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Scrub Fowl.

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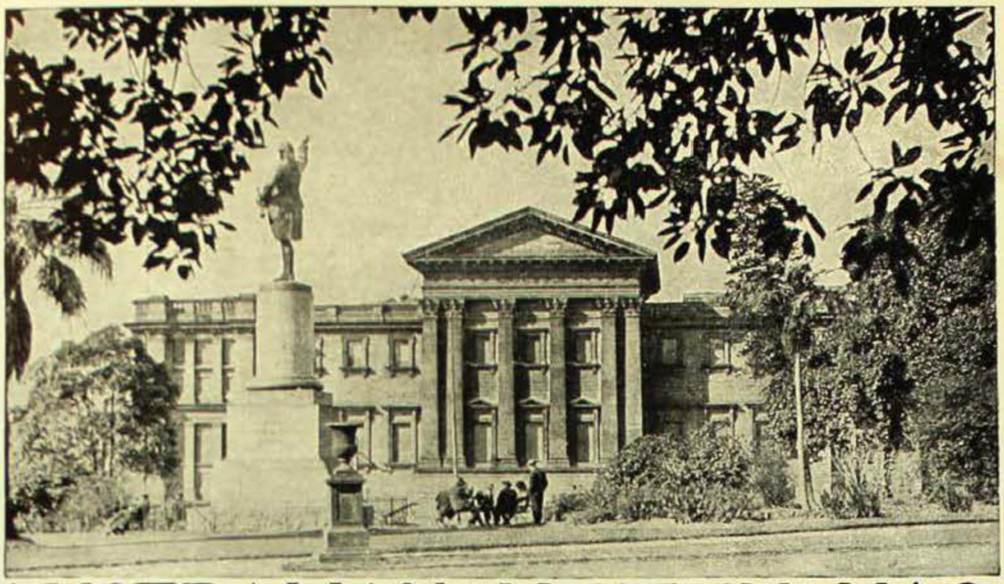
THE AUSTRALIAN MUSEUM

HYDE PARK, SYDNEY



THE AUSTRALIAN MUSEUM MAGAZINE

(*Photography, unless otherwise stated, is by G. C. Clutton.*)

● OUR FRONT COVER. The Scrub Fowl (*Megapodius reinwardt* Dumont) is by Lilian Medland. It is one of a series of post cards issued by the Australian Museum.

The Scrub Fowl is one of a group of very remarkable birds, which have solved the problem of hatching out their eggs by the invention of an incubator. The generic name of the bird means "great-footed", signifying the great feet used to scratch up an enormous mound of sand and leaves, which may be as much as twenty feet long by ten feet wide and six feet high. When the temperature of this artificial hotbed is right, the eggs are buried two or more feet below the summit, and are left to themselves. The eggs are large for the size of the bird, and are of a beautiful pinkish buff colour. The young are hatched with well-formed wings, are able to make their own way to the surface, and can fly within a few hours of leaving the mound.

The bird feeds on fallen fruits, and on insects and other creatures, which it discovers by scratching with its powerful feet.

The Mound Builders range to Samoa in the east, the Philippines in the north, and the Nicobar Islands to the west; but are not found in the large islands west of Celebes in the East Indies. Australia possesses two other Mound Builders, the Brush Turkey and the Mallee Hen.

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Natives striking flakes from cores on a kitchen-midden near Port Macquarie, New South Wales. (See page 257.)

Photo.—T. Dick.

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The Small Cabbage White Butterfly

By G. A. WATERHOUSE, D.Sc., B.E., F.R.E.S.

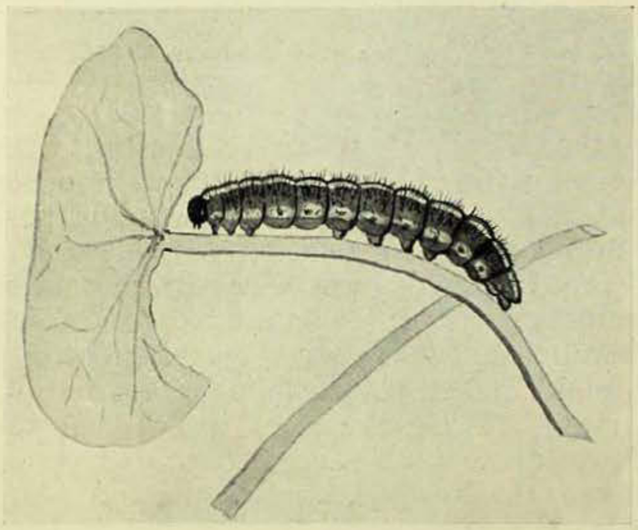
THIS butterfly, whose original home is Europe and northern Asia, has unfortunately made its appearance in New South Wales, where its caterpillars are likely to cause considerable damage to our vegetables. It arrived here from Victoria, where it was flying in great numbers last year.

On 23rd January of this year a specimen was caught by Mr. C. W. Wyatt in Cooper Park, Double Bay, Sydney, and it is most unlikely that it was a solitary specimen. It has also been recorded from near the Victorian border.

As the caterpillars feed on cabbage, cauliflower, Brussels sprouts and other plants of the order Cruciferae, they cause a great amount of destruction to these important vegetables, making them unfit for human consumption. This has already happened in Victoria and New Zealand and is now likely to occur in New South Wales.

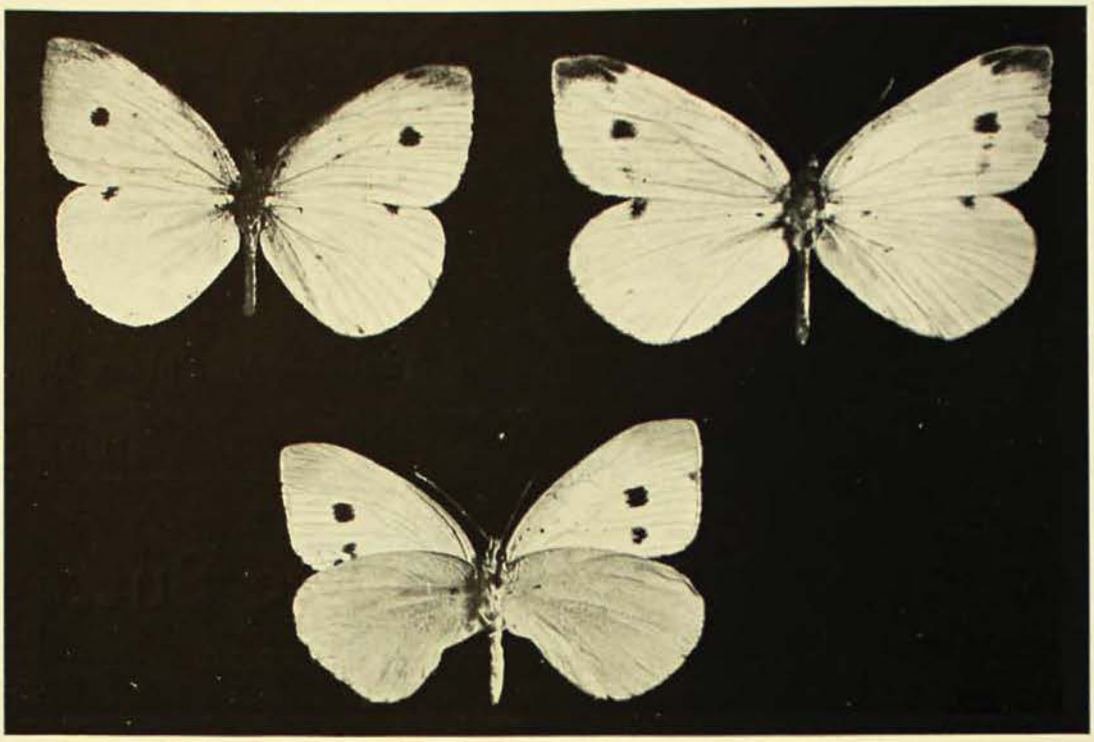
The illustration shows the upper and undersides of this butterfly taken from specimens caught in Victoria last year. They are about natural size.

The egg is much higher than wide; when first laid it is greenish, but afterwards turns yellowish. The full-grown caterpillar has a brownish head and a green body, sprinkled with black and with short blackish hairs. Along the back is a yellowish line and there is a row of yellow spots on either side. The chrysalis varies in colour from pale brown, through grey to greenish, sometimes with black markings. It is pointed at either end. The caterpillars usually leave the food-plant to change to the chrysalis. There are two broods, sometimes three, during the year.



Larva, or caterpillar, of the Small Cabbage White Butterfly, about one and a half times natural size.
N. B. Adams, del.

Specimens of this butterfly are on exhibition at the Museum. Our readers are urged to send any suspected specimens



The Small Cabbage White Butterfly (*Pieris rapae*), approximately natural size.

to the Museum for identification, with the place and date of capture, in order that it may be ascertained how the pest is spreading in this State.

The butterfly was introduced either accidently or intentionally into North America about seventy years ago and spread rapidly there, doing considerable damage. From America it reached the Hawaiian Islands and eventually found its way to New Zealand about ten years ago. Quick modern transport has been the cause of this. Cabbages and cauliflowers for use on the voyage bring full-grown caterpillars which pupate on the steamer and when the butterflies emerge they fly ashore when the steamer is in port. There is little doubt that this is the way the insect has been introduced into Australia. Increased vigilance must be exercised by the quarantine authorities to cope with cases like this.

It is hoped that some method of control of the Cabbage White can be devised before too much damage has been done.

The large, red butterfly known in America as the Monarch and in Australia as the Wanderer, was introduced here about seventy years ago and is well established, as in other countries to which it has travelled. However, as its caterpillars feed on weeds it has not become a pest and is now under natural control.

"Tess", the well-known Alsatian police dog which died recently, is being prepared as an exhibit by the Australian Museum for the New South Wales Department of Police.

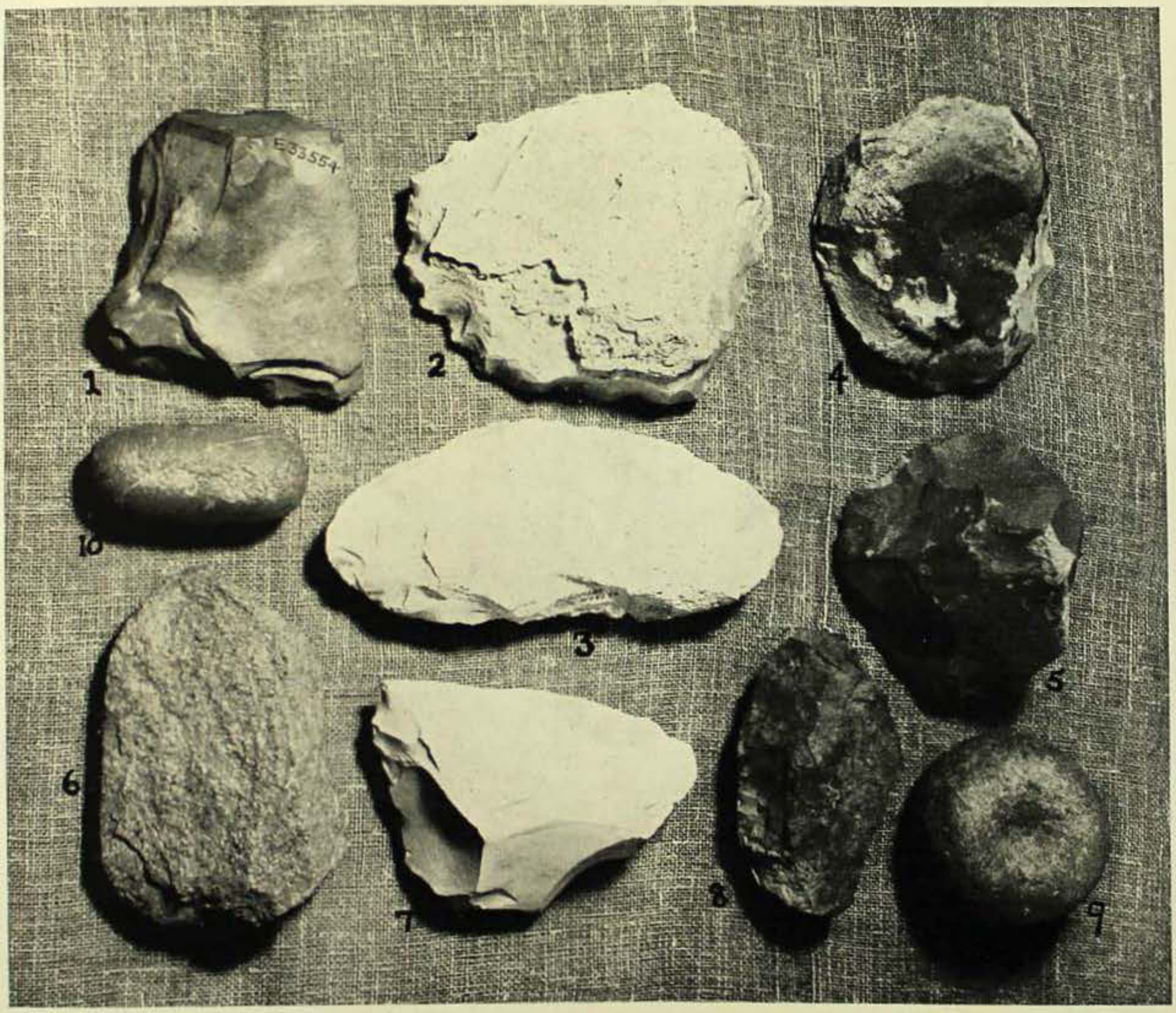
*   *   *   *

Mr. H. V. V. Noone, a prehistorian from England, is at present studying The Australian Museum collection of aboriginal stone and bone artifacts. Mr. Noone has worked on excavations of Upper Palaeolithic deposits in France, and of prehistoric cave sites in Perak, Malay Peninsula. He is an authority on the techniques employed in making stone implements.

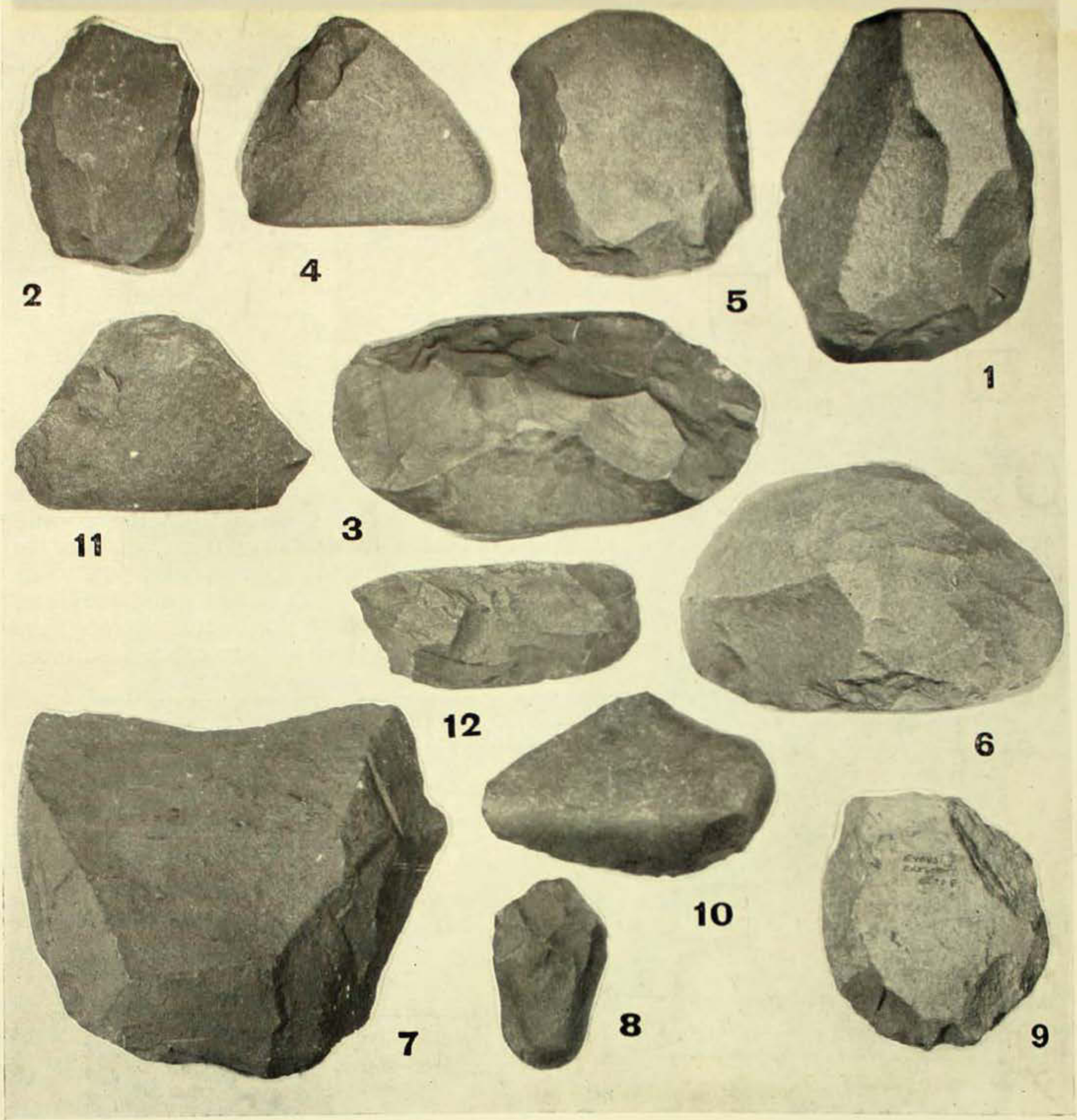
Chipped Stone Implements of the Aborigines

By FREDERICK D. McCARTHY

ONE of the most surprising things about primitive man's stone implements is the vast numbers that are found in all countries. Australia is no exception to this rule. Throughout the continent, in the vicinity of water-holes, on lake and river banks, and where there are suitable stone out-crops, implements of the flake industries occur, not in hundreds, but in hundreds of thousands. These "factory" and camp-sites cover areas from an acre to several square miles. On them are to be found flakes of all sizes, hand-axes and cores, and other artifacts. Along the coast the implements are often associated



Large implements of the flake industries. Hand-axes are shown in No. 1 from Tasmania, Nos. 2-3 from the flint industry of south-east South Australia, and No. 4, Arapia (Lake Narran), from the tula industry; No. 6 (Morna Point) of porphyry and wedge-shaped, and No. 7 (Anna Bay) of chert, are from the elouera industry. No. 8 is a large quartzite scraper from Anna Bay, and No. 5 is a core implement of the "tea-cosy" type from Lake Peery. No. 9 is a hammerstone from Dunolly, Victoria, and No. 10 an example from Quibray on the coast of New South Wales. ¼ nat. size.

