very early period under physical conditions not wholly different from those of the present day, except that there may have been a change from anaerobic to aerobic conditions during the Pre-Cambrian.

The early presence of an anaerobic organic medium finds support from another quarter. We know now that the larger planets have developed enormous atmospheres of hydrocarbons and ammonia from the solar material of which they are composed. The overwhelming reducing character of this material thus leads to the development on a planet of an anaerobic organic medium. In a planet such as Venus, there has been further atmospheric evolution through the inability of the gravitational field to retain hydrogen, so that carbon dioxide has been produced. Venus and the Earth are very close in size. A similar condition must once have prevailed on the Earth, and would rapidly do so again if photosynthesis ceased. The reducing character of planetary material leaves no place for free oxygen except through the intervention of photosynthesis or some analogous process.

We do not know how complex would be the organic molecules formed in the original medium.

Molecules of kinds utilizable by bacteria would fairly certainly be produced. We have seen that still simpler organisms require a still more complex organic environment, the nature of which we do not yet know. It helps us little to point out in our ignorance that an original planetary organic medium might develop the required environment. But one thing seems certain, an organic environment developed in physical equilibrium on a planet could not of itself develop living organisms. For one of the characteristics of life is that its existence requires a supply of energy, either as radiation or as substances at a higher chemical potential than their surroundings. A system in equilibrium cannot provide this; but solar radiation might have done so, at least before the atmosphere developed oxygen and absorbed its most active components.

The answer to the question "How did life originate?" thus seems to depend on the question "What are the environmental requirements of simple bodies such as the viruses, and could these requirements have been met in the original organic environment?" The answer to these questions will carry with it the answer to many other fundamental questions in biology.

THE SEARCH FOR ECONOMIC PLANTS*

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THE history of the spice plants has been dealt with at some length since they have played so important a part in geographical discovery, territorial acquisitions, and wars between European nations. There are however several plants of great economic importance which have travelled far from their lands of origin, of the wanderings of which we have no certain records. Among these are the coco-nut, sugar cane, banana, cassava, ground nut, and possibly the West African oil palm.

The coco-nut has no doubt been transported partly by ocean currents and partly by natives voyaging from island to island in the remote past when they took the nuts with them for food and planted them in the islands or coastal regions to which they migrated. Of ocean transport we have recent evidence in the germination of coco-nuts washed up on Anak Krakatau IV in 1932. The original home of the coco-nut seems definitely to have been the East Indian Islands, whence it has travelled to the West Indies and to America.

* Continued from p. 16.

Sugar cane, also East Indian, must have been similarly conveyed by natives for food on their voyages and then planted by the settlers in their new homes. In this way it has been distributed throughout the tropics before the existence of historical records. The edible banana, probably native in Thailand and Malaya, must also have been transported in much the same way.

Both the ground nut (*Arachis hypogea*) and the oil palm (*Elæis guineensis*) afford puzzling problems. The ground nut is now the staple product of The Gambia, but all its near allies are natives of Brazil and there is none in Africa. Similarly, the closely related species of *Elæis* occur in Brazil, but there is an allied species in Madagascar. It is an open question whether either economic plant is truly native in West Africa; if not, then it seems probable that natives voyaging from Brazil to West Africa may have brought over both the ground nut and oil palm, and also the American cassava (*Manihot utilissima*), as food in their

vessels, and so they became established on the west coast of Africa.

The cashew nut (*Anacardium occidentale*), much used in confectionery and like salted almonds and pine kernels on our dinner tables, which is a native of tropical South America, was introduced into South India in early days probably by the Portuguese. South India now supplies the major part of the world demand, and particularly the large markets of the United States of America. Nearly all the nuts imported to Great Britain and to the United States come from the south-west coast of India. Cheapness in the preparation of the product is the main reason for this somewhat anomalous condition of affairs.

