper is removed; and the sand, charged with the sediment from the water, is washed into a wide test-tube with 5 or 10 c.c. of distilled water. The mixture is shaken, and the water, charged with the organisms, is rapidly decanted into another vessel. A definite fractional part, one-tenth, for instance, of this 'concentrate,' after agitation, is microscopically examined in a rectangular, brass-rimmed cell of known area; and the enumeration of the organisms can be effected by the aid of an eye-piece micrometer.—(5) *A. W. Blyth* uses a cylindrical tube, holding a little more than a litre and tapering below to a narrow opening which can accurately be closed by a plunger. Ground on to the conical end is a removable shallow glass cap for the reception of the deposit. When this has collected in the cap, the plunger is inserted, and the cap containing the sediment can be removed for microscopical examination of any organisms present.—(6) *W. J. Dibdin* filters 1 litre of water through a filter-paper, the contents of which are washed into a 'micro-filter,' made by plugging with a mixture of baked clay and kieselguhr the drawn-out capillary end of a piece of combustion-tubing. By drawing through the micro-filter the residual water, by means of a suction-pump, the deposit is collected into a compact, cylindrical layer, which can be measured in millimeters per litre, removed, and microscopically examined.[1]

It will be observed that the efforts of successive investigators have chiefly been directed to the twofold object of expressing numerically—(*a*) the comparative amounts of deposit, and (*b*) the quantities of organisms present in different waters.

Of the Nature and Significance of the Microscopic Flora and Fauna in Water.

A convenient general term for the microscopic organisms in water is 'plankton,'[2] a word applied by Dr. V. Hensen, Professor of Physiology at Kiel, to the minute drifting and floating organisms in lake- and ocean-water. Used in its broadest sense, this term includes the bacterial flora, as well as the less infinitesimal animal and vegetable forms occurring in water. The present volume treats mostly of the last-named, which, indeed, are sufficiently numerous and varied in character. The plankton of water includes:

1. *Living and defunct animals* (chiefly 'animalcula,'[3] crustacea, annelida, and entozoa), or their products.

2. *Bacteria or Microbes:* (*a*) Common water bacteria; (*b*) pathogenic bacteria; (*c*) filamentous or thread-bacteria. (Only these last bacteria dealt with in the present work.)

3. *Other forms of plant-life.*

But there are many other objects likely to be met with by the analyst of water; these come under the following categories:

4. *Fragmental organic matters, or débris:* (*a*) Animal; (*b*) vegetable.

[1] 'The Purification of Sewage and Water.'—W. J. Dibdin, 1898, pp. 88-95.

[2] πλαγκτος, roaming, wandering.

[3] Though not always so used in popular speech, the term *animalculum*, Eng., 'animalcule,' is best restricted to a member of one of the three following classes: *Ciliata*, *Flagellata*, and *Rotatoria*.

5. *Inorganic or mineral matter:* Clay, sand, chalk, and the like.

6. *Miscellaneous manufactured products,* such as threads of linen, cotton, wool, and silk.

Taking these classes of objects in order, omitting the two first divisions of the bacteria, which are outside the province of this work, and beginning with (1) **Living and defunct animals**—the following is a summary of the sub-kingdoms, classes, orders or groups, and genera of the more important aquatic animals with which it is desirable that the animalculist, or student of plankton, should have some acquaintance. The names of certain frequently occurring species are included. A corresponding summary of plant-forms will be found a few pages further on.

MICROSCOPIC FAUNA.

Sub-Kingdom.	Class.	Sub-Class, Order, or Group.	Genus.	Species.
PROTOZOA [Unicellular organisms, or pluricellular by aggregation. The lowest forms in the Animal Kingdom.[1]]	**Rhizopoda** [Minute, structureless, gelatinous animals, with pseudopodia. Mouth absent.]	RADIOLARIA [Pseudopodia long and ray-like.]	Actinophrys	*Eichornii*
				Sol
				viridis
		LOBOSA [Pseudopodia variable and short.]	Amœba	*coli*
			Arcella	
			Difflugia	
			Euglypha	
		RADIOLARIA	Heterophrys	
	Flagellata (Mastigophora) [Furnished with *flagellæ*. Sometimes included among the Infusoria, and called 'Flagellate Infusoria.' By some authors regarded as plants.]		Cercomonas	*hominis*
			Cœlomonas	*grandis*
			Cryptomonas	*ovata*
			Euglena	*viridis*
			Lamblia	*intestinalis*
			Monas	*attenuata*
			Peridinium	*cinctum*
			Phacus	*longicaudus*
			Synura	*uvella*
			Trichomonas	*intestinalis*
			Uroglena	

[1] It is difficult to differentiate the *Protozoa* from the *Protophyta*,—unicellular plants which contain chlorophyll, possess a vegetable mode of nutrition, but move, and otherwise resemble animal forms, such as the above Flagellata. *Peridinium*, for instance, contains starch and chlorophyll. But, as indicated in the text, some authorities would regard *Peridinium* as a plant. Professor Haeckel, of Jena, proposed that these doubtful organisms should be placed in a special group—the *Protista*, since called *Phytozoa*.

Sub-Kingdom.	Class.	Sub-Class, Order, or Group.	Genus.	Species.	
PROTOZOA —*continued*	**Ciliata (Infusoria)** [Furnished with *cilia*, not flagellæ—'Ciliate Infusoria.']		Amphileptus	*fasciola*	
			Balantidium	*coli*	
			Bursaria	*truncatella*, *vernalis*	
			Coleps	*hirtus*	
			Dileptus	*folium*	
			Enchelys	*nodulosa*	
			Euplotes	*charon*	
			Glaucoma	*scintillans*	
			Nassula	*elegans*	
			Oxytricha	*gibba*	
			Panophrys	*chrysalis*	
			Paramecium[1]	*aurelia*, *caudatum*, *chrysalis*	
			Pleuronema	*crassa*	
			Stentor	*Mülleri*, *polymorphus*	
			Stylonychia	*histrio*	
			Trachelocerca		
			Vorticella	*convallaria*, *nebulifera*	
			Zuplotes		
	Spongida		Spongilla	*fluviatilis*, (spicula of)	
ANNULOIDA	**Rotifera (Rotatoria)** [Organisms furnished with vibratory *cilia*, which, when moving, resemble revolving wheels.]		Albertia		
			Anuræa	*aculeata*, *cochlearis*	
			Brachionus	*pala*, *polyacanthus*	
			Chætonotus	*larus*	
			Colurus	*deflexus*	
			Diglena		
			Melicerta	*ringens*	
			Microcodon		
			Notholca		
			Polyarthra	*platyptera*	
			Rotifer	*vulgaris*	
			Synchæta		
	Scolecida	Nematoidea [Round-worms and thread-worms.]	Anguillula	*fluviatilis*	
			Ascaris	*lumbricoides*	Ova and larvæ of.
			Filaria	*dracunculus*, *sanguinis hominis*	
			Oxyuris	*vermicularis*	
			Trichina	*spiralis*	
			Trichocephalus	*dispar*	
		Trematoda [Flukes.]	Bilharzia	*hæmatobia*	
			Distomum	*hepaticum*	
		Cestoidea [Tape-worms.]	Bothriocephalus	*latus*	
			Tænia	*echinococcus*, *solium*	

[1] παραμήκ-ης oblong, oval: from παρα against and μῆκος length, in allusion to the oval form: *cf.* Lat. *ob-longus* (Murray). The word is sometimes incorrectly spelled 'Paramœcium.'

Sub-Kingdom.	Class.	Sub-Class, Order, or Group.	Genus.	Species.
ANNULOSA [Segmented or ringed.]	Crustacea [Shell-covered animals, with jointed appendages.]	Entomostraca	Bosmina	*longirostris*
			Canthocamptus	*minutus*
			Chydorus	*sphæricus*
			Cyclops	*quadricornis*
			Cypris	*virens*
			Daphnia	*pulex*
	Arachnida	Acarina	Hydrachna	*cruenta*
		Tardigrada	Macrobiotus	*Hufelandii*
	Annelida		Nais	*serpentina*
MOLLUSCA	Bryozoa (Polyzoa)		Pectinatella	*magnifica*
			Plumatella	*repens*

Some of the foregoing microscopic animals may be met with in water which can safely be consumed. Certain highly organized forms—such as *Daphnia, Cyclops,* and other Entomostracan Crustacea (Figs. 269, 270, 274, 279), for instance, appear to act as scavengers. By feeding on dead organic matter and lower forms of life, they assist in removing impurities. These animals are much larger than the majority of microscopic organisms occurring in water, and are visible, without a lens, as minute, white, darting specks. Few persons, except, perhaps, lovers of locomotive cheese, populous game, or long-hung venison, would by preference drink water peopled by many of these active little creatures. And such water, though possibly harmless, cannot be pure. If a small number only be present, the indications are more satisfactory: but it is usually considered that a litre of water of great purity should yield no animalcula, nor other animals, living or dead, nor flora (apart from harmless bacteria), and that the sediment, if any, should be wholly mineral matter.

Other forms included in the above list are seldom discovered in uncontaminated water, and their appearance is a sign of danger. Not in themselves necessarily harmful, they abound in ponds and similar stagnant water, and point to contamination with decaying or putrescent organic matter, often to the presence of sewage. Such forms are the rhizopods, *Actinophrys* (Figs. 273, 279), and *Amœba*; the flagellate organisms, *Euglena* (Fig. 274), *Synura, Cercomonas, Cœlomonas*, also, probably, *Peridinium* (Fig. 274); and the ciliate infusoria, especially *Paramecium*[1] *aurelia, P. caudatum, P. chrysalis, Glaucoma scintillans, Oxytricha gibba, Stentor, Vorticella*, and *Trachelocerca* (see Figs. 268, 271, 275, 280, etc.). The *Rotatoria* (Figs. 269, 275, 277, etc.), *Acarina*, and *Tardigrada* also are denizens of stagnant water.

'These animalcules [the *Ciliata*, or ciliate infusoria] are generally very voracious, notwithstanding the simplicity of their organization; and it is noteworthy in a hygienic sense that if the water in which they are found is deficient in organic matter available for food, either from its actual purity, or from the thorough decay of what may have been originally present, the transparency and leanness of their bodies, and the restlessness of their search for aliment, will show that they are in a half-starved condition. . . . The notable presence of the Ciliata . . . would indicate not only stagnant water, but such as may contain organic matter in solution to some relative extent not yet precisely determinable.'[2]

More dangerous and disgusting than the infusoria and associated organisms are certain objects which find their way into water contaminated by animal dejecta. Such are the ova and larvæ of entozoa, or endoparasites, belonging to the class Scolecida. Occasionally the worms themselves are found. Some of these parasites have been described and figured in a previous section; and mention has been made of the serious consequences which may arise from their introduction into the body (see pp. 238-240, and 246-251). *Ascaris lumbricoides* (Fig. 205, p. 244), *Oxyuris vermicularis* (Fig. 203 A, B, p. 243), *Bothriocephalus, Bilharzia, Distomum*

[1] *Paramecium* occurs in considerable numbers only in water highly charged with decaying organic matter. In 1850 Dr. A. H. Hassall discovered innumerable *Paramecia* in the water of the Thames, below Brentford; but higher up at Kew, where the water was purer, they had nearly disappeared. This organism is sometimes named the 'slipper animalcule,' in allusion to its shape.