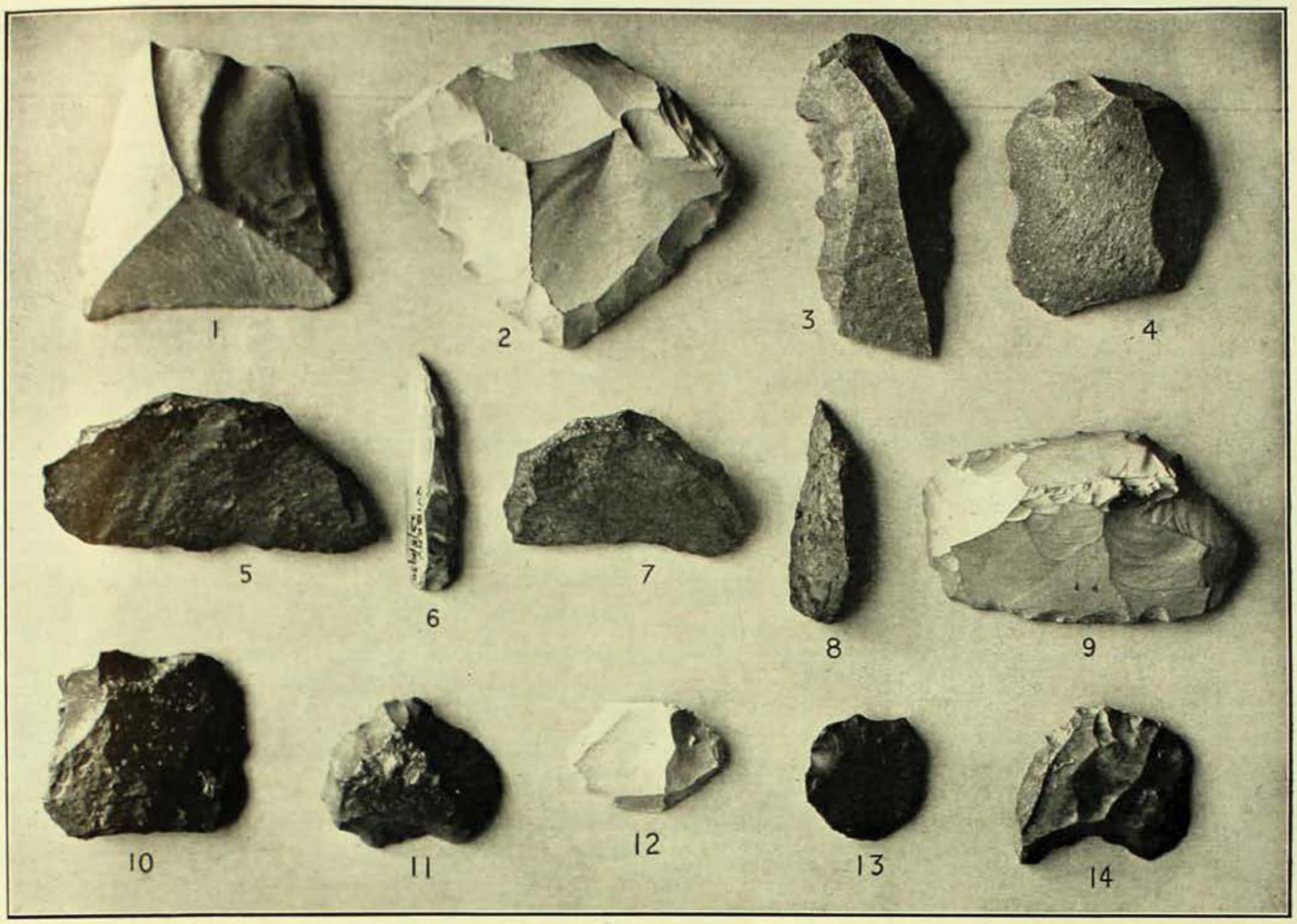


Hoabinhien I type implements. No. 1 is a core, 2 a karta, 3-6 are sumatra forms, from Yamba. Nos. 7-8 are cores, 9-10 are karta, 11 a large crescentic tool, and No. 12 a sumatra from Crescent Head.

with kitchen-middens. Very few people can recognize the chipped stone implements; many country residents are surprised when it is pointed out that these tools occur in profusion on their property.

Primitive man naturally utilizes supplies of local stone, and if these sources are not available, the material is obtained by barter with neighbouring tribes. Often the prepared implements are traded, and knowledge about them is exchanged at tribal gatherings, with the result that the use of some artifact types is spread throughout wide areas, especially ground-edge axes, hafted chisels, spear-points and grindstones. The diffusion of techniques and varieties of stone tools in Australia is an important aspect of the study of the subject in general. On the other hand, it is clear that some of the variations of localized flake tools bear a close relationship to the kind of stone used in such characters as the form of the flake and the nature of the chipping.

Flake industries consist of flakes of innumerable shapes and sizes, cores from which flakes are struck with percussion stones, fabricators used to chip the edges



Chipped flakes of the elouera industry. Note the two asymmetrical points and the elouera in the middle row.

of the flakes, and hand-axes.[1] The nature of these implements varies widely throughout the continent, and where they are similar in localized areas, they form "industries". The flakes are used as scrapers to clean skins and to smooth wooden articles, as knives to cut flesh and fibres, and for other purposes, such as carving. The hand-axes are employed as choppers to cut sections of bark and wood out of branches and trunks of trees for the making of weapons, canoes and containers, and for roughly shaping these objects; they are also used for knocking molluscs off rocks and breaking open the shells.

This article has been written to serve two purposes. Firstly, to give readers a brief description of the chipped stone implements of Australia. Secondly, to summarize for collectors our present knowledge of the various industries and their relationships. Since we lack comprehensive data about the pre-history of Australia, it is not possible to establish chronological sequences of flake stone implements over the continent. It has been considered advisable, then, to describe the industries in a geographical order, from south to north, because the older forms occur in the southern parts of the continent, and the more recent introduced types in the north. Stone implements form the most important group for utilitarian purposes in the tool box of the aborigines.

The Hoabinhien industry first claims our attention because it is the earliest known link between Australia, Malaysia and South-East Asia. Its three phases form the mesolithic period in French Indo-China. Hoabinhien I consists of two

[1] The term "hand-axe" is used here for large chipped implements, often termed choppers, without a ground-edge blade.

hand-axes; the *sumatra*[2] is a pebble chipped on one surface only, and the *karta* is a split pebble chipped on the crust surface only. At present it is known that these two artifacts occur in eastern Australia and South Australia and in Tasmania. The flakes struck off the pebbles in the making of the hand-axes are rarely chipped, but some were no doubt used as knives and scrapers. In Hoabinhien II the pebble hand-axes are prepared on both surfaces, and the majority of them have a ground-edge blade; in Hoabinhien III the implements are smaller, and in Indo-China they are mixed with neoliths.

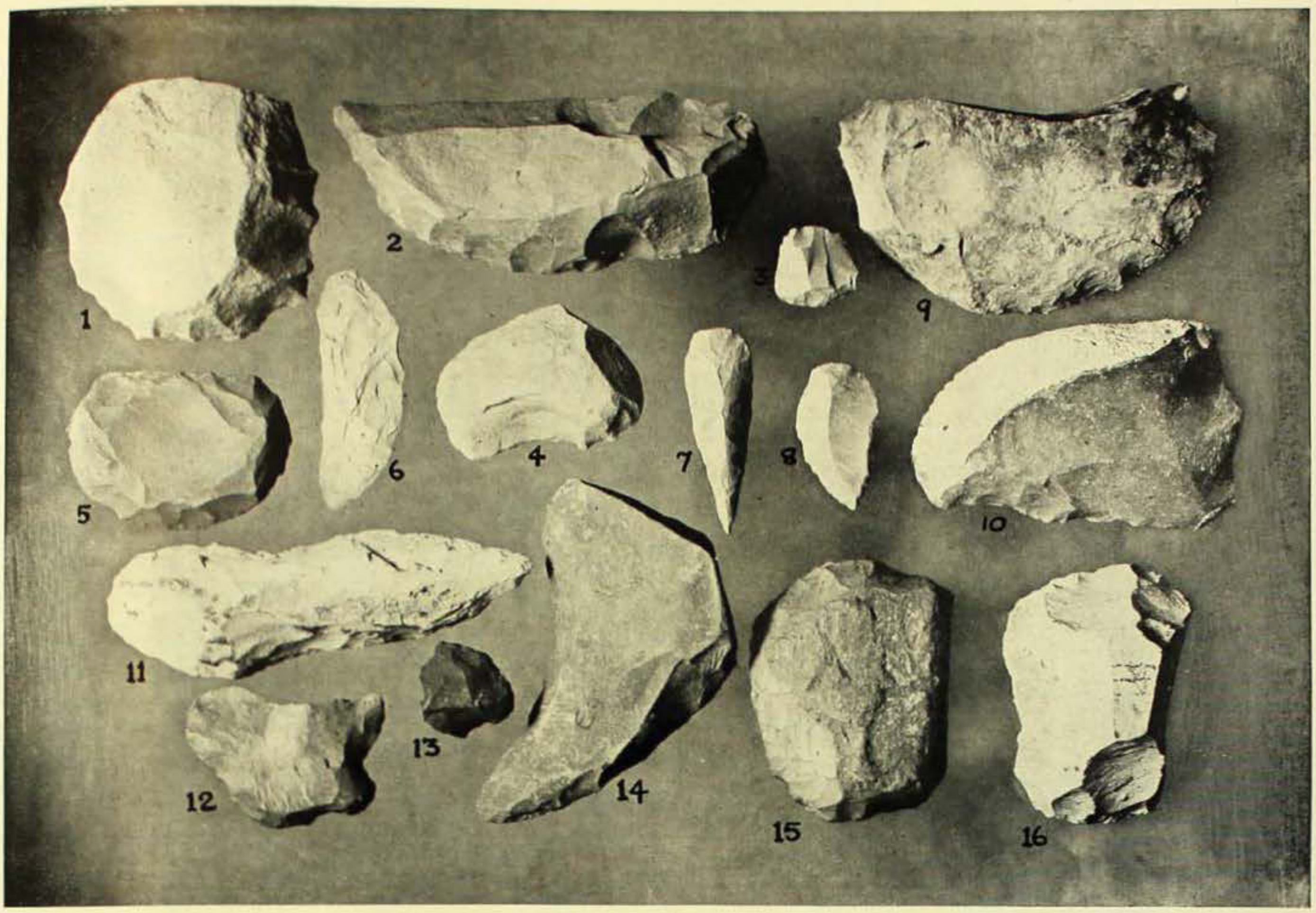
A flint industry that occurs in the south-east of South Australia is of great interest. The implements chipped on one surface vary from large choppers to beautifully chipped flakes of many varieties; other interesting types are the wedge-shaped and split pebble choppers. A great variation in size is present also in the implements chipped on both surfaces, which range from coup-de-poings, with a blade at one end, to a highly developed type of which the blade is continued right round the nodule and the whole of the crust is removed on both surfaces. There is a plentiful supply of flint nodules in the locality, the stone being a bluish-black in colour. The chipped parts of many of these implements are heavily weathered, and bear a white patina, which on some specimens has been stained to a biscuit colour owing to the presence of iron in the vicinity. This patina suggests a high antiquity, and typologically the constitution of the industry is similar to Lower Palaeolithic industries. On the other hand, the implements occur on kitchen middens where they are associated with ground-edge axes and mortars. Hoabinhien types are also present. The problem of the antiquity of these flint tools may be solved only by archaeological work.

One of the most attractive industries in Australia is that of the microliths, also known as pygmy implements, the average size of which is three-quarters of an inch. It is comprised of points, thumbnail-shaped scrapers, crescents of several different kinds, cores, hammer-stones and fabricators. They are beautifully shaped by neat pressure-chipping on the edge of the thick side. These fascinating little implements occur in abundance in Victoria, extending westwards to the Great Australian Bight and northwards into New South Wales, Queensland, Central and Western Australia, where their numbers are comparatively sparse on most sites, but plentiful on others. Unfortunately, nothing is known about when and how they were used. Microliths are found in Europe, Asia and Africa. In Java and the Philippine Islands they are made of obsidian and are larger than elsewhere. The distribution of microliths, and their specialized nature, indicates a relationship between Australia and Asia and other parts of the world, but how they came to this continent is a mystery yet to be solved.

In eastern New South Wales is a localized industry of which asymmetrical flakes are characteristic. On the south coast the cores of silicified wood, chert, jasper and other stones are generally ill shaped, with poorly prepared striking platforms. The implements consist of side, end and concave scrapers, points and choppers. Among them the "*elouera*" is the best known. In the Newcastle district an abundance of grey and cream chert provided the aborigines with a supply of excellent material both for flaking and chipping; consequently the implements are beautifully made. Among them is an interesting series of large hand-axes of various shapes. At Port Stephens the hand-axes are wedge-shaped, and are made of red and grey porphyry. It is possible that this type of chopper is merely a variation of the *sumatra* pebble hand-axe, the lateral form of which has the same shaped section.

One of the most widespread industries is found throughout most of the interior of the continent, extending as far eastward as western New South Wales and

[2] It has a long ancestry, being present in the Mousterian sites of Spain.

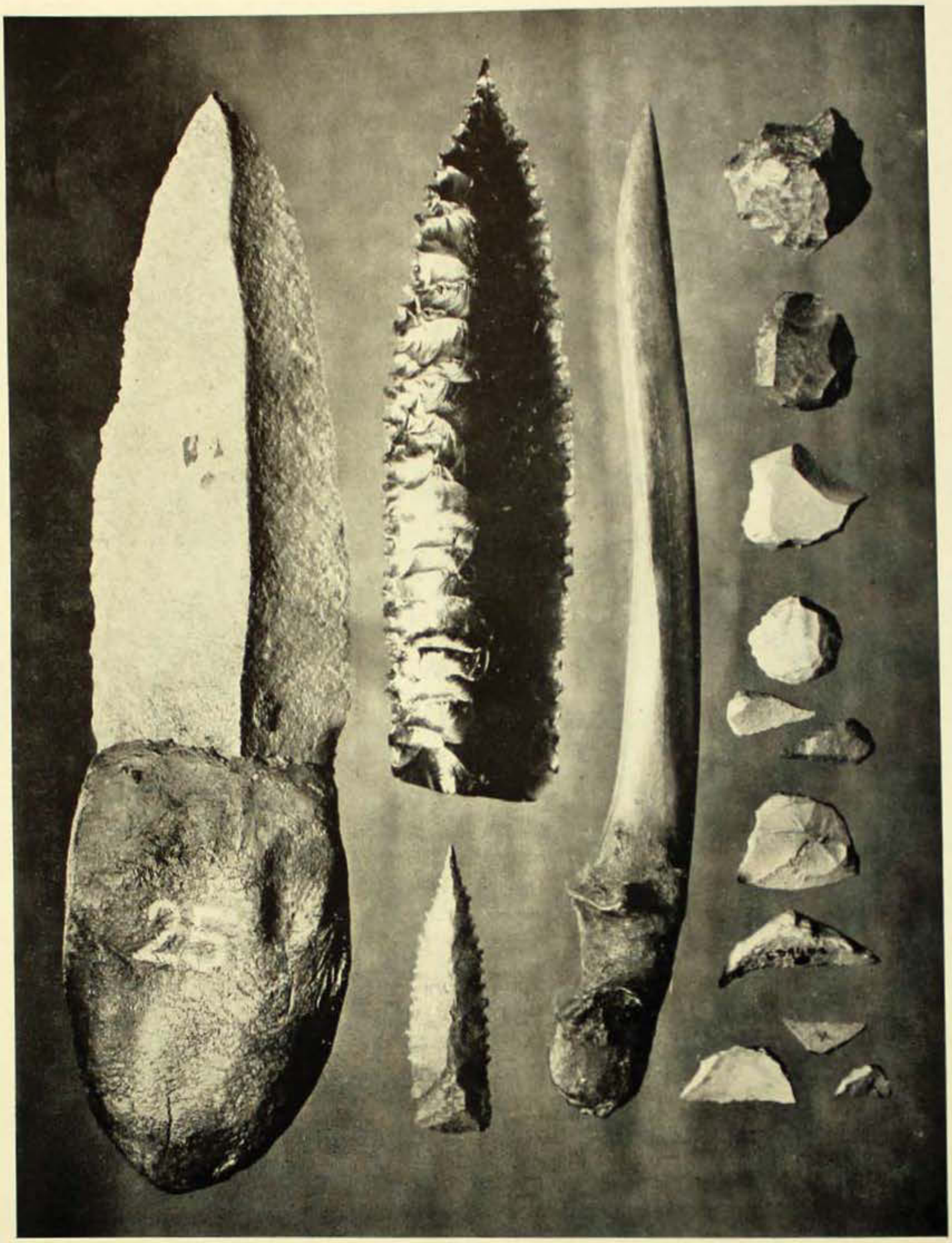


Various types of flake implements. The tula industry is shown by scrapers (Nos. 1-4), an unused tula (No. 5), a worn-down and discarded tula (No. 6), and pirri points (Nos. 7-8). The two flint scrapers (Nos. 9-10) are from south-east South Australia. Among the series of scrapers (Nos. 11-16) from the east coast of Tasmania, the "duckbill" projection is shown on No. 12. ½ nat. size.

