

(of which some thirty species are known), and (b) that due to animal cell-products known as luciferin and luciferase which are secreted and expelled at intervals, in response to a stimulus, from two kinds of gland cells, the secretions, when mixed, producing light.

Portier's Hypothesis.

The numerous cases in which symbiosis occurs in Nature have naturally led some biologists to ask if symbiosis is not a phenomenon of general significance, and perhaps essential, in living organisms. In this connexion reference must be made to the hypothesis advanced by Portier (1918), because it formulates extreme views. On faulty premises he built up an hypothesis that may be likened to a house of cards. He divides living organisms into two groups, autotrophic (bacteria only) and heterotrophic (all plants and animals), according as they are provided or not with symbionts. According to Portier, the mitochondria that are present in all plant and animal cells are symbionts. Space precludes further consideration of the subject here.

CONCLUSION.

The term "symbiosis" denotes a condition of conjoint life existing between different organisms that in a varying degree are benefited by the partnership. The term "symbiont," strictly speaking, applies equally to the partners; it has, however, come to be used also in a restricted sense as meaning the microscopic member or members of the partnership in contradistinction to the physically larger partners, which are conveniently termed the "hosts" in conformity with parasitological usage.

The condition of life defined as symbiosis may be regarded as balancing between two extremes—complete immunity and deadly infective disease. A condition of perfect symbiosis or balance is realised with comparative rarity because of the many difficulties of its establishment in organisms that are either capable of living independently or are incapable of resisting the invasion of organisms imperfectly adapted to communal life. In these respects the conclusions of Bernard and Magrou in relation to plants apply equally to animals. It is difficult to imagine that symbiosis originated otherwise than through a preliminary stage of parasitism on the part of one or other of the associated organisms, the conflict between them in the course of time ending in mutual adaptation. It is, indeed, probable that some supposed symbionts may prove to be parasites on further investigation.

In perfect symbiosis the associated organisms are completely adapted to a life in common. In parasitism the degree of adaptation varies greatly; it may approach symbiotic conditions on one hand, or range to vanishing point on the other by leading to the death of the organism that is invaded by a highly pathogenic animal or vegetable disease agent. There is no definite boundary between symbiosis and parasitism. The factors governing immunity from symbionts or parasites are essentially the same.

No final conclusions can as yet be reached regarding the function of symbionts in many invertebrate animals, owing to our ignorance of the physiological processes in the associated organisms. The investigation of these problems is one fraught with difficulties, which we must hope will be surmounted.

New knowledge is continually being acquired, and a glance into new and even recent publications shows that symbionts have been repeatedly seen and interpreted as mitochondria or chromidia. Thus in *Aphis* the long-known pseudovitelus has been shown to contain symbiotic yeasts by Pierantoni and Sulc, independently and almost simultaneously (1910); Buchner (1914) has demonstrated symbiotic luminiscent fungi in the previously well-studied pyrosomes, besides identifying (1921) as bacterial symbionts the mitochondria found by Strindberg (1913) in his work on the embryology of ants. The increasing number of infective diseases of animals and plants, moreover, which have been traced, especially in recent years, to apparently ultramicroscopic organisms, cannot but suggest that there may exist ultramicroscopic symbionts.

From the foregoing summary of what is known to-day of symbiosis we see that it is by no means so rare a phenomenon as was formerly supposed. Symbiosis occurs frequently among animals and plants, the symbionts (algæ, fungi, bacteria) becoming in some cases permanent intracellular inhabitants of their hosts, and at times being transmitted from host to host hereditarily. Among parasites, non-pathogenic and pathogenic, we know of cases wherein hereditary transmission occurs from host to host.

It is evident that we are on the threshold of further discoveries, and that a wide field of fruitful research is open to those who enter upon it. In closing, it seems but fitting to express the hope that British workers may take a more active part in the elucidation of the interesting biological problems that lie before us in the study of symbiosis and the allied subject of parasitism.

