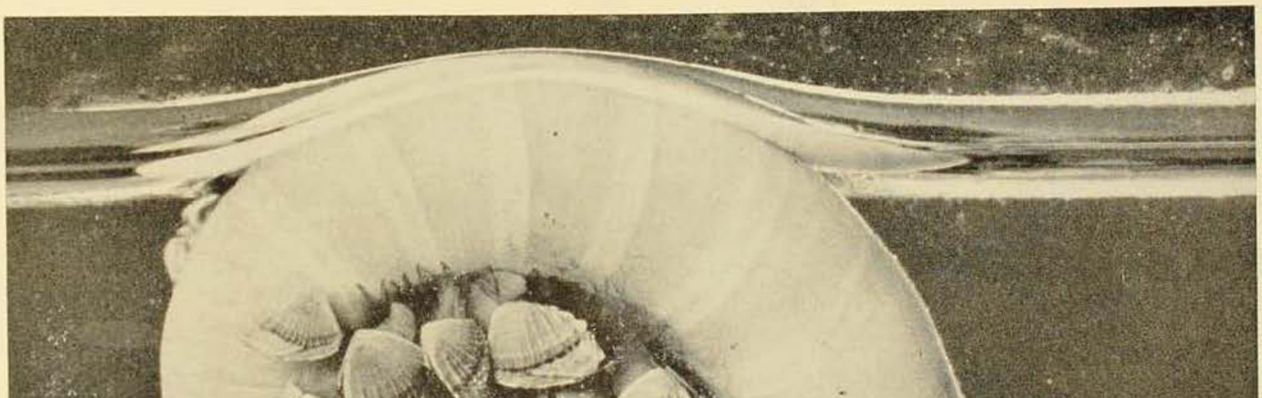
DECEMBER 15, 1959

The AUSTRALIAN MUSEUM MAGAZINE

VOL. XIII, No. 4 Price—TWO SHILLINGS



These Stalked Barnacles, attached to a Ram's Horn shell floating just below the surface of the water, are protruding their feathery cirri to trap the minute organisms on which they feed. (See article, "Some Australian Barnacles," on page 116.)

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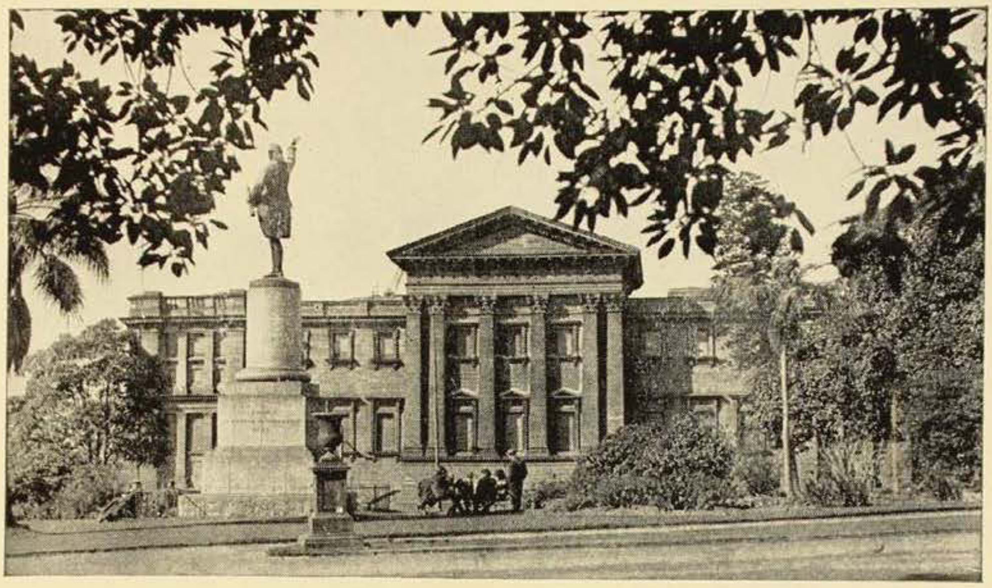
THE AUSTRALIAN MUSEUM

HYDE PARK, SYDNEY



THE AUSTRALIAN MUSEUM MAGAZINE

This special issue commemorates the centenary of the publication of Charles Darwin's "The Origin of Species."

● OUR FRONT COVER: This photo, by Howard Hughes, shows a cluster of Stalked or Goose Barnacles (*Lepas pectinata* var. *spirulae*) feeding. Their feathery feeding-limbs, or cirri, are extruded to catch, with a swooping action, the minute planktonic organisms which make up their food. The Ram's Horn shell (*Spirula spirula*), which belonged to a squid-like mollusc, is buoyed up by air trapped in its chambers. (Four times natural size.)

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THE LIFE AND WORK OF CHARLES DARWIN

By J. W. EVANS

ON November 24, 1859, there was published in London by the firm of John Murray a book entitled "The Origin of Species by means of natural selection, or the preservation of favoured races in the struggle for life". The author was Charles Darwin; and this year the centenary of the publication of this epoch-making work has been celebrated throughout the world.

Charles Darwin, the son of a doctor, was born at Shrewsbury in 1809. When his school-days were over, he went to Edinburgh University to study medicine. However, he did not stay long there (he couldn't stand what he saw in the dissecting room) and he transferred to Cambridge with the intention of preparing for the church.

While he was at Cambridge two things happened to him which were to help determine his career—he read two books, one by Humboldt and the other by Herschel, and he came to know the Professor of Botany, Henslow. It is sufficient to mention one only of these books, Humboldt's "Personal Narrative" of his travels in various parts of the world. This book fired Darwin with a wish to travel himself and see the world.

One day, on his return from a visit to north Wales, he found a letter from Professor Henslow awaiting him. It stated that Captain Fitzroy, of H.M.S. *Beagle*, which was about to sail on a hydrographic and geodetic survey of the world, had offered to share his cabin with any young naturalist who would come without pay. Darwin went to London to meet Fitzroy, and matters were arranged to their mutual satisfaction.

The *Beagle* sailed from Devonport in December, 1831. Though the next five years (for they didn't return to England until October, 1836) were to be ones of wonderful experiences for Darwin, they were also to be ones of acute discomfort, for he was a very bad sailor.

The *Beagle* first called at Cape Verde Islands, and then sailed to South America, where Darwin had numerous opportunities of going ashore both in the sub-tropics and cold southern regions and on both the east and west coasts. After rounding the Horn and visiting Chile and the Galapagos Islands, the *Beagle* crossed the Pacific to Sydney, visiting Tahiti and New Zealand en route. From Sydney it sailed to King George's Sound, Western Australia, and Mauritius on its return voyage to England.

After returning to England Darwin paid short visits to his family home at Shrewsbury, but lived mostly in London and Cambridge. His idea of entering the church, which had never been formally abandoned, died a natural death. He had but one desire, which was to collect facts about nature and to endeavour to interpret them. Fortunately, he had inherited enough money to enable him to lead the life he chose, and this was just as well, because for the rest of his life he suffered ill-health, and his "wretched stomach," as he called it, seldom allowed him a day free from pain.

In 1839 he married his cousin, Emma Wedgwood, whose sympathy and encouragement made his career possible. They settled three years later in a vast old house near the village of Down, in Kent. Here he had an ample estate, with plenty of space for gardens, greenhouse, laboratory and the rest of a naturalist's equipment, and here he spent the remaining 40 years of his life.

Charles Darwin as a young man.

Galapagos Islands Finches

One of the places visited by the *Beagle* had been the Galapagos Islands. These islands, which are of volcanic origin, lie approximately 600 miles west of northern South America. There are 10 principal islands, five of which are considerably larger than the rest.

In the book best known as "The Voyage of the Beagle" Darwin gives an account of the animals and plants of the Galapagos, and his observations on the finches are of particular significance since they helped turn his thoughts to the subject of evolution. He wrote: "The remaining land birds form a most singular group of 13 species of finches, related to each other in the structure of their beaks, short tails, form of body, and plumage: all of which are peculiar to this archipelago. The most curious fact is the perfect gradation in the size of the beaks in the different species, from one as large as that of a hawfinch to that of a chaffinch. Seeing this gradation and diversity of structure in one small, intimately related group of birds, one might really fancy that from an original paucity of birds in this archipelago, one species has been taken and modified for different ends."

When Darwin made these observations he, like all his contemporaries, took "special creation" for granted. It naturally stretched his credulity to suppose that all the finches had been specially created to inhabit these small volcanic islands, and if they had it was remarkable that they should be so similar in general characteristics to mainland form.

In July, 1837, less than a year after returning to England, he opened his first notebook for the collection of facts bearing on the origin of species. "I worked", he states, "on true Baconian principles, and without any theory collected facts on a wholesale scale, more especially with respect to domesticated productions, by printed enquiries, by conversation with skilful breeders and gardeners, and by extensive reading . . . . I soon perceived that selection was the keystone of man's success

Magazine Subscription Rate

Due to increased costs of printing and postage it has been found necessary to raise the annual subscription to The Australian Museum Magazine from 9/- to 10/- (posted). This increase will take effect with this issue.

in making useful races of animals and plants. But how selection could be applied to organisms living in a state of nature remained for some time a mystery to me.

"In October, 1838, that is fifteen months after I had begun my systematic enquiry, I happened to read for amusement 'Malthus on Population,' and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favourable variations would tend to be preserved and unfavourable ones to be destroyed. The result of this would be the formation of new species. Here, then, I had at last got a theory by which to work."

Apart from a number of papers read before scientific societies, his next work to appear, after the publication of "The Voyage of the Beagle," was a series of monographs on barnacles. This eight-year task—five in the writing—grew out of an attempt "to have described only a single abnormal individual Cirripede from the shores of South America." It absorbed him so thoroughly that his children supposed that "to do one's barnacles" was the normal activity of an adult.

The "species question" was never dropped, but for years nothing more was written except entries in notebooks and letters to personal friends, of whom two in particular were of great help to him. One of these was Sir Charles Lyell, the geologist, and the other Sir Joseph Dalton Hooker, who had succeeded his father as Director of Kew Gardens.

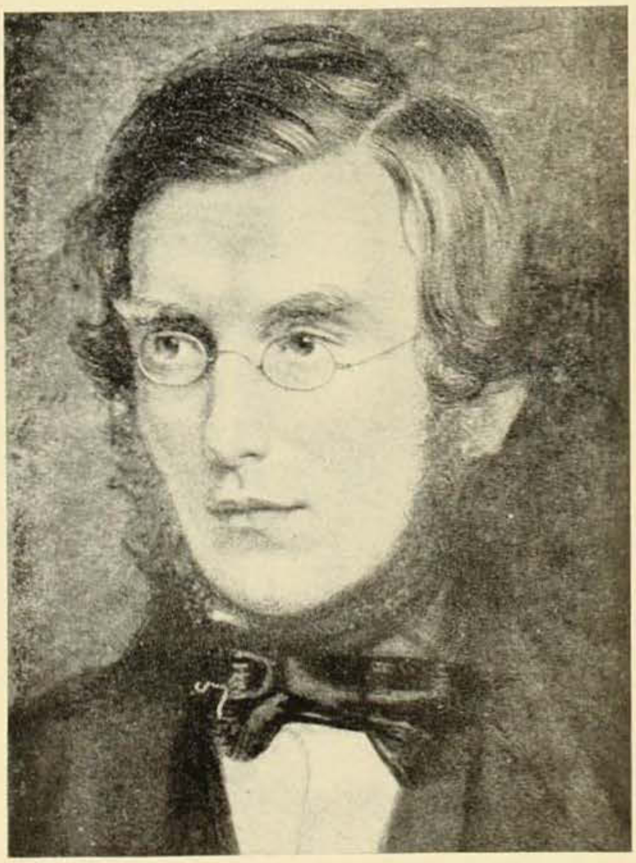
Both Lyell and Hooker urged Darwin to publish his ideas and told him something ought to be done with the vast material he had accumulated. Lyell, in particular, was afraid that someone might forestall him.