Queensland. The principal material used is a quartzite, which is fine-grained and from cream to red in colour; it is easy to work and produces symmetrical tongue-shaped flakes. Here again we find implements varying from large choppers, several pounds in weight, to all sorts of scrapers and knives. A point, known as the *pirri*, neatly chipped and beautifully shaped, is typical of this industry. The cores are of the "tea-cosy" type, carefully chipped around the edges to provide a striking-platform for the hammerstone in the removal of flakes. One of the flake implements, known as the *tula*, is set in gum on the end of a short handle or spear-thrower as a chisel. This tool is used for innumerable purposes from cutting flesh to the making of weapons and wooden containers, and, in fact, constitutes a toolbox in itself. The flakes are often bartered, sometimes hundreds of miles distant from their place of manufacture. The distribution of the industry coincides to a large extent with circumcision, and special knives were made for this and other operations.

In North and Central Australia, and in Western Queensland, a quartzite blade up to 8 or 9 inches long is used for cutting flesh. The butt end is covered with gum-cement to form a grip. These blades are also mounted on a handle to form a fighting pick, and on the end of spears to serve as the points.

There remains to be described a spear-point industry in the Kimberleys of north-west Australia. Three points are made in this area, the *pirri,* chipped on one surface only, and two forms chipped on both surfaces, one of which has a serrated edge. The latter is widely bartered by the natives and knowledge of the way in



On the left is shown a quartzite knife, with a gum grip, from Central Australia; in the middle are serrated stone (lower) and glass (upper) spear-points from the Kimberleys and a bone fabricator used in chipping them to shape; on the right a group of microlithic scrapers, crescents and points. $\frac{2}{3}$ nat. size.

which it is made is also spreading as time goes by. Similar points occur in Celebes and Java, and it is probable that they were introduced into the Kimberleys from Malaya.

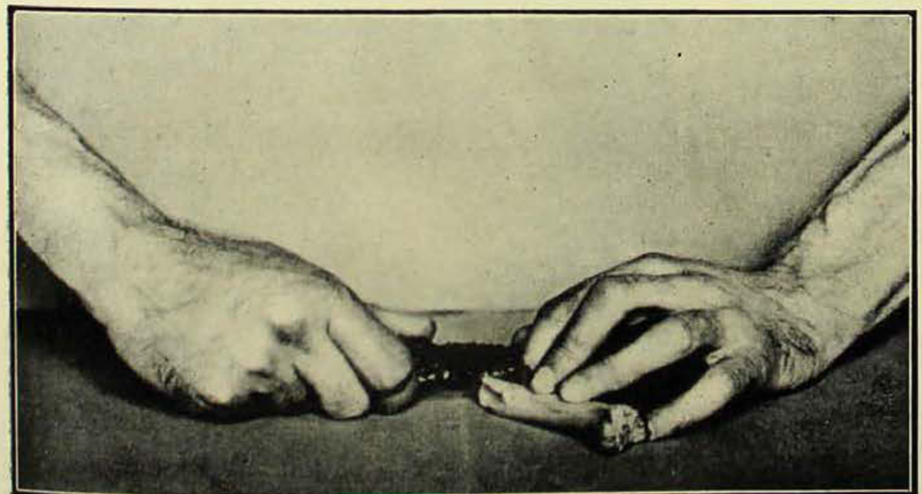
In Tasmania chipped pebble hand-axes (*sumatras* and *kartas*) occur, and also a very interesting range of well-made chipped implements. The latter are symmetrical in form, and many of them are tongue-shaped. Numerous scrapers from the east coast are characterized by concave edges and the so-called "duck-bill" projections. The concave edge is most suitable for shaping spear and club shafts, but the function of the duck-bill is not known. Points and microliths do not occur in Tasmania. Comparisons have been made between the chipped implements of the coast of New South

An aboriginal using a hammerstone to strike flakes from a core. Avon Downs, Western Queensland.
Photo.—Dr. W. E. Roth.

Wales and those of Tasmania. Apart from the pebble *sumatra* and *karta*, however, the few similarities that exist are fortuitous. The flakes of the former industry are asymmetrical, and those of the latter are symmetrical, an important distinction due to the different flaking techniques employed by the natives. As I have already pointed out, the same difference exists between the flakes of the far west and those of eastern New South Wales.

The hammerstones for striking flakes off cores are usually pebbles of quartzite or igneous rock. On the east coast the majority are oval flattened pebbles which bear marks of percussion on edges and sides. In the interior the commonest type is cylindrical in shape, and from one to two inches thick. On many specimens the percussion marks form depressions due to their use as an anvil in the striking of flakes from a core. Large hammerstones are used for the latter purpose and small ones for chipping the edges of flakes. Another type of fabricator is a flake which bears a slightly concave and battered edge, due to its use. The edges of boomerangs and other weapons are also employed in chipping by percussion. Bones and pieces of wood form fabricators for pressure-chipping, for which purpose the workman sometimes employs his teeth.

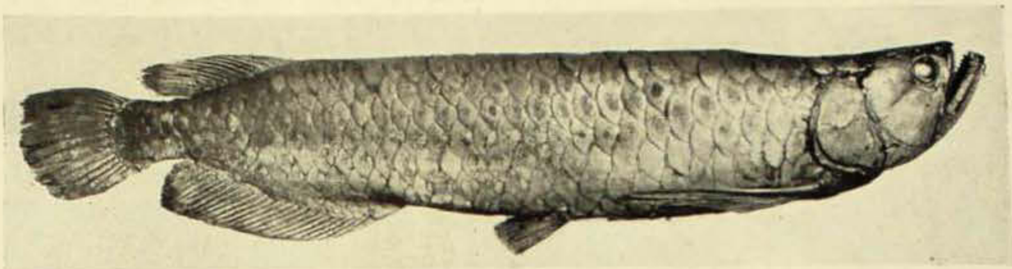
The collecting of stone implements is a fascinating hobby. Unfortunately, however, many private collections are valueless because of negligence. When a stone implement is collected the first thing to be done is to write on it with waterproof ink or paint the locality in which it was found. Many collectors fail to carry out this essential duty, and their implements are of no use to museums or universities, nor to students of the subject. Again, some collectors dig out cave deposits containing implements and destroy valuable scientific data, instead of reporting the sites to a state museum so that they may be properly investigated.



Chipping a glass spear point by pressing off the chips against the bone fabricator. In another method the bone implement is held in the hand and the spear-point is placed on an anvil.
After Balfour.

Burramundi

By GILBERT P. WHITLEY



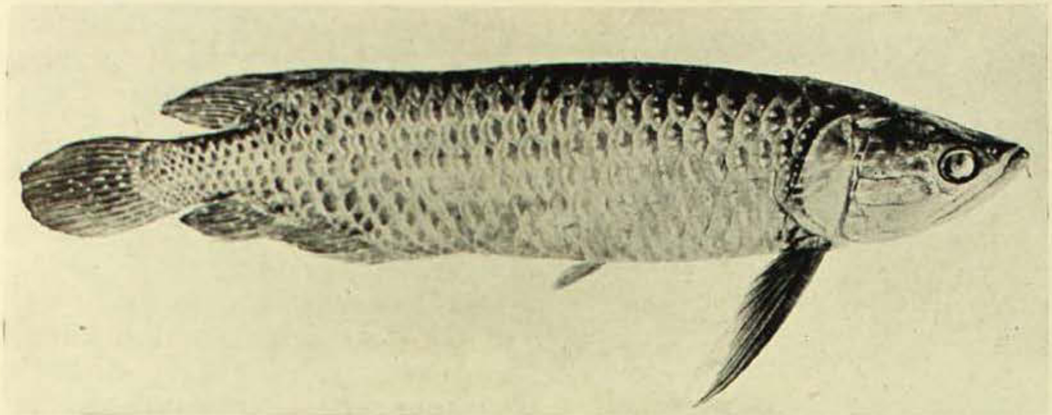
The Burramundi or Dawson River Salmon (Scleropages leichhardti). A specimen, 2 ft. 3½ in. long, in the Fish Gallery of the Australian Museum, from the Dawson River, Queensland.

THE sound of gunshot and a commotion in the water disturbed the comparative quiet of the Queensland bush nearly a century ago. No ordinary animal then fell to the gun of the little 16-year-old lad Murphy, but a fish, a most extraordinary fish, the first Burramundi beheld by white men. Murphy's tent-mate was John Gilbert, a noted naturalist, who immediately pencilled down particulars of the remarkable capture in the small notebook wherein he kept, in a minute and tidy hand, his daily journal. Probably, by now, you have guessed the locale of the discovery: Ludwig Leichhardt's camp on the Mackenzie River in January, 1845, and we can visualize the learned Dr. Leichhardt himself, a gaunt and somewhat bizarre looking figure in the conical Malayan hat which he wore on those sunny days, stooping over the specimen and (good naturalist!) recognizing it for what it was, a soft-rayed fish allied to the living fossils known in other lands as *Osteoglossum*.

John Gilbert was fated to be speared by aborigines not long afterwards, but his diary, after extraordinary vicissitudes, has come to rest in the Mitchell Library, Sydney, where I can just make out the faded entry: "Large. . . . Fish shot in the Mackensie Jan. 18th. . . . Dorsal fin 18 rays. Caudal 16 or 18. Pectoral 8. Ventral 6·1. Anal 28 or 27. Irides bright yellow . . ." These field-notes refer to the numbers of rays in the various fins and the colour of the eyes.

We may be sure too that Gilbert, Murphy and Leichhardt also examined the large oblique bony mouth with its coarse teeth, the granulated scales and head-bones, the long body, dark olive green above becoming silvery, "herring-gutted" and keeled below, and perhaps even noticed the pair of little barbels or feelers on the chin. Though the weight has not been recorded, it might have been about 25 lbs. In his *Journal*, published in 1847, Leichhardt noted: "Murphy shot an Ostioglossum, a Malacopterygious [soft-finned] fish, about three feet long, with very large scales, each scale having a pink spot. We afterwards found this fish in the waters flowing into the Gulf of Carpentaria; both on its eastern and western sides; and, according to the natives of Port Essington,[1] to whom I shewed the dried specimen, it is also found in the permanent water-holes of the Cobourg Peninsula." Thus was discovered the Burramundi, as the aborigines called

[1] A note in John Gilbert's diary for June 18 reads: "Busy most of the day skinning fish. Charlie [an aborigine] today was much more successful with his line than yesterday; he caught very fine examples of the *large-scaled fish* of the Mackenzie. . . ."



The Gulf of Carpentaria Burramundi (Scleropages leichhardti jardinii) has crescentic marks, sometimes broken up into several spots, on the scales.
After Saville-Kent.

it, or the Dawson River "Salmon", as the whites miscalled it. Nowadays the word Burramundi is generally corrupted to Barramunda, or Barramundi, through the influence of the name Barracouta for another kind of fish. Unfortunately, the term Barramundi is also used in Queensland for two kinds of marine perches, the delicious Palmer (*Lates calcarifer*) and the smaller Sand Bass (*Psammoperca*), and has also been employed for the Queensland Lungfish (*Neoceratodus*). It would be well to restrict the name Burramundi to the Dawson-Mackenzie-Fitzroy River fish which was given the scientific name *Scleropages leichhardti* in honour of the explorer.

Head of a Dawson River Burramundi showing teeth, rasp-like tongue, and barbels on chin.

Although the Australian Museum has several very old specimens, there is, unfortunately, now no definite information to link any of them with Leichhardt's expedition.

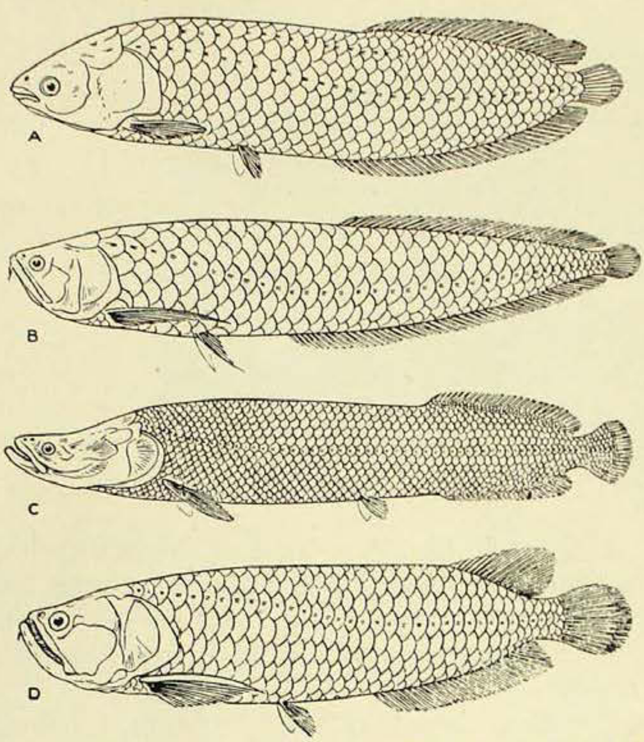
The Rev. Leo Hayes of Taroom, Queensland, remarked, in a letter dated 1927:

> Leichhardt came this way in 1844 and marked a coolibah tree in what is now our main street. The tree is carefully looked after. The explorer was on his way to Port Essington and discovered the Dawson River flowing by Taroom. There is a barramundi in the Dawson not found in any other Australian river. It is known as the Dawson River Salmon. One solitary barramundi, haunting one of the river reaches here, is cardinal red in colour. It has no mates of that colour. We call it here the Red Barramundi. It is to us what Pelorus Jack is to New Zealand people. No one here can catch the red barramundi. He has dodged them since 1922—the year of its discovery.

We do not know how long the Burramundi lives. Is it possible that some of the fishes of Leichhardt's day may still be alive?

The Gulf of Carpentaria Burramundi, sometimes depicted in aboriginal drawings in the Northern Territory, appears to represent a zoogeographical subspecies called *jardinii*; its scales have red crescentic marks which, towards the back, are broken up into three or four spots; this form has also been recorded from the Digul River, southern New Guinea.

