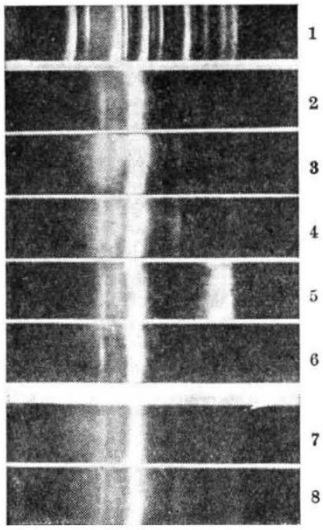

Fig. 4 X-RAY PHOTOGRAPHS OF DICALCIUM PHOSPHATE (1), OF FOLLICULINIC BONE (2–6), AND OF NORMAL DIAPHYSEAL PIGEON BONE (7–8)

As is shown in the accompanying table, the refractive index of new and of old mineralized bone exactly corresponds to that of α-tricalcium phosphate, the hydrated form of tertiary salt[12].

In collaboration with H. Brasseur, we submitted old bone and folliculinic bone to X-ray diffraction, and we obtained in every instance the radiogram of α-tricalcium phosphate, which is very different from that of dicalcium phosphate[13].

These radiograms are grouped together in Fig. 4.

There remains only to consider the opinion of Kramer and Shear in respect to tricalcium phosphate.

We are enabled to characterize tricalcium phosphate in its two forms, hydrated and non-hydrated, by the use of X-ray diffraction and by precise chemical research in collaboration with H. Brasseur[14]. The principal salt present in bone, isomorphous to apatite, is constituted of three molecules of $Ca_3(PO_4)_2$ combined with two molecules of water. When heated to 700° C., the latter are eliminated and tricalcium phosphate answers to the classic formula $Ca_3(PO_4)_2$. Heated to 900°, with a stoichiometrically defined amount of calcium chloride, of fluoride, of carbonate or of oxide, it combines with the latter to form a true apatite.

There is therefore no longer any doubt as to the nature of the stable chemical composition of tricalcium phosphate.

Greenwald[15] introduced an important element which might, if supported by new experimental proofs, cause a modification in the arrangement of the atoms of calcium and of phosphorus in the formula of tricalcium phosphate and which would furnish an answer to Kramer and Shear's objection relative to the manner of formation of tertiary salt. Greenwald submits that tricalcium phosphate is a salt of the acid $HCaPO_4$, the existence of which he thinks he has observed in solution, both in the ionized and non-ionized form. Thus, tricalcium phosphate might originate in course of a second-order reaction which agrees perfectly with the manner of its experimental formation. In its hydrated form, then, α-tricalcium phosphate would correspond to the formula $[Ca(CaPO_4)_2]_3.H_2(OH)_2$.

Thus the theory of primary calcification, having lost both its experimental and theoretical foundations, fails to explain the mechanism of calcification.

How then can we explain, apart from the theory of primary calcification, the progressive rise of the Ca/P ratio in bone in course of formation?

It is clear that the ions $PO_4^{\equiv}$, when freed from phosphoric esters in the course of the second phase of ossification, must attach themselves to an organic element, for at this point we do not find a sufficient quantity of mineral cations in the bone to constitute an insoluble compound with phosphorus. Possibly it may be to the pre-osseous organic substance itself that they become attached? But we can say with certainty that by whatever means the $PO_4^{\equiv}$ ions may be fixed in the precursor of the bone ossein, the Ca/P ratio of bone in formation continually rises because the microcrystals of α-tricalcium phosphate are progressively deposited in a tissue rich in $PO_4^{\equiv}$ ions. It is but a coincidence that the Ca/P ratio touches the value 1·29 and in no way explains the presence of brushite in bone in course of formation.