Accordingly, Darwin set to work on his book. His letters of the period show that it was designed on heroic proportions. He did not mean to publish "for several years." There were still many experiments to be tried, conclusions to be retested, facts and rumours to be verified, masses of material to be sifted . . . .

By the spring of 1858 he had finished the first draft of about 10 chapters. The Great Book would be in at least three volumes, and as yet little more than half had been written. Five years more might pass before it would be published—just a quarter of a century after he had conceived the central idea of his theory.*

Darwin's home near the village of Down, Kent.

And then something tragic, though obviously foreseeable, happened. On the other side of the world, at Ternate in the Celebes, a collector of natural history material, Alfred Russel Wallace, while suffering from an attack of malaria, turned over in his mind similar problems to those which had so long interested Darwin, and came to identical views on the importance of natural selection. When he was well enough, he put his ideas on paper and sent them to Darwin, asking him to read the essay and pass it on to Lyell.



Sir Joseph Dalton Hooker, Director of Kew Gardens, who urged Darwin to publish his ideas on the origin of species.

Darwin sent the manuscript, as Wallace asked, to Lyell, and wrote, "I never saw a more striking coincidence; if Wallace had my manuscript sketch written out in 1842, he could not have made a better short abstract! Even his terms now stand as heads of my chapters."

Lyell and Hooker decided to sponsor a joint paper by Darwin and Wallace, to be presented to the Linnean Society of London. It was communicated on the evening of July 1, 1858, less than two weeks after the receipt of Wallace's letter.

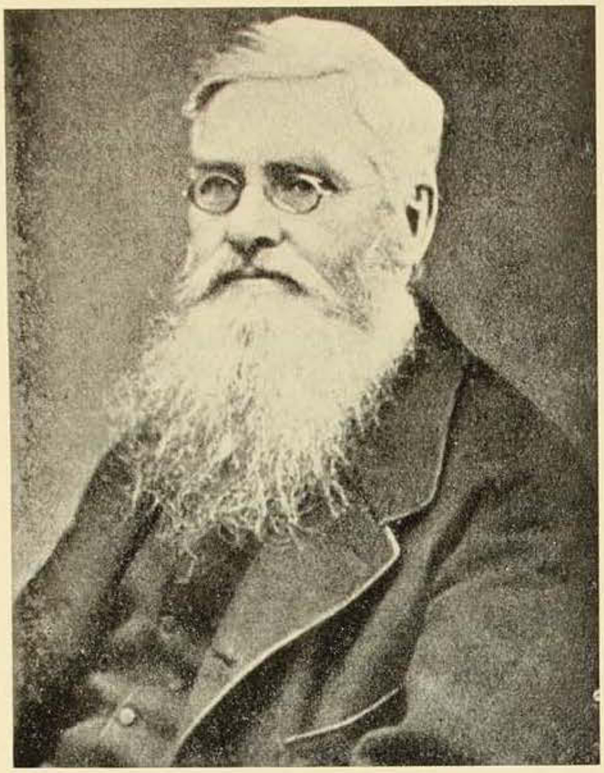
The joint paper takes up no more than 17 pages of print and makes no pretence at unity or completeness. The first reaction to it was an utter and stupefied silence. Hooker has described it thus: "The interest excited was intense, but the subject was too novel and too ominous for the old school to enter the lists before armouring. After the meeting it was talked over with bated breath: Lyell's approval, and perhaps in a small way mine, as his lieutenant in the affair, rather overawed the Fellows, who would otherwise have flown out against the doctrine."

Book Reviewers Hostile

Within a few days of the fateful meeting, Darwin's mind was made up. He resolved to prepare another abstract, fuller than any yet written but much briefer than the book he had planned, and it was this abstract which was to become "The Origin of Species". The first edition was published on November 24, 1859, and the entire stock of 1,250 copies was sold on the day of publication. The book was widely reviewed, many of the reviews being not only unfavourable but hostile. This hostility was continued when the subject was discussed at the meeting of the British Association for the Advancement of Science in Oxford in July, 1860, when the church, as represented by the Bishop of Oxford, crossed swords with science, as represented by Huxley.

Following the publication of "The Origin of Species" Darwin lived for 23 years, and during those years he accomplished a great deal of work on the fertilization of orchids, on earth worms, on the origin of coral reefs and on the descent of man.

The last work of his life concerns the importance of earthworms. He learned that worms bring up fresh soil from a depth of many feet, and, perpetually at work, perpetually stir and turn over and aerate and renew the loam on which our lives depend. He also investigated the intelligence of worms, endlessly taking notes on the particular way in which they plug up their burrows with leaves.



Alfred Russel Wallace, a collector of natural-history material, came to the same conclusions as Darwin on the origin of species while Darwin was at work on his great book.

During these years deep sorrows came to Darwin. Three of his children died. There were disappointments and long spells of ill-health. Fewer and fewer people saw him, but when he attended a public gathering those present were delighted and applauded him.

Sitting on a chair with extra long legs to match his extra high table, he would work at his old simple lens dissecting microscope, or measure with a plain yardstick, or pour liquids from one beaker to another. The hundreds of experimental seedlings sprouting on his window-sills, bookcases, tables and desks were grown in old household jars and covered over only by sheets of broken glass. In the evening he would lie down and listen to novels, of which he asked only that the heroine be pretty and the ending happy. He liked to hear his wife play the piano, but had no ear at all.

Before he died, on April 18, 1882, he had asked to be buried at Down, but he was interred in Westminster Abbey, his pall-bearers being Hooker, Huxley, Wallace, Lubbock, Canon Farrar, Spottiswoode (the president of the Linnean Society), James Russell Lowell, the Earl of Derby and the Dukes of Devonshire and Argyll. It is certain that no one buried within the Abbey precincts has made a greater contribution to the thought and enlightenment of mankind.

Book Review

SHARK ATTACK, by V. M. Coppleson (1958), Angus & Robertson, Sydney; 266 pp., illustrated. Price, £1 12s. 6d.

Few tragedies are more horrible than a shark attack. In one moment a man, woman or child, full of life, is struck and mutilated or savagely killed. An outbreak of particularly ferocious attacks in South Africa in recent years has overshadowed the unenviable reputation for shark attacks Australia used to have.

Although the risk of attack is slight, there have been numerous Australian cases, and the problem of combating sharks is commanding the earnest attention of an increasing number of people in various parts of the world. This book is, therefore, timely. Not only does it review a good number of cases, but the tragedies are analysed as regards locality, season, water-temperature, off-shore drainage, etc., in an endeavour to find some reason for their occurrence.

Dr. Coppleson shows graphically how meshing has evidently reduced the shark danger in New South Wales. However, one Bondi attack in 1951 has been omitted from his graph on p. 212.

The book contains illustrations of man-killers and a guide to their identification, but it must be emphasised that every effort should be made to deliver sharks to an expert for precise identification, as it is difficult for the layman to tell them apart. The photographic illustrations are a notable feature of "Shark Attack".

The book also contains much general information of absorbing interest on sharks. It gives the stories of the "shark arm case", the "shark papers" (documents recovered from a shark's maw and used as court evidence) and sundry tales of horror and shipwreck, relieved by amusing incidents and cases of heroism. It tells of swimmers' experiences of sharks all over the world, particularly in Australia, the Caribbean, South Africa and the United States. It reviews attacks on fishermen and fishing boats and the undersea perils of divers, frogmen and spear-fishermen.

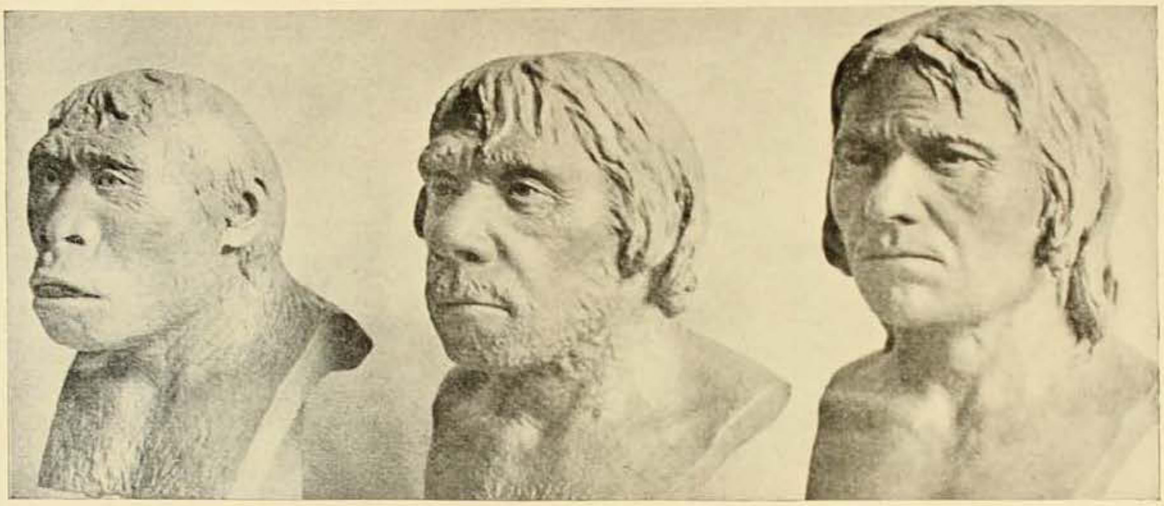
Dr. Coppleson's book is the first to deal solely with shark attacks, and is of great value, not only for the immense amount of information summarized in its pages, but as a reference book for those who wish to study the subject further.

—G.P.W.

DARWIN AND THE EVOLUTION OF MAN

By N. W. G. MACINTOSH

Challis Professor of Anatomy, University of Sydney.



Restorations by Dr. J. H. MacGregor, of the American Museum of Natural History, of (left to right) the Java man (*Pithecanthropus*), Neanderthal man and *Cro-Magnon* man.

IN the 100 years since Darwin presented the principles which explained his theory of evolution, the theory itself has been indisputably confirmed and reinforced and the principles scarcely modified.

Compared with the revolution in understanding which immediately followed Darwin's publication, elaboration of perception in the subsequent century has been relatively small, although the volume of published work is enormous.

Two generalisations stand unquestioned. One expresses the greatness of Darwin, the other emphasises how still incomplete is our progress towards a full understanding and application of the evolutionary mechanism.