Two misconceptions as to the original homes of economic plants may be mentioned here. First, the Jerusalem artichoke had nothing to do with the Holy Land—the name Jerusalem probably being a corruption of Terneusen in Holland, as Sir David Prain has ingeniously suggested, where tubers were first landed when they were brought over from America. Nor were either the New World pine-apple or prickly pear to be found in the Garden of Eden as figured by Parkinson on the title-page of his "Paradisus".

Coming to more recent times, one is reminded of the attempt by Captain Bligh in the ill-fated voyage of the *Bounty* to introduce the bread fruit (*Artocarpus*) from Tahiti to the West Indies, and of the success of his efforts on his second voyage, and of the introductions of economic plants and also, alas, of weeds to Australia and New Zealand as impurities in the seeds of the imported crop plants.

A brief reference must be made to the introduction of Cinchona and Para rubber from South America to Kew, and thence to India, Jamaica, Ceylon and Malaya, in 1861 and 1876 respectively. Flourishing plantations of Cinchona exist in the Nilghiri Hills and at Mungpoo and Munsong near Darjeeling, but those in Jamaica have not been maintained. Attempts are now being made to extend the cultivation in East Africa and also in Panama and Porto Rico. Java, however, is the chief source of the drug, mainly because the climate of the island is particularly favourable for the cultivation of the species which yield the greatest amount of quinine. Java, unlike India, has two rainy seasons, the south-west and north-east monsoons, which produce conditions very like those which occur in the Andes. The soil also is very favourable, but Java's success with *Cinchona Calisaya* types is mainly due to climate. Java has also been fortunate in obtaining seed of a high-yielding form of *C. Calisaya*—*C. Ledgeriana*—which has flourished under Javan conditions.

After the stocks of *C. succirubra* and *C. Calisaya* had reached India, Mr. Charles Ledger, who had obtained seed of a high-yielding form of *C. Calisaya* collected near Pelechuco, to the east of Lake Titicaca, offered this seed to the superintendent of the Government Cinchona Plantations at Ootacamund, who rejected it. He then offered it to the Dutch, who had been experimenting, somewhat unsuccessfully, with Cinchona in Java. The Dutch bought the seed, and so came about the flourishing industry in the island.

One of the assistants in the Nilghiris, however, a gardener from Kew, extracted some of Ledger's seed, and sowed half of it in the Nilghiris and sent the other half to Mungpoo. When the superintendent saw the seedlings and learnt their origin he had them all thrown away. Those at Mungpoo, however, were under the care of Mr. Gammie, who appreciated their value and kept them; they proved to be as valuable as had been stated by Ledger. This form and other good-yielding strains of *C. Calisaya* are still in cultivation at Mungpoo and Munsong. In any event, as it has since been found, *C. Calisaya* and its forms do not succeed under the conditions in the Nilghiris, nor do they thrive quite as well in northern India as they do in the better climatic conditions of Java.

More recently Kew has taken an active part in the growing and distribution of species of *Hydnocarpus* (Flacourtiaceæ), native in Burma, Indo-China and the East Indies, the seeds of which yield chaulmoogra oil, a specific for leprosy. With regard to this product it is interesting to mention that the resident physician of an asylum at Bangkok was treating the lepers there and trying to get chaulmoogra oil for the purpose when a botanist visiting the hospital was able to point out that supplies were close at hand: a tree was actually growing in the hospital compound, and it grows plentifully in Thailand.

Seeds of *Aleurites* (Euphorbiaceæ), the source of the Chinese tung oil, a high-class drying oil used for paint and varnish, have also recently been distributed by Kew to suitable parts of the Empire.

The recent widespread introduction of plants of economic importance to the tropical possessions of Great Britain and other countries has opened up political, as well as botanical, problems of considerable difficulty.

The growing of the West African oil palm in the Dutch East Indies, where they have been fortunate in establishing a pure-breeding type of good quality oil palm, is a case in point which may set up a state of economic warfare, as also the establishment of the clove industry in Madagascar and cocoa in West Africa versus Trinidad. The effect of the sugar beet subsidy on sugar-cane

cultivation in the West Indies, the competition of sisal in East Africa with the native product from Mexico, and the plantations of uniform varieties of New Zealand flax in the Argentine afford further examples where economic botany and policy may conflict.