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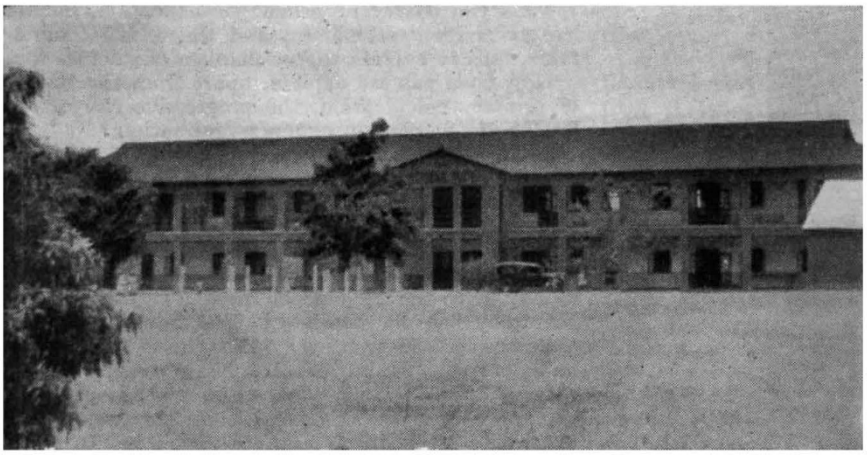
THE WEST AFRICAN CACAO RESEARCH INSTITUTE

By O. J. VOELCKER

A STATEMENT made by the Secretary of State for the Colonies in the House of Commons in 1946 disclosed the fact that a sum of £1¼ million was to be set aside from the profits of the West African Cocoa Control Scheme for cacao research in West Africa. This decision gave effect to the proposal put forward by the previous Government[1].

That a sum of this magnitude should be devoted to research on one specific crop is a matter of considerable interest and importance in the history of agricultural research in the British Colonial Empire. The reason for research on this scale is not far to seek. The territories of the Gold Coast and Nigeria normally produce for export about half the world's 600,000 tons annual consumption of cacao beans, and the wealth of the Gold Coast, and to a lesser degree that of Nigeria, is intimately bound up with the production of cacao. Within recent years, pests, diseases and the degradation of certain soils have led to marked reduction in crops.

The genus *Theobroma* is not indigenous to Africa. The introduction of *Th. cacao* to West Africa is generally considered to have taken place in the



THE WEST AFRICAN CACAO RESEARCH INSTITUTE, TAFO

latter part of the nineteenth century. Over certain areas climatic and edaphic conditions proved favourable for the growth of cacao, and its cultivation by peasant farmers spread rapidly. The migration of pests and diseases from indigenous vegetation to cacao might have been expected under these conditions and has, in fact, occurred. There is evidence that equilibrium has not yet been reached between cacao and indigenous pests and diseases, and further trouble must be expected.

Prior to 1930 cacao research throughout the world had not been impressive, and cacao might well have been termed the Cinderella of tropical plantation crops. In West Africa little attention had been paid to selection, and none to controlled pollination or to methods of propagation; experiments designed to investigate the best methods of growing cacao were few and far between. There were, however, notable exceptions, and among these may be mentioned Cotterell's investigations into the capsid pests *Sahlbergella singularis*, Hagl. and *Distantiella theobroma*, Dist., and Dade's work on black pod disease (*Phytophthora palmivora*), Butl.

In 1930 the Department of Agriculture, Nigeria, followed some years later by that of the Gold Coast, commenced programmes of cacao research on a small scale. Stimulation was further afforded by the inauguration of planned cacao research at the Imperial College of Tropical Agriculture, Trinidad.

The observed deterioration of cacao farms in the Eastern Province of the Gold Coast led, in 1938, to the creation of a research station at Tafo in that Province, to investigate the causes of deterioration and to provide facilities for other lines of cacao research in the Gold Coast. One year later, Posnette demonstrated that much of the deterioration was due to virus disease—commonly known as swollen-shoot. The significance of the discovery of a lethal virus disease of cacao became fully appreciated in London; this and disturbing reports on the prevalence of capsid pests throughout the West African cacao belt resulted in a visit in November 1943 by Sir Harold Tempany, agricultural adviser to the Colonial Office. It was then decided to broaden the scope of the work being done at Tafo to cover all fundamental problems affecting the crop in West Africa. As part of the research programme it was considered necessary to gain reliable information on the conditions prevailing on the cacao farms: the presence or absence of specific diseases and pests, the age of the trees and the location of the farms themselves. The Governments of the Gold Coast and Nigeria, financed to the extent of £105,000 from the £1¼ million, agreed to put in hand at once surveys to provide these data. The adjacent French Colonial Governments also agreed to survey the cacao farms in their territories.