The first is expressed by G. Gaylord Simpson. He says, "Darwin was one of history's towering geniuses and ranks with the greatest heroes of man's intellectual progress". ("The Meaning of Evolution." 5th Printing, 1955.) Illustrating the second are the provocative words of J. B. S. Haldane: "I am convinced that the knowledge required both of past evolution and present genetics and cytology is considerably greater than the whole body of scientific knowledge on which our present civilization is based". He adds the piquant corollary that, if he had had to pick a hopeful ancestor in the past, he doubts if he would have got the right answer, and if he was made eugenic world dictator now he would have only one chance in a hundred of choosing the right path.

Role Of The Geneticist

A retarding factor in elucidation has been the gap between the fields of palaeontology and genetics. Palaeontology is the geological record of the history of life. With the aid of comparative anatomy and taxonomy it can present the history of morphological change together with the ecological circumstances associated with such changes. Chemical and physical techniques have helped fill in the record by assessing an absolute chronology. If the total geological and palaeontological record was available we would know exactly all that happened in the history of life, but not necessarily how or why.

In contrast, the geneticist is concerned with interpretations and predictions derived from experiments; from these he formulates laws or concepts, and then tries to test these to the hilt in the field as well as in the laboratory. At the simplest level, the geneticist wants to know how genes behave under a multitude of circumstances, how they are distributed in populations and how all this can be expressed in terms of "genetic situations".

The concepts deduced and tested offer a mechanism for the interpretation of data presented by the geologist and palaeontologist. Genetics is a modern science. The gap between the geneticist and palaeontologist is therefore recent and, happily, is being closed, as instanced, for example, in the publication "Genetics, Palaeontology and Evolution," edited by G. L. Jepsen, G. G. Simpson and E. Mayr, 1949. The morphologist and the taxonomist have been useful links between the geneticist and the palaeontologist, and their combined work reinforces evolutionary transformation as an historical fact.

The gap between "savant and mystic" is much older, and in some facets remains intractable. As one writer has pointed out, "in the Pythagorean Brotherhood, there was a unity of mystic and savant", but subsequently separations, reunions and entanglements.

The separations were in some instances rancorous following the publication of "The Origin of Species," and became more so after Darwin's "The Descent of Man" in 1871. Rancour has subsided, but entanglement is no less to-day than in the latter part of the 19th century.

These entanglements were striking in that they contrasted so violently with the union of science and religion in the first half of the 19th century. This union is very clearly demonstrated in a series of lectures on "The Cranium" by John Hilton, F.R.S., published in 1854. Hilton was a great morphologist and his exposition of the morphology of the human cranium is not to be faulted to-day. But every trait, every feature was interpreted by him as being the forethought provision of a wise Beneficence. In Hilton, science and religion were simply and indissolubly welded together.

Marx and Engels, however, used Darwin's biological principles for the basis of a theory of dialectical materialism. T. H. Huxley and Haeckel emerged as frank materialists, Huxley as an agnostic, Haeckel as an atheist. Charles Kingsley, in his alleged fairy tale "The Water Babies," made fun of the morphologists: "Come read me my riddle, each good little man; If you cannot read it, no grown-up can," and tried to lead the application of Darwin's revolutionary concepts into liberal reunion with religion.

These various attitudes in their original form, and a complex combination of varieties of them, persist to-day.

Sociological Impact Of Darwinism

It is probably true that Darwin did not anticipate that his ideas on evolution would be seized upon to formulate new doctrines in sociology, economics and religion. This use and misuse of his theories—for example, even his protagonist T. H. Huxley expounded a tooth-and-claw concept far in excess of Darwin's exposition—must have been a sore trial to Darwin. In the second edition of his "Descent of Man," 1889, he says, somewhat cryptically "..... I have endeavoured to profit by the fiery ordeal through which the book has passed, and have taken advantage of all the criticisms which seem to me sound".

It is necessary to mention a further rift in understanding, that between the biologist and the sociologist. An attempt to examine objectively the applicability of the two disciplines to each other was made this year at the Edinburgh Conference on Darwinism and the Study of Society. Apparently the conclusions remained nebulous as to the extent to which biological processes affect man's social history. C. H. Waddington expressed this uncertainty most succinctly by asking whether the grouping of certain social characteristics paralleled such biological facts as the linkage of genes. The answer was not available.

Clearly highlighted by the conference, however, is the fact that the stimulus of Darwin is even greater 100 years later than it was at the time of his publications. That stimulus is provocative to philosophers, historians, theologians, economists, sociologists and biologists. Each has been compelled to some awareness of the disciplines in fields outside his own.

How, in such a brief article, can one state what Darwin did? It is impossible to summarise the wealth of detailed observations in "The Origin of Species," or enumerate his thought processes which surmounted the lack of knowledge in his time of how heredity actually operates. At the simplest possible level one might try the following:

Firstly, he established evolution as a fact, not as a probability to be further tested; secondly, he established natural selection as the major factor in adaptation.

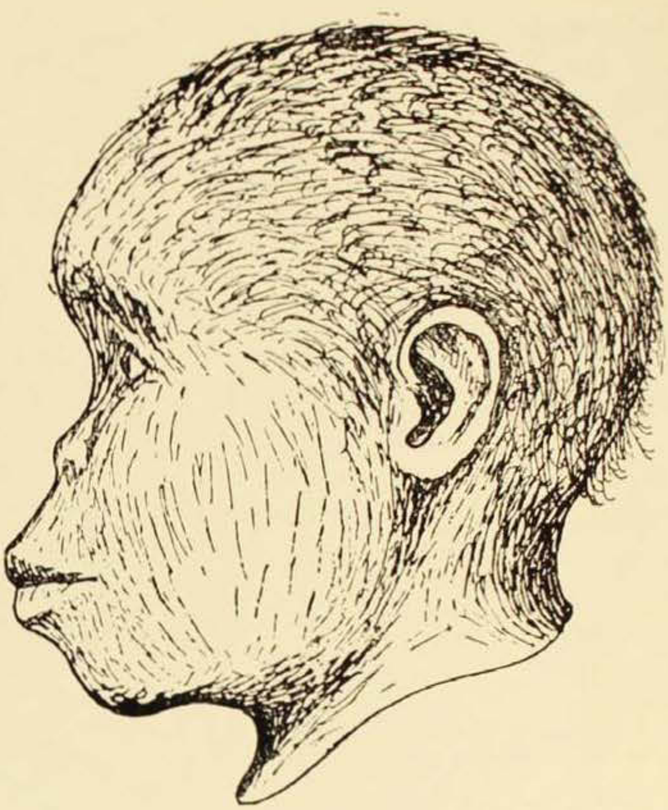
In reference to the evolution of man, it is necessary to recall that when "The Origin of Species" was published only two specimens of prehistoric man had been recovered, the Gibraltar skull (1848) and the Dusseldorf skull (1856). Neither was recognised at the time for what it was.

Ape-and-man Controversy

In establishing the principle of evolution by a process of continuous variation and selection in adaptation, Darwin incidentally referred to man as descended by this process from something like an anthropoid ape. He did not say from an ape. The subsequent unfortunate and unnecessary controversy about ape and man had untoward results. Much time and emotion were wasted on a vicious side-issue which Darwin himself had not raised.

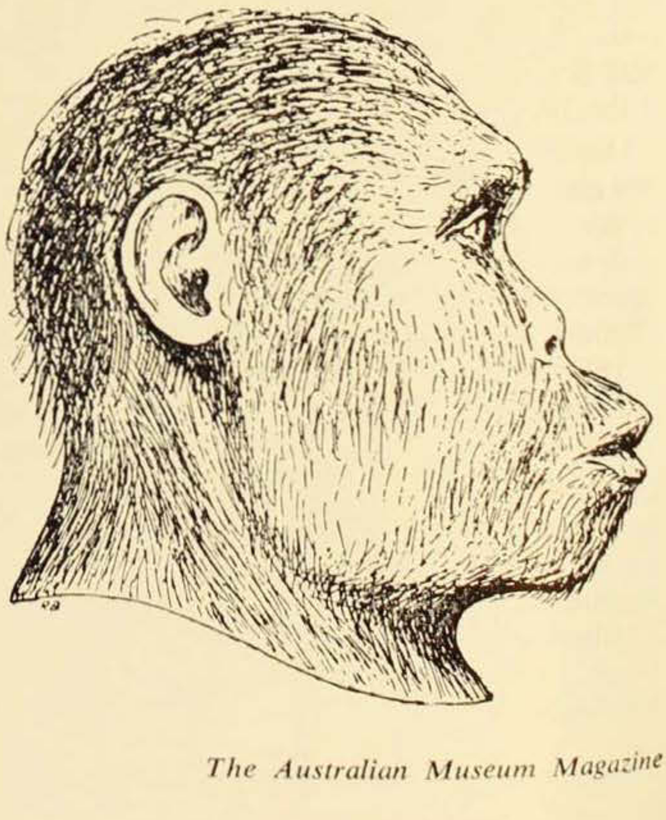
Unfortunately, there is not room here for a consideration of man's history prior to a million years ago. As a brief statement, it is believed to have been one of various changes ultimately deriving from the common ancestor of the primates, presumably dating from the Miocene period, some 30 million years ago.

We have no intermediate fossil types to confirm this. Remembering that no human fossil remains were available when Darwin published his work and that in the short space of 100 years we have now recovered a human fossil record covering a million years or less, it would be a stubborn mind to claim that no earlier fossil proof will come



Restorations of the heads of two Australopithecines, also known as South African fossil ape-men: a Taungs child (above) and a Sterkfontein female (below).

From Robert Broom's "Finding The Missing Link".



to light. It is a further tribute to Darwin's genius that, in the absence of this factual data, he had the courage and perception to apply his principles of evolution to man himself.

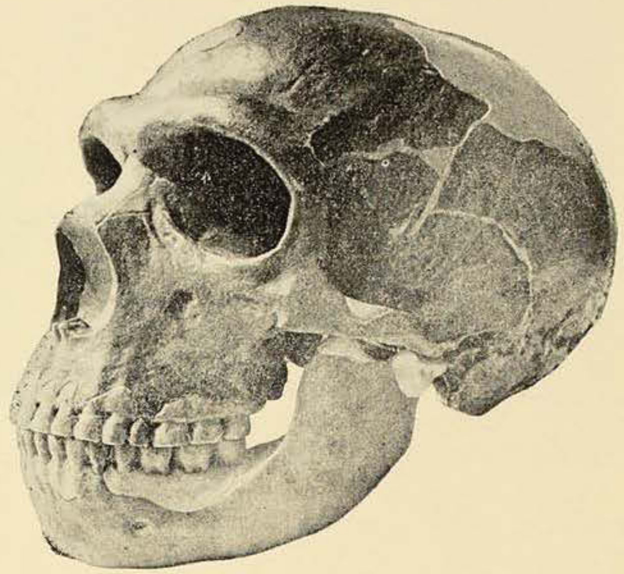
There is no space to write about the uniqueness of man, with his possession of speech and therein the potential power to influence his own evolution. But we have noted one of Haldane's comments about this.

It was not until 1911 that the anatomical description by Marcellin Boule of a skeleton found at La Chapelle-aux-Saints established beyond doubt the reality of the Neanderthal people. Additional material now indicates at least two clear-cut types of Neanderthalians, one earlier in time, the other later, showing distinct morphological differences. In geological time they existed from approximately 150,000 to 70,000 years ago. In geographical range they extended from the western shores of Europe eastward into Russia, showing structural modification commensurate with such varied ecological pressures. It is possible that they are represented also by morphological types, much modified, in Africa and Java.