Crete as a Stepping-Stone of Early Culture: some New Lights.¹

By Sir ARTHUR EVANS, F.R.S.

THE unique geographical position of Crete, lying almost midway between Europe, Asia, and Africa, marked it as the point where the primitive culture of Europe was first affected by that of the older civilisations of Egypt and the East. But geographically it belonged in late geological times to Anatolia, being separated from Europe by the irruption

of an arm of the Miocene Sea which later became the Ægean. Thus the fauna of Crete show nearer connexions with Asia Minor, as, for example, the Cretan wild goat; and this affinity is still reflected in its Neolithic culture, of which at Knossos in places we have a mean thickness of some 6½ metres (23½ feet) as compared with about 5½ metres (19 feet) for the whole of the superincumbent strata.

The builders of the Great Palace had themselves

¹ Abridged from a lecture delivered before Section H (Anthropology) of the British Association at Liverpool on September 18.

removed the earlier Minoan or Post-Neolithic strata from the top of the original "Tell" to form the Central Court, and immediately below its pavement level some traces of rubble masonry appeared, my investigation of which, in the summer of this year, resulted in the discovery of a complete house belonging—as its contents showed—to the latest Neolithic phase.

This has supplied a most valuable record of the final stage in the development of the original culture of the island, still preserving the impress of its fundamental relationship with the mainland to the East. A female clay idol of "squatting" type is in this respect very significant. Still more important is a feature in the house plan itself, not traceable in any dwelling of the pure Minoan Age that has hitherto come to light—the appearance, namely, of the fixed hearth. The same arrangement conforms to the traditional Anatolian usage as illustrated, for example, by Troy and Sindjirli. This arrangement, as we know, was also shared by the primitive house-plans of mainland Greece from Thessaly to the Morea, but in Minoan Crete it was superseded by the use of movable hearths. On the other hand, the "but and ben" type of this Neolithic house with its side magazines itself survived in a religious connexion, as may be seen from the similar plan presented by the little shrine or "Casa Santa" of the Minoan goddess set up on the neighbouring peak of Mt. Juktas.

Whence then did the usage of the movable hearths reach Crete, which also entailed important modifications in structure? There are reasons for bringing this phenomenon into relation with a wave of southern influence which set in about the beginning of the earliest metal age in Crete, and to which was ultimately due the differentiation of the insular culture from that of the neighbouring Ægean region, and the rise of the brilliant Minoan civilisation, which in turn impressed itself on mainland Greece. A variety of evidence can be adduced indicating a very early intercourse between the Nile mouths and Crete, going back even to the age before Menes, when we know that navigation was already well advanced among the Delta population.

Remains of a series of typical predynastic vases of porphyry and other materials have come to light on the site of Knossos, while imitative stone vessels in variegated materials of indigenous fabric date back to similar models. A class of Early Minoan idols, either pointed or square below, claims a similar lineage, and—as Prof. Newberry has shown—the Minoan 8-shaped shield is itself the outcome of that which formed part of the emblem of the Egypto-Libyan Delta goddess Neith. A Minoan goddess holding this shield seen at Mycenæ seems to have been the prehistoric forerunner of Athena, and something of the cult of the Delta goddess also survives in that of the Snake goddess of Knossos.

Later influences of the same Egypto-Libyan class are traceable in certain Cretan bead-seals and amulets of the period succeeding the VIIth Dynasty. So intensive was the predynastic connexion with Crete that it seems possible that, at the time of Menes' conquest, part of the older population had found a refuge in the island.

As no objects due to this intercourse have yet appeared in the Neolithic Strata of Crete, we incidentally obtain a *terminus ad quem* for the close of the Neolithic period in the island. The date of the late predynastic epoch in Egypt cannot on any showing be brought down later than about 4000 B.C.

From the earliest dynastic period in Egypt proofs of direct intercourse with Crete continually multiply; and fresh examples of this, in the shape of fragments of diorite bowls, including a remarkable specimen with ears inside the rim, from the site of Knossos, are now available. Most of these vessels seem to date from the IVth and Vth Dynasties, from which we have the first monumental records of Egyptian sea-going fleets.