The Burramundi is edible, its flesh having been compared with salmon as to flavour. However, it is not an easy fish to see or catch. Burramundi sometimes



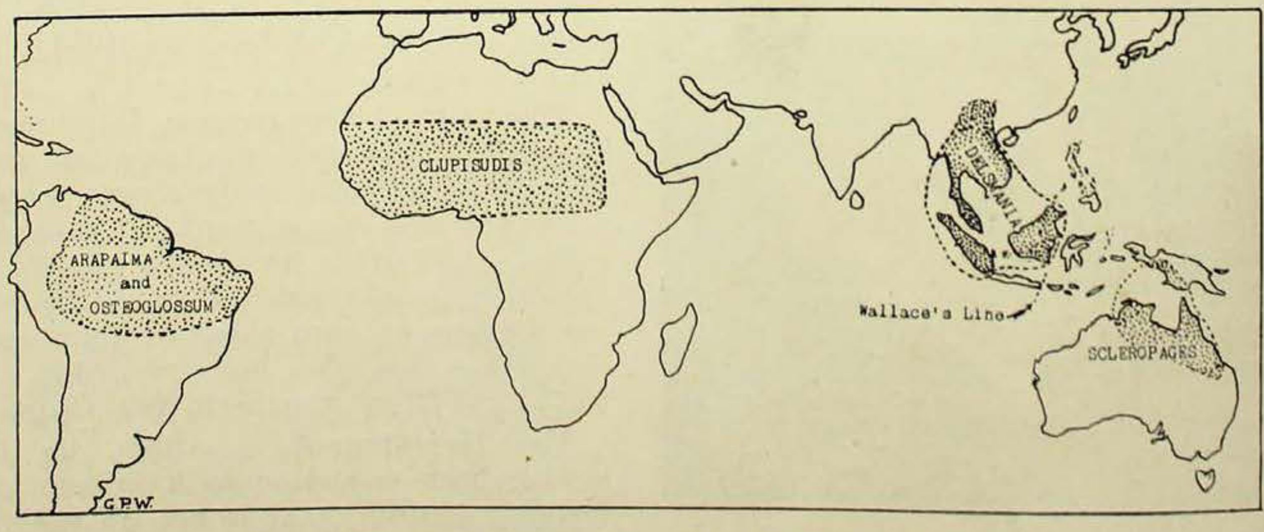
The living relics of an ancient family: A, the Heterotis of Africa (Clupisudis niloticus); B, Osteoglossum bicirrhosum from South America; C, the gigantic Pirarucu (Arapaima gigas) of Brazil and Venezuela; and D, the Australian Burramundi (Scleropages).
After Norman.

lurk in deep water or hide amongst snags where they are safe from nets; at other times they scout along the surface, "come from nowhere" when food is about, or can be attracted by throwing sticks into the water. The bony mouth is difficult to hook, besides which the fish can shake an ordinary hook free, so the bushmen use a three-pronged jag. The Burramundi looks as ferocious as a pike, but its food consists of insects (grasshoppers, flies, etc.), crayfish, Bony Bream (*Nematalosa*), frogs and other animals, which are crushed and partly masticated by its formidable teeth, set not only around the jaws but over the sides of the palate and studding the tongue as well.

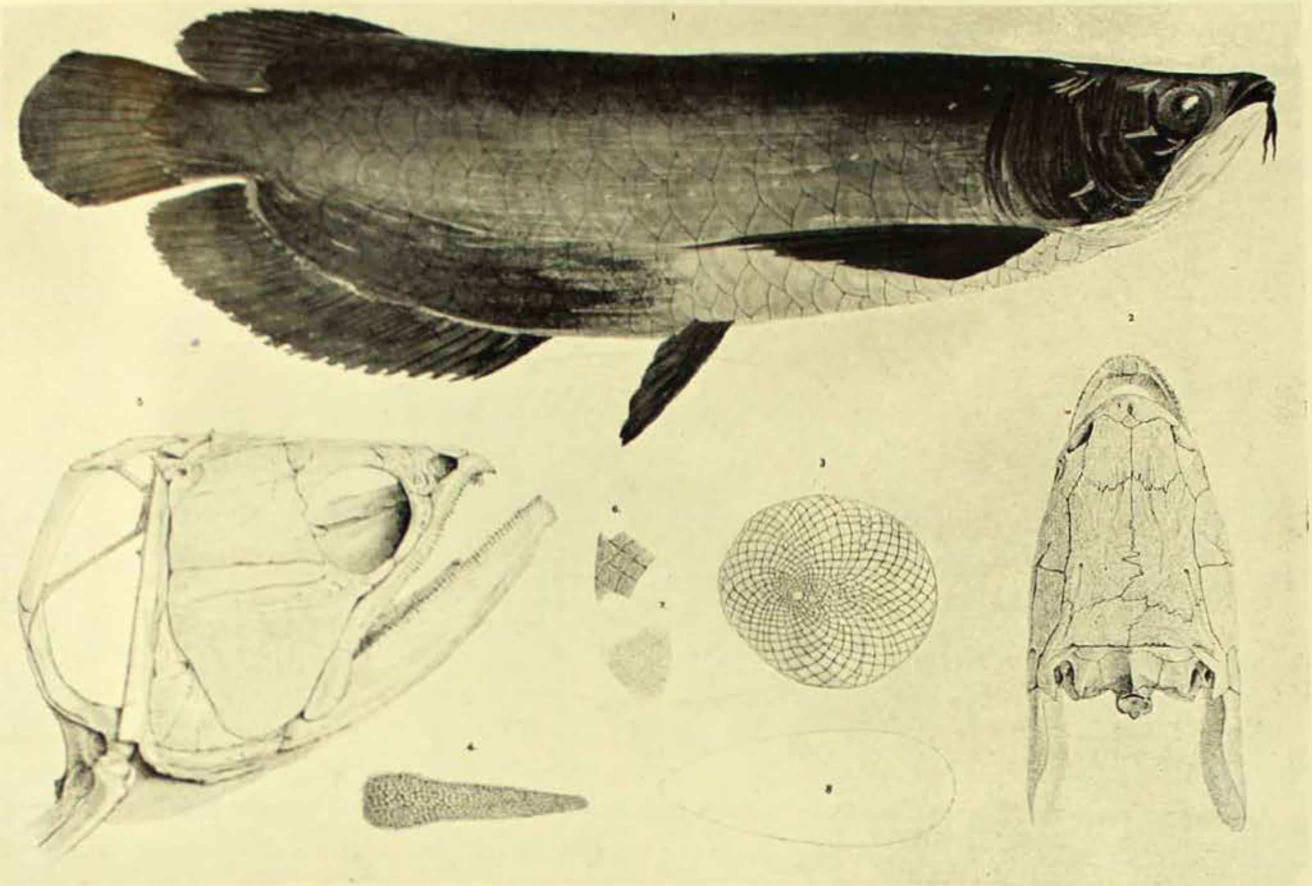
It spawns about October and is one of the few fishes which care for the eggs and young. This it does in a curious manner: the Burramundi (probably the male) carries the eggs in its mouth until the young hatch and shelter in this unusual nursery. During the period of incubation, the parent fish cannot feed.

Our Burramundi is also extraordinary because it has many structural characters so primitive that its lineage extends further back than most other fishes in the world. It belongs to the family Osteoglossidae (the "bony tongues") containing several fossil species, dating back to the Eocene period, over fifty million years ago, when Burramundi-like fishes swam in the waters of Wyoming, in Brazil, India, Queensland, and, according to some authorities, in Kent as well.

Nowadays only relic-forms remain, having a unique distribution. Our Burramundi (*Scleropages*) is most closely allied to its cousin (*Delsmania formosa*), just over the Wallace Line, a mysterious zoogeographical boundary between Bali and Lombok, which, for some reason, prevents the freshwater



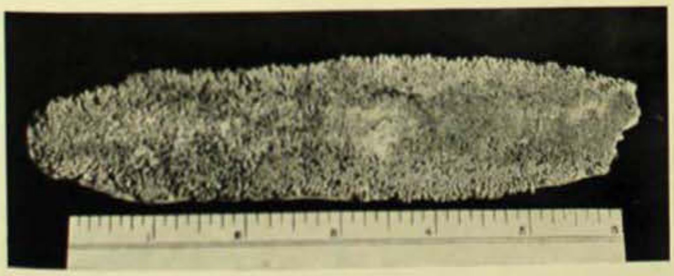
Map showing distribution of living Osteoglossid fishes.



Delsmania formosa, from Borneo: 1. The whole fish, about ¼ natural size. 2. View of skull from above. 3. Side view of skull, showing bony jaws. The gill-cover has been removed. 4. The toothed tongue-bone. 5 to 7. A scale and portions thereof enlarged. 8. Transverse section through body.

After Schlegel and Muller.

fishes of Asia from trespassing into New Guinea and Australia. *Delsmania* is found in the rivers of Thailand, southern Annam, the Malayan Peninsula, Sumatra, Banka and Borneo. As Leichhardt perceived, our Burramundi is similar to *Osteoglossum bicirrhosum* from Brazil and the Guianas, whence also comes another relative, the Pirarucu (*Arapaima gigas*) of the Amazon and Orinoco, which grows to at least fourteen feet in length and is probably the largest freshwater fish in the world.[2] I have seen a small *Arapaima* from Brazil in the Shedd Aquarium, Chicago. Natives of South America, after eating the Pirarucu, use the large tongue or hyoid bone, with its erect teeth, as a ready-made rasp for scraping out the pulp of gourds. The late Professor Archibald Watson presented such a rasp, together with some *Arapaima* scales, to the Australian Museum. Certain authorities consider the Heterotis of the Nile and West Africa (*Clupisudis niloticus*) to be another Osteoglossid, but it has such a different head, scales and fins that I am inclined to agree with those who regard it as belonging to a separate family. Dr. Sunder Lal Hora, finding fossil scales of

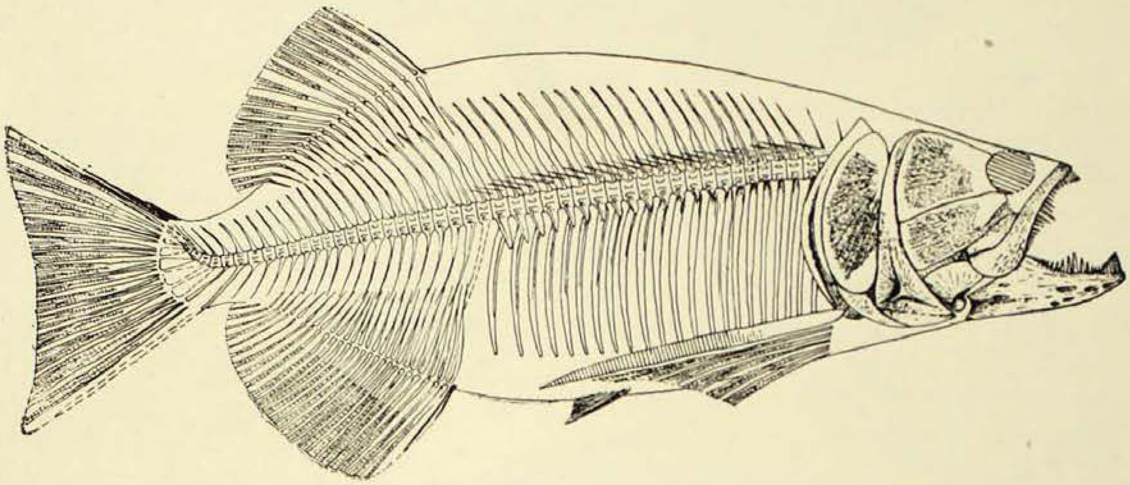


The large toothed tongue-bone of the Pirarucu of the Amazon is used as a rasp by the natives. From a specimen nearly 7 inches long in the Australian Museum from a fish weighing about 150 lbs.

[2] The largest freshwater fish is believed to be the Beluga Sturgeon of the Volga, of which a specimen measuring 14 feet 2 inches in length weighed 2,250 lbs.

Osteoglossidae in India, thinks that that country was the ancient centre of dispersal of the strangely distributed modern Burramundis mentioned above.

Probably nobody will ever satisfactorily reconstruct the family tree of this ancient group of fishes, but in these modern times we might well reflect that in Australian rivers we have still a heritage of extraordinary fishes, older than the hills, creatures which should not be senselessly slaughtered for food, but studied, protected and conserved for generations to come.



Reconstruction of an extinct Australian Burramundi (*Phareodus queenslandicus*) from Tertiary clay shale, southern Queensland.
After E. S. Hills. Block by courtesy of the Director of the Queensland Museum.

Dr. K. K. Spence's collection of Coleoptera (beetles) has for long been one of the most important of those privately owned in Australia. Its purchase for the Australian Museum is, therefore, of considerable importance, and it forms a very valuable addition to its cabinets.

Dr. Spence has long been an indefatigable collector, and he had the opportunity to spend a number of years at Clermont, Queensland—a district of special interest to entomologists, since it is the type locality for many of our insect species—Peak Downs. Latterly he has lived in Sydney, and although this district might well be considered to offer little new in its insect fauna, Dr. Spence has not failed to discover many novelties.

The collection, which comprises some twenty thousand specimens, includes not only large and striking species—many of them rare and sought after—but thousands of those minute and inconspicuous forms which only a keen and tireless collector will bother about, even more important than the showy things since they include many obscure and little known insects.

* * * *

The Australian Museum has recently acquired a collection of 140 negatives, made by the late Mr. T. Dick, depicting the life of the natives of the Port Macquarie district. This is the only series of photographs extant showing how the coastal aborigines of New South Wales gathered and cooked their food, hunted, made their weapons, implements and bark canoes. Some aspects of camp and ceremonial life are illustrated. Although the natives photographed were in contact with the local settlers, it is known that Mr. Dick had great influence with them, and he was able to persuade both men and women to carry out various activities in the traditional manner. One of these photographs forms the frontispiece of this issue of the MAGAZINE.

Australian Insects. XII

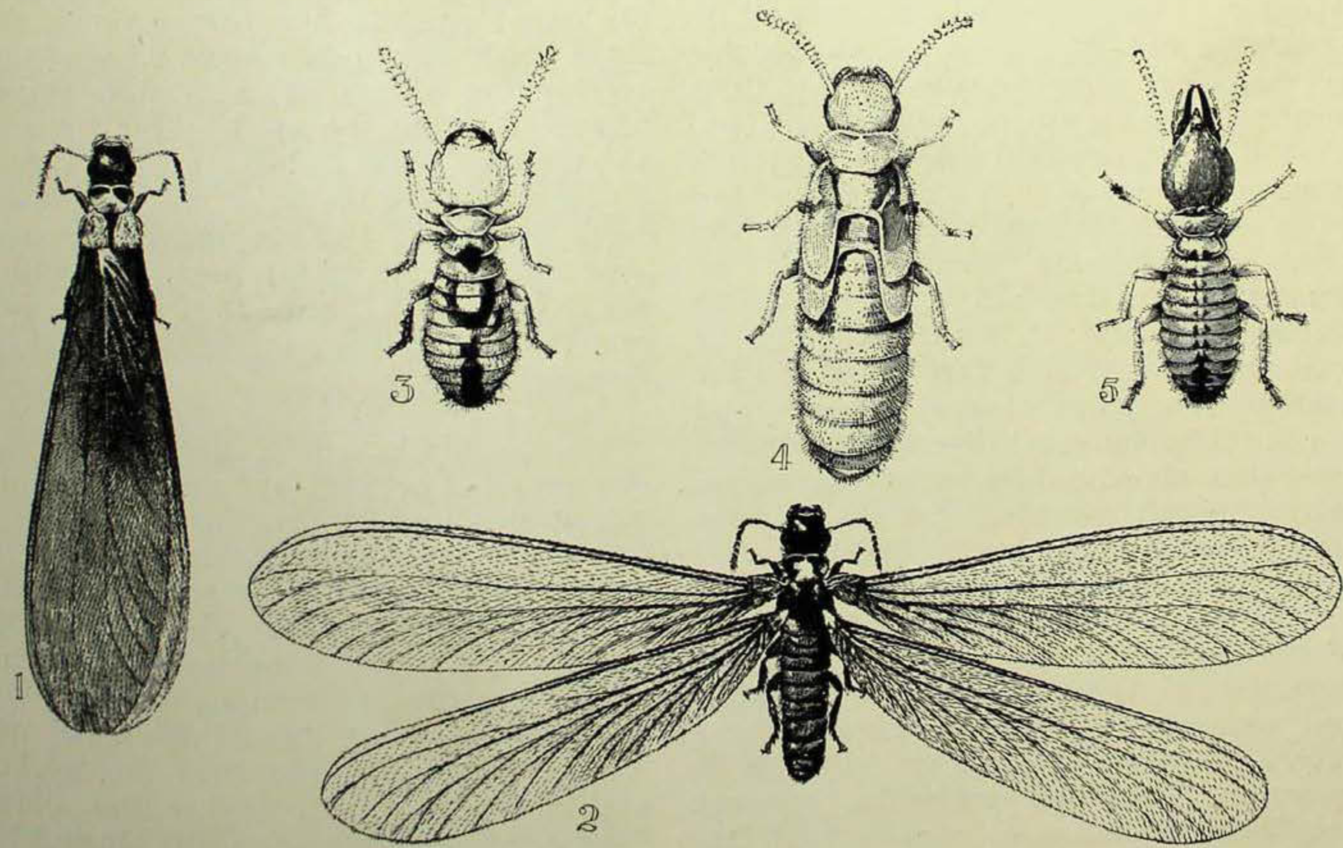
Isoptera — The Termites

By KEITH C. McKEOWN

THE task of presenting a reasonably adequate picture, however generalized, of termite life in the limits of one short article is a difficult one, for the subject is of the greatest complexity and offers so many temptations for digression. Yet, there is still much that remains unknown. Detailed treatment in such a space is quite impossible, or would require the skill and craftsmanship of one of the old Chinese ivory carvers who could fill a sphere little more than an inch in diameter with a world of varied life.

The Termites—or, as they are popularly called, "White Ants"—are now placed in an order by themselves, the Isoptera. Formerly they were included in that group of diverse forms, the Orthoptera, or were thought to be allied to the Earwigs (Dermaptera). Certain primitive termites, it is true, show affinity with the Cockroaches, but actual evidences of any direct relationship are lost in the past, and little fossil evidence has been recovered.