[2] J. D. Macdonald, 'A Guide to the Microscopical Examination of Drinking Water,' 1883, p. 50.

(Fig. 203 C, p. 243), *Filaria sanguinis hominis*, *Filaria dracunculus* (the Guinea-worm), and *Trichocephalus dispar* (Fig. 204, p. 244), have been discovered in water; also the eggs and proglottides of *Tænia solium*, *T. saginata*, and *T. echinococcus* (Figs. 199, 200, and 201).

Water to be used for drinking purposes should be subjected to a very careful search for the ova of worms belonging to the order of parasites. 'All spherical and ovoid bodies with albuminous-looking and segmented contents should be looked upon with suspicion, until their real nature is determined.'[1] By no other means are endoparasitic organisms more likely to be transmitted from one host to another, than by the medium of drinking water.

A comparatively innocent, minute worm, *Anguillula* (Figs. 270, 271), not infrequently occurs in water; and a worm-like annelid, *Nais* (Figs. 273, 276, 279), is also found: but, apart from the fact that their appearance is indirect evidence of impurity, no especially baleful significance attaches to the presence of these organisms. Sewage, however, has sometimes been observed to contain many annelids.

Certain of the protozoa impart characteristic 'tastes' and 'odours' to water, or render it turbid and unfit for laundry use. *Uroglena* (a genus of Flagellata) imparts to water an offensive odour resembling that of cod-liver oil. The odour appears to be associated with the disintegration of the colonies. *Synura* in 1892 was the cause of a 'cucumber odour' observed in the water supplied to Boston, Massachusetts. *Peridinium* (Fig. 274) has been known to impart to water 'a very ancient and fish-like' smell; and the Bryozoon, *Pectinatella*, has been accused of a similar offence.

The spicula of fresh-water sponges are very frequently observed during the microscopical examination of ordinary waters: but they possess no great significance.

Passing now to (2) *Bacteria*, and to (3) *Other Forms of Plant Life*, a summary here follows of the classes or groups, genera,

[1] J. D. Macdonald, 'A Guide to the Microscopical Examination of Drinking Water,' 1883, p. 12.

and—in many instances—prominent species, of the fresh-water plants most important to the microscopist of water.

MICROSCOPIC FLORA.

Division or Group.	Class.	Order, Tribe, or Family.	Genus.	Species.
DIATOMS	**Diatomeæ or Diatomaceæ** [Usually amber-coloured or brown, and sometimes called 'Brown Algæ.' Uni-cellular plants, possessing siliceous cell-walls, surrounded by sarcode. Forms very various: often beautifully marked. Some motile.]	Tr. Raphidieæ. [Possessing a distinct raphe or cleft.]	Amphora	
			Cocconeis	
			Cocconema	*lanceolatum*
			Cymatopleura[1]	*solea*
			Cymbella	*Ehrenbergii*
			Gomphonema	*capitatum*
			Gyrosygma	
			Navicula	*amphisbæna*, *sphærophora*, *viridis*
			Pinnularia	*grandis*
			Pleurosigma	*attenuatum*
		Tr. Pseudo-raphidieæ [With a false raphe: a mere line or space.]	Asterionella[2]	*formosa*
			Diatoma	*vulgare*
			Epithemia	
			Eunotia	
			Fragilaria	*capucina*
			Meridion	*circulare*
			Nitzschia[2]	*elongata*, *sygmoidea*, *Sigma*
			Surirella	
			Synedra	*ulna*, *minutissima*
			Tabellaria	*fenestrata*
		Tr. Crypto-raphidieæ. [Without a raphe.]	Cyclotella	*operculata*
			Melosira	*varians*
SCHIZO-PHYCEÆ [Plants propagated by cell-division: no chlorophyll; or chlorophyll plus cyanophyll; or some other pigment.]	**Schizomycetes** [Lower Fungi: multiply by cell-division.]	(*a*) Common Water Bacteria.	—	
		(*b*) Pathogenic Bacteria.	—	
		(*c*) Filamentous or Thread-Bacteria, of especial significance to the water-examiner. [Filamentous plants, without chlorophyll or related pigment.]	Beggiatoa (colourless filaments)	*alba*
			Cladothrix (colourless filaments)	*dichotoma*
			Crenothrix (yellowish-brown filaments, coloured by iron)	*Kühniana*
			Leptothrix (filaments generally colourless)	*ochracea*

[1] = *Sphinctocystis* (Hassall). [2] Genus founded by Dr. A. H. Hassall.

Division or Group.	Class	Order, Tribe, or Family.	Genus.	Species.
SCHIZOPHYCEÆ —*continued*	**Cyanophyceæ** (Blue-green algæ) [Unicellular or multicellular plants, often associated by successive cell-division into filaments, or irregular or spherical masses, containing chlorophyll and some other pigment. Colour, blue-green, orange, red, brown, or violet: never bright green.]		Anabæna	*circinalis*, *flos-aquæ*
			Chroöcoccus	
			Hassallia (Berkel: afterwards Trevisan: later Bornet and Flahault[1])	*byssoidea*
			Lyngbya	
			Microcystis	
			Nostoc	
			Oscillatoria	
			Rivularia	
			Scytonema	
			Sirosiphon	
TRUE ALGÆ [Plants very various: some unicellular; others similar to protozoa; others branching complex forms, resembling higher plants. Contain starch and chlorophyll. Colour, in the fresh-water forms, usually green.]	**Chlorophyceæ** (The true, or green, algæ)	Fam. DESMIDIACEÆ [Unicellular or multicellular, bright green colour: cells divided into two equal halves.]	Closterium	*lunula*, *acerosum*
			Cosmarium	
			Desmidium	
			Penium	*Brebissonii*
			Sphærozosma	*vertebratum*
		Fam. ZYGNEMACEÆ [Multicellular cylindrical cells, joined and forming articulated simple threads.]	Mesocarpus[2]	
			Spirogyra	
			Staurocarpus[2]	
			Zygnema	
		Ord. PROTOCOCCOIDEÆ [Unicellular: frequently grouped into clusters.]	Palmella	
			Pediastrum	*Boryanum*
			Protococcus	*viridis*
			Scenedesmus	*quadricauda*, *acutus*, *obtusus*
			Tetraspora	
			Urococcus (Ouracoccus)[3]	
		Ord. VOLVOCINEÆ [Unicellular: in clusters.]	Eudorina	*elegans*
			Pandorina	*morum*
			Volvox	*globator*

1 Genus allied to the Oscillatoriaceæ, named after Dr. A. H. Hassall.

2 Genus defined and established by Dr. Hassall.

3 Hassall.

Division or Group.	Class.	Order, Tribe or Family.	Genus.	Species.
TRUE ALGÆ —*continued*	**Chlorophyceæ**— *continued*	Ord. Confervoideæ [Multicellular: simple or branched filaments.]	Conferva	*ærea*
			Ulothrix	
			Cladophora	
			Chætophora	
		Ord. Siphoneæ [Unicellular: cells tubular, often branched.]	Vaucheria	
	Charoideæ	Ord. Characeæ (Stone worts)	Chara	
			Nitella	
EUMYCETES (The Higher Fungi) [Destitute of starch and chlorophyll.]		Fam. Saccharomycetes (Yeasts)	Saccharomyces	*cerevisiæ*
		Zygomycetes	Mucor	*mucedo*
		Ascomycetes [With endogenous spores enclosed in an *ascus* or sac.]	Aspergillus (Yellowish-green mould)	*glaucus*
			Penicillium (Blue mould)	*glaucum*, etc.
		Oomycetes	Leptomitus [Found in sewers and on the banks of foul streams.]	
			Saprolegnia [Parasitic on animals or plants in water: the cause of 'salmon disease.']	*ferox*
VARIOUS PLANTS (More highly organized)			Lemna (Duck-weed)	
			Potamogeton (Pond-weed)	
			Sphagnum (Bog-moss)	

It has been stated that bacteria are mostly omitted from this book: but certain bacterial plants known as the filamentous or thread bacteria, presenting superficial resemblances to the Oscillatoriaceæ, are so especially indicative of a high degree of organic contamination that they are included in the summary, as of almost prime importance to the scientific examiner of water.

Many of the plant-forms named in the above summary are of exceedingly common occurrence in water, and only a limited number can be regarded as suspicious or objectionable. These latter include the *Eumycetes* or Higher Fungi (Figs. 268, 271, 273, 280), the hyphæ and spores of which (particularly of such forms as *Leptomitus*) occur more often in sewage than in water: some of the thread bacteria, especially *Beggiatoa alba*, the presence of which generally indicates sewage contamination,[1] *Cladothrix*, and possibly *Leptothrix* (Figs. 278, 279, 281, 282): also certain of the *Cyanophyceæ*, or bluish-green water-plants, such as *Nostoc*, *Anabæna*, and the *Oscillatoriaceæ*, which can flourish only in stagnant, organically-polluted water. *Anabæna* is especially objectionable, because it imparts what has been described as a 'pig-pen' odour; and a suffocating smell has been attributed to *Lyngbya*. *Beggiatoa* is sometimes the cause of an odour of sulphuretted hydrogen.

The *green* water-plants, *Chlorophyceæ*, or true *Algæ* (Figs. 268, 271, 273, etc.), are not, as a rule, considered suspicious or hurtful: but some, such as *Volvox*, and *Pandorina* (Fig. 271), impart a fish-oil odour; and the *Desmids* (Figs. 273, 277), included in this group, are very often found in surface water, more or less impure. The *Diatomaceæ*, a group of very beautiful microscopic objects, and among the most commonly occurring of aquatic plants, have no hygienic importance; though certain genera, such as *Asterionella* (Figs. 270, 271, 282), *Meridion*, and *Tabellaria*, have been observed to impart an aromatic odour. Many diatoms are represented in the illustrations which follow, notably in Figs. 269, 270, 271, 273, 274, 275, 280, and 282.

Fossil diatoms are sometimes met with in the sediments of river waters. Fig. 272 shows some examples discovered

[1] *Beggiatoa*, one of the sulphur-storing fungi, is so commonly occurrent in sewage effluents, where it sometimes chokes the pipes, that it is colloquially termed 'the Sewage Fungus.' See Royal Commission on Sewage Disposal, Interim Report, 1902, for many references to this plant.

by the author in the deposit from a specimen, submitted to him for analysis, of water from the River Pará, Brazil.