One remarkable outstanding phenomenon is that though copies of Egyptian prehistoric and early dynastic stone vessels occur elsewhere in Crete—notably of VIth Dynasty ointment-pots—the originals so far have been found only on the site of Knossos. Knossos from about the close of the Neolithic Age in Crete was thus becoming a staple of commerce with the Nile Valley.

The question thus arises, By what route did these predynastic and protodynastic objects reach this site? In view of the prevailing northerly winds it does not seem probable that early navigators from or to Egypt coasted round the iron-bound promontories of northern and eastern Crete.

Further discoveries made during the course of this year by me at Knossos and in the central region of the island throw a new light on this question. On the southern slope of the site two parallel lines of massive foundations were unearthed—evidently forming part of a monumental approach to the Palace by a broad step-way, starting from a platform on which had abutted a main southern highway. The remains of the paved way itself were brought out on the opposite side of the ravine, which had been crossed by means of a bridge; and explorations in the interior have now made clear the existence of a Minoan road-line crossing the central region of the island. Remains of this, with massive terrace walls below and above, have been followed along the western steep of Mt. Juktas in the direction of the important Minoan station of Visala, and further south are traceable at intervals ascending and crossing the watershed—here about 1800 feet in elevation—and thence heading towards Phæstos and the southern ports.

It is, therefore, probable that the Egyptian trade was conducted by means of the direct sea-passage to these ports and thence by this very ancient transit route to Knossos. While endeavouring, however, to fix the exact site of the Minoan havens, a disconcerting phenomenon presented itself, which is of some geological interest. At Matala, the Roman harbour of Gortyna, the floors of rock-cut tombs of late Greek date lie nearly two metres beneath sea-level, implying a total subsidence of some four metres at least since the beginning of the Christian era. Similar evidence comes out at the Minoan port of Nirou Khani on the north coast, where there is actually a submarine quarry. The subsidence, therefore, probably extends to the whole of central Crete, and is in strong contrast to the fact that at Phalasarna, in the extreme west

of the island, the Roman harbour has been raised from 5 to 5.50 metres above sea-level.

The direct maritime intercourse between Egypt and Crete had also its reaction betimes on Egyptian art. The spiralfirm and curvilinear system that Crete itself seems to have received from the North Ægean, which affects Cretan ornament by the third Early Minoan Period—*c.* 2400–2100 B.C.—is taken on in Egypt at a somewhat later date, about the beginning of the XIIth Dynasty. But the system thus implanted in Egypt had in its turn an almost immediate reaction in Crete, and the spiralfirm and other curvilinear patterns of the Middle Minoan Age often betray, by their combinations with sacred symbols and the lotus or papyrus, direct indebtedness to the scarab and ceiling patterns of Middle Kingdom Egypt. From Crete in turn these Egypto-Minoan forms passed at Mycenæ and elsewhere to continental Greece. The most characteristic patterns on the grave stelæ of the Mycenæ—often cited as an evidence of northern influence—in fact, belong to this Egypto-Minoan class.

In spite of the very ancient underlying community of Crete and Anatolia, it is clear that the earlier wave of civilising influence came not from the East but from the Nile Valley. Already in Early Minoan times this influence manifests itself in a great variety of ways, and nothing gives a better idea of the intimacy then subsisting than the spread in the island at this early epoch of the Egyptian game of draughts. By the beginning of the Age of Palaces, about 2000 B.C., however, we begin to have definite evidence of direct importation of objects and concomitant influences from the Syrian and Babylonian side. Two cylinders—one from near Knossos—date from the Age of Hammurabi. Hittite forms of signets also occur, and clay tablets of oriental type.

