THE COCOANUT—ITS COMPOSITION AND GERMINATION.

BY J. E. KIRKWOOD.

Instructor in Botany, Syracuse University.

It is not strange that some of our most common articles of commerce should yield some very interesting facts when properly investigated, and the cocoanut is one of these. Probably every one knows the general characteristics of this fruit, and some may know its value as a food and the particular nature of its food content. Some recent investigations,* however, have shown that such knowledge as we have is in the form of rather fragmentary information contributed from various sources. Inasmuch as the cocoanut is not a native of these latitudes and is cultivated only in conservatories, some of the very interesting features of its early growth are also entirely unknown to many. The investigations, the results of which are given in the paper just cited, were undertaken with a view to determining the nature and quantity of the food content of the fresh nut and the manner and extent of its utility to the young seedling.

It is a matter of common observation that the meat of the cocoanut contains much fat. In the manufacture of the commercial cocoa-oil this is obtained by pressure or by other mechanical means. In the fibrous residue from this process there is still some of the fat left, hence it is evident that one cannot by this means come by a knowledge of the exact percentage of fat in the meat. If, however, the tissue is ground to a pulp and then placed in some solvent of fat, preferably ether or benzine, by proper manipulation even the last trace of the fat may be removed, and, knowing the weight of the raw material and the extracted fat, after evaporation of the solvent, its percentage may be obtained by a simple calculation. By this means we obtained from the fresh meat of the nut 37.29 per cent of substance soluble in ether, which may, of course, contain traces of other bodies besides fat.

(*) Kirkwood & Gies, Chemical Studies of the Cocoanut with some Notes on the Changes during Germination. *Bull. Tor. Bot. Club.* 29:321-359. June, 1902.

The solid residue of the tissue, which had been thus treated, was freed from ether by evaporation, and placed in a ten per cent solution of common salt and allowed to stand, with occasional agitation, for a day or two; the proteid bodies, at least the most of them, were thus removed. The salt solution, after filtering, was placed in a bag of vegetable parchment and hung in running water. As proteid bodies not affected by digestive agents are indiffusible, they remained in the parchment vessels after all the salt had diffused out, which took sometimes several days. The contents of the vessel were then removed and the proteid which had been partly precipitated by removal of the salt was separated by filtration and the filtrate heated and treated with chemicals to remove whatever proteid remained. Details of the process need not be described here, as the methods are those given in some of the laboratory manuals in botany.[†] This treatment yielded 4.08 per cent of albuminous substance.

As to the presence of sugars and other soluble carbohydrates, it was found that the fresh meat of the nut or endosperm contains about 7.9 per cent. Both cane sugar and grape sugar are present, but the exact quantity of carbohydrate is probably not expressed in the figure given above, as they were not especially investigated and the expression of the approximate quantity was obtained by subtraction. Other non-nitrogenous substance is probably included in this as well. The fresh meat contains 46.31 per cent water and 52.69 per cent solid matter. The solids besides including the substances already named contain 1.03 per cent of mineral and 3.39 per cent of fibrous matter. Among the mineral substances present are found usually silica, iron, aluminum, calcium, magnesium, potassium, phosphorus and sulphur. The percentage figures given above were the averages of many different determinations made both upon fresh nuts directly imported from Jamaica and upon nuts from the market in New York city. It will be seen from the figures given that the cocoanut is a very nutritious article of diet. Nearly fifty per cent of the weight of the fresh meat is food in the ordinary sense of the word, that is, proteid, carbohydrate and fat. The milk of the nut contains 4.77 per

(†) MacDougal, *Practical Text Book of Plant Physiology*. Ch. IX. Longmans, Green & Co. 1901.

cent of solids, of which 0.56 per cent is mineral substance, and 4.21 per cent is organic (carbohydrate, fat, etc.). Only traces of proteids are present; fat may be seen floating about in small globules if a drop of the milk is examined under a lens. Sugar forms the principal part of the solid matter. The fresh milk is slightly acid, due to the presence of acid phosphate. Both alkali and earthy phosphate are present, and the latter can be precipitated, in part at least, on boiling. Evaporation of the milk to a small bulk by heat produces a dark colored, molasses-like substance from which cane sugar crystallizes on cooling.