4. *Fragmental Organic Matters, or Débris.*—Among the most offensive objects, of human or animal origin, which have been discovered in water intended for drinking use are: fragments of voluntary or striated muscle-fibre (Figs. 268 and 275: see also, *ante*, Fig. 196, p. 235), probably derived from human or animal dejecta present in sewage; human hair; the hairs of animals (Figs. 268, 270, 276, 279); small, non-nucleated epithelial scales from the human cuticle; and the larger, nucleated scales of epithelium from the buccal and other mucous surfaces. In addition may be mentioned the scales of lepidoptera, and various other parts of insects; also the barbs or spikes of feathers. All these objects, entirely foreign to water of average purity, and some of the most self-evident significance, have from time to time been observed.

Among the very numerous fragmental *vegetable* matters, not infrequently to be detected in impure water, are pieces of wood-fibre, and threads of cotton (Fig. 274) and flax, derived from paper: also particles of those cellular and vascular elements of plants, described in other sections of this book—*e.g.*, cuticular, epidermal, and parenchymatous tissues; scalariform, reticulated, spiral, and other forms of vessels; the pitted tracheides, or 'discoidal tissue,' of deal and other coniferous woods (see Fig. 122, p. 133); phloem, bast, or liber fibres; multicellular and simple vegetable hairs (Figs. 275 and 276); pollen grains (Figs. 123 and 124, under HONEY); starch-granules (Fig. 275 also Figs. 3, 7, 9, 11, 13, 15, etc., Section I.); and the cells of saccharomycetes and torulæ (Figs. 26 and 27, p. 41). Fragments of the husk of wheat, barley, and oat are by no means uncommon (Figs. 2, 6, and 10, Section I., and Figs. 275, 276, 278, 281, this section).

5. *Inorganic or Mineral Matter.*—Water of great organic purity may contain in suspension a considerable amount of finely divided mineral matter. Clay, marl, chalk, and sand are often present, and impart a characteristic turbidity, dis-

appearing only very slowly, in the cases of clay and marl especially, as the liquid gradually becomes clear by the subsidence of the floating particles. The cloudiness caused by clay and fine sand is yellowish-white. The microscopical examination of siliceous matter, so deposited, usually reveals many thin, angular, colourless particles (Figs. 272, 278): sometimes intermingled and liable to be confused with splinters or scales of glass, derived from the vessel or cover-glasses used. Occasionally, fragments of sand exhibit water-worn or rounded outlines: this is more often the case with calcareous and argillaceous particles, of which the first-named are identified by their ready solubility in acids.

6. *Manufactured Products.*—These comprise numerous kinds of factory or domestic refuse, and may be of animal or vegetable origin. Wool, cotton, hemp-fibres from string, silk threads, fragments of wood, straw (Fig. 278), bran, and the like, are to be found. Some of these have already been mentioned under fragmental organic matters.

In conclusion, reference must again be made to the value, in certain cases, of a microscopical examination of the solid residue of the evaporation of water: whether it be crystalline or amorphous; if the former, the shape of the crystals, how acted upon by reagents, etc.

The fifteen figures which follow include representations of the more common forms constituting the plankton, or microscopic fauna and flora, likely to be discovered in water more or less charged with organic matter in a decaying condition. Most of the miscellaneous objects, to which allusion has been made, are also figured. The numerous organisms shown (except those in Fig. 272) were present in the unfiltered, or very imperfectly filtered, Thames and other water supplied to London in 1850-55. The nature of the vegetable and animal forms discovered, and of the miscellaneous matters associated therewith, will be seen to furnish the clearest proofs of the sewage-polluted and repulsive condition of the water at that period—now, fortunately, in the 'historic past;' and water-sediments, exhibiting similar characteristics, even in far smaller degree, should be considered weighty evidence against the quality and wholesomeness of the waters which have yielded them. The classified summaries on pp. 350-352 and 355-357, together with the following illustrations, should be serviceable in the identification of the most common algæ, infusoria, crustacea, and other forms of plankton likely to be met with in specimens of river and shallow-well water.

[*For figures, and names of the objects, see pp.* 362-391.]

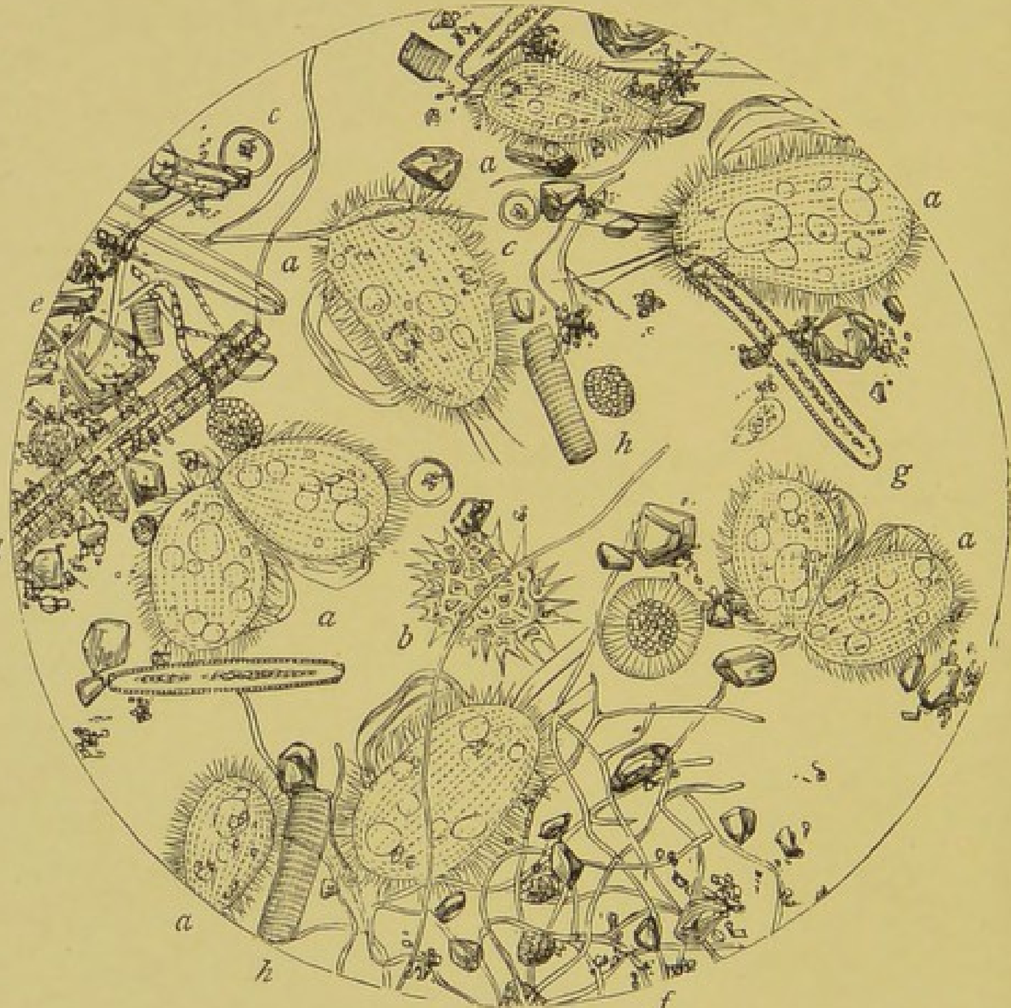


FIG. 268.—MICROSCOPIC FAUNA AND FLORA, OR PLANKTON, OF WATER; AND MISCELLANEOUS DÉBRIS.

[*Magnification of objects in this and the following figures,* × 220, *unless otherwise stated.*]

FAUNA.

CILIATA (INFUSORIA).

a, a, Paramecium aurelia.[1]

FLORA.

DIATOMACEÆ.

c, Cyclotella operculata ;
g, g, Nitzschia (Hassall) *linearis.*

CHLOROPHYCEÆ (ALGÆ).

b, Pediastrum Boryanum.

EUMYCETES (THE HIGHER FUNGI).

f, Hyphæ.

MISCELLANEA.

d, Animal hair (wool) ;
e, Grit and organic débris ;
h, Muscle-fibre.

× 220.

[1] The unicellular organism, *Paramecium*, is reproduced sexually and asexually. The opposite figure shows a stage of the first-named process ('conjugation')—two pairs of individuals conjugating for the purpose of the fusion of the male and female pronuclei. Fig. 277, p. 380, illustrates in the same genus asexual reproduction, or agamogenesis, the simple transverse fission, or dividing, of one individual organism into two other cells.

FIG. 269.—PLANKTON.

FAUNA.

CILIATA (INFUSORIA).

i, i, Coleps hirtus ;
j, Stylonychia histrio ?
k, Enchelys nodulosa.

ROTIFERA.

g, Anuræa cochlearis ;
h, Anuræa aculeata.

ENTOMOSTRACA.

b, Daphnia pulex, mas. ; } × 25.
d, Daphnia pulex, fem. }

FLORA.

DIATOMACEÆ.

a, a, Synedra ulna ;
c, Cyclotella operculata ;
e, Nitzschia (Hassall) *sigmoidea ;*
f, Pleurosigma attenuatum.

× 220.