Within the first few months of the commencement of these surveys, small outbreaks of cacao virus disease were discovered in Nigeria. The disease was also found to be widely distributed through the Gold Coast and Ivory Coast, but has not yet been disclosed in the Cameroons. Delay in the discovery of these sources of virus infection and in devising control measures would have jeopardized the whole future of West African cacao.

It stands to reason that the immediate programme of research is to devise control measures against the two major menaces to West African cacao, namely, virus disease and capsid pests. The long-term programme includes fundamental work on the physiology of cacao (edaphic and climatic factors limiting growth and yield), the breeding of improved varieties and the evolution of technical methods of growing cacao and preparing the beans for market. Constant attention will always have to be paid to minor pests and diseases, since experience has shown that these may become of major importance.

The Institute came into being on April 1, 1944, with a European establishment of twenty approved during the year. It has been deemed inexpedient immediately to increase the staff to twenty-seven as recommended by the Cocoa Research Conference held in London in 1945 [2]. The establishment consists of a director, a principal research officer, specialists in the Divisions of Pathology and Botany, Entomology, Soil Science and Agronomy, and a secretary. Normally the head of each Division will be a senior specialist. The African staff includes forty technical assistants.

Since 1944 rapid expansion has taken place at Tafo to cater for the increased staff and research activities. The existing laboratories have been purchased from the Gold Coast Government and extended; plans have been drawn up for the erection of permanent houses to replace the ten temporary bungalows, for an administrative building, quarters for African staff and for other permanent structures. Pipe-borne water is to be supplied, and the old station of 270 acres has been increased by the acquisition of a further 640 acres. Detailed topographical, geological, soil and vegetational surveys as well as an aerial photographic survey have been made of the Institute's land. Four experimental sub-stations and one started by the Department of Agriculture in 1940 have been set up in the vicinity of Tafo, and an entomological sub-station has been started in Nigeria.

In spite of the inevitable difficulties of recruiting staff and of obtaining equipment and apparatus, the first three years of the Institute have been productive of results of great importance to the West African

cacao industry. This achievement has been made possible by working in the closest collaboration with the Departments of Agriculture, from which the Institute has taken over and developed several lines of investigation initiated prior to 1944.

Much remains to be explored in connexion with swollen-shoot disease; but the field vectors are now known and considerable data have been accumulated concerning the viruses and virus strains causing this disease. While no example of immunity in *Th. cacao* has been discovered, work on tolerance is leading to results which may be of more than academic interest. Control of the disease in the field by rogueing infected trees has been proved, and this method is being adopted with vigour by both the British and French West African Governments.

Although no practical control of capsid pests of cacao has yet been proved, small-scale trials with recently developed insecticides are giving promising results. The system of cacao farming adopted by the Africans and their lack of mechanical skill will, however, act as a severe handicap to the use of mechanical apparatus on which chemical control so largely depends. Unfortunately, no success has yet been obtained on the biological control of cacao capsids. The discovery by the Institute that much of the damage formerly ascribed to capsids alone is, in fact, due to subsequent invasion by the fungus *Calonectria rigidiuscula* (Berk et Brme) Sacc. further complicates the problem.

Definition has now been given to soils in West Africa which are suited to permanent cacao cultivation, and it has been shown that the presence of virus disease or capsid pests is in no way dependent on the type of soil on which cacao is grown. A rapid method of soil surveying, based on the American system, has been evolved by the Institute, and the Gold Coast and Nigerian Governments are now considering putting into effect soil surveys, one object of which would be to assess the area of actual and potential land suited to permanent cacao cultivation.