Australia is rich in these insects—too rich, possibly, on account of their great economic importance—and some one hundred and twenty species have been recorded from the Commonwealth. Feeders upon wood, the losses caused annually by termite destruction of buildings, fences, telegraph poles, sleepers and similar objects, as well as living trees,



Castes of Milk Termites (Coptotermes lacteus). 1-2. Winged sexual forms. 3. Worker. 4. Nymph. 5. Soldier.

After Froggatt.

must amount to many thousands of pounds.

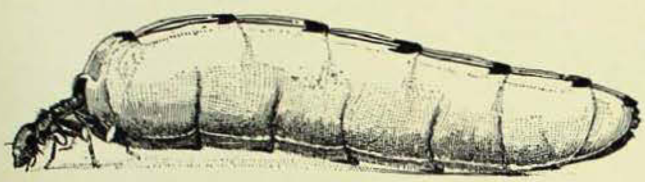
The association of the name "ant"—albeit "white"—is curious since, with the exception of their social habits, they possess few of the attributes of the true ants. Ants pass through the well-defined stages, egg, larva, pupa, and imago, while the baby termite on hatching from the egg is a miniature of its fellows and grows by a series of moults, and lacks a marked resting period. They differ greatly in structure, and the term "white" is rarely applicable.

Almost everyone must be familiar with at least one form of termite nest, or white ant mound. The most typical in south-eastern Australia are the rounded mounds of the Milk Termite (*Coptotermes lacteus*); they are large, somewhat domed, clay-covered mounds rising to a height of five or six feet, and are conspicuous objects in the bush. In the north of the continent, the nests may attain to huge size, and be fashioned into bizarre shapes. The tower-like mounds of *Eutermes palmerstoni* may rise above the ground to a height of twenty feet, an amazing architectural effort when we consider the comparatively minute size of the builders; nor must it be overlooked that the subterranean workings of such a nest extend far below the surface of the soil. Perhaps the most world-famous termite nest, or termitarium, is that built by the so-called Magnetic Termite; it is a huge wedge- or tombstone-shaped structure in which the narrow ends point generally north and south, although the direction may be somewhat influenced by prevailing winds. It is generally accepted that the orientation of the nest is due to the fact that most of the building and repair work is carried out in the wet season; the facing of the long sides east and west enables them to get the maximum of sunshine, and ensures rapid drying of the damp clay. How far this may be true is uncertain, for other species in the same conditions do not make such nests. Other termites, again, construct rounded nests—"negro-heads"—high in the branches of trees, connected with the ground below only by a narrow clay gallery. Still more make their homes below the earth with nothing to indicate their presence above the surface. Each of these nests, irrespective of its form, has been built over some stump or log, or, perhaps, a root deep in the ground, or similar object. Galleries have been traced extending as much as fifty yards from the nest to some food supply.

What is the interior of the nest like? The clay covering is several inches thick throughout, and is thickest at the base; the material composing this protective covering appears, in part at least, to be gathered grain by grain from the surface of the surrounding soil. The greater part of the structure is built up of a mass of woody material which has passed through the bodies of the insects; it is honeycombed with innumerable passages and galleries, through which the busy life of the colony passes. Towards the base of the mound is a large cell the size and shape of an inverted saucer; this is the heart of the nest, the royal cell, in which the queen spends her life. Above this royal abode one finds a large mass of thin overlapping sheets of a friable papery texture forming the nursery for the eggs and young. Close to this, in those species which indulge in the habit, are the "mushroom gardens", and on the outer areas near the summit of the nest, just within the clay wall, are the storehouses, cemeteries, and the sanitary and garbage disposal systems.

The population of a nest of average size numbers between one and two million inhabitants, which are divided into a number of groups or castes adapted in structure and habit to the specialized part each must play in the economy of the colony. There are wingless workers and soldiers, males and females, together with supplementary or neoteinic male and female forms. In the bees the worker, and in the ants both worker and soldier castes are sterile females, but among the termites these castes may be sterile members of one or both sexes, and in almost all species they are quite blind.

The workers are small soft-bodied creatures of a whitish colour with large rounded heads equipped with powerful jaws well fitted for cutting, gnawing and shaving wood. Upon the workers devolves the work of constructing and repairing the nest, the collection and storage of food, the sanitation of the nest and the preparation and care of the fungus gardens, together with the feeding and grooming of the queen and the tending of eggs and young.



Queen of Milk Termite (Coptotermes lacteus).

The soldier is usually about the same size as the worker, but here the head is heavily armoured and of a reddish-brown colour; the jaws are long, slender and curved, and prove efficient weapons against an enemy. In other species the head may be produced forward into a slender pointed beak or snout, while in the forehead above there is a cavity filled with a milky fluid which can be ejected with considerable force against a foe. The fluid coming in contact with the eyes or body of an intruder seems to possess irritating qualities. The soldier termites carry out the defence of the nest, and provide guards for the queen and foraging parties of workers. In the event of an attack upon the nest the soldiers beat out a warning upon the floor or walls of the galleries with their horny heads.

The males and females are yellowish-brown in colour, and are equipped with efficient eyes. When they first emerge from the nest they bear two pairs of smoky wings which are later detached along a fold near the base, and lost. These insects found new colonies. When the female begins to lay eggs her body swells into a white sausage an inch or more in length and about the thickness of one's little finger. In some African forms the queen may grow to five inches or longer! The head, thorax, and limbs are still those of the slender winged insect, but the legs are no longer capable of moving the massive body; the plates of brown armour which once encircled her body are now merely a series of widely-spaced patches along her back. Incapable of movement, the queen, as she is now called, lies enclosed in the royal cell, tended by countless workers who carry away the eggs as they are laid—to the number of up to four, or even seven, thousand a day. These attendants also feed and clean the queen-mother, and so assiduous are these ladies in waiting that they sometimes rasp holes in the delicate skin of their charge! The queen may live for a number of years. The male, unchanged but for his lost wings, may live in the royal cell with his mate, but in several Australian species no sign of this prolonged association has been found.

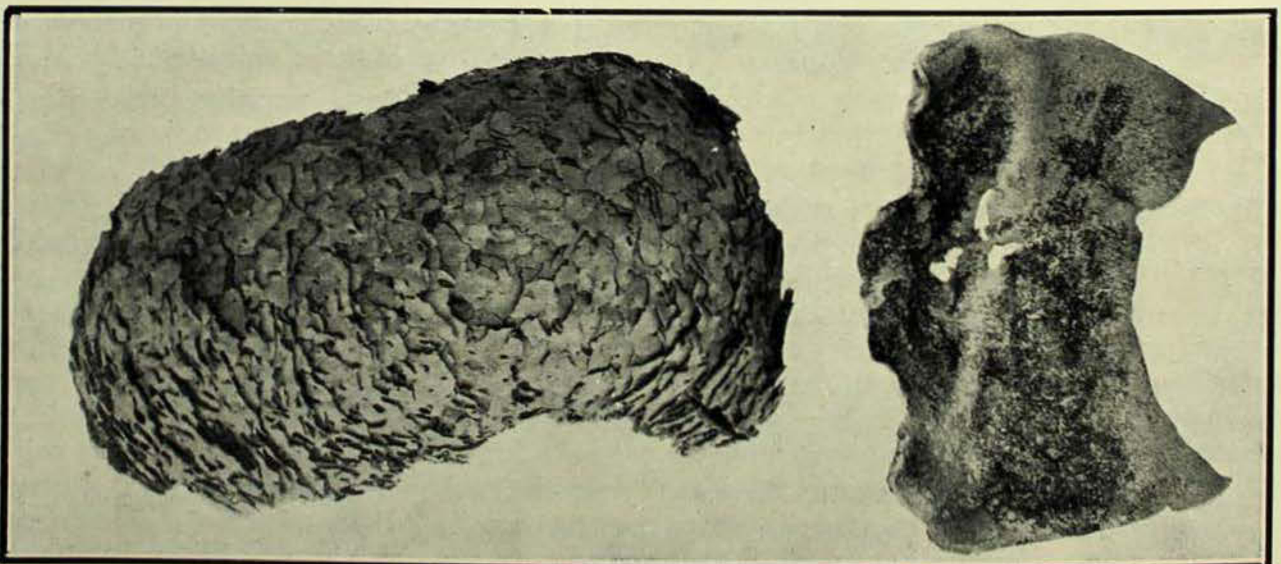
Supplementary, or neoteinic, males and females are produced in the colony apparently to augment the decreasing output of eggs from a failing queen, although in many instances large numbers of these neoteinic royalties are to be found in nests where the true queen is still at the height of her productivity. These supplementary forms never leave the nest upon a marriage flight, and are pale and wingless with vestigial eyes.

Such is the constitution of the termite colony. What then of their life? This may be briefly summarized from the nuptial flight which takes place prior to the founding of new colonies.

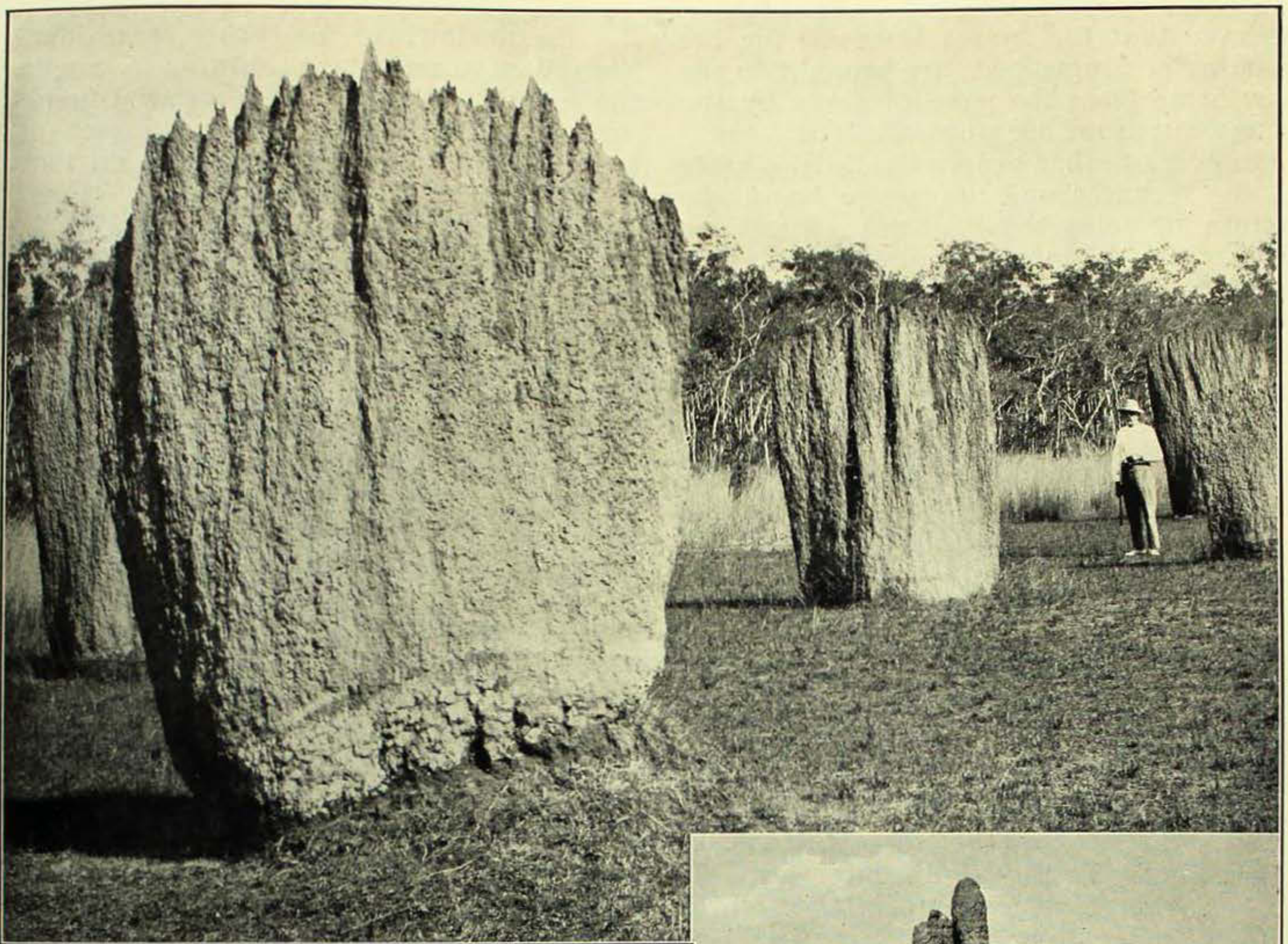
On a hot day, usually preceding or following a storm or a shower of rain, the parent colony presents a scene of intense activity. The workers cut openings in the clay walls of the mound, the soldiers mounting guard over these until the psychological moment arrives; then their ranks open, and the winged males and females pour out in an apparently endless stream. Their flight is weak and fluttering, and the adventurers seldom travel far before dropping to the ground and divesting themselves of their wings—appendages which would only hamper them in their future life. By some mysterious telegraphy the news of the flight seems to spread abroad, and birds of many kinds, lizards, frogs, ants and other predaceous insects, assemble in great numbers to avail themselves of this wonderful banquet provided by Nature, and it is few indeed of the winged termites which survive to found new homes. The female alights on some convenient grass stem, shivers her wings rapidly, and then, with a sudden effort, rids herself of the gauzy sails; males in the vicinity similarly remove theirs; then the female runs off over the damp ground, closely followed by one or more males, the whole procession looking like a miniature railway train. The ground must be damp, or the scent is lost and the suitors find it difficult to pick it up again. At last but one suitor is left, and he and his mate crawl beneath a log or dig a tiny burrow in the ground, the pair digging away furiously at the soil like a pair of miniature dogs. This is the beginning of a new nest.

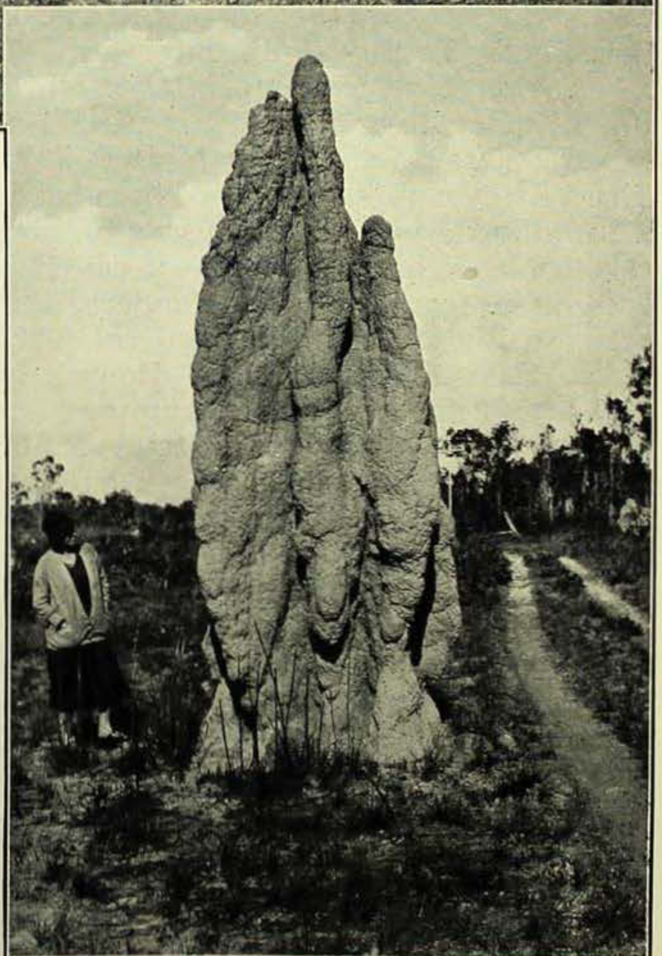
Within a few weeks the female lays her first few eggs, from which workers and soldiers emerge; they are fed and cared for by their parents until they are old enough to undertake the work of the new colony, leaving the queen free to devote herself entirely to the task of egg-laying. From this time forward the growth of the colony goes forward without interruption; the mound is built and added to from time to time, as may be rendered necessary by the growth of the population, until, after possibly many years, the colony attains its full size. Food is obtained for the colony through a series of underground galleries extending often for long distances to logs, stumps and other woody material. Where the source of food is situated well above ground, the termites obtain access to it by constructing covered earthen passageways up the exposed surface, as was done in the Australian Museum many years ago. Here the insects carried their galleries up the stone walls until they could reach the roof timbers, for the worker and soldier termites, despite their blindness, are intolerant to light, although in some species foragers will work in broad daylight. Such foraging parties cut up dry grass and other herbage into short lengths like chaff and store it in special cells situated near the outer wall of the nest.

It is possible that from this custom of storing up vegetable matter as food in the humid atmosphere (93 to 95% humidity) of the nest, that the termites evolved, in certain species, the amazing habit of preparing and cultivating "mushroom gardens", an occupation also carried on by certain specialized groups of the true ants—surely one of the most astonishing cases of the parallel evolution of the same habit in two distantly related groups of



Wood and lead damaged by "White Ants". The lead was eaten through to enable the termites to reach the timber framework.