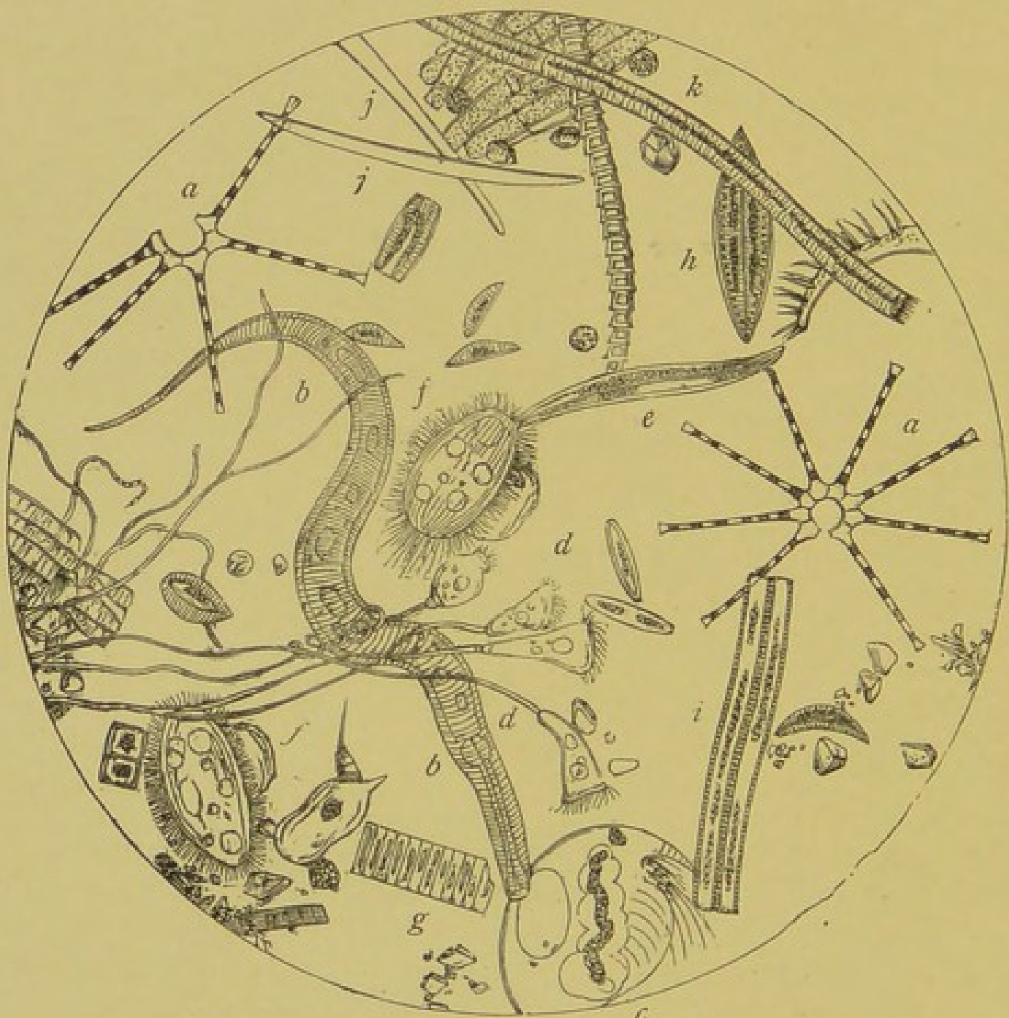


FIG. 270.—PLANKTON.

FAUNA.

CILIATA (INFUSORIA).

f, f, Paramecium chrysalis ;
d, Vorticella nebulifera.

ENTOMOSTRACA.

c, Bosmina longirostris. × 100.

NEMATOIDEA.

b, Anguillula fluviatilis.

FLORA.

DIATOMACEÆ.

a, a, Asterionella (Hassall) *formosa ;*
e, Pleurosigma attenuatum ;
g, Himantidium undulatum (?)
h, Cymbella Ehrenbergii ;
i, Nitzschia Sigma (?)

MISCELLANEA.

j, j, Spicula of fresh-water sponge ;
k, Hair of mammal (wool).

× 220.

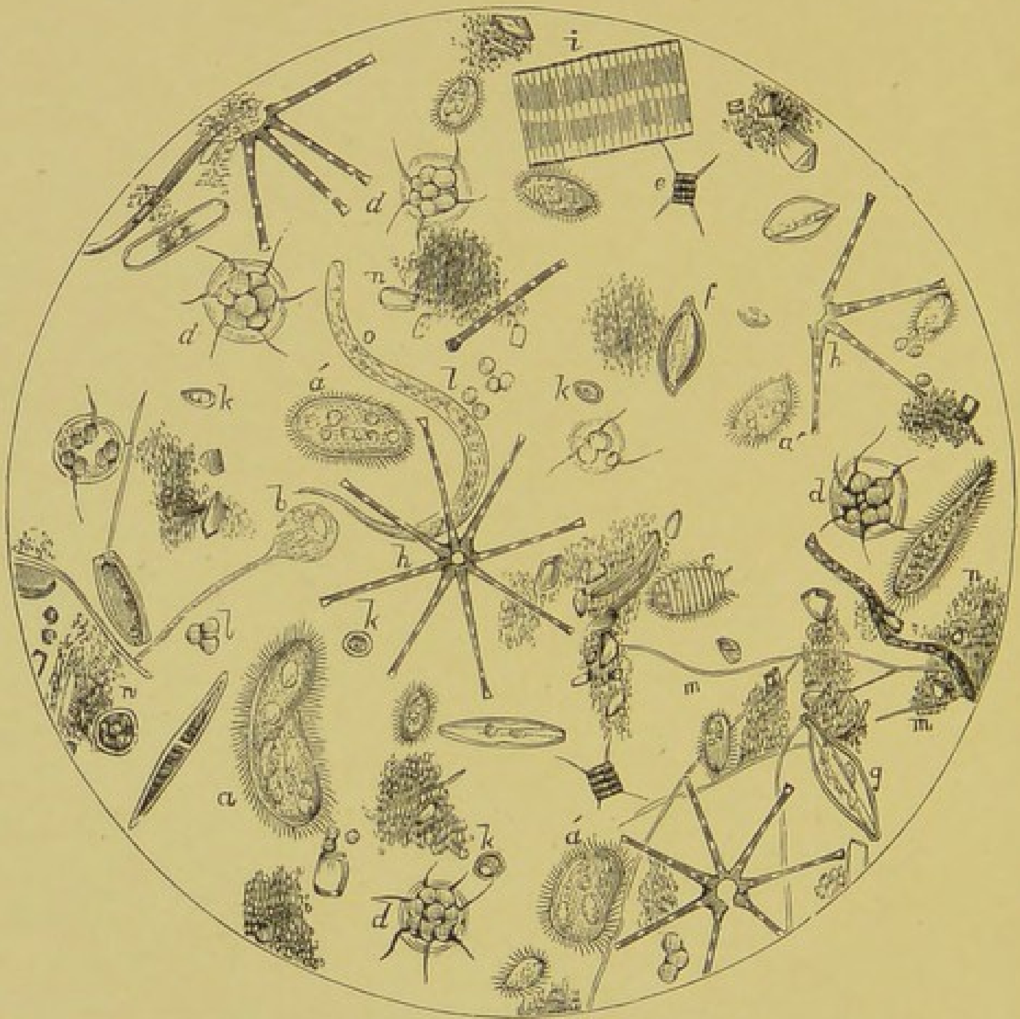


FIG. 271.—PLANKTON.

FAUNA.

CILIATA (INFUSORIA).

a, *Paramecium aurelia ;*
a′, *a′*, *Panophrys chrysalis ;*
c, *Coleps hirtus ;*
b, *Vorticella convallaria.*

NEMATOIDEA.

o, *Anguillula fluviatilis.*

FLORA.

DIATOMACEÆ.

f, *Navicula amphisbœna ;*
g, *Navicula sphœrophora ;*
h, *h*, *Asterionella* (Hassall) *formosa ;*
i, *Fragilaria capucina.*

CHLOROPHYCEÆ (ALGÆ).

d, *Pandorina morum ;*
e, *Scenedesmus quadricauda.*

EUMYCETES.

m, Hyphæ.

MISCELLANEA.

k, Brown active sporules ;
l, Stationary green sporules ;
n, Organic and earthy matter.

× 220.

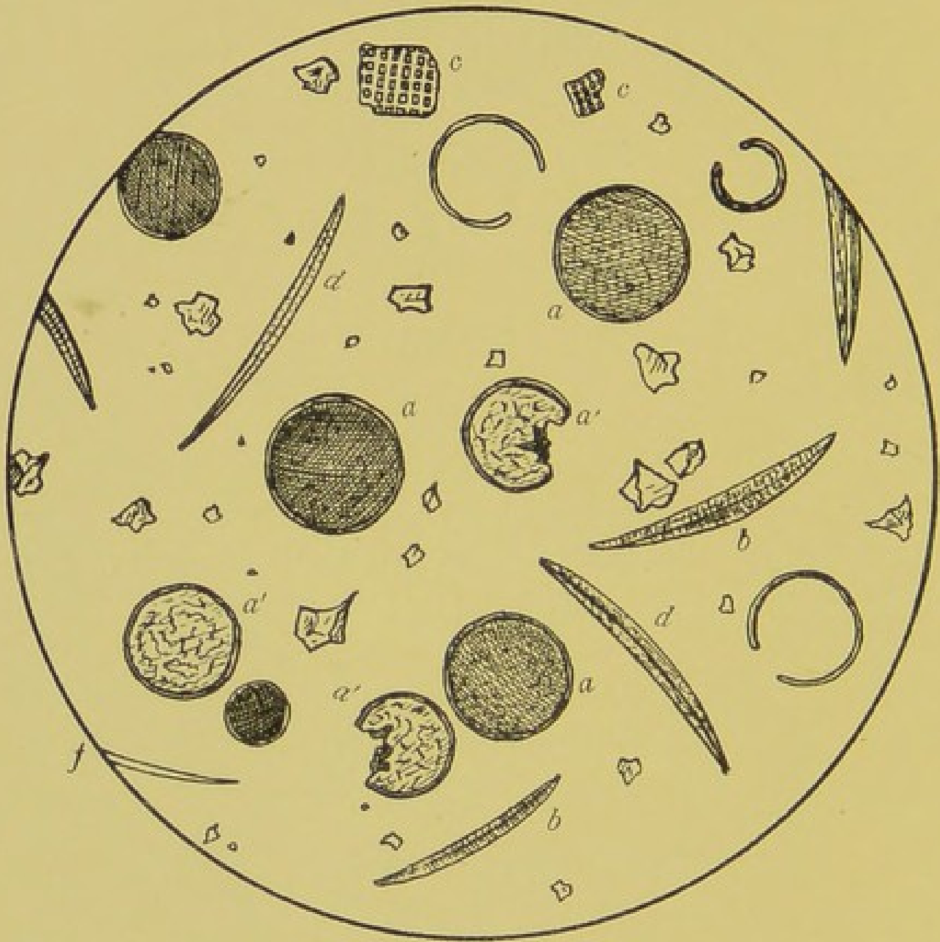


FIG. 272.—DEPOSIT FROM WATER OF THE RIVER PARÁ, BRAZIL, CONTAINING FOSSIL DIATOMS.

[E. G. Clayton, *del.*]

FLORA.

DIATOMACEÆ.

b, *Cocconema* ;
c, *c*, *Isthmia*(?) ;
a′, *a′*, *Mastogonia* ;
d, *d*, *Nitzschia* ;
a, *a*, *Stephanodiscus*.

MISCELLANEA.

e, Sand, and earthy matter.
f, *Spiculum* of sponge.

× 220.