At Mount Carmel, in Palestine, the remains of Neanderthal and Cro-Magnon types, together with intergrades, were recovered. The Cro-Magnons were tall, straight-limbed, large-brained and very like modern *Homo sapiens*. Here was clear evidence of capacity for miscegenation between extremely different morphological types of mankind.

Java Man, or *Pithecanthropus erectus*, first discovered by Eugene Dubois in 1891, now has companions which are generally regarded as first cousins to *Sinanthropus pekinensis*. These odd and primitive-looking representatives of mankind, living some 500,000 years ago, were for a time regarded as being very close to ape-like limits, while still permitting classification as man.

Their oddity has been minimised in more recent years by the spectacular recognition of the Australopithecines, sometimes referred to as the South African fossil ape-men. These little creatures, with erect posture but rather small brains, are still the subject of controversy. Their geological horizon is not certain, but may be as far back as a million years ago. Some authorities refuse to admit them into the portals of humanity, but agree that they are very close thereto. Others, notably Dr. Raymond Dart, Professor of Anatomy in the Witwatersrand, who in 1925 correctly identified the Taungs skull, which was the first of these creatures discovered, believes that they were fully human and knew the use of weapons, tools and fire.



Skull of Neanderthal man, found at La Chapelle-aux-Saints, France. The forehead is receding, the eyebrow ridges are large and the jaws project.

Photo.—G. C. Clutton.

Had these bizarre looking types of humanity or near-humanity been the only fossils recovered, it might have been possible to retain a theory of orthogenesis or straight-line evolution from more primitive to less primitive forms, as visualised by Franz Weidenreich. Such a theory is dislocated by the finding of true *Homo sapiens* types co-existent in time with the more outlandish specimens. Examples are Hotu Man (70,000 years ago), Cro-Magnon (100,000 years), Fontéchevade (150,000 years), Swanscombe (300,000 years) and the Kanam jawbone and Kanjara skulls found by Dr. Leakey in Nairobi and estimated as possibly 400,000 to 700,000 years old.

To complicate the picture further, giant forms, such as the teeth and jaw bones recovered from Java by Koenigswald in 1941 and for which he coined the term *Meganthropus*, have been variously referred to as

Gigantopithecus and *Gigantanthropus*. Anatomically they are hominids, and might roughly be regarded as giant forms of *Pithecanthropus*.

This diversity of morphology and size at various geological levels has led to the elaboration of the idea of radiation and reassemblage over progressive periods of time, summarised by the word "reticulation," so adequately expounded by Dobzhansky in referring to man as a single polytypic species. ("Genetics and the Origin of Species," 3rd Edition, 1951).

This network idea accommodates all the hominid fossil remains. The contributions of the ancestral types have been broken up and re-combined many times before incorporation into modern races, and some may have contributed more than others.

Dobzhansky says, "No more than a single hominid species occurred at any time-level in the Pleistocene," and Simpson says, "All known hominids, recent and fossil, could well be placed in genus *Homo*".

It may appear that this interpretation departs appreciably from Darwin's views. Closer scrutiny will show that this is not the case. At the present time the peoples of the world show remarkable diversity of appearance, bizarre or orthodox, depending on who is looking at whom, and they range in size from pigmy to giant.

Darwin, in his "Descent of Man," instanced the systematic difficulties of definition, and pointed out how this gave support for nominating species among mankind. He elected a compromise, regarding man as a borderline case with races in process of elevation to the dignity of species, and, in any case, regarded this diversity as support for his view that man is a product of evolution.

We have already seen that on any horizontal level of geological time the diversity of mankind has been roughly of similar degree. But when we make a vertical comparison between different geological time periods, the extent of variability in human morphology is of a higher order. Nevertheless, intergrades have been established for almost every gap. Hence, we are not dealing with sympatric or allopatric species, but with races of a polytypic species. It is true that this is different, but only a little different, from Darwin's concept that man was almost in process of specific differentiation.

Rediscovery Of Mendel

As to the mechanism of what has happened, Darwin was fundamentally right. He said the source of hereditary variation was the key to the solution. The rediscovery of Mendel in 1900 provided this key. Subsequent work has shown that division of the gene simply reproduces, but mutation of the gene is the source of new evolutionary material. The products of mutation are influenced by selection and adaptation. As Dobzhansky puts it, the greatest gap in our understanding of hominid evolution is lack of data on the adaptive significance of the inherited and/or mutated characters.

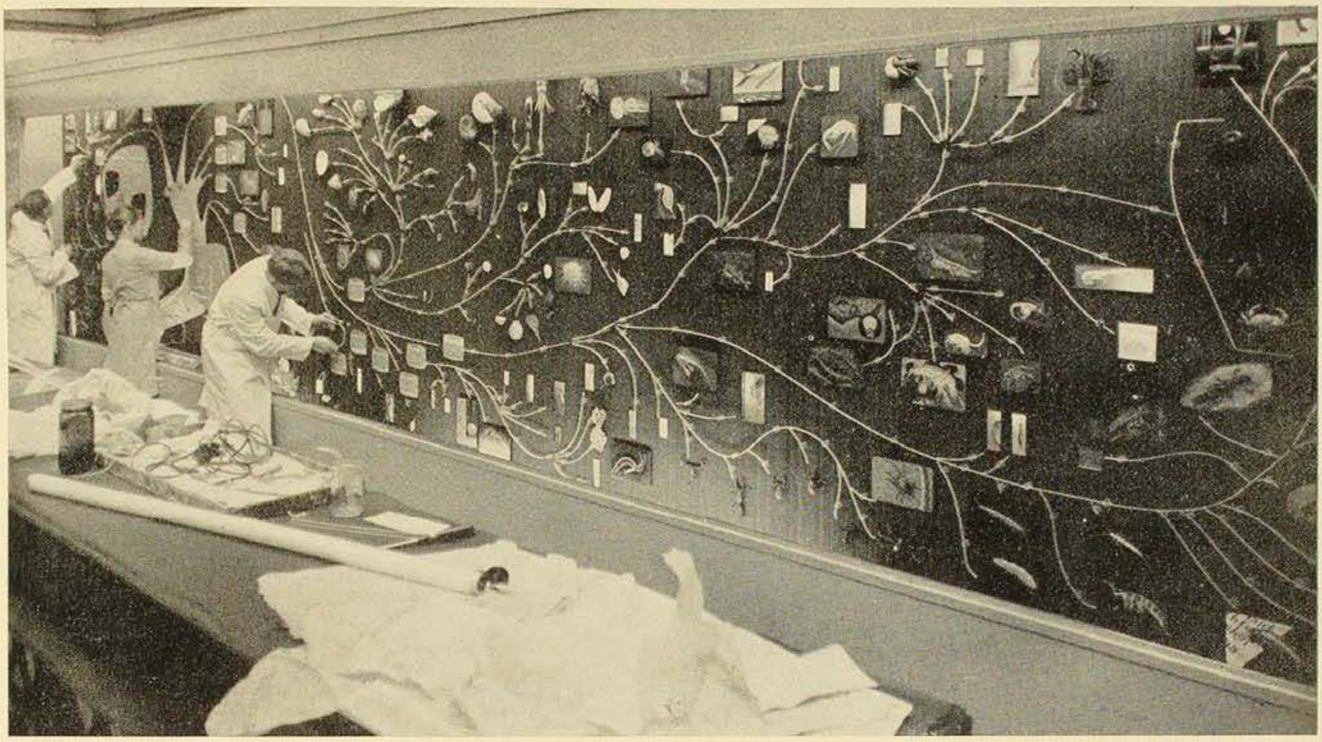
Evolutionary changes in man are not entirely random. There is some orientation, for example a trend towards increased stature and brain size, but the trend has been fluctuant, not steady.

As illustrations of this fluctuation, the Cro-Magnon brain was larger than that of modern man; the more recent Neanderthals were more primitive in appearance than the earlier Neanderthals; the giant forms (*Meganthropus*) occurred 500,000 years ago, pigmoid forms still earlier, but coincident with the giants was stature comparable with that of the present day. Associated with this fluctuant orientation, there has been, according to Simpson, "opportunism"—by which he means that all avenues available have been exploited by all the material available.

It will be seen, then, that modern biological thinking differs from Darwin's views only in a fuller explanation of the mechanisms of the principles expounded by Darwin.

It is rare indeed that any one man can assemble an enormous range of relevant facts and derive therefrom an interpretation whereby he becomes an historian of all life. Such a man was Darwin. There have been great names synonymous with the addition to biological knowledge since Darwin, but all stand in his shadow.

THE "INVERTEBRATE TREE"



A unique exhibit, "These Are Invertebrates," also known as "The Invertebrate Tree," was officially opened at the Australian Museum on July 31 by the president of the Museum's Board of Trustees, Mr. Wallace C. Wurth, C.M.G. This exhibit, 32 ft. long and 9 ft. high, shows the main groups of invertebrate animals (which constitute 97 per cent. of the animal kingdom) and their relationship to each other. It is an important feature of the modernisation and reorganisation of the Museum now being carried out, and its opening this year was part of the Museum's commemoration of the centenary of the publication of Charles Darwin's "The Origin of Species."

At the opening ceremony the Director of the Museum, Dr. J. W. Evans, mentioned some of the difficulties associated with making attractive displays of animals without backbones. In the new exhibit these difficulties have been overcome by using accurately coloured models; by restoring to their natural colours those animals which had faded after preservation; by using special lighting for animals enclosed in plastic boxes, and also, to a large extent, by the use of accurate paintings of animals which are too small to be seen by the naked eye or which are otherwise unsuitable for display. Of the total of 215 species of animals displayed, 55 are paintings and 43 are models. The paintings are by Miss Eileen Mayo, the well-known natural-history illustrator.

The relationships of the various groups of invertebrates may be traced by a system of fluorescent plastic lines and lights which flash in sequence. Eight hundred light globes and ultra violet light are used. Labels outline the characteristics of each major group, and the scientific and popular names of the individual species are shown. A panel informs visitors how to use the exhibit and how the invertebrates are divided into their main groups. The display is the result of close co-operation by curators, artists, modellers, casters, preparators, artificers and a ticket-writer. The special lighting effects were planned by an officer of the Public Works Department, and that department was responsible for the lighting installation.

Photo.—Howard Hughes.

Millions of barnacles stud the rocks on many parts of the Australian coast. This photo was taken at Harbord, New South Wales.

Some Australian Barnacles

By ELIZABETH C. POPE

MYRIADS of barnacles grow on our coastal rocks. Stalked ones (Goose Barnacles), which are attached to bits of timber or pumice, are often stranded on surf beaches; millions more live on the hulls of ships and on harbour structures, and still others attach themselves to marine animals ranging from sedentary sponges to fast-swimming whales. In fact, barnacles flourish almost anywhere in the sea and are among the commonest animals of the seashore.

In spite of this, their true nature and relationships with other animals are but little known and appreciated by most people, who believe them to be related remotely to the Mollusca, or shellfish, because of the limy nature of their outer shells.