As the cocoanut comes to our markets it is deprived of its husk. This husk is of a coarse fibrous structure and covers the nut so thickly that in its original form the fruit is broadly oval, the nut occupying an eccentric position with the "eyes" directed toward the stem end of the fruit. In its natural habitat the cocoa palm grows abundantly near the water and as the fruit falls from the tree it often floats about until it comes to rest in some shallow place and there germinates. The husk not only makes the fruit lighter, but probably serves under any condition by virtue of its absorptive quality to keep the seed more moist and so facilitate germination. Many of the nuts imported in the husk for our work were germinated by keeping them about half covered with earth, saturated and at tropical temperature.

The germ of the nut is to be found under one of the so-called "eyes" at the end. The longitudinal ridges separate the hard coat into three parts, which evidently were once the three parts of an ovary which bore three seeds, one for each division or carpel. The seeds have become reduced to one, which fills all the space within the hard shell which is in reality a part of the ovary wall. The fertile carpel may be detected as the one lying in the largest angle formed by the divergent ridges at the end of the nut.

When the nuts are kept under proper cultural conditions for about three months the first signs of germination will be evident by the appearance of the shoot through the husk above and the roots below. By this time the germ, which is in its resting condition, cylindrical and lying perpendicular to the surface of the nut, has elongated and pushed its inner end into the cavity of the nut and the other end outward. The outer end develops the

stem and roots. The inner end expands into an oval body which ultimately, after about ten months, fills the entire cavity. This expanded inner end is the cotyledon which functions as an absorbing organ. Wherever this cotyledon comes in contact with the meat of the nut it softens, dissolves and finally absorbs it. The surface of the organ is covered with villiform structures and corrugations which give it much the appearance of a stomach turned inside out, and as far as function goes that is just what it amounts to. Wherever the endosperm has not been attacked by the cotyledon it remains as palatable as ever and apparently unaltered.

This process of digestion proceeds by means of ferments or enzymes. In any digestive organ, animal or vegetable, the transformation of insoluble and indiffusible proteid, carbohydrate, or fat into a soluble and diffusible form is accomplished by means of enzymes. It is often possible to separate these ferments from the organs or cells which produce them and to demonstrate their activity upon foods when thus separated. For example, the active principle of yeast may be separated from the yeast cell; the starch-digesting diastase found in many seeds has long been in use for various purposes. But enzymes are often found mixed with the food material in resting cells where the special digestive organ either is or is not present, and it becomes active only when conditions are right for germination. A common means of extracting the enzyme is to cover the finely divided tissue with water and allow it to stand for several hours. The water is then filtered and the enzyme precipitated by adding several volumes of alcohol. The precipitate may be separated by any convenient means such as filtering and dried. It is active, however, only when in solution. The presence of an enzyme may be detected by watching its action on starch paste, fibrin, fat or substance taken from the tissue in which it is found. In the cocoanut the cotyledon shows a very active enzymatic action. The study of this particular seed in its germination is instructive, both from the morphological and physiological point of view. The transformation of the fat of the meat into starch takes place, and this is readily evident to the investigator, although there is no starch in the meat, but during germination there is much of it to be seen in the cotyledon. Proper tests on microscopic sections demonstrate the presence

of fat in the outermost layer of cells of the cotyledon and the absence of starch there; likewise the presence of starch in the inner tissues and the absence of fat.

The food reserve in the cocoanut lasts about a year after germination has begun. During this time the plant gets much of its nutriment from the soil and the air. The proportion of water diminishes from the cotyledon to the tips of the leaves and there is a corresponding increase in the amount of solid matter. The substance of the cotyledon, the stem and the roots, contains much more mineral matter than is to be found in the endosperm and the leaves. The problems of nutrition in this plant which are suggested by these observations have not yet been attacked, but they will no doubt afford some very interesting facts at some future date.

THE EUROPEAN EDIBLE SNAIL.

BY M. A. BIGELOW.

Department of Biology, Teachers' College, Columbia University, New York.

The value of the European edible snail (*Helix pomatia*) for observation on the living animal, as well as for anatomical study, deserves to be more widely known to teachers of biology and nature study than appears to be the case at present. I know of no animal which is at once so available, so easily kept living in the laboratory until needed for class work, and so interesting to pupils of all grades. These snails are now regularly imported from France and Germany, and may be found in the provision markets of the large cities during the cooler months, *i.e.*, from about October 15 to April 1. In New York they may be ordered from C. Perceval, dealer in table delicacies and fine provisions, 100 Sixth avenue. They usually cost about \$1.25 per hundred. The Brooklyn Biological Supply Co., 333 Halsey street, Brooklyn, supplies them in small quantities. Less than two dozen in a package may be sent by mail.