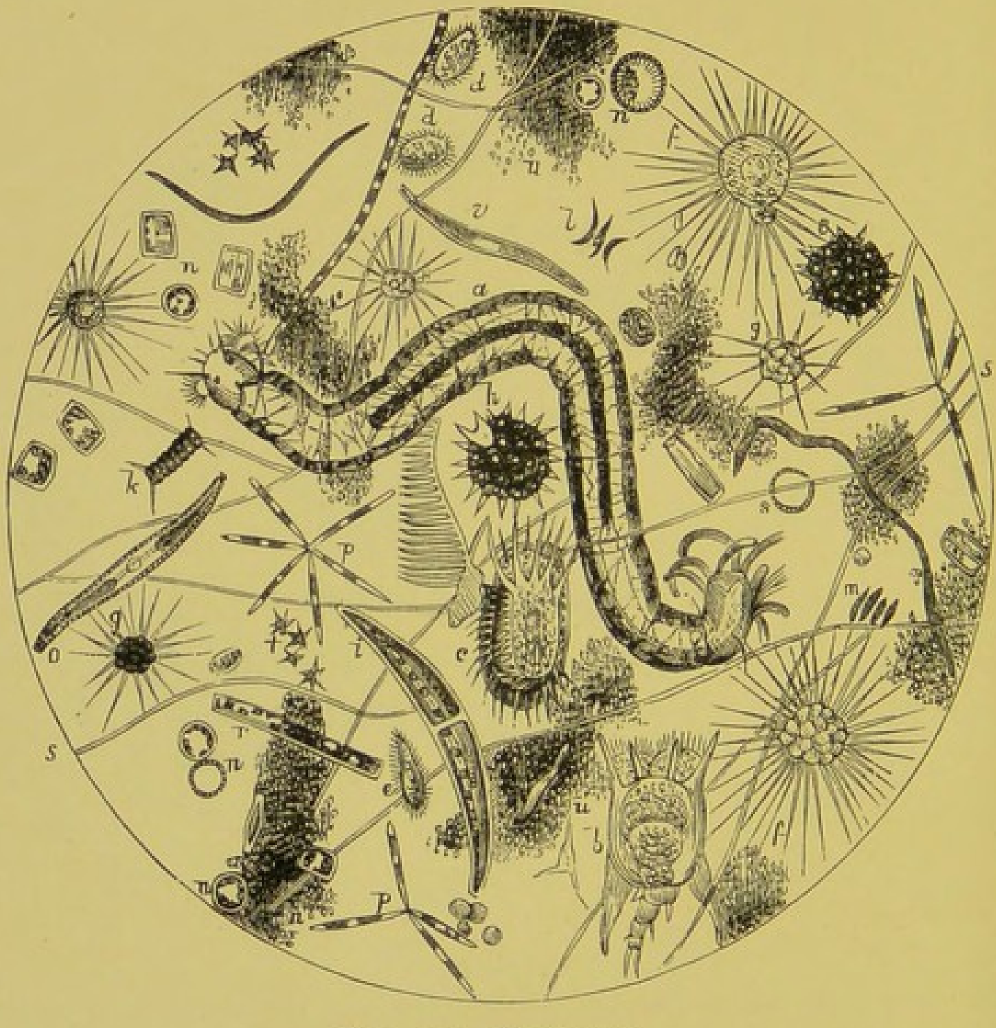


FIG. 273.—PLANKTON.

FAUNA.

RHIZOPODA.

f, f, Actinophrys Sol.;
g, Actinophrys viridis.

CILIATA (INFUSORIA).

c, Euplotes charon;
d, d, Glaucoma scintillans;
e, Amphileptus fasciola.

ROTIFERA.

b, Brachionus polyacanthus.

ANNELIDA.

a, Nais. × 12.

FLORA.

DIATOMACEÆ.

n, Cyclotella operculata;
o, Nitzschia (Hassall) *Sigma*;
p, p, Synedra minutissima;
r, Melosira varians;
v, Pleurosigma attenuatum.

CYANOPHYCEÆ.

t, Tetrapedia (?).

CHLOROPHYCEÆ (ALGÆ).

h, Pediastrum Boryanum. × 100.
i, Closterium lunula;
k, Scenedesmus quadricauda;
l, Scenedesmus acutus;
m, Scenedesmus obtusus.

EUMYCETES.

s, Hyphæ.

MISCELLANEA.

u, Organic débris and earthy matter.

× (except *a* and *h*) 200.

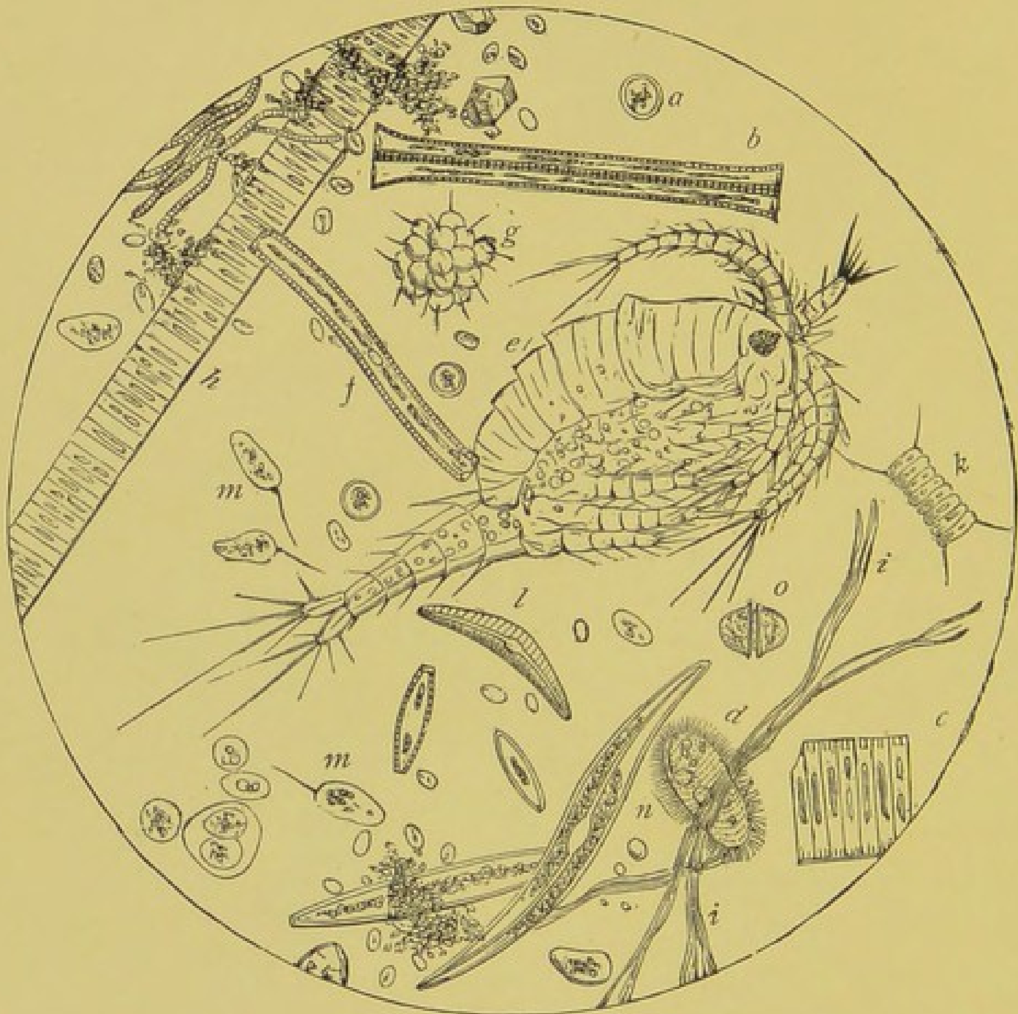


FIG. 274.—PLANKTON.

FAUNA.

MASTIGOPHORA (FLAGELLATA).

m, *m*, *Euglena viridis*;
o, *Peridinium cinctum*;

CILIATA (INFUSORIA).

d, *Paramecium chrysalis*.

ENTOMOSTRACA.

e, *Cyclops quadricornis*. × 100.

FLORA.

DIATOMACEÆ.

a, *Cyclotella operculata*;
b, *Synedra ulna*;
c, *Fragilaria capucina*;
h, *Himantidium undulatum* (?);
f, *Nitzschia linearis*;
l, *Cocconema lanceolatum*;
n, *Pleurosigma attenuatum*.

CHLOROPHYCEÆ (ALGÆ).

g, *Pediastrum Boryanum*;
k, *Scenedesmus quadricauda*.

MISCELLANEA.

i, Fibres of cotton.

× 220.

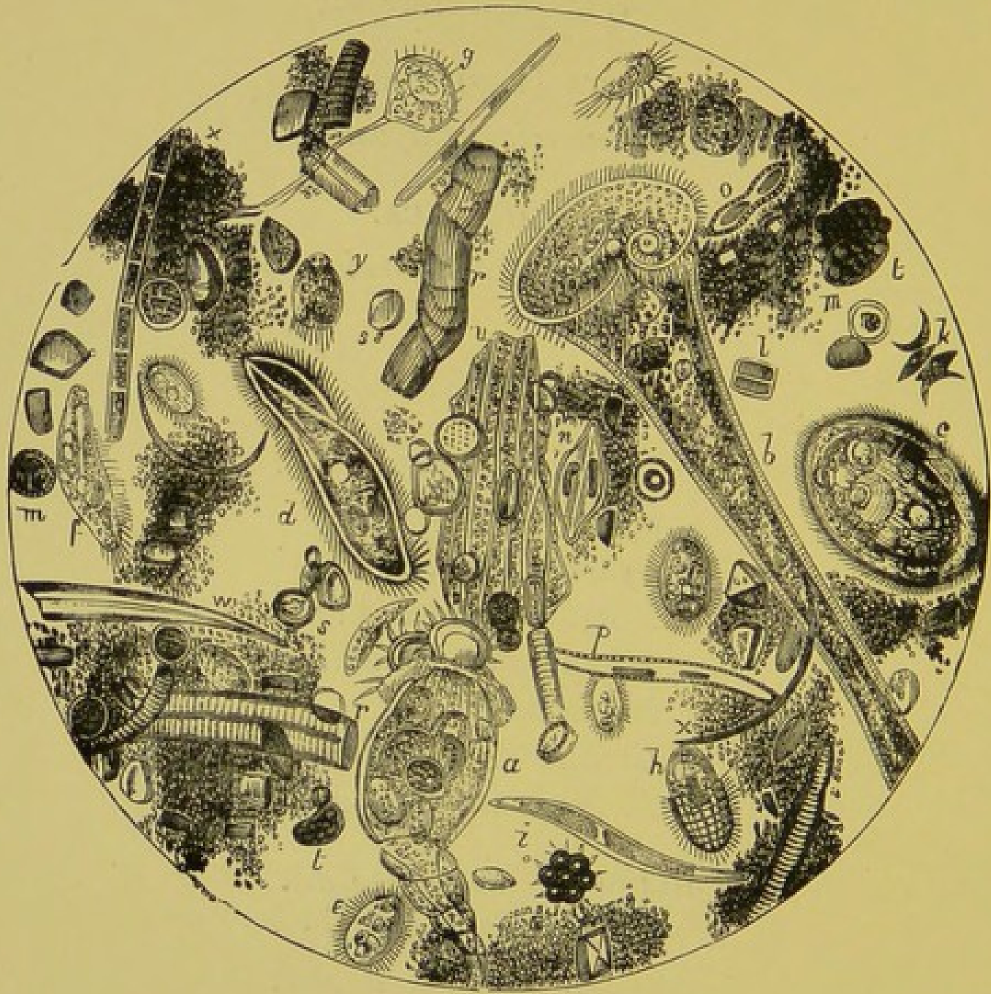


FIG. 275.—PLANKTON, ETC.