This confusion is not altogther surprising because, until 1829, when J. Vaughan Thompson cleared up the mystery by working out the life-history of barnacles for the first time, zoologists also were uncertain of their true affinities. Thompson showed that barnacles pass through a series of free-swimming larval stages similar to those of the great crustacean group which includes animals such as prawns, lobsters and crabs, and that they are in no way related to molluscs. The hard shell of the barnacle is developed only after a metamorphosis has taken place and a free-swimming larva has settled on a suitable substratum.

Food Caught In Fine Hairs

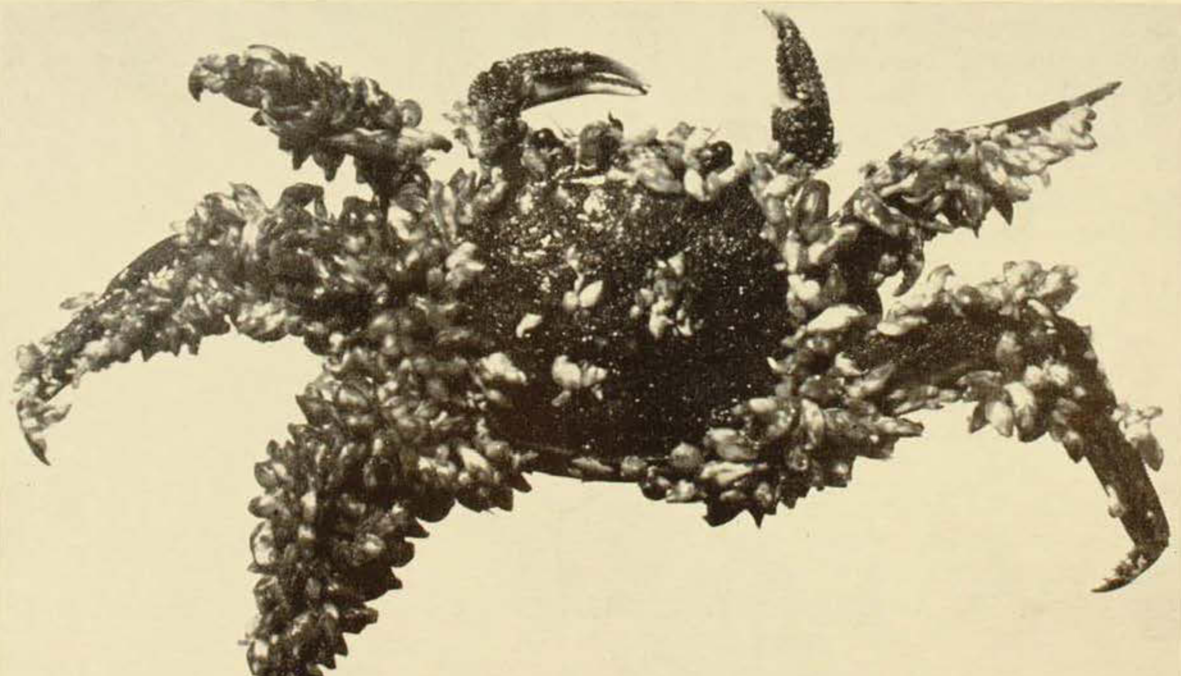
The crustacean nature of barnacles can be fully appreciated if one side of the "shell" of a Goose Barnacle be removed. This discloses the animal inside with its six pairs of jointed, typically crustacean limbs. Each of the many limb-joints bears a series of fine hairs, so that the curved limbs, or cirri, have a feathery appearance. The group name for the barnacles, *Cirripedia* (meaning curl-footed), describes these limbs when they are protruded in a bunch through the shell-opening during feeding. This is done with a sort of "clutching-dip-net" action, which traps food among the fine hairs. After a few dips, the whole bunch of cirri is withdrawn into the shell and any entangled food particles are then picked up by a series of minute, intricate mouth-parts and swallowed.

There is still no better brief description of a barnacle than that coined by T. H. Huxley, who said that a barnacle was "a crustacean fixed by its head and kicking the food into its mouth with its legs".

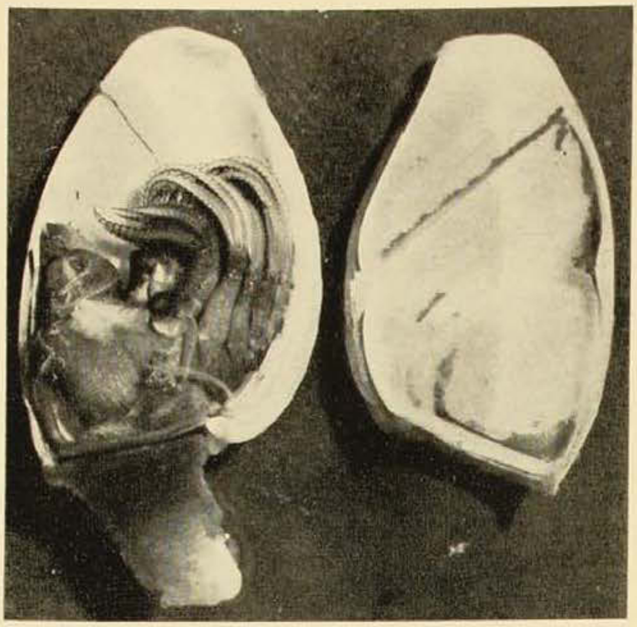
To the unaided eye, the soft parts of the body seem to vary only slightly from species to species. It is in the protective shell plates, secreted around the body, that the most obvious differences may be seen. Thus, there are rock barnacles which have a shelly ring of plates made up of four, six or eight plates. One of this last group, *Catophragmus polymerus*, has, in addition, several rings of limy scales fringing the base of the eight-plated shell. Because of this characteristic, *Catophragmus* is the most easily distinguished of local rock species. It seems to be favoured by surf, and flourishes on the exposed coasts of the southern half of Australia, except along the coast of Western Australia. It is known locally as the Surf Barnacle.

Some Common Barnacles

Another easily recognized rock barnacle, peculiar to Australia, is the Imperial Purple Barnacle (*Balanus imperator*). Chips of its shell plates, polished by rubbing in the sand, are frequently to be found among the shell debris cast up on eastern Australian beaches. This species grows on rocks, near low-water mark, along the coast from Thursday Island in the north to Narooma in southern New South Wales. It is characterized by the bright purple colour of the six shell plates, frequents slightly sheltered places on the open coast and is tolerant of a certain amount of silt in the water.



A red Groper-bait Crab heavily infested with *Heteralepas* sp. stalked barnacles. Several of the crab's legs are missing, and it seems likely that the barnacles settled on it when it was sluggish from the injury. (Slightly under natural size).



A Goose Barnacle, *Lepas anatifera*, with one side of the "shell" removed to show the soft animal parts with the paired feathery limbs. (Slightly larger than natural size).

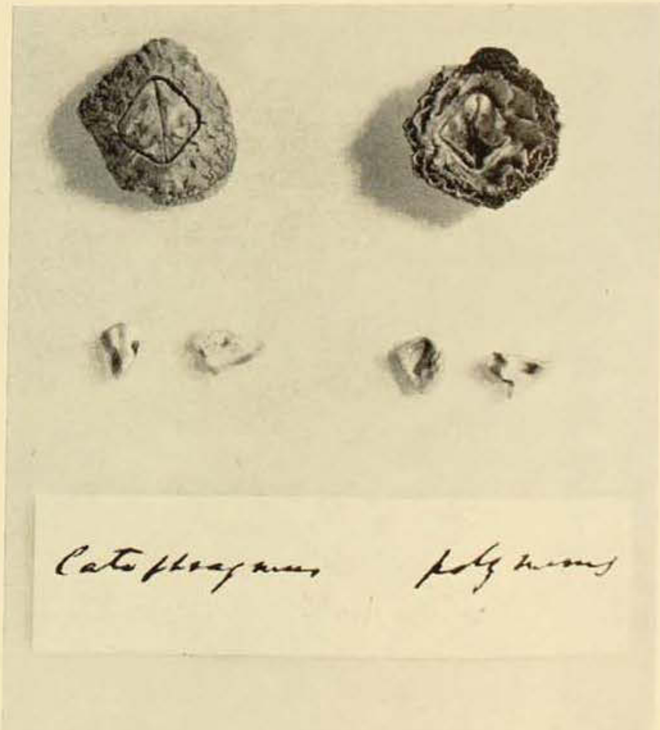
Possibly the best known of Australasian rock barnacles is a smallish, four-plated species, *Elminius modestus*, which grows in temperate seas on rocks in harbours and inlets above the oyster band. This barnacle, after accidental transportation, successfully colonised the waters off southern England in the early 1940's. It became established near Chichester and Portsmouth, and from there invaded not only the coasts of the British Isles generally but also Holland. It is now spreading its range in Europe at a rate of about 50-70 kilometres a year.

The species of barnacles which have been mentioned—*Catophragmus*, *B. imperator* and *Elminius modestus*—are only three of the 22 Australian barnacles which owe their recognition and first description to Charles Darwin, who must certainly be considered the father of cirripede studies in Australia. Of the 70 or so species now known to occur in Australian waters, all but 15 were described in Darwin's great Ray Society Monographs, which were published in 1851 and 1854, though it so happens that at the time he wrote only 31 of these species had been recorded in Australasian seas.

Darwin spent eight years working on barnacles from all over the world, and in later years he commented, "The cirripedes form a highly varying and difficult group of species to class, and my work was of considerable use to me when I had to discuss, in 'The Origin of Species', the principles of natural classification."

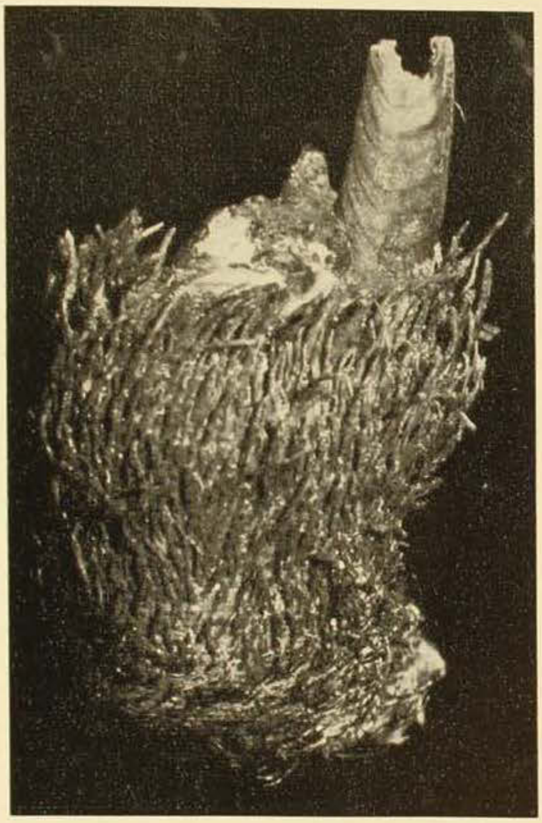
The tropical fauna of rock barnacles differs markedly from the temperate-seas fauna, and while it is rich in species the actual size of the populations of each of these species in a unit area is much smaller than it is in temperate seas; as a result, barnacles are much less in evidence on tropical shores. There is one northern Queensland species, *Chthamalus withersi*, which lives on trees, flourishing best on the stilt roots or stems of mangroves. It is sometimes found quite a long way inland in the muddy tidal streams.