Two very interesting objects in the Roselle collection at New York now make it possible to trace a characteristic class of Minoan libation vessels to a remote Sumerian source, ascribed by Dr. Hall to the time of Ur-Ninā, *c.* 3000 B.C. These are a small bull and a bull's head of diorite hollowed out for the pouring of liquids, much as the Cretan vessels of the same kind that first appear about the beginning of the Middle Minoan Age, a thousand years later. Even the inlaid decoration of these shows a correspondence with that of Cretan steatite examples. "Rhytons" of this class occur also among Hittite remains, and a kindred lion-headed type was known in Syria. It can scarcely be doubted that intermediate links may ultimately be established.

The function of Crete as a stepping-stone is curiously illustrated by the fact that perhaps the most artistic object found in the Mycenæ Shaft Graves was a silver bull's-head rhyton of Minoan fabric, while part of an alabaster example of the lion's-head type, a replica of one from the Temple Treasury of the Palace of Knossos, occurred at Delphi, confirming the tradition that connects its earliest cult with this Cretan site.

Among the contents of the remarkable tomb recently discovered on the site of Byblos, containing obsidian ointment pots with the cartouche of Amenemhat III., were not only a part of a silver bowl with spiralfirm repoussé work of a Minoan kind, but also a spouted

teapot-like vase of the same material, which has also been attributed to a "Mycenæan" source. The nearest parallel to this is a hitherto unpublished blue faience vase from the treasury of the Central Sanctuary at Knossos, but the indebtedness here is probably the other way, since similar forms in clay, as is shown from the contents of Hittite tombs, were at home in North Syria.

Together with these oriental connexions the reciprocal intercourse between Egypt and Crete continued to operate on either side, and a curious parallel to the history of the animal rhytons is presented by another series to which an ostrich egg forms the starting point. The Egyptian prototype is actually supplied by a vessel found by Prof. Garstang in an early Middle Kingdom tomb at Abydos and now in the Brussels Museum, where a mouthpiece of translucent blue marble is fitted to an ostrich egg recipient. It is scarcely necessary to mention here the discovery of imported polychrome pottery in XIIth Dynasty deposits in the Fayûm and elsewhere, or of the diorite Egyptian monument—probably the offering of a resident Egyptian—and the alabastron lid with the Hyksos King Khyan's name found at Knossos. It is a pregnant symptom of the maritime enterprise of Crete at the close of the Middle Minoan Age that ships of more advanced type now appear on seals that have been discovered.

The early operation of Cretan influences in Malta has recently received fresh illustration from the incised designs on the pottery of Hal Tarxien and the painted scrolls of the hypogæa of Hal Saflieni. At a somewhat later date it seems possible to ascribe to Minoan or Mycenæan agency—at least in its initial stages—the diffusion of faience beads of the segmented and other Egyptian types to the Iberic and Britannic West. So, too, the amber-trade from the north by way of the Adriatic coast to the Peloponnese and Crete, which attained its apogee about the beginning of the Late Minoan Age, may account for the survival of Minoan and Mycenæan forms among the relics found in Illyric cemeteries like that of Glasinatz in Bosnia, as well as for certain elements in the affiliated Gaulish and Late Celtic culture.

Of the Minoan relations with inner Africa, either through Egypt or by way of the Libyan ports of the Tripoli region, some striking new evidence has been brought to light by the recent excavations at Knossos. In some of the newly discovered frescoes, apes of the *Cercopithecus* genus, not found nearer than the Sudan, are so vividly depicted that it is clear that the artist had studied them from the life. Tame specimens must, therefore, have existed in the great Palace, probably introduced through Egyptian agency. Of even greater interest is a frieze in which a Minoan captain in a typical embroidered loin-cloth and wearing a black goat's-skin cap is seen leading a negro troop wearing a similar uniform. It seems more than probable that such black mercenaries reached Crete through some Minoan factory on the Libyan coast. The negro element in Crete, which reached it from Tripoli and Derna under Turkish rule, is still noticeable. The employment by the Minoans of black mercenaries in the days of their expansion on the European side suggests the most modern parallels.