FAUNA.

CILIATA (INFUSORIA).

b, *Stentor Mülleri*;
c, *Bursaria vernalis*;
d, *Paramecium aurelia*;
e, *Glaucoma scintillans*;
f, *Oxytricha gibba*;
g, *Vorticella convallaria*;
h, *Coleps hirtus*.

ROTIFERA.

a, *Brachionus amphiceros*;
y, *Polyarthra platyptera* (?).

FLORA.

DIATOMACEÆ.

l, *Melosira varians*;
m, *Cyclotella operculata*;
n, *Navicula amphisbœna*;
o, *Cymatopleura* (W. Smith[1]) *Solea*;
p, *Nitzschia sigmoidea*.

CHLOROPHYCEÆ (ALGÆ).

i, *Pediastrum Boryanum*;
k, *Scenedesmus acutus*.

MISCELLANEA.

r, Fragments of muscular fibre;
s, Starch granules of wheat;
t, Starch;
u, Husk of wheat;
w, Hairs of wheat;
x, Earthy and organic matter.

× 220.

[1] Genus founded by A. H. Hassall, as *Sphinctocystis*—a better name than W. Smith's.—E. G. C.

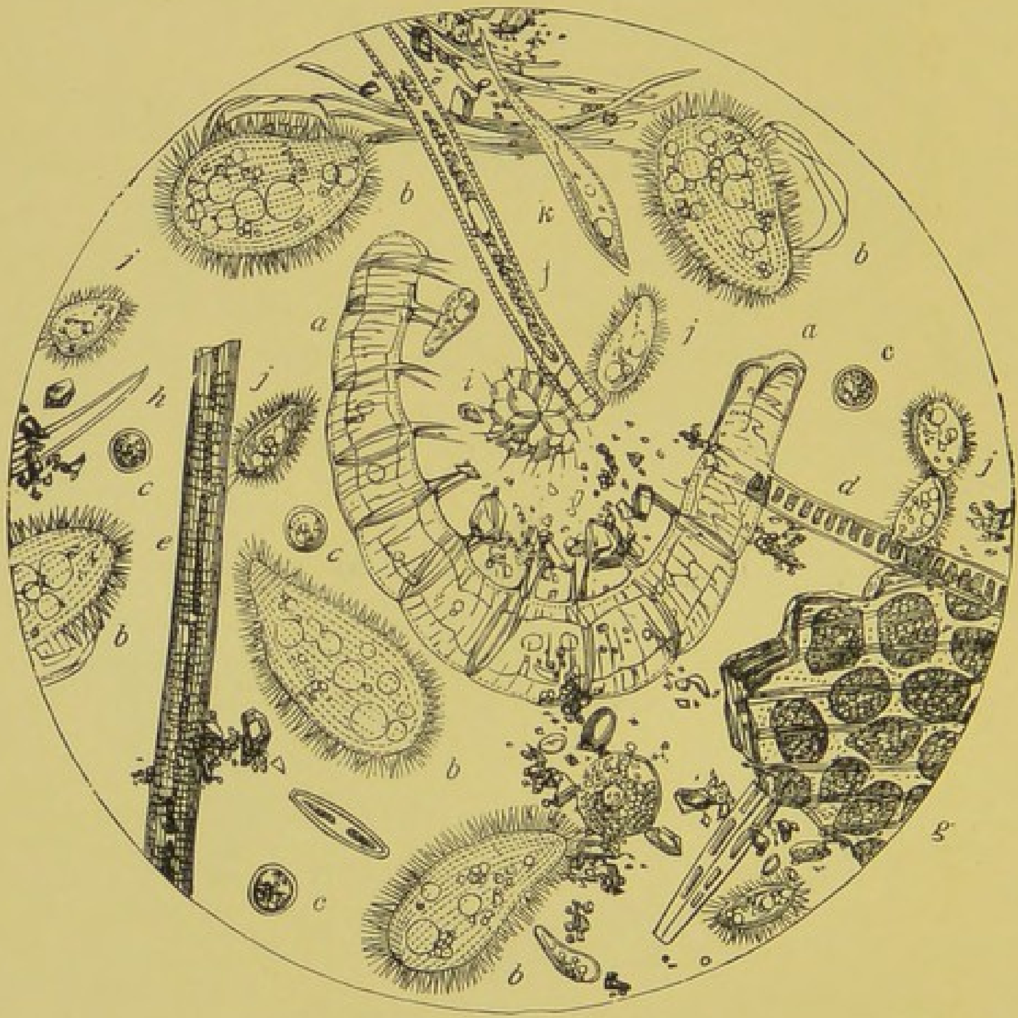


FIG. 276.—PLANKTON, ETC.

FAUNA.

CILIATA (INFUSORIA).

b, b, Paramecium aurelia ;
j, Panophrys chrysalis ;
k, Amphileptus fasciola.

ANNELIDA.

a, Nais. × 12.

FLORA.

DIATOMACEÆ.

c, c, Cyclotella operculata ;
f, Nitzschia sigmoidea.

CHLOROPHYCEÆ (ALGÆ).

d, Ulothrix mucosa ;
i, Pediastrum Boryanum.

MISCELLANEA.

e, Hair of mammal (wool) ;
g, Husk of wheat ;
h, Hair of wheat.

× 220.

FIG. 277.—PLANKTON.

FAUNA.

CILIATA (INFUSORIA).

a, Paramecium chrysalis ;[1]
b, b, Bursaria truncatella ;
d, d, Glaucoma scintillans ;
h, Holophrya ovum.

ROTIFERA.

e, Brachionus pala.

FLORA.

DIATOMACEÆ.

c, c, Cyclotella operculata ;
f, Navicula viridis.

CHLOROPHYCEÆ (ALGÆ).

g, g, Closterium acerosum.

× 220.

[1] The figure shows *agamogenesis*, or the asexual reproduction of this organism, by simple transverse fission of the cell. See *ante*, p. 363.

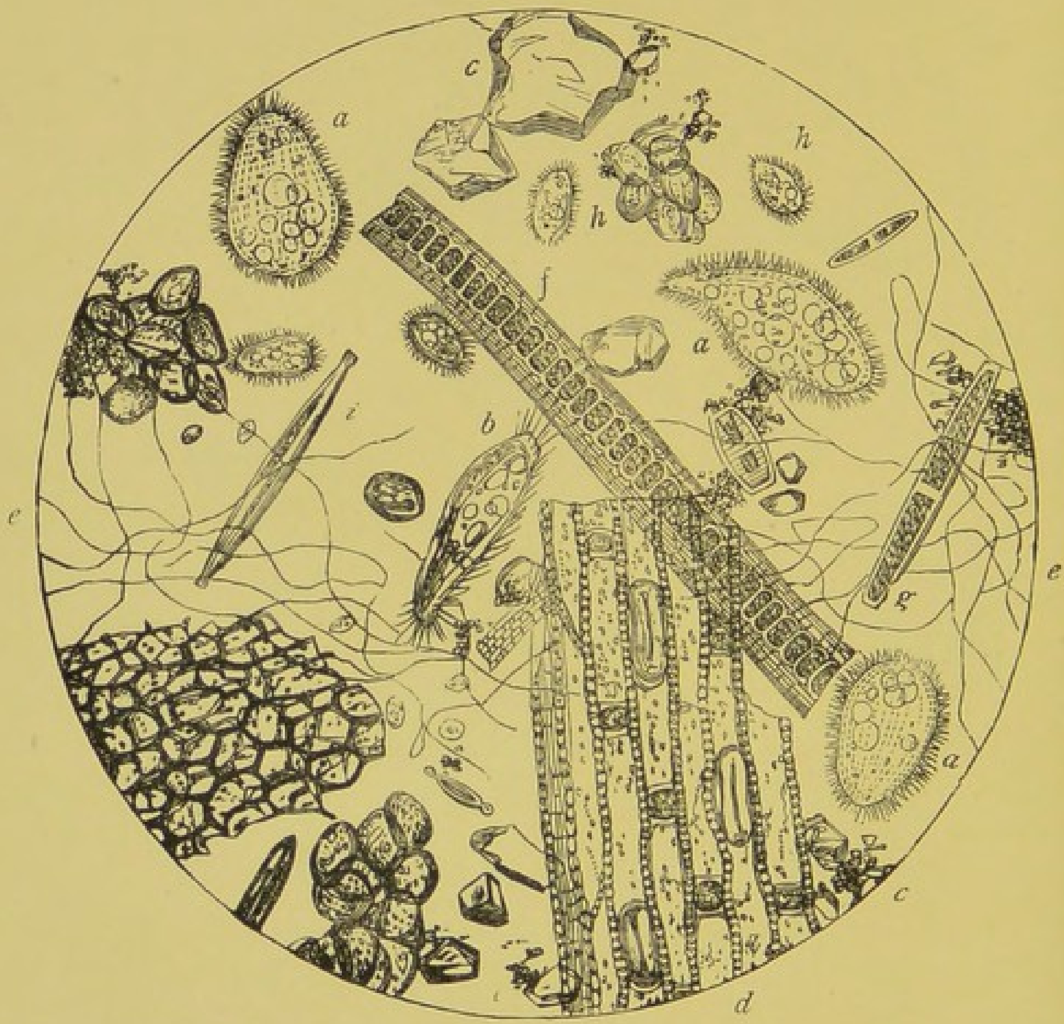


Fig. 278.—Plankton.

FAUNA.

CILIATA (INFUSORIA).

a, a, Paramecium aurelia ;
h, h, Glaucoma scintillans ;
b, Oxytricha gibba.

FLORA.

DIATOMACEÆ.

i, Stauroneis acuta (?).

SCHIZOMYCETES.

e, e, Leptothrix, filaments of.

CHLOROPHYCEÆ (ALGÆ).

f, Sphærozosma vertebratum, filament of;
g, Penium Brebissonii.

MISCELLANEA.

c, Grit, sand, débris, etc.;
d, Fragment of straw.

× 220.