Stalked barnacles are not less common than rock barnacles, and, in addition to frequent strandings of the well-known Goose Barnacles *Lepas anatifera*, *Lepas hilli* and *Lepas anserifera* (the last-named generally attached to pumice), an occasional fragile clump of the



The Surf Barnacle, *Catophragmus polymerus*, displayed to show the upper and lower surfaces of the "shell" and, below, the opercular valves. (Three-quarters natural size.) This group was included in the Museum's special Darwin exhibit (Page 122). Under it is a photo of Darwin's own label.

extraordinary *Lepas fascicularis* may be found washed up on beaches. This last species is peculiar in that it can dispense with the need to attach itself to flotsam and can make for itself a light-weight inflated raft from a secretion which "froths out" at the free end of the stalk.



The Hairy-stalked Barnacle, *Ibla quadrivalvis*. (Four times natural size.)

Probably the most interesting Australian stalked barnacle is the peculiar hairy-stalked *Ibla quadrivalvis*, which is all stalk and opercular valves, the rest of the shell being missing. Most barnacles are hermaphrodite (i.e. the one individual possesses the organs of both sexes), but *Ibla quadrivalvis* has complementary males of dwarf size which live an almost parasitic existence inside the mantle cavity of the larger hermaphrodites. A second species of *Ibla* from tropical Australia, *Ibla cumingii*, has gone a step further, as the larger individuals are female only and their attendant dwarf males also live inside the females' shells. Charles Darwin was the discoverer of these fascinating semi-parasitic males and, when he announced his find, a rival scientist accused him of making up the whole story, so fantastic did it seem. Both species of *Ibla* are found at about mid-tide level on the coastal rocks, but are hard to see because they grow in crevices and tiny cracks between rocks. *Ibla quadrivalvis* is often found among the tubes of *Galeolaria* worms.

There are many more interesting barnacles to be found in Australia, but space will not permit their description here. An account of their remarkable adaptations to a difficult environment has been given in the Australian Museum publication "Exploring Between Tidemarks," in which illustrations of the commonest New South Wales species may be found.

[*All photos in this article are by Howard Hughes.*]

Book Review

TIME, LIFE AND SPAN—THE FOSSIL RECORD, by Professor R. A. Stirton, University of California. 558 pp., 291 figures. (New York: John Wiley & Sons. Inc., 1959. Price $9.00.)

This excellent book will appeal not only to students but also to the layman with little or no knowledge of geology or biology. The author has had many years of teaching experience and of palaeontological research, and is therefore particularly well fitted to contribute a teaching book on the subject.

During the past few years there has been an ever-increasing interest in the fossil record and its significance on the part of many people with little or no academic training. For them this book fills a need and more than adequately serves its purpose as a most accurate and pleasing guide to palaeontology.

The first seven chapters are mainly devoted to background information of a general nature. The next 17 describe in a most interesting manner the life of the various geological periods. The last chapters are elaborations on selected topics, such as the foraminifera and the evolution of the horses and primates. The author is a world authority on the evolution of the horse, and he leads the reader from the first horse, which appeared 60 million years ago and was about the size of a cat or a fox terrier, to the different breeds of modern horses, which are the result of selective breeding over many centuries.

This book, printed in the United States, is beautifully produced and attractively illustrated with more than sufficient excellent line drawings.

H.O.F.

Charles Darwin in Australia

By GILBERT P. WHITLEY

ON January 12, 1836, when Charles Darwin first set foot in Australia, he was a practically unknown man of 26. While the visit of H.M.S. *Beagle* was mentioned in the Sydney newspapers of the time, Darwin personally was not. After all the marvels of the *Beagle's* voyage, Sydney seems to have appeared to Darwin merely a remote British settlement. It was, he wrote, "a most villainously dear place".

We do not know if he visited the Australian Museum, but his servant, Syms Covington, wrote in his journal for January, 1836, "went in Museum while here", so it seems that Darwin, too, may have honoured our infant Museum with his presence. Darwin hired a man and two horses to take him over the Blue Mountains to the "village of Bathurst" and back, no mean journey in those days. On his travels he was particularly interested in our gum trees and aborigines, and the "bays" or gulf-like valleys of the Blue Mountains, and he saw living platypuses.

When in Australia, Darwin had not worked out his evolutionary theories and what they implied. He was an orthodox Christian and, when musing in our bushland beside some ant-lion pits, so similar to those in the Old World, his belief was confirmed that "one Hand has surely worked throughout the Universe". By 1837, however, Darwin had become convinced that evolution had occurred.

The *Beagle's* next port of call was Hobart. Darwin made several geological excursions thereabouts, noting also the great size of the eucalyptus trees and tree ferns. A search of some contemporary newspapers reveals no record of the activities of the *Beagle's* complement in Tasmania.

Corroboree For Darwin

From March 6, 1836, a rather dull week was spent at King George's Sound, that magnificent harbour in Western Australia, where Darwin collected a number of specimens of insects, plants and fishes. There a corroboree was arranged by the White Cockatoo tribe "and Mr. Darwin ensured the compliance of all the savages by providing an immense mess of boiled rice, with sugar, for their entertainment". The aborigines may have been more entertained than Darwin was, since the latter wrote, "a most rude, barbarous scene and, to our ideas, without any sort of meaning......Everyone appeared in high spirits and the group of nearly naked figures, viewed by the light of the blazing fires, all moving in hideous harmony, formed a perfect display of a festival among the lowest barbarians".

Darwin's famous lines of farewell to Australia, from which he parted on March 14, 1836, are almost as unkind as those to New Zealand, but Australia forgives him, respecting his opinions, which he himself later modified: "Farewell Australia, you are a rising infant and doubtless some day will reign a great princess in the South, but you are too great and ambitious for affection, yet not great enough for respect. I leave your shores without sorrow or regret".

On his return to England, Darwin corresponded with scientists in Australia, a number of his letters being still extant in libraries and collections here. He wanted to know, for example, in what districts the Australian wild bee was being exterminated by the common hive bee, and he was very interested in our orchids, sundews and other plants in relation to insects.

In the Mitchell Library, Sydney, are a number of holograph letters from Darwin. One, to Sir Thomas Livingston Mitchell (A. 295, pp. 85-88), gave a method for describing Blue Mountains valleys, the structure and development of which interested him:—

"The chief object in the description of the valleys, which would interest geologists, I should think would lie in as clear an indication as possible of the amount of solid stone removed in these excavations. To show this of course would require only measurements of the depth, breadth & length—you might describe the boundary line of some one valley & state (if you have knowledge of the fact) that a line of cliffs, such as those given in your drawing, stretch continuously for so many miles, inclosing such an area & having a height nearly equal or lowering towards some point of the compass, or whatever the facts might turn out.—The second class of facts to mention; is the direction through which the great area of stone has been removed this will require a description of the lower part of those valleys of which the upper forms one of these basins.—the width & depth of the gorge; its impassibility &c.—the present size and form of the stream &c &c. I suspect, no one, at present, could do more than state the problem, its solution appears to me most difficult. Of course you must allude to the nature of the sandstones on the Blue Mountains, its horizontal stratification &c; & the consequences that these valleys are due to excavation, & not to the elevation of a line of hills on each side, as might be supposed. These are the few suggestions which occur to me."

Letters To Museum Curator

The Mitchell Library has five letters from Darwin to Gerard Krefft, a former Curator of the Australian Museum. The last letter is undated and very difficult to decipher, but appears to read as follows:

"I have been ill and must be very brief.—Your letter amused me and my family greatly, & I read with much interest your letters to the newspaper.

"Many thanks for t fact abt t globular worm-castings; but no bottle has yet reached me. I wish you heartily all success. Your letter is so fresh and spirited. You ought to write a book tinctured with Nat. Hist. about t Colony."

Darwin sent Krefft a copy of the 1872 edition of his "The Origin of Species," but I have not been able to trace this book anywhere in Sydney. The Public Library has an 1860 edition with a title page from which someone, an autograph-hunter perhaps, has cut away the top.

At least two attempts were made to name the Northern Territory of Australia Darwinia, the first about the 1860's and the second in 1916, but neither succeeded. *Darwinia*, instead, is the name of a genus of Western Australian shrubs. Charles Darwin is commemorated in nomenclature by many animals and plants named in his honour. Port Darwin was named on H.M.S. *Beagle's* second expedition, in September 1839, under Captain J. L. Stokes, who wrote (Discoveries in Australia ii, 1846, p. 6), in connection with a newly-discovered sandstone there: "A new feature in the geology of this part of the continent, which afforded us an appropriate opportunity of convincing an old shipmate and friend, that he still lived in our memory; and we accordingly named this sheet of water Port Darwin."

Book Review

ON THE TRACK OF UNKNOWN ANIMALS, by Bernard Heuvelmans, D.Sc. Translated from the French by Richard Garnett, with 120 drawings by Monique Watteau and an introduction by Gerald Durrell; pp. 558, 52 photographic illustrations. Rupert Hart-Davis, London. Price, 43s. 6d.

It would seem that in every continent, even, surprisingly enough, including Europe, much circumstantial evidence has accumulated concerning the possible existence of large animals which so far have eluded capture. Examples in Australia are the Bunyip and the Queensland Marsupial Tiger.