Above: Magnetic Ant Hills, Northern Territory.
Right: The Overland Track, Birdum to Darwin.
Photos.—C. Barrett.

animals. The "mushroom gardens" are formed in large cavities in the nest around the nursery and are filled with decaying vegetable matter upon which the fungus grows. The so-called "mushrooms" are really a development of the fungus threads of a species of toadstool, which in abandoned mounds grow up through the dome and develop their normal form. But such large growths are not desired by the termites, and are useless for their purpose, so, as the threads spread through the decaying matter, they are carefully tended and pruned by the workers, so that they develop into minute white knobs which are used as food. Bugnion has described the young nymphs grazing over the fungus-beds like little white lambs! It is believed that the spores essential for the starting of fungus-beds are brought to the new home from the parent colony by the young queen on her nuptial flight.

Insects of other orders live in the nests of the termites and appear to be in the nature of tolerated "guests"; these are mainly flies (Diptera) and small Staphylinid beetles. Whether it is due to the conditions under which they live is not known, but many of these little creatures bear a strange resemblance to their hosts in the development of their bodies. Nothing appears to be known as to their habits.

Ants—and especially the large Meat Ant (*Iridomyrmex detectus*)—are inveterate enemies of termites. The Meat Ant appears to attack the mounds systematically, first securing entrance through the wall, and occupying a small section of the interior; then, step by step, extending the area of occupation until the whole nest has been seized and the population exterminated. The termites' method of dealing with a breach of the fortifications is interesting. If the stout outer wall is broken, the soldiers immediately swarm into the gap, filling it with a palisade of armoured heads and threatening jaws. After a little while the ranks of the guards part to allow a worker to emerge, bearing a load of clay in its mandibles, which it deposits in front of the defenders, and covers with cement-like saliva. The worker then retires, to be followed by another and another, until a rampart has been built; this wall is extended and raised until the breach has been entirely filled. The work will be completed under cover of darkness, when the patched area will be rendered indistinguishable from the whole.

The Australian termites are divided into three families: the Mastotermitidae, the Calotermitidae, and the Termitidae. The Mastotermitidae contains a single species (*Mastotermes darwiniensis*) found in north Australia, a large insect of exceedingly primitive form—and on that account of particular interest.

Of the family Calotermitidae some thirty species are known from Australia belonging to the genera *Solotermes*, *Protermes*, and *Calotermes* which live in dead trees and logs in forest areas. The *Calotermes* are remarkable in having no true workers, all the labour of the nest being carried out by the nymphs.

By far the largest family is the Termitidae (the Mesotermitidae of some workers). This contains about ninety species, and includes most of those which are of economic importance, and are mound builders. The genus *Coptotermes* includes the common coastal species (*Coptotermes lacteus*), *Hamitermes*, the famous Magnetic Termite (*Hamitermes meridionalis*), while the genus *Eutermes*, which includes forms ranging from *Eutermes palmerstoni*, the builder of the huge tower-like mounds, to those which inhabit the south-western plains of New South Wales. These live beneath the surface of the ground, feeding on grass-roots, and which, on the occasion of the nuptial flights, construct fragile tubes, rising but a couple of inches above the ground, and which seem to serve to protect the winged insects from enemies as they emerge.

Many writers have written in praise of the complex social life of the termites, ants, and bees, but, as will be apparent from this very condensed account of certain aspects of the life of the termite colony, it is essentially a mechanical and wholly soulless state, and comparable with that existing in totalitarian countries.

To the Red Heart of Australia

By A. MUSGRAVE

TO visit Central Australia had long been a cherished ambition, and so when an opportunity occurred I decided to avail myself of the facilities afforded by the well-known tourist organization, the Pioneer, which yearly makes trips from Melbourne to Darwin and back. Therefore to Mr. W. Caffery and his associates Messrs. C. Carroll and W. Chadwick, I would tender my sincerest thanks for their assistance in making my ambition materialize.

Our means of transport consisted of a large eleven-seater car and a four-ton truck. Both car and truck were fitted with oil engines which gave great hauling power, though a speed greater than 30 m.p.h. was not possible. However, after we left the good roads between Melbourne and Port Augusta, we rarely reached 20 m.p.h. The party consisted of the three Pioneer men and four tourists.

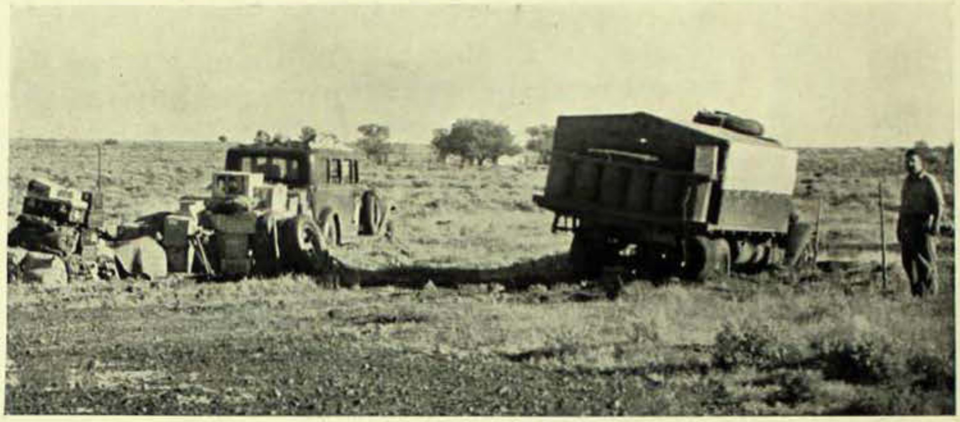
Port Augusta, from which we set off into the wilderness, is a large town and the last we were to see until our arrival at Alice Springs, nearly a thousand miles away. After leaving Port Augusta and travelling for some hours through desert country, we camped in a patch of mulga and saltbush.

MULGA AND SALTBUSH.

A few words about the mulga, *Acacia aneura*, under whose branches we so often camped, might not be out of place. It is a small tree or shrub, 12 to 20 feet in height, and its grey-green leaflets are rather reminiscent of those of a she-oak. The wood is hard, is yellowish on the outside and dark-red on the inside. It is used by the aborigines for making various articles such as boomerangs, pitchis, etc., and Europeans make all sorts of articles of the souvenir type from the wood. The tree was with us more or less all the way to "the Alice", and extends north of the MacDonnell Range. It has a wide distribution in South Australia, ranging from the north of Eyre's Peninsula, westward to Ooldea, and it occurs in the dry parts of New South Wales, Queensland and Western Australia. The bluebush, one of the saltbushes which grew abundantly on the Arcoona tableland, looked very attractive, somewhat like a blue madrepore coral. The saltbushes, bluebushes and cotton bushes (*Rhagodia, Chenopodium, Atriplex and Kochia*), all members of the family Chenopodiaceae (i.e., in reference to the goose's foot leaves), are valuable fodder plants for

Mulga, Acacia aneura, and Saltbush at Camp near Port Augusta, S.A.
Photo.—A. Musgrave.

The road to Coober Pedy across the open plain.
Photo.—A. Musgrave.



Cars bogged in middle of a vast plain, about 60 miles from Coober Pedy.
Photo.—A. Musgrave.

stock, and flourish in such arid country as we pass through to Central Australia.

Zoologically and botanically the whole of the interior of our continent is one great unit, that is to say, the same animals and plants for the most part extend the length and breadth of this arid area. This fact has been pointed out by various entomologists and other zoologists, while a chart in colour issued by the Federal Government shows the distribution of the plants to be very uniform. This zoo-geographical area begins in western New South Wales and Queensland and extends clear through to the Western Australian coast and down to the Bight, with the exception of an area in S.W. Australia, where there is a fairly high rainfall with a corresponding change in flora and fauna. But although we may weary of the eternal salt-bush and mulga, we find as we draw near the mountainous red heart of the continent that we encounter plants which were lacking in the country to the south.

THE ARCOONA TABLELAND TO COOBER PEDY.

Soon after leaving our first camp we came to gibber plains formation, small stones lying on the surface of the clay. From now on we were to pass through country which differed but little in many respects, though for convenience we may divide it like ancient Gaul into three parts, viz., (1) the country of the salt pans and lakes (near Port Augusta), (2) the land of the rivers (usually of sand), (3) the mountains (of the centre). We passed through Hesso where ballast is prepared for the E.W. Line, crossing the railway several times and came to a large plateau, sometimes disturbing kangaroos and emus. Passed by Wirrappa with Lake Windabout nearby, then we mounted the plateau once more, and away in the distance we could see Island Lagoon, the island standing up like a peak from the lake. The road was only a track or wheel ruts, the country strewn with gibbers and dotted with saltbush and usually quite treeless. We lunched near the Pines

Homestead, then travelled past the deserted Phillips Ponds station, and rising gradually. In fact the country continued to rise until we came near Alice Springs situated at an elevation of 2,000 feet. We camped near East Well where we took on water, and resumed our journey passing some large camel yards and crossing Lake Younghusband. Owing to various vicissitudes not entirely unrelated to the effects of a night's rain, we did not arrive at Vivian Well outstation, 45 miles from East Well, until three days later. Here we were hospitably received, and during the day spent here we learnt something of the district—the Arcoona Tableland. The nearest railway station is Kingoonya, 52 miles distant, and their closest neighbours on the party line 17 miles away at Mt. Eba. From a chart on the kitchen wall we further learnt that the average rainfall for 14 years was 452 points. In 1938, 873 points had been recorded, and up to June, 1939, exceptional rains of 10 inches. Most of the rain occurs in heavy falls. We also discovered that East Well is an outstation of Coondambo Station, which is 700 square miles in extent. Vivian Well, managed by our hosts, is 640 square miles or 409,600 acres, but it will carry only 18,000 sheep. Later we were to pass through Henbury Station on the Finke River, the third largest station in Australia, of 4,800 square miles and unfenced. Our elevation at Vivian Well was about 700 feet, but if the reader's interest in this part of Australia would be further quickened, his attention is directed to a book by Francis Ratcliffe, *Flying Fox and Drifting Sand,* which devotes a chapter to this little-known area.

Continuing our journey we passed by Mt. Eba and Twin Wells stations, through flat or undulating country with mulga, saltbush and tussocky grass predominating, and though the road was flooded in places we got on fairly well before we "sat down" near some rain pools about 60 miles from Coober Pedy. Here we found ourselves in the midst of a vast plain with low ridges which sloped down to form a catchment for the rain pools. A patch of mulga about a quarter of a mile up the road gave us fuel and shelter for the night, and next day we were able to extricate the cars and proceed on our way. That night we camped on the banks of Carringallana Creek about 12 miles from Coober Pedy. Here there was a fine pool with a fringe of eucalyptus trees and spiny acacias. The nest of a hawk was in a river gum, and the spiny acacias were filled with the nests of zebra finches.

Nest of Termite, Eutermes sp., near Mt. Willoughby Station, S.A.
Photo.—A. Musgrave.

We arrived at Coober Pedy Opal Field next morning. From a distance we could see the low hills which constitute the Stuart Range where the small community of about 30 live underground in dugouts. Here we met some of the miners and learnt a little about opals. Starting with the rough matrix, we discovered that there are three kinds, "pin-fire", "barry" and "flashy" opal; the poorer kinds are sent to the East. Some opals are polished on the field. From the hill above the Commonwealth Bank we had views over the neighbouring hills, bare and arid, the white heaps of crystalline gypsum showing where the miners had been excavating.

We left Coober Pedy about midday, passed Mabel Creek Station after lunch, and then rose gradually until we came to a long rocky ridge. Over the endless plain we had traversed we had seen no trace of kangaroo, emu or any animal save crows, eagles and hawks to relieve the monotony of grass and mulga, though all along the track as we bowled along we often disturbed Crested Bronze-Wing Pigeons. Some 60 miles from Coober Pedy we camped in the mulga, and here we came across small termitaria usually standing at the base of a mulga tree. They were constructed by a termite or white ant of the genus *Eutermes*. The nests stand from 12 to 24 inches in height and vary in thickness as well as in the shape of their summits which may be turretted.

NORTHWARDS FROM COOBER PEDY.

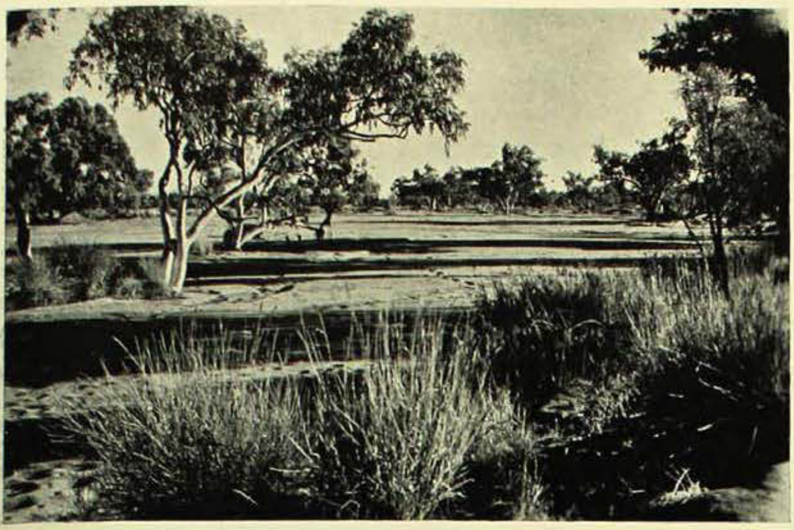
We rattled on through various stations, Mt. Willoughby, Wintinnia on Wintinnia Creek, Wellbourn Hill, at each of which we tarried awhile. In London some years ago someone remarked, "it is not the number of miles in a country that counts, but the number of people that you meet within a mile". The truth of this contention was amply proved by the enthusiasm shown every time a homestead with its human inhabitants appeared. We camped one night on beautiful Koongra Creek, and next day crossed the Alberga River at the notorious Lambina Crossing where the year before a small boy had died from thirst. Some three years previously, to go to the other extreme, Lambina Station had been washed away in a flood. We found the river here about a quarter of a mile in width but of sand only, but by deflating our tyres we got over.

The northern side of the Alberga River proved quite different from the southern bank, no gibbers, but a red sandy loam, and sandy ridges on which grew spinifex, our first introduction to the plant.

The "Spinifex" or "Porcupine" grass constitutes the genus *Triodia* (which name, as J. M. Black points out,[1] is in reference to the flowering glume or bract having three obtuse teeth). Four species are listed by Black. Each plant forms a tussock and resembles a giant pincushion, the basal part being hard and spiky and giving off the long yellow flowering stalks which shine in the sunlight. To a zoologist the spinifex is of great interest on account of the number of animals which shelter neath its spiky leaves. Lizards, spiders and insects of various kinds may be found when a plant is turned over. Sir Baldwin Spencer has shown how the aborigines utilize the resin of the spinifex by chopping the leaf stalks into pieces, burning them, and so making lumps of black resin that set hard, and thus serve as handles in which to fix the points of spears. He has also shown how a species of ant, *Hypoclinea flavipes* Kirby, utilizes the resin in the construction of its tunnels which are made of red sand and resin and which it places on the spiky leaves of the spinifex. In these tunnels are scale insects which secrete a fluid prized by the ants, and so are tended by the ants as cows are tended by man. The nest of the ant is at the base of the spinifex grass clump. These spinifex tussocks are highly inflammable, and this fact was demonstrated for us, a small plant being placed in the middle of the road and ignited.

We camped one night on the bank of the Hamilton River, which like all the rivers hereabouts at this time of the year, midwinter, was a river of sand. The river gums were on the point of flowering, and budgerigars were much in evidence, and the Lesser Wanderer Butterfly, *Danaida chrysippus petilia* Stoll, was common among the rushy grasses along the banks. Butterflies otherwise are rare in the Centre. Next day we followed the Hamilton through country similar in many respects to that further south, viz., gibber, mulga and red termitaria. Then we came to our first cork bark trees,

[1] Black.—*Flora of South Australia*. Adelaide, 1922-1929.



Hamilton River—a typical river of the centre, dry during the winter months. Red or River Gums grow in and along the banks of all these streams.
Photo.—A. Musgrave.

Spinifex growing near Erldunda Station, C. Australia.
Photo.—A. Musgrave.

Hakea lorea, an interesting plant which grows to a height of 20 to 23 feet and has leaves from 6 to 16 inches in length. On other trees we saw the flowers, which occur in long cylindrical golden-yellow racemes. This plant, according to Black's *Flora of South Australia,* is restricted to the N.W. of South Australia and extends to Western Australia.

Mountains looming up ahead showed that we were now about to enter the "Red Heart of Australia" in reality, and at Mt. Tieyon Station we came on some strange outcrops, though the homestead was situated on a plain surrounded by reddish sandstone mountains. About a mile beyond the homestead we drove by a wonderful series of outcrops, small hills all highly coloured, the colours ranging from red ochre to burnt sienna. This display lasted for twenty miles when we came to a plain, and the mountains lay behind us and some distance away. We then rose gradually to a height of 2,150 feet, and then descended to where the old road goes off to Kulgera and the new road on the right to Erldunda Station, which was our next port of call. On this road we passed through what seemed an interminable belt of mulga, but at one point we came on an area where the spinifex grew in profusion.