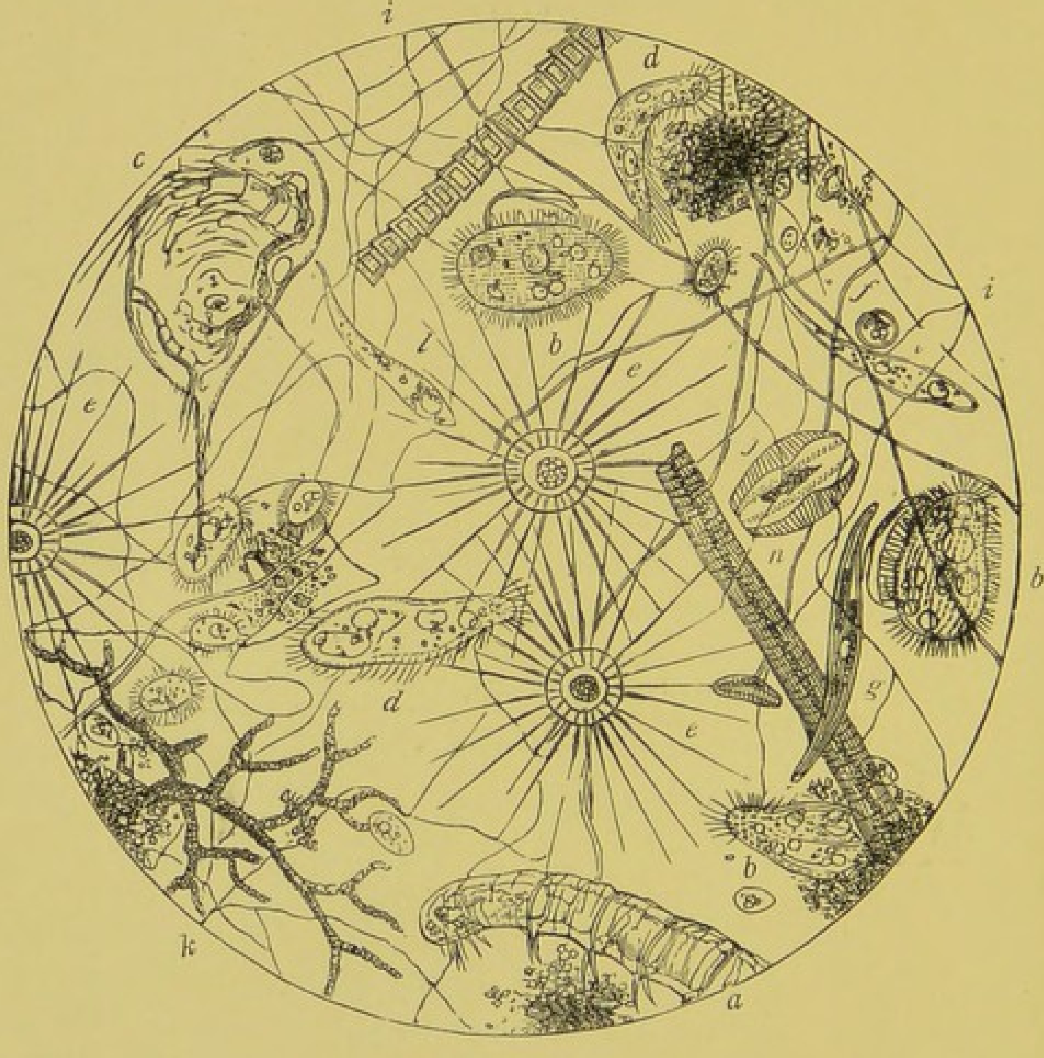


FIG. 279.

FAUNA.

RHIZOPODA.

e, *e*, *Actinophrys Eichornii*.

MASTIGOPHORA (FLAGELLATA).

k, *Anthophysa vegetans*.

CILIATA (INFUSORIA).

b, *b*, *Paramecium chrysalis*;
d, *d*, *Oxytricha gibba*.
l, *l*, *Amphileptus fasciola*.

ENTOMOSTRACA.

c, *Daphnia pulex*.
× 12.

ANNELIDA.

a, *Nais*.
× 12.

FLORA.

DIATOMACEÆ.

f, *Cyclotella operculata*;
g, *Pleurosigma attenuatum*.
j, *Amphora ovalis*.

SCHIZOMYCETES.

i, *Leptothrix*, filaments of.

MISCELLANEA.

h, Hair of mammal (wool).
× 220.

FIG. 280.

FAUNA.

MASTIGOPHORA (FLAGELLATA).

i, *Phacus longicaudus.*

CILIATA (INFUSORIA).

c, *c*, *Paramecium aurelia ;*
g, *Oxytricha gibba ;*
j, *Dileptus folium.*

FLORA.

DIATOMACEÆ.

a, *a*, *Melosira varians ;*
b, *b*, *Cyclotella operculata ;*
h, *Pleurosigma attenuatum ;*
d, *Synedra ulna ;*
k, *Cocconema lanceolatum.*
l, *Campylodiscus costatus.*

EUMYCETES.

e, *Hyphæ.*

MISCELLANEA.

f, *Spiculum* of fresh-water sponge.

× 220.

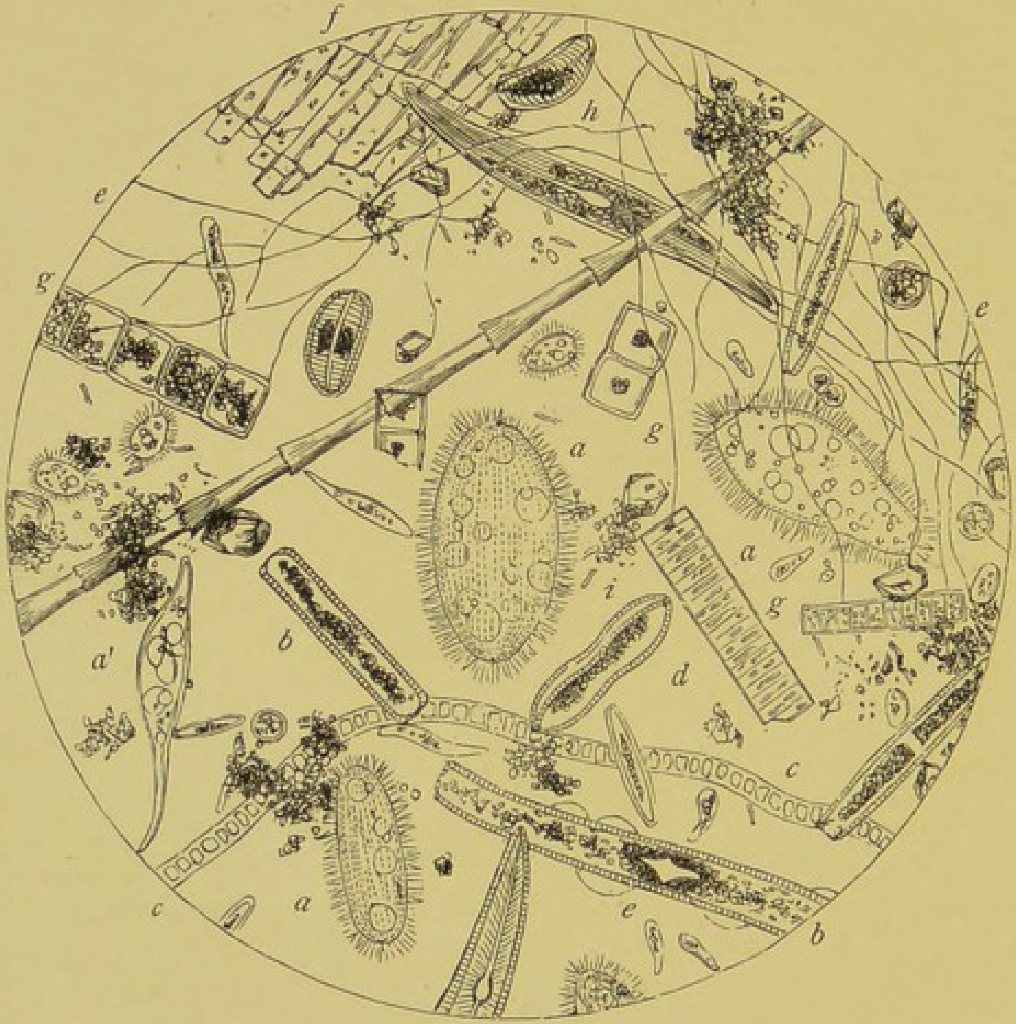


FIG. 281.

FAUNA.

CILIATA (INFUSORIA).

a, *Paramecium aurelia.*
a', *Amphileptus fasciola.*

FLORA.

DIATOMACEÆ.

b, *Nitzschia sigmoidea.*
d, *Himantidium undulatum ?*
h, *Pleurosigma attenuatum.*
i, *Cymatopleura = Sphinctocystis Solea.*

SCHIZOMYCETES.

e, *Leptothrix*, filaments of.

CHLOROPHYCEÆ (ALGÆ).

c, *c*, *Ulothrix ;*
g, *g*, *Conferva ærea.*

MISCELLANEA.

f, Husk of oat.

× 220.

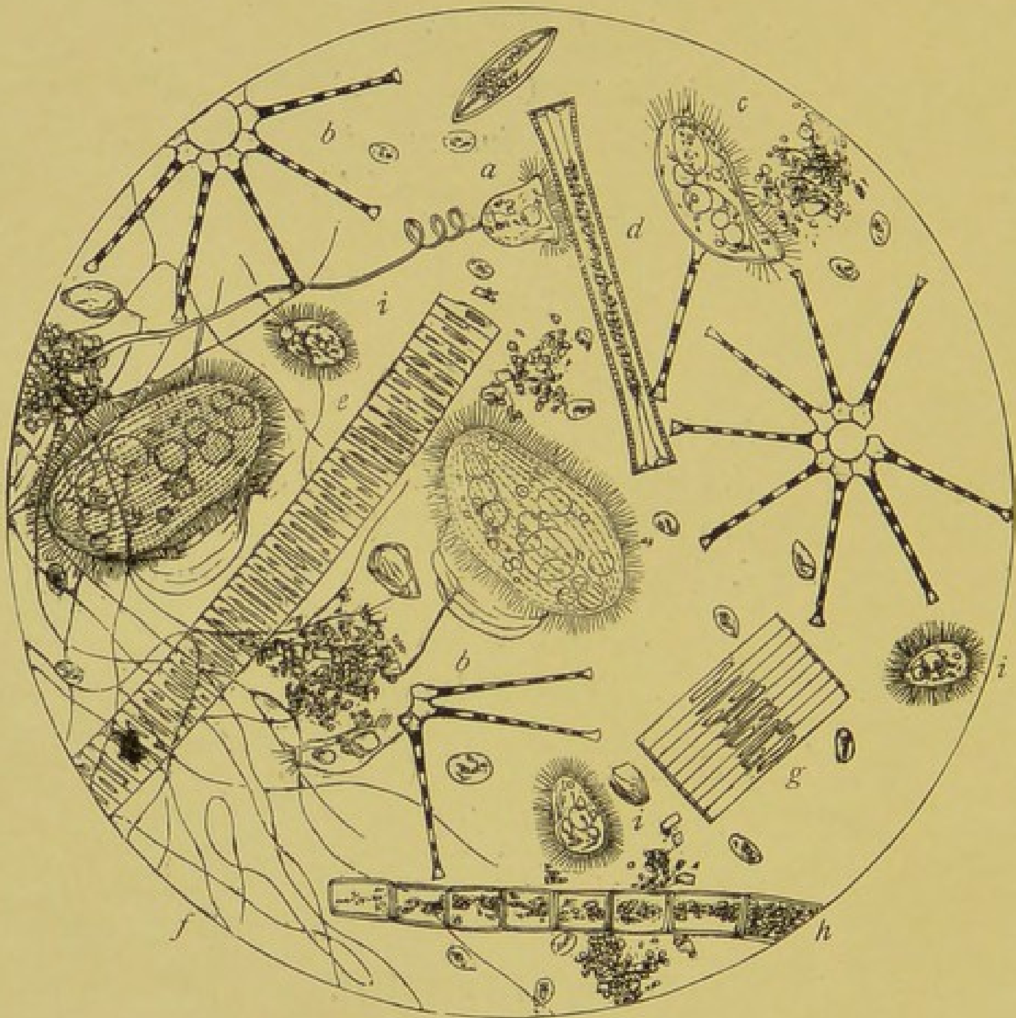


FIG. 282.