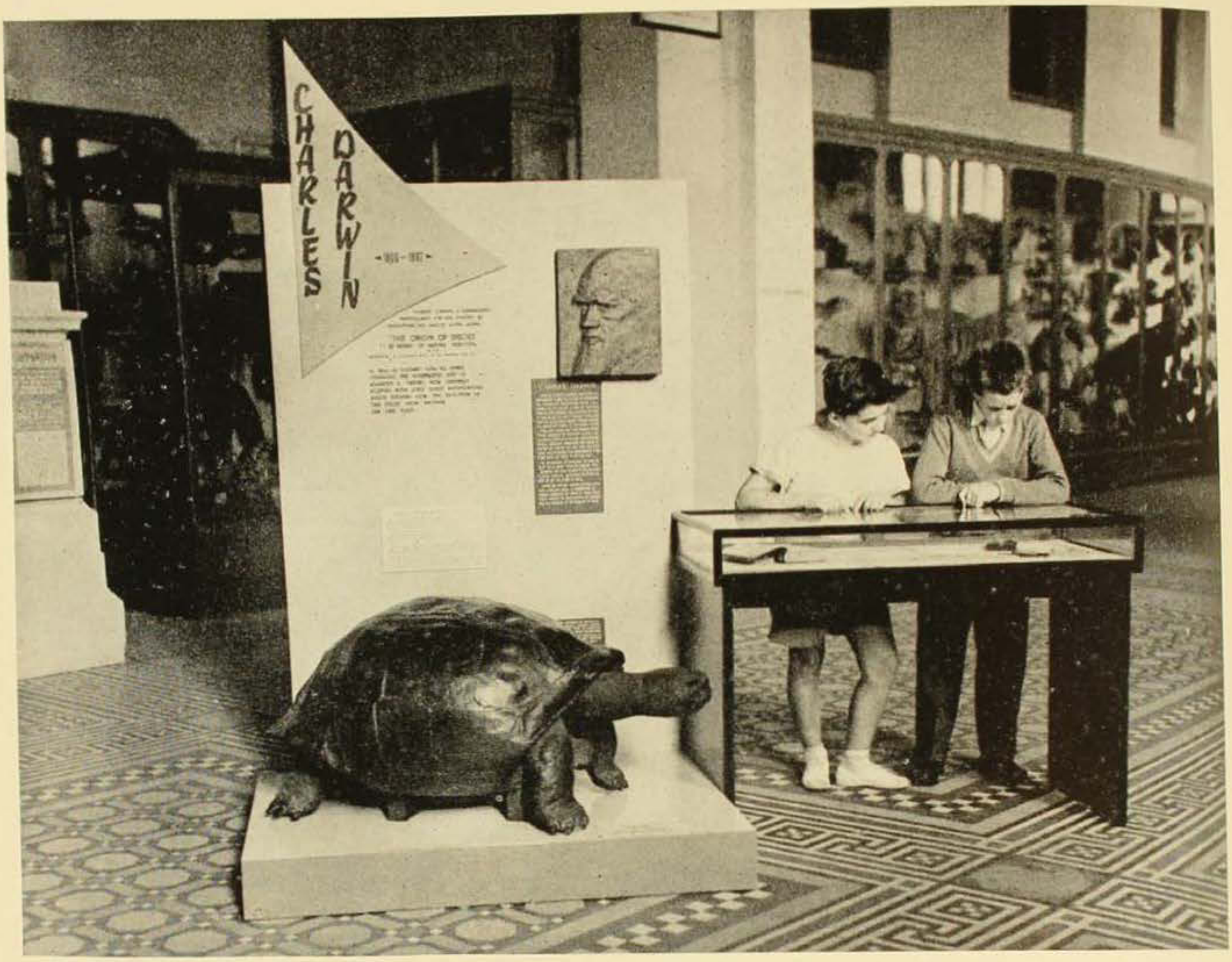
Dr. Heuvelmans has spared no pains to gather all the information available about such creatures and bases his case for the possible existence of some of them on the fact that there are several animals now known to science which, until comparatively recently, came into the category of "unknown animals". For instance the Australian Lungfish, *Neoceratodus*, was not described until 1869, and even though the Giant Panda was described in 1869, a living specimen was not captured until 1936. More familiar examples include the African Okapi, first captured in 1900, and the Coelocanth fish, *Latimeria*, first taken in 1938.

Accounts of various large animals which may be living include ones of the Patagonian Giant Sloth, *Diprotodon* and *Australopithecus*. The author examines the evidence in each instance in an objective manner and, though sometimes he may seem to err on the side of credulity, his approach on the whole is a scientific one.

Unfortunately the numerous "authorities" he quotes, even though their names may be prefixed by "well known" or "distinguished", cannot be regarded as of uniform reliability, and some statements are made, as if they were factual, which are open to question.

The book, which has an extensive bibliography, can nevertheless be highly recommended as an extremely interesting one which should appeal equally to the scientific and to the general reader.

—J.W.E.



A popular feature at the Australian Museum during 1959 was this special exhibit commemorating the centenary of the publication in 1859 of Charles Darwin's "The Origin of Species." The exhibit included a relief of Darwin's head; brief accounts of his life, work and visit to New South Wales; one of the Galapagos Islands Giant Land Tortoises, of which he made a particular study; some of his original letters to his colleagues; the combined pocket compass and universal sundial which he used during his voyage on H.M.S. *Beagle*, and an 1886 edition of his great book.

Photo.—Howard Hughes.

Book Review

AUSTRALIAN SEA SHELLS, by J. Child, M.A., D.Phil.; pp. i-viii, 1-59, 112 text figs., 1 coloured plate; Periwinkle Press, Sydney. Price, 7s. 6d.

Not very long ago, Dr. Child conceived the idea of preparing a simple guide to the common sea-shells of the Sydney district. He had written a similar book on New Zealand shells while resident there, and knew that such a work would be of great value to those just beginning to collect shells, especially children whose interest in natural history is so often destroyed by the lack of suitable reference books.

Dr. Child has produced an excellent little book which will prove invaluable not only to children but to teachers and adults who are starting to make a shell collection. The simple drawings are adequate for the identification of the common Sydney shells, and they are accompanied by brief descriptions, common and scientific names, and some indication of size, habitat and distribution. More than 100 species are dealt with, and there are brief accounts of the structure and biology of the mollusca.

It is a pity that the title "Australian" was chosen, for the book deals almost entirely with the common New South Wales shells, though the majority of these range into other States; Victorian collectors, for example, will find many of their common mollusca illustrated. This book will fill a large gap in the literature on Australian shells, and can be recommended to all who wish to know a little more about the shells which they find on our beaches.—D. F. McM.

GENETICS AND EVOLUTION

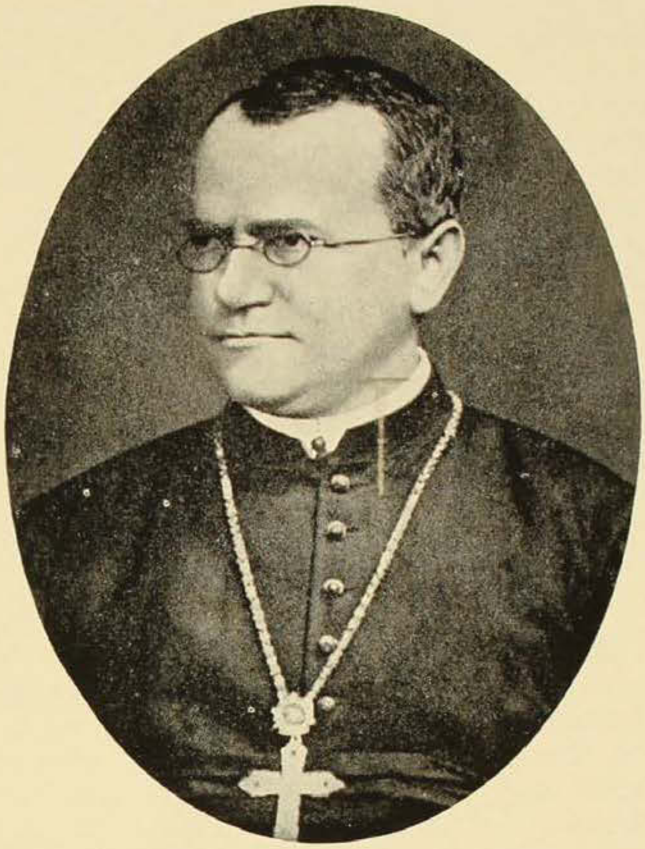
By L. C. BIRCH
Reader in Zoology, University of Sydney.

CHARLES DARWIN didn't invent the idea of evolution. But he was the first person to give mankind a sound reason for believing in it. He compiled a great deal of evidence which showed quite conclusively that evolution had occurred and, secondly, he produced a theory to explain how it all happened.

Darwin was convinced of the first before he had successfully discovered the second. He delayed publication of "The Origin of Species" until he had discovered a convincing explanation of the mechanism of evolution. The mechanism was, of course, natural selection.

According to the concept of natural selection, the individuals of species differ from one another in various ways. Some are better than others because they have characteristics which give them a greater chance of surviving—for example, more adeptness in escaping from predators. These favoured individuals will tend to survive in the struggle for existence, the others will perish. The "fit" which survive transmit their desirable characteristics to their offspring. In this way there will be a gradual improvement in adaptiveness of the species.

It was Darwin's contention that changes wrought in this way would eventually give rise to new species. That is why he called his great work "The Origin of Species." What evidence did Darwin have for this belief? He had good evidence of a struggle for existence, since far more individuals are produced than can survive; you have only to think of the million or more eggs produced by a single oyster to appreciate that point. He had good evidence that individuals of the species varied from one another. He also had good evidence of the effectiveness of artificial selection practised by man on domesticated animals and cultivated plants in producing new useful varieties. He inferred from this that selection in nature would also produce new creatures, and that this selection would automatically happen in the struggle for existence when the favoured individuals survived to reproduce.



Gregor Mendel, abbot of Brunn, Czechoslovakia, founder of the science of genetics.

There were two scientific weaknesses in this theory. One was that Darwin had no direct evidence that, in fact, natural selection did occur. He inferred that it did. But he was inclined to think of it as such a slow process that it couldn't be observed directly. The second weakness of the theory at the time it was put forward was this: the crux of the theory was that individuals with advantageous characteristics not only survive and reproduce but also transmit their favourable qualities to their offspring. In other words, the theory depends on the inheritance of desirable variations. Yet Darwin did not really know if such variations were inherited in nature and, if so, how they were inherited. He desperately wanted to know this, but the science of heredity, which we call genetics, wasn't yet born.

It is precisely these two gaps in Darwin's knowledge and in his theory of evolution by natural selection that the science of genetics fills. Genetics is the science which tells us what it is that makes one person's eyes blue and another's brown, or why some persons are born with the terrible disease congenital amaurotic idiocy, which kills them before adolescence. It also tells us how these characteristics are transmitted from parents to offspring, or what we might term the mechanism of inheritance. The chief difference between Darwinism and what is now called neo-Darwinism is that neo-Darwinism has built into Darwin's principles our modern knowledge of genetics. In so doing it has filled the two major gaps in Darwin's own theory.

When Darwin wrote his great work on evolution it was commonly believed that the characteristics of offspring were a blend of the characteristics of the parents. A tall father and a short mother might produce offspring of intermediate height. If this were generally true, then variations would soon disappear from one generation to the next. It would be just as though you mixed two colours and produced one which was a blend. Yet Darwin's theory depended on the transmission of desirable qualities, not their blending with undesirable ones. Darwin recognised this difficulty of the blending theory and tried to produce a better theory, which he named "pangenesis". But this wasn't satisfactory, either.