Then again, the ease of transport and the cultivation of economic plants under plantation conditions disclose serious botanical problems. Not only may insidious diseases be easily transported by air, but also large areas of crops grown under plantation conditions afford a very ready means for the spread of any insect or fungus disease. Among the diseases which now threaten important economic products may be mentioned the Panama and the leaf spot diseases of bananas. Cacao witchbroom of cocoa, mosaic of cassava and other economic crops, wither tip of limes and cloves in particular. Such maladies necessitate researches in order to try to produce forms and varieties which may be immune to the diseases, and research in this direction is being undertaken especially by the Imperial College of Tropical Agriculture in Trinidad (see NATURE, March 8, p. 282; March 15, p. 313; March 22, p. 344; March 29, p. 380) and the East African Research Station, Amani, as well as by specialist officers in the Departments of Agriculture in the Dominions, Colonies, and in India. Attempts are also being made to discover higher-yielding forms of such economic plants as sugar cane, rice, para rubber and cacao, by cross-breeding and selection, and when found, propagating them by budding and grafting, cuttings or seed.

With regard to bananas, research is being undertaken to find wild types of *Musa* in the original home of the edible banana, in the hope of finding types immune to Panama disease, which can be used for cross-fertilizing with cultivated forms; similar work is also being undertaken in Trinidad with regard to Cacao. As we have recently found at Kew that young shoots of Cacao strike fairly rapidly, it will be possible to take cuttings from pure races of high-yielding plants, and so save the labour of budding and grafting.

Other economic plants which are receiving the attention of Kew at the present time for the benefit of our tropical possessions include passion fruit, papaw, cassava, Ephedra, Derris and tuba root or barbasco. The first three mentioned are affected by virus diseases and various types have been sent out to Amani in order that forms resistant to the virus disease may be raised in East Africa. Ephedra, Derris and tuba root yield important insecticides, and attempts are being made to cultivate plants yielding the highest quantity of rotenone, which is very variable in different strains and species.

Stocks obtained at Kew have been sent to the West Indies in the hope that a profitable industry may be established to meet the demand.

It may be useful to summarize, in conclusion, some of the more important economic plants which now form the principal industries of the countries to which they have been introduced.

Cacao, which is native of South and Central America, has been introduced to Trinidad and other West Indian islands and has for many years been one of their staple crops. More recently it has been introduced to the Gold Coast and is now the mainstay of that Colony.

Cinchona, also from South America, has been of great benefit to India and to Java.

Para Rubber (Hevea), which was brought from South America, is now an important source of revenue to Malaya.

Sisal (Agave), native of Central America, is now extensively planted in Kenya and Tanganyika and is a staple product in East Africa.

Cloves from the Spice Islands are the chief product of Zanzibar and Pemba.

Cotton has been introduced to various parts of the Empire, and is now a very important source of revenue to the Sudan, Uganda, Nigeria, etc.

The introduction of *Tea* from China to Ceylon and India has transformed vast areas of these countries and is a very important source of their revenue, while the introduction of *Coffee* to Jamaica and Costa Rica has resulted in important economic developments in those countries.

Reference may also be made to the introduction of *Wheat* to Canada and Australia, which has added so largely to the prosperity of these Dominions. Nor should we forget what the introduction of the *Potato* from South America, and the American *Tomato* has meant in the way of valuable foodstuffs and financial benefit to the growers of these plants in Great Britain and Eire, on the Continent of Europe and elsewhere.

Then, as one further example, there is the great bulb industry of Holland, where the growing of hyacinths and tulips especially, natives of the near East, has brought so much wealth to the country.

The problems raised by the introduction of economic plants from one country to another and their cultivation under plantation conditions provide ample occupation—apart from political considerations which may arise—for the plant pathologist, physiologist, agricultural chemist, the geneticist and systematic botanist. As the writer of the book *Ecclesiasticus* has so truly said, "When a man thinketh he hath finished, then he is but at the beginning, and when he ceaseth, then shall he be in perplexity".