FAUNA.

CILIATA (INFUSORIA).

a, *Vorticella nebulifera* ;
c, *Paramecium aurelia* ;
i, *Glaucoma scintillans*.

FLORA.

DIATOMACEÆ.

b, *Asterionella formosa* ;
d, *Synedra ulna* ;
e, *Himantidium undulatum* ?
g, *Fragilaria capucina* ;
h, *Melosira varians*.

SCHIZOMYCETES.

f, *Leptothrix*, filaments of.

× 220.

GLOSSARY.

GLOSSARY.

Achene: a monospermal, one-celled, hard, dry fruit; indehiscent, and separate from the integuments of the seed.

Acicular: needle-shaped.

Aggregate, Aggregation: a combination into a cluster, of crystals or starch-grains.

Aleurone: granular and crystalloid proteid matter, occurring in seeds.

Aleurone Cells: usually, cells containing aleurone; in the cereal grains, cells containing fat-globules surrounded by proteid matter.

Alveoli (plural of *Alveolus*): regular superficial cavities.

Amylodextrin: an amorphous, gummy substance, intermediate between starch and dextrin.

Anastomosing: uniting, so as to form a network.

Anisodiametric: possessing unequal diameters.

Areolæ (plural of *Areola*): separate areas or spaces on a surface.

Arillus, or **Aril**: an additional covering or appendage to a seed, known as the seed-mantle.

Ascospore: a spore contained within an ascus.

Ascus: a sac; a species of fungal spore-case.

Bast: fibre composed of greatly elongated cells, forming the outer part of a fibro-vascular bundle in a stem.

Bast Cells / **Bast Fibres**: thick-walled flexible cells of great length, tapering to a point at each extremity, forming the outer fibrous portion (liber or phloem) of a fibro-vascular bundle.

Bract: a modified leaf attached to a flower-stalk.

Bractiole: a smaller bract beneath a separate flower.

Cambium: the middle part of a fibro-vascular bundle.

Carpel: a pistil, or component of a pistil.

Cell-Bridges: bridges of communication between adjacent cells, as in involuntary muscle-fibre.

Chlamydospore: the brood cell, resting cell, or *gemma* of a fungus.

Chromatophore: a pigment granule.

Cleistocarp: the closed vessel investing the asci of a fungus.

Cocci: a group of bacteria.

Collenchyma: tissue in which the angles of the cell-walls are thickened.

Colostrum: milk first secreted after parturition.

Columella: the pillar occupying the centre of a fungal sporangium.

Conidiophore : a mycelial branch, bearing *conidia*.
Conidium (plural, *Conidia*) : a fungal unicellular reproductive body.
Cortex : rind or bark.
Cotyledon : the embryonic lobe, or first embryonic leaf of a plant.
Crenate : provided with marginal curved indentations.
Cross Cells : cells with the major axes transversely disposed.
Crystal Clusters, Crystal Rosettes : aggregations of crystals, usually non-acicular.
Curcumin : the orange-yellow colouring matter of turmeric.
Dissepiment : a partition or division of the ovary.
Distal : terminal, or remote from the central portion of an organ.
Drupe : a fruit consisting of a monospermal carpel, fleshy externally, ligneous within.
Drupelet : a little drupe.
Embryo : the rudimentary plantlet present in the seed.
Endocarp : the innermost stratum of the pericarp, nearest to the seed.
Endoderm : the inner cell-layer or layers in a seed coat.
Endosperm : the protein produced within the embryo-sac.
Endospore : a spore formed within the fruit-bearing organ of a fungus.
Epicarp : the outermost coating of the pericarp.
Epidermis : the surface cell-layer of plants.
Eumycetes : the higher fungi.
Exospore : see *Conidium*.
Fasciculi : little bundles or packets.
Fence Cells : parallel-walled, elongated cells, disposed perpendicularly to a surface, so as to resemble a wooden fence or paling.
Fibril, Fibrilla : a minute fibre.
Fibro-vascular Bundle : a sheaf of fibres and vessels.
Filiform : thread-like.
Gemma (plural, *Gemmæ*) : see *Chlamydospore*.
Glandular Hair : one provided with a gland or cellular secreting organ.
Gluten Cells : aleurone cells (which see).
Hassallian Bodies : elongated bodies, first observed by Dr. A. H. Hassall in the cacao-bean (pp. 101, 105). Sometimes called 'Mitscherlichian bodies,' from the supposed discoverer, A. Mitscherlich.
Hesperidin : a glucoside present in the orange.
Hilum : the cavity or mark characterizing many starch-granules; the organic centre of a granule, or portion which was at first formed.
Hyaline : colourless or transparent; glass-like.
Hypha : the filament or thread of a fungus.
Hyphomycetes : filamentous fungi; also used as a synonym for *Eumycetes* (which see).
Hypoderm : the cells just beneath the epidermis.
Imbricated : overlapping.
Indehiscent : without regular openings.

Intercellular Space : a non-cellular cavity among the cells.
Internode : the space between two nodes of a plant-stem.
Isodiametric : of equal diameters.
Lacuna (plural, *Lacunæ*) : see *Intercellular Space*.
Lamina : the flat or extended part of a leaf.
Latex Tubes / **Laticiferous Tubes** : ramified and anastomosing ducts, containing the *latex*, or milky juice, of many plants.
Liber : see *Bast*.
Lumen : the cavity of a cell.
Medullary Rays : lines radiating from the centre to the bark.
Mericarp : one carpel, or monospermal section of a fruit, consisting of several monospermal carpels.
Mesocarp : the middle part of the pericarp.
Mesophyll : the central or internal parenchyma of a leaf.
Micrococcus : a genus of bacteria, of a spherical or nearly spherical form.
Midrib : the most prominent vein or nerve in a leaf.
Mitscherlichian Bodies : the multicellular hairs of the cacao-bean : see *Hassallian Bodies*.
Mycelium : the matted hyphæ of a fungus.
Nuclei : spheroidal or oval granular bodies within fibres or cells.
Nucleoli : granular specks within nuclei.
Oidia : chains of cells into which fungal mycelium is sometimes converted.
Oil Cells : cells containing essential oil, or fat oil.
Paling Cells / **Palisade Cells** : see *Fence Cells*.
Parenchyma : cellular tissue composed of large more or less thin-walled cells.
Parietes : the walls of a cell or cavity.
Peduncle : a stalk.
Pericarp : the fruit-coat enveloping the seed or seeds.
Perisperm : tissue in a seed developed from the body of the ovule.
Perithecium : the receptacle in which the asci are formed in certain fungi.
Phloem : see *Bast*.
Pigment Cells : cells charged with colouring matter.
Placenta : the portion of the ovary to which the ovule is attached.
Planktology : the study of plankton.
Plankton : the minute, floating organisms in water.
Polygonal : possessing many angles.
Proglottides (plural of *Proglottis*) : the segments or joints of *Tænia solium* and allied organisms.
Prosenchyma : tissue composed of greatly elongated or fusiform cells, with tapering extremities applied to each other.
Raphides : acicular crystals occurring in cells, especially of roots.
Reticulated Vessel : a vessel or duct possessing ridges and depressions or pores, which give a net-like appearance.

Rhizome: an underground, or partly underground, horizontal stem often branched, and with rootlets beneath.

Rootstock: see *Rhizome*.

Saprophytic: subsisting on dead organic matter.

Sarcolemma: a sheath enclosing muscle-fibre.

Scalariform: applied to vessels having ladder-like bars or markings.

Schizomycetes: fission-fungi.

Sclerenchyma: cellular tissue, consisting of cells with thickened walls, often with pores.

Sclerotium: the compacted or hard *mycelium* of a fungus.

Sclerous or **Sclerotic Cells**: cells with thickened walls—*e.g.*, stone cells.

Seed Coat: the shell, husk, or covering of a seed, developed from the outer part of the ovule.

Septa: partitions or dissepiments.

Septate: divided by partitions.

Spermoderm: see *Seed Coat*.

Spermophore: a prominence bearing seeds.

Sphacelia: the light-coloured conidial modification of *Claviceps purpurea* (Ergot).

Sphæraphides, Spherocrystals: spherical aggregates of acicular crystals.

Sporangiophore: a hypha bearing a sporangium or spore-case.

Sporangium: the spore-case of a fungus.

Stellate Cells: usually (*a*) star-shaped parenchyma cells, like those in the mesocarp of the orange; sometimes (*b*) sclerotic cells, the walls of which show radial pores, imparting a star-like aspect.

Sterigmata (plural of *Sterigma*): elongated protuberances which develop into spores.

Stomata (plural of *Stoma*): the breathing pores in epidermal cell-layers.

Stone Cells: see *Stellate Cells*.

Strobili (plural of *Strobilus*): imbricated scaly inflorescences.

Suber: cork.

Teleutospores: winter spores of the *Uredineæ*, or Rust Fungi.

Testa: see *Seed Coat*.

Thalamus: the receptacle at the top of the peduncle of a flower.

Thallus: the vegetative body of the lower plants.

Tracheides, **Tracheids**: ligneous vessels, elongated, and with transverse partitions.

Tracheæ: see *Vessels*.

Uredospores: summer spores of the *Uredineæ*, or Rust Fungi.

Utricle: a little cavity, sac, or cell.

Vessels: ligneous tubes or ducts present in the fibro-vascular bundles.

Vittæ (plural of *Vitta*): oil-ducts.

Wood Fibre: see *Xylem*.

Xylem: thick-walled prosenchymatous cells, or wood-fibres, forming the inner portion of a fibro-vascular bundle.

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