[In the next issue of THE AUSTRALIAN MUSEUM MAGAZINE Mr. Musgrave will describe the country from Erldunda Station to the Macdonnell Ranges.—EDITOR.]

New Parts for Old in the Shellfish World

By JOYCE ALLAN

MANY animals have the faculty of growing anew, or regenerating, portions of their bodies which have been lost as a result of accident, or of attack by other animals, or which have been cut off by the animals themselves. This capacity for replacing lost parts by new ones (regeneration) belongs to the general category of growth phenomena. In certain instances, particularly amongst the simplest forms of animal life, it is used as a means of propagation. The higher up the scale we proceed, the less is the phenomenon displayed, until in man, the ability to replace lost parts is restricted mainly to the healing of cuts and wounds with new skin growths, and re-growth of toe and finger nails. In spite of his high organization, man certainly cannot replace lost limbs, or portions of lost limbs, with new ones.

Apart from the simplest animals, where two individuals arise simply by the splitting of a single one into two parts, each part becoming a complete animal, those capable of regeneration in a marked degree are worms, sea-stars, brittle-stars, anemones, crabs, lobsters, shellfish and lizards. Worms have a considerable power of regeneration, and make interesting subjects for experimental work; sea-stars, with little difficulty, regrow one or more arms to replace lost ones, and in extreme cases, an entirely new animal can be grown from a single arm, provided a small portion of the central disk is present; crabs and lobsters regrow legs and chelae; and new legs and tails appear on certain lizards, when such members have been lost or discarded.

The capacity for regeneration varies widely even in closely related groups. When a limb is lost, the making of a new structure entails migration and mobilization of cells at the wounded area to replace injured ones, cell division takes place, various tissues become differentiated, and growth continues until a new portion replaces the old, possessing, as a general rule, its functions and shape.

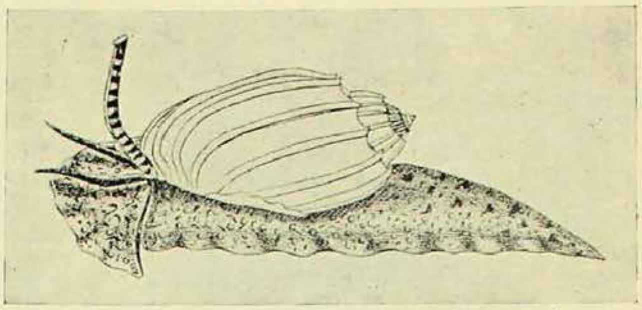
Closely associated with regeneration in the lower animals is the process known as *autotomy*, a term applied to the voluntary throwing off of a limb, or surrendering a portion of the body in response to some external stimulus, such as irritation or pursuit. Two familiar examples of animals displaying autotomy are the brittle-stars of the seashore and the small Gecko lizards. A brittle-star, if handled, will drop its writhing arms one by one, and a Gecko, when pursued, will frequently dart to safety, leaving its tail wriggling on the ground. In these instances, and in many more, the act of discarding is purely voluntary, and replacement with new parts is soon accomplished.

The general tendency is to regard autotomy as a means of escape, or at least, as an adaptive response to a particular feature of an environment. Some cases of autotomy may be nothing more than the normal asexual method of reproduction as displayed amongst the simplest, single-celled lower animals, and sometimes by anemones and sea-stars. That some animals possessing this ability to sacrifice portion of their body may, temporarily at least, save their lives from immediate danger is not disregarded as a possibility.

Though not restricted wholly to sea-shore life, the relatively frequent occurrence of autotomy on the seashore, where the struggle for existence is recognized as being particularly severe, gives us ample opportunity to witness this phenomenon. The voluntary discarding of parts of the body and their replacement, as also of those lost by accident or in conflict, occurs to a considerable extent among shellfish, both marine and terrestrial. So many examples can be found exhibiting both autotomy and regeneration, that only a few notable ones are given here, namely, certain sea snails, such as Wide-mouthed, False Ear and Harp shells, a small bivalve shellfish, *Lima*, land snails, the octopus group, and the sea-slugs, a short account of which follows.

SEA SNAILS.

Certain sea snails are too large to retire completely within their shells for safety, and the tail portion of the body protrudes permanently beyond the shell. It has been noticed that these snails, if subjected to some external stimulus, are able to cut this tail portion off voluntarily; the animals apparently suffer little inconvenience, and fresh growths soon replace the lost ones. In rock pools along our coastline, one can often see the actively moving little False Ear shell perform this act. If disturbed or handled, this species, by exerting pressure on the protruding tail with the edge of its shell, causes it to drop off, where it lies wriggling in the pool for some considerable time. The owner, having made this sacrifice, then retires into its shell, and clings firmly to rock or weed, where it remains quietly, and comparatively safe. A similar habit occurs in the Wide-mouthed shellfish, whose round, pearly lined shell is very common on most Sydney beaches, and in certain of the Harps, very beautifully marked shellfish which are found in the Indo-Pacific. These voluntarily discarded parts do not regrow a new animal, although the discarder, like the Gecko, is able to grow a new tail. In the case of the Harps, which crawl about briskly over the sands with their large crescent-shaped head protruding in front and a long tail stretching



The protruding tail of the Harp is cut off by pressure of the sharp edge of its shell. The discarded portion lies wriggling on the ground for some time, during which the animal escapes to safety.
After Tryon.

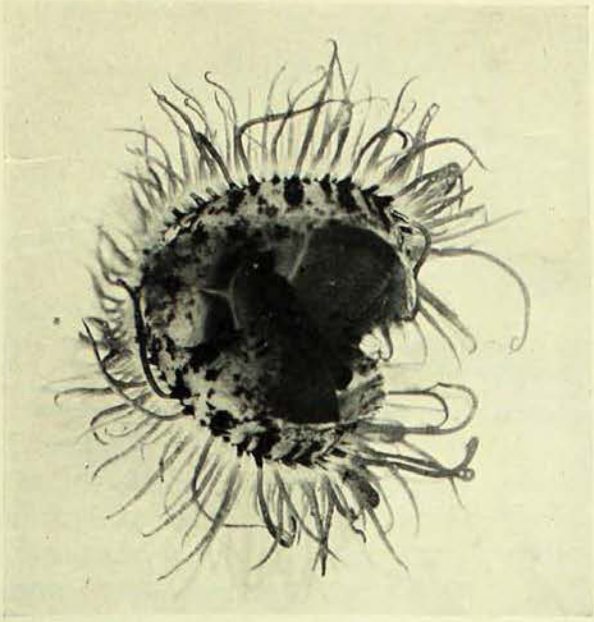
behind, sacrificing of the tail portion mostly occurs when natives of Mauritius rake the sands for them. If hard pressed, they withdraw as far as possible into their shell, and then snap! down goes the strong edge of the shell, and the tail is left wriggling about on the sand. It is possible that many other species built structurally along these lines would employ similar methods when necessary.

LAND SNAILS.

Amongst the land dwelling snails, of which the common garden snail is the best known representative, are a number able to throw off voluntarily that portion of their tail, or, as it really is, the tail portion of their crawling foot, for which there is insufficient room within the shell. As with sea snails possessing the same habit, a new tail replaces the old. One example is the small shiny snail of the Philippines, *Helicarion,* which whisks its tail up and down with convulsive rapidity when irritated, until it drops off. This is to its advantage, for it can then retire within its shell under leaves or bushes, and leave the cast-off portion for its main enemies, predatory birds.

THE BIVALVE, LIMA.

One of the most beautiful shellfish to watch swimming is the bivalve, *Lima.* At times the shell is completely hidden by very graceful creamy white or pink filaments extending from the animal's body round the two valves of the shell. It swims by opening and snapping



As they gracefully extend round the two valves of the shell, the fleshy mantle filaments of the Lima are tempting morsels of food to hungry fish. When such danger threatens, however, their owner casts them off and retires within the shell.

together the valves of the shell, forcing itself through the water in jerky movements in the manner of a scallop, whilst the protruding filaments maintain a constant rhythmic movement. The grace and beauty of these, however, can become a liability to their owner, as they offer themselves as tempting morsels of food to hungry fish. To meet this situation, the *Lima* discards them if necessary, and replaces them later with fresh growths. The discarded filaments, in the meantime, wriggle about for some while, like so many worms and, when they do settle, are hard to remove from an object owing to their adhesive quality. Some species of *Lima* build nests as shelters, and it is not unusual also to see one suspended by the tip of its tail to a rock while the shell and remainder of the animal float in the water.

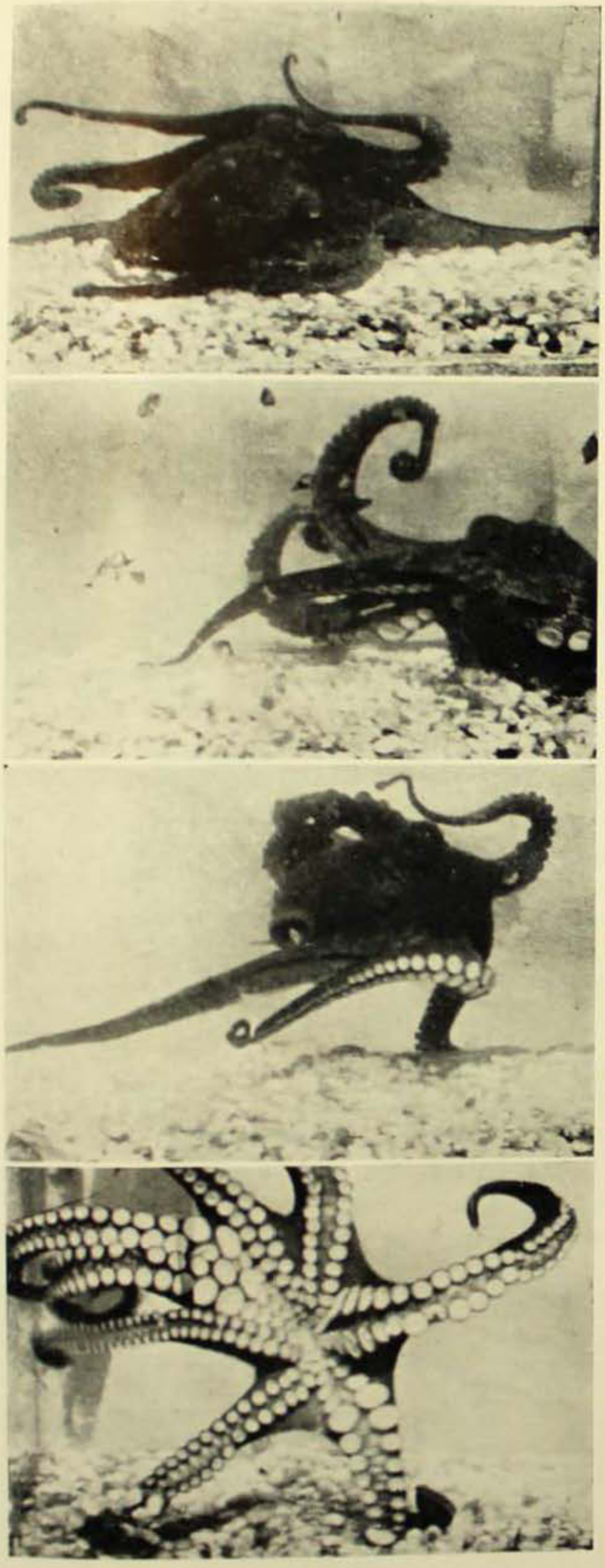
THE OCTOPUS.

In the class containing the octopus and allied shellfish, such as squids, cuttle-fish, the Paper and Pearly Nautilus and others, autotomy, and the subsequent phenomenon regeneration, are present to a certain degree in most members, in so far as the males are able to regrow a specially modified arm which is discarded in the breeding season. But other instances beyond this have been noticed, such as the replacing of arms torn off in conflict, or voluntarily discarded. There is a very interesting little octopus about two inches long found on the Great Barrier Reef, which drops its arms at will, leaving mere stumps behind. New arms soon replace these, and specimens have been found in which both phenomena can be seen at the one time. Large octopods in captivity in Taronga Park Aquarium, Sydney, frequently fight among themselves and portions of their arms are torn off. In a confined space, where escape is impossible, such a fight is usually to a finish and results in a loss of most arms before one of the animals dies. In the open sea the animals have a chance of escaping total destruction, and specimens have proved that regrowth can occur.

A small octopus, inhabitant of the Great Barrier Reef, provides an interesting example of autotomy and regeneration. One or more of its arms are cast off voluntarily and new growths later appear on the remaining stumps.

SEA-SLUGS.

Sea-slugs, a large group of shellfish without shells, are common along rocky shores, especially in the warm shallow

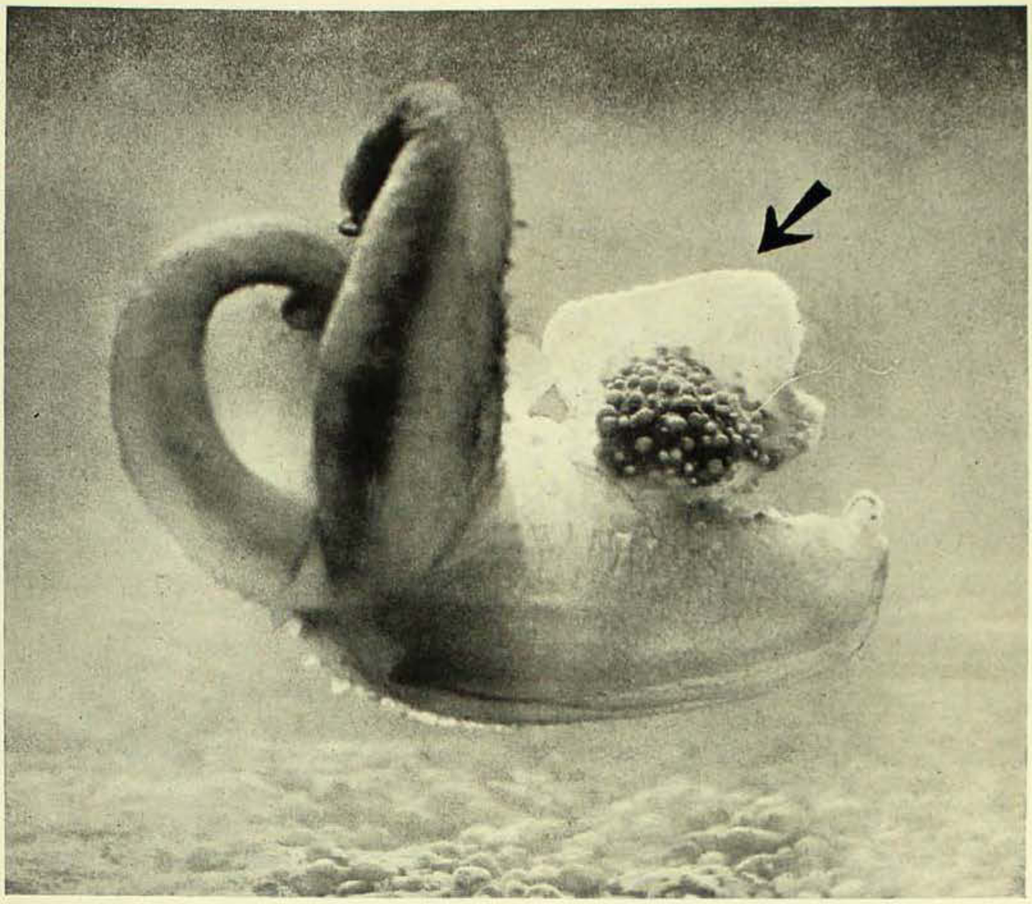


The strength of the sucker studded arms of large octopods is not displayed when the animals rest quietly, but stirred to action, the writhing arms tear and grasp at nearby objects. During fights between large octopods in the Taronga Park Aquarium, portions of their arms are frequently torn off, although re-growth may later take place.

waters of the tropics where they reach their greatest perfection of beauty. Amongst these, voluntary discarding of portion of their bodies is a common habit, and varies in its manner according to the type of sea-slug. In the simpler forms, such as the Dorids, it may take the form of simply throwing off the whole outer edge of the animal in a complete ring, leaving only a central portion to which a new edge later grows. The animal in the meantime appears to suffer no ill effect. Several species of Dorids found in Australia display this faculty. The most common method of autotomy amongst sea-slugs, however, is the casting off of body appendages, such as cerata, papillae and filaments, which frequently serve the animals as breathing organs, and are situated as a rule on the sides and upper surface of the bodies. More often these are brilliantly coloured, and are tempting morsels for hungry prey, and the owners, being sensitive to outside irritation or stimulus, at the slightest provocation discard a few or even the whole mass.