A valuable collection of varieties of *Th. cacao* has been introduced from the West Indies, South and Central America, and is now established at Tafo. Marked differences in growth are already apparent, and many varieties exceed the West African Amelonado (a lower Amazon type) in robustness. Seven species of *Theobroma* other than *Th. cacao* have also been introduced. The collection is by no means complete; but it will be surprising if that now established by the Institute does not produce plant material of the utmost value either through resistance to diseases or pests, or through increased yields. There is the further possibility that certain varieties may thrive on soils which are not suitable for the growth of West African Amelonado, and thereby extend the range of cacao cultivation.

An ordinance passed in March 1947 by the Gold Coast Government provides for the legal establishment of the Institute and for a statutory committee to control and administer it. After meeting the expenditure on the surveys, the recurrent expenditure of the Institute during 1944–47, and the extraordinary expenditure at Tafo, a sum of some £850,000 remains. The interest from this, fortified by the periodic sale of investments, will provide the Institute with means of meeting recurrent expenditure over the next twenty years.

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EXHIBITION OF INDIAN ART

IT must at the outset be confessed that to those who know India the Exhibition of Art from India and Pakistan at the Royal Academy, London, is a little disappointing. Since architecture could not be exhibited, it could not really be comprehensive of Indian art; but even so, and in spite of a few superb examples of the carvers' and the armourers' craft, some fine cast bronze and a few magnificent carpets, the bulk of the exhibition consists of sculpture and of painting in miniature. Textiles in general are poorly represented. Nor is all the exhibition very happily displayed. In the first gallery, the material on which small objects are shown is badly chosen in regard to colour, and the labelling is sometimes questionable; the Mohenjodaro copper bull (No. 5) is probably a species of sheep or goat, and the so-called girdle (No. 29) is really too long (4½ ft.) for that purpose, and was probably a neck ornament like some very similar that still survive in at least one marginal area.

The sculpture is inevitably disappointing. Reft from its architectural background, most of it on a very small scale, it would have stood more concentrated grouping than it has received, and it is little helped by a background which fails to show it up. How much difference an appropriate background can make can be judged by the marble arch from Bikanir (No. 279). Even in its own surroundings, and seen on the scale of Ellora, Madura, or Seven Pagodas, Indian sculpture is not easy to appreciate—probably because it is impersonal in style, and the individuality one looks for in European sculpture is suppressed here and subordinated to an abstraction. Indian sculpture bears perhaps to European much the same relationship as the ballet bears to the drama: it is generalized, and individuality is absent. It is possibly significant, therefore, that some of the most attractive sculptures are figures which have lost their heads, like the red sandstone Bodhisattva (No. 207), which is perhaps the best piece in the exhibition, though the magnificent horse from Konarak (No. 276) runs it very close. This horse, it is true, has a head; but it is a live, individual head and it is difficult to suppose that the living prototype had not a personal name given him. An eleventh-century basalt Brahman from Orissa (No. 302) is notable, and among the wood carvings a sixteenth century carving of Krishna (No. 293) in the same gallery.

But the most substantial part of the exhibition is the very large series of Rajput and Mughal paintings. These have much in common with the miniatures in illuminated medieval manuscripts, and the fascination of their execution and conception is often enhanced by their naïvety. On the whole, the Rajasthani and Kangra paintings please more than the Mughal. This is perhaps to be expected, since Muslim painters must often have worked with some misgiving at their infringement of religious injunction, while no such inhibition would trouble a Hindu. There was something particularly suggestive of a Book of Hours about No. 662—Krishna sheltering Radha from the rain, and the Kangra paintings of the heroine, the cat, and the lovebird (No. 652), of Krishna and Radha by moonlight (No. 655), of the messenger's arrival in a storm (No. 680), or of Krishna with the *gopas* (No. 684), struck one in passing as particularly attractive. If one must select among the Mughal paintings, Mansur's hornbill (No. 911) and the portraits of Murad on an elephant (No. 1100), of Muhammad