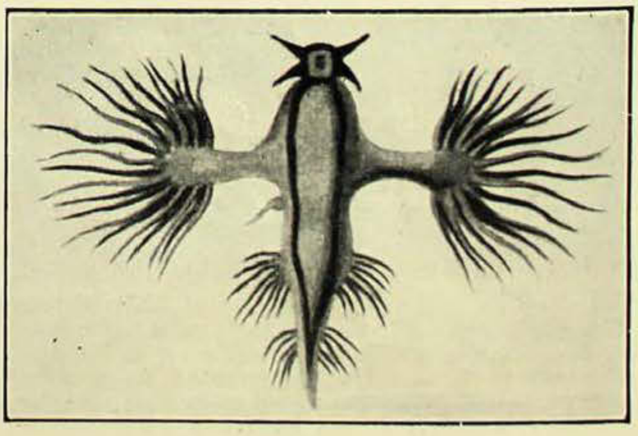
Amongst the beautiful members of the Aeolid sea-slugs, and the Sea Lizards, or *Glaucus*, the habit is most prevalent, and no greater disappointment can be had than to carry home from the sea-shore a jar of sea-water containing some of these, only to find on examination that they have discarded their greatest beauty, the masses of delicate body appendages. These, so rapidly lost, lie quivering in the bottom of the jar, and the animals, shorn of their glory, look entirely different; yet in their natural environment no lovelier sea creatures can be found. The *Glaucus*, a pelagic sea-slug which is sometimes washed up on our beaches, normally floats on the surface of the water, with its gracefully moving blue and white arms stretching out on each side of the body.

Some years ago a very beautiful sea-slug about a foot long, belonging to the genus *Propemelibe*, was captured in a bucket off Cairns wharf, Queensland, by the crew of a boat, and brought to



The arrow indicates one of the body appendages discarded by a large sea-slug, Propemelibe, during its captivity in Taronga Park Aquarium. For two weeks the animal cast off similar appendages, and the growth of the new ones was very rapid.
Photo.—Taronga Zoological Park.

Taronga Park Aquarium, where it provided a wonderful opportunity to witness the phenomena of autotomy and regeneration in an animal rarely seen before. The slug lived about a fortnight, swimming actively, performing somersaulting movements, or resting on the sandy bottom, scooping in food to its mouth by means of a large, veil-like hood reaching round its head. Along the body, besides raised pustules, and branching filaments, were 5–7 very large, beautifully marked appendages, which kept up a constant swaying and bending movement. It was no uncommon sight, even in that short time, to see these appendages cast off by the animal at will, and the next day to find others rapidly growing in their place. As they lay on the bottom of the tank, the discarded appendages, or cerata, displayed activity for some days, curling up at the sides when touched, and generally pulsating. A peculiar cloying, but sickly, odour was given off by them when removed from the water for examination. This may be a protective measure of the animal, as many of the sea-slugs, such as the Aeolids, which



Self-mutilation rapidly robs the Sea Lizard or Glaucus of its greatest beauty, the graceful blue and white arm filaments.

are liable to attack from other marine creatures, have the ability to give off a strong smelling mucus, or eject poison from their papillae.

No mention is made here of the repairs to the actual shells of shellfish, as that is another matter altogether. It may briefly be stated, however, that any shellfish is able to repair breakages or cracks to its own shell by adding fresh deposits of shelly matter.

Autotomy and regeneration are problems in themselves, and their study, especially that of regeneration, serves as an approach for many other problems facing research workers today. Some authorities consider it is not impossible that the tendency of lower multicellular animals to reproduce by fission may have formed the material upon which, under the stimulus of shore struggle, natural selection may have worked in order to produce the more specialized form of autotomy, as seen in, for instance, crabs and sea-stars.

In a special exhibit recently set out in the Australian Museum are shown some of the types of curios offered to members of the Australian Imperial Force in Egypt. These include scarabs, beads, statuettes and ushabti figures, together with forgeries of some of these objects. Coins, known as billons, issued by the Romans during their occupation of Egypt, are also shown. A summary of the history of Egypt, and brief description of the pyramids and the Sphinx, are given.

* * * *

Recently there has been installed in the Invertebrate Gallery of the Australian Museum an exhibit of Australian Butterflies consisting of two table cases, one devoted to the Butterflies of the Sydney District, the other treating with Australian Butterflies in general.

The primary object of the exhibit is to interest children in the butterfly fauna of their native land, and at the same time to provide them with interesting information about the life histories.

Dr. G. A. Waterhouse, the well-known authority on the group, has placed at our disposal many of the specimens shown, as well as a number of the illustrations, and most of the information has been taken from his work *What Butterfly is That?*

Representatives of each of the following families are shown: the Whites and Yellows (Pieridae), the Swallowtails Papilionidae), Danaids (Danaidae), Nymphs (Nymphalidae), Blues, Coppers, and Hairstreaks (Lycaenidae), Skippers and Darters (Hesperiidae).

These give a variety of form and colour to delight the eye, and range in size from such well-known forms as the black and green males of the Cape York Birdwing, with their larger brown-winged consorts, to the more soberly-coloured Meadow Brown of the Sydney district, or the dainty representatives of the Blues and Skippers.

* * * *

To enable our readers to see the actual objects which are described in this issue of THE AUSTRALIAN MUSEUM MAGAZINE, a special exhibit featuring them has been arranged. This has been placed on view at the main entrance to the Museum galleries.

* * * *

Mr. A. D. Sapworth, of London, who has been engaged in ornithological collecting in the Seychelles Group and Malaya, visited this Museum recently. He inspected our collection of Birds of Paradise and was interested particularly in McNicoll's Ribbon-tailed Bird of Paradise. It may be recollected that in March-May, 1940, issue there appeared an article and coloured plate of this bird.

Professor Theodore Sizer, representing the Carnegie Corporation of New York, was also a visitor. Professor Sizer is visiting the Commonwealth in connection with the loan collection of Australian art which is to circulate through Canada and the United States of America.

The Story of the Diamond

By T. HODGE-SMITH

WHY is it that the famous Cullinan diamond was cut into a number of stones valued at a million pounds sterling, while its glass model would be worth only a few shillings? First and foremost, a diamond of such perfection and transparency is exceedingly rare. The mineral sturtite is much rarer than the diamond, but its value, weight for weight, compared with the diamond is practically negligible, so that something more than mere rareness is necessary.

A gemstone must be hard in order to withstand wear and tear, and the diamond is the hardest of all known minerals. Everyone knows that corundum or emery is very hard and that talc is so soft that it is used as a powder for babies. The difference in hardness between the diamond and corundum is greater than that between corundum and talc.

It is rather curious that the diamond should be so hard, since it has exactly the same chemical composition as soot, which is neither hard nor beautiful. Soot and diamond are different forms of carbon. The diamond burns with a very pale blue flame and is converted into a gas, carbon dioxide, the gas which gives the sparkle to wine or the fizz to lemonade. If a diamond were heated strongly out of contact with air—for example, in an atmosphere of nitrogen—it would turn black, become soft, and change into graphite, another form of carbon.

Although the diamond is the hardest known substance, it does not follow that you can place it on a blacksmith's anvil and hit it with a sledge hammer, for it is brittle, and, further, it has a perfect cleavage. Cleavage is a property possessed by certain crystalline substances. It is sufficient for our purpose to say that some crystalline substances split with perfectly even surfaces along certain definite directions. A well-known example is mica. It has a perfect cleavage in one direction and so it can be split off in very thin sheets. The diamond will cleave not only in one direction, but in four different directions, so that, in the hands of the skilful worker, it can be cleaved into a perfect octahedron. (Figure 1.)

In ancient times the blacksmith's anvil test was applied, often with the result that many valuable stones must have been scattered ignominiously among the parings of horses' hoofs.

OPTICAL PROPERTIES.

Perhaps the most striking thing about the diamond is its effect on light transmitted through it. When a ray of light passes obliquely from air into another substance, be it diamond, water, or glass, it is bent or refracted. The diamond bends a ray of light much more than any other gemstone, or, as the mineralogist would say, it has the highest refractive index. Sunlight or white light is a composite affair, made up of all the colours of the rainbow. Each colour is bent or refracted to a greater or smaller degree than the other colours. Always the violet rays are bent more than are the red rays. This difference is more marked in some substances than in others, and it is greatest in the diamond or, to quote the mineralogist again, it has the highest dispersive power of all gems.

THE ROUGH DIAMOND.

The diamond as found by the miner is nothing like the beautiful stone that we admire in the jeweller's shop. Some of the diamonds are quite rough, resembling poorly polished glass, and they are often dull as though covered with a thin coating of gum. Sometimes they are found as crystals with smooth bright faces which are often curved. Again, the crystals may be twins.[1]

[1] Hodge-Smith, Aust. Mus. Mag., vi, 12, 1938, pp. 423-428.

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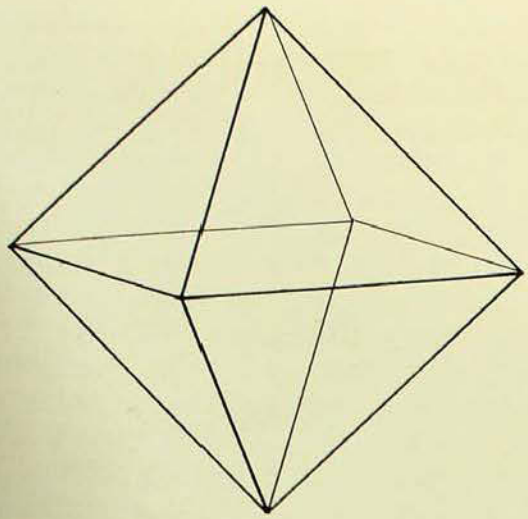

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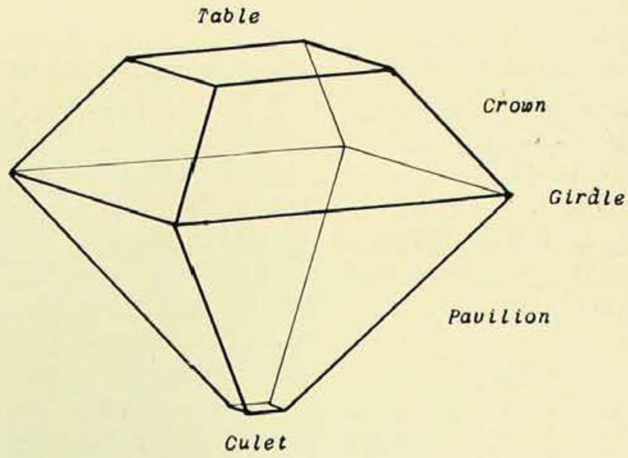

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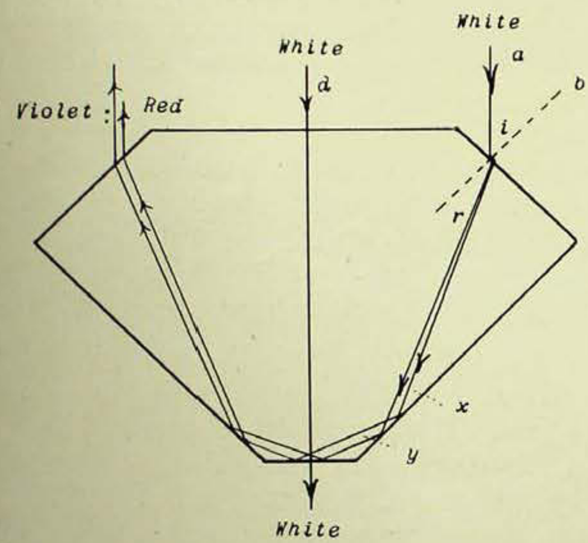

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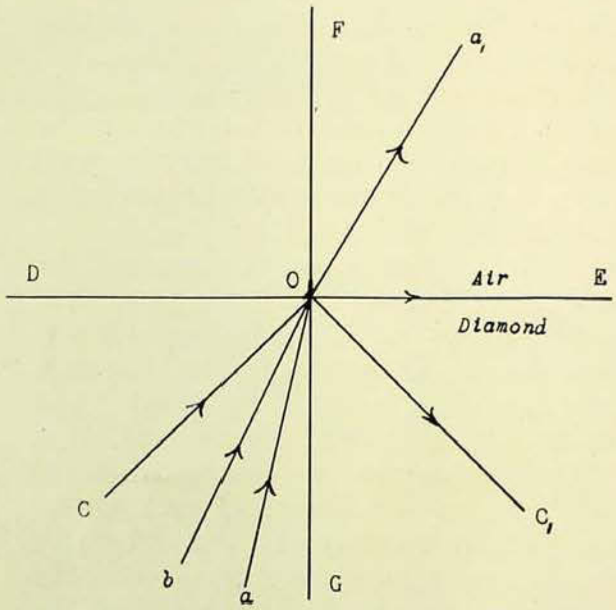

Figure 1.—This is the form, the octahedron, into which the skilful worker may cleave the diamond.

Figure 2.—After cleaving, the table and culet facets are cut as shown. Subsequently the facets of the crown and pavilion are added.

Figure 3.—A section of the brilliant to show the passage of light through the stone. The ray of white light on the right is bent on entering and is split into its component colours. It finally emerges from the stone on the left side as a tiny rainbow. The ray of white light in the centre passes straight through the table and culet facets without bending or dispersion.

Figure 4.—Diagram showing the passage of light from a diamond. DE is the surface of the diamond in contact with the air. a is a ray passing from the diamond into air where it is bent away from the normal FG along a, o. b is a ray that emerges along the contact of the diamond and air OE. GOb is the critical angle, which for the diamond is 24° 26′. c is a ray lying beyond the critical angle and so cannot pass out of the diamond but is reflected so that the angles DOC and EOC, are equal.

As a matter of fact, if a rough diamond were dropped into a parcel of rough zircons, it might be very difficult for the layman to find it; even the mineralogist would have to exercise care.

DIAMOND CUTTING.

How does the diamond cutter convert this gummy-looking pebble into an object for which men have given up their hard-earned savings, or have stooped to theft, or even to murder? Diamonds have often been cut into fancy shapes to satisfy a whim or passing fashion, but always the best effect is produced when it is cut in the form of the "brilliant", and so it is only this form that we need consider.

The diamond cutter first examines the stone very carefully. It has been reported that in the case of a very valuable stone this examination has occupied a whole year before the stone was even touched.

Then he cleaves it, his object being to form an octahedron. He first cuts a slight groove; then he places the blunt edge of a small steel blade in the groove and, with a sharp blow of a steel rod, cleaves the stone. Upon this first blow depends the success or failure of the treatment of the stone.

The next process is to cut the table and culet faces (Figure 2). This used to be accomplished by rubbing two stones together, a process known as bruting. To-day this is replaced by sawing. The cleaved stone, suitably mounted in a holder, is held against a rapidly-revolving, thin, bronze disc, the edge of which is impregnated with diamond dust and lubricated with olive oil. At this stage the fundamental form of the brilliant is produced, and it may be well to pause here to learn why the brilliant is so brilliant.

Figure 3 is a section cut through the centre of a brilliant. The line marked *a* represents a ray of light falling on the upper surface. As stated before, the ray, on entering the diamond, is bent. The line *b*, which is called the normal, is a line at right angles to the surface of contact between the diamond and air at the point where the ray of light enters it. As the diamond is denser than air, the ray is bent towards the normal, so the angle *i* is greater than the angle *r*. When the ray reaches the lower facet it cannot pass into the air again, but is reflected, as if the facet were a mirror, so the angle *x* equals the angle *y*. Figure 4 shows that the ray *a*, in passing from the diamond into the air, is bent away from the normal. As the ray becomes more oblique it will come to a position (indicated by *b* in the figure) where it will pass along the surface of contact of the diamond and the air. This is called the critical angle. Any ray (*c*) more oblique than *b* cannot pass out of the diamond at all, but will be reflected back into the diamond.

In Figure 3, as the angle *x* is greater than the critical angle for diamond, the ray has to remain within the diamond and so it passes on until it emerges from the top of the stone as shown. If it is a ray of white light, it does not emerge from the stone in the same form as it entered, because the violet rays are refracted more than the red rays. Instead of a single ray, it will be a bundle of rays of all the colours of the rainbow and so the diamond shows "fire". If all possible rays striking the top facets of the brilliant are examined in the same way, it will be found that they will all be returned except a small pencil of rays which strikes the table face perpendicularly and directly over the culet facet. As only the oblique rays are refracted, these rays will pass straight through the stone as shown by the ray *d*. Thus it should be impossible to see through a well-cut brilliant except directly over the culet facet. It is now clear why the term brilliant is applied to this form of cut stone and why it is that a colourless diamond should show such a play of colours.

Now let us return to the diamond cutter. He proceeds to cut all the other facets in exactly the same way as he did the table and culet facets. This is no haphazard procedure; each facet has its own position and, indeed, has its own name, and it is only the skilled operator who knows where and how to place them. Finally they are polished on rapidly revolving discs fed with olive oil and diamond dust, and the gummy-looking pebble is now a thing of beauty and life, even though it has lost about half its original weight.

In the early days diamonds were worn in the rough with only the top surface polished. When Louis de Berquem introduced the art of diamond cutting it was a table form with a row of facets above; it was not until 1520 that the rose cut was introduced. More than a hundred years later, in 1660, Cardinal Mazarin first introduced the brilliant cut.