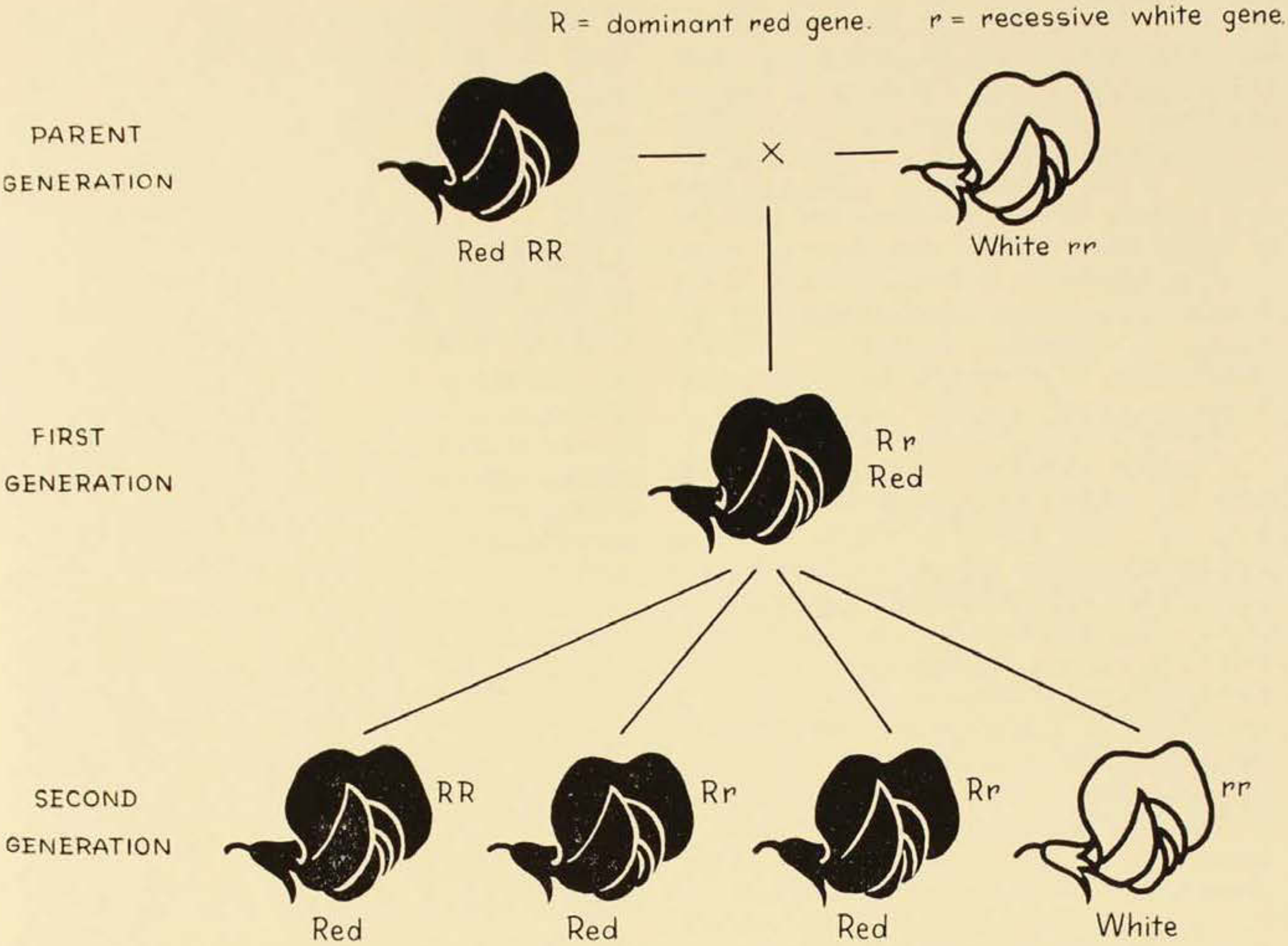
We now know that inherited qualities do not normally blend in the offspring, but that the inherited factor retains its integrity. This great discovery was made by Gregor Mendel in 1866 and became known to the world only in 1900. With this discovery the science of genetics was born. It is interesting to recall now that Mendel said he was led to his experiments on inheritance partly because of the importance of such knowledge for an understanding of evolution. His experiments were quite simple, and they were beautiful, too, because they had clear-cut results.

Let us look at just one of them. He crossed pure-bred, red-flowering peas with white-flowering peas. All the seeds of the cross grew into red-flowering peas. When these red hybrids were crossed with each other, one fourth of their offspring were white-flowered plants, the rest red-flowered. Mendel concluded that the pollen grains and the ovules of the pea contained factors (now called genes) of two kinds, dominant and recessive. The gene for red-floweredness is dominant, the gene for white-floweredness is recessive. When red and white flowering plants are crossed the progeny get both genes, but the dominant red suppresses the recessive white gene and the result is a red-flowering pea in the first generation. The red hybrids contain both sorts of genes and transmit both sorts to their offspring in perfectly predictable proportions. Here was an extraordinarily simple result which was to revolutionize a whole science.

Mendel's observations proved that inside the cells of plants, and, we can now add, animals too, there is a mechanism, incredibly small, that rules inheritance with precise mathematical rules. The integrity of the gene for redness and the gene for whiteness was preserved in the crossings. The qualities they conferred on plants didn't blend in the offspring, but the two colours appeared in the offspring according to definite mathematical laws. This is called the principle of particulate inheritance, and it gets over all the difficulties of the blending theory, which now became defunct. There is no longer the problem of a disappearance of desirable qualities through blending with undesirable ones in cross-breeding. Mendelism thus filled one of the gaps in Darwin's theory.

Differences In Genes

Thus far so good. But Mendelism doesn't tell us how genes came into existence or how new and different ones might arise. Without this there could be no real evolution. The differences between individuals of the species on which natural selection operates are due to differences in their genes. How did these differences arise? Soon after the rediscovery of Mendel's work in 1900, the Dutch botanist De Vries made a suggestion along the lines that the gene for red-floweredness might have come from the gene for white-floweredness, or vice versa, by some sort of spontaneous change in the past history of pea-plants.



This diagram illustrates Mendel's revolutionary experiment, described on the previous page, in crossing red-flowering and white-flowering peas.

Drawn by David Rae, from information supplied by the author.

There was no evidence for this sort of change until, a decade or so later, the American zoologist T. H. Morgan noticed in his bottles of fruit flies in his laboratory a single individual with white eyes instead of the normal red ones. There was no doubt that a spontaneous change had occurred. The gene for red eyes in the parents had changed into a gene for white eyes in one of the offspring. This is called mutation, meaning change. This is not the only kind of mutation, but it is the main kind.

Here was another most important step in genetic discovery, because mutations provide the building blocks for evolution. We now know that mutations occur in all genes—not every time a gene is transmitted to offspring, but once in every thousand or tens of thousands of times it is produced. Every time a cell divides one gene produces two daughter genes. Sometimes the daughter genes are not identical with the parent gene. This is mutation. Well, it is one thing to have a source of building blocks, but this doesn't build a house, nor does a collection of genes build an organism. This creative task is the role of natural selection. Just as a house may be built in innumerable ways out of a pile of bricks, so an organism might be built in innumerable ways out of its building blocks, which are the genes. And just as some houses are much better for living in than others, so some of the arrangements of genes produce a much better organism than others. The building best fitted to the environment in which it has to stand is the one which survives. It will have to have strong foundations and buttressed walls if it is to survive in a place swept by tornadoes. The same is true of organisms. That organism survives which is so constructed that it can withstand best the rigours of its environment. What I have said in these very simple terms has been put in highly mathematical and rigorous terms by living geneticists such as Professor Sewall Wright, and proven experimentally by his equally distinguished colleague, Professor Dobzhansky, of Columbia University, New York.

A serious difficulty for many people has been that mutations occur at random—that is to say, they appear to be accidents to genes and, because they are accidents, most of them are deleterious. But just a few of all the mutations that do occur confer some sort of benefit on the organism. These are the all-important ones for evolution. The appearance of a new gene of advantage to the organism is an accident. It is most important to realize that it does not arise simply because the organism would benefit by having such a gene in its make-up. I think the point is illustrated very nicely in the following example of evolution in bacteria, quite a modern example of evolution and one that happens to be of great medical importance:—

A concentration of the antibiotic streptomycin as low as 25 milligrams per litre stops the growth of the colon bacteria *Escherichia coli*. However, if several billion bacteria are placed in a nutrient medium containing streptomycin, one or several bacterial cells continue to grow and multiply, and from these can be obtained bacteria which are resistant to even very high concentrations of streptomycin. These bacteria contain mutant genes. One in every thousand million bacteria is a mutant resistant to streptomycin. The mutations are not induced by streptomycin, as you might imagine. They occur spontaneously, and they occurred even before streptomycin existed in their environment. The role of streptomycin is that of a selecting agent. It kills all the non-resistant bacteria and permits only the resistant mutants to survive and multiply. You have heard of insects that are resistant to D.D.T. This has happened in much the same way.

Another fascinating example is the evolution, since the industrial revolution in Britain and Europe, of black moths from white ones. This has happened in more than 70 species of moths. The black colour, in most cases which have been studied, is due to a single dominant gene. It has occurred as a mutation at a regular, but slow, rate, probably ever since moths have existed. But not until the countryside became blackened with soot and filth from factories was there any advantage for a moth to be black. The blackness conceals it as it rests on the sooty trunks of trees and protects it from its ever-present predators. The white moths are easy prey for birds, which feed on them in large numbers. The birds in this example are the selecting agents. Of course, in the non-sooty countryside the whites are still the common form.

Perhaps you can accept all this and say, "Yes, I can see how streptomycin resistance can evolve and how a black moth can evolve. But can this also explain how I have evolved from some remote ancestor quite different from me? This seems too much to expect me to swallow." So it does on first thoughts. The evolutionist answers that it has happened that way and the clue to it all is time. Small advantageous changes made step by step can eventually make enormous changes, producing totally new creatures. But without a long time to work the step-by-step process, evolution would be an impossibility. Probably at least a million mutations were involved in our evolution from a simple microscopic ancestor—not just one, as in the case of the evolution of a black moth from a white one.

How could all these million changes have occurred to produce us? To expect this to happen by chance without the intervention of selection is to expect the impossible. A simple calculation will illustrate the point. Let us suppose that only one in every 1,000 mutations are favourable. This means that we would have to breed 1,000 strains to get one with one favourable mutation, a million strains to get one with two favourable mutations, and up to a thousand to the millionth power to get a million favourable mutations in one. Of course it couldn't happen that way, but it is a way of visualising the odds against getting, through chance alone, a million mutations in one strain. One with three million noughts after it is the measure of the unlikeliness of a man evolving—the odds against it happening by chance alone, without selection. You wouldn't bet on anything as improbable as that. However, it has happened in another way—that is, by a succession of steps with natural selection preserving the few favourable mutations at each step and multiplying them. Natural selection makes the improbable probable.

Books For Laymen

If this is the first time you have thought about this sort of wonder of nature then it is unlikely that you are yet convinced. In a short article I have greatly simplified the genetical basis of evolution. However, I would suggest that these days you can quite easily get a real insight into these enthralling problems by reading one or two books written on this subject specially for the intelligent layman. In particular, I would suggest "Evolution, Genetics and Man," by Professor Theodosius Dobzhansky, who will be visiting Sydney in 1960, and "Evolution in Action," by Sir Julian Huxley, which is published in the cheap Mentor paper-book edition.

In the frontispiece of Dobzhansky's book you will find a reproduction of Michaelangelo's "Creation of Adam" in the Sistine Chapel. This is a little surprising, since Dobzhansky is in more senses than one the Darwin of this century and one of the greatest geneticists of our time. But it is not surprising when you grasp the meaning of genetics in the evolution of species. Genetics has shown us that evolution is essentially a creative process. Dobzhansky gave eloquent expression to this idea in his address to the 9th International Congress of Genetics in Italy, when he compared the creative process of genetical evolution with the production of a work of art. Both involve the risk of ending in failure. There is nothing predetermined about evolution. Without the possibility of failure there would be no creation—indeed the path of evolution is littered with countless failures which did not pass the trials of natural selection. There were countless evolutionary blind alleys. This is the cost of evolution, just as there is a cost in great creative art.

But from it all there emerge creatures which are more wonderful than those that have gone before, moulded by the creative forces of genetics and natural selection. I don't want to suggest that this is all. But it is part of the story which genetics is unfolding to the 20th century.

New Technique Used in Museum Exhibit

An exhibit giving an outline of the evolution of vertebrates is now being completed at the Australian Museum.

This "Tree of Vertebrates" consists of welded mild-steel silhouettes of animals, and is lighted by 60 fluorescent tubes behind a sheet of translucent fibreglass.

The exhibit, which is at the top of the main stairway, has an area of 124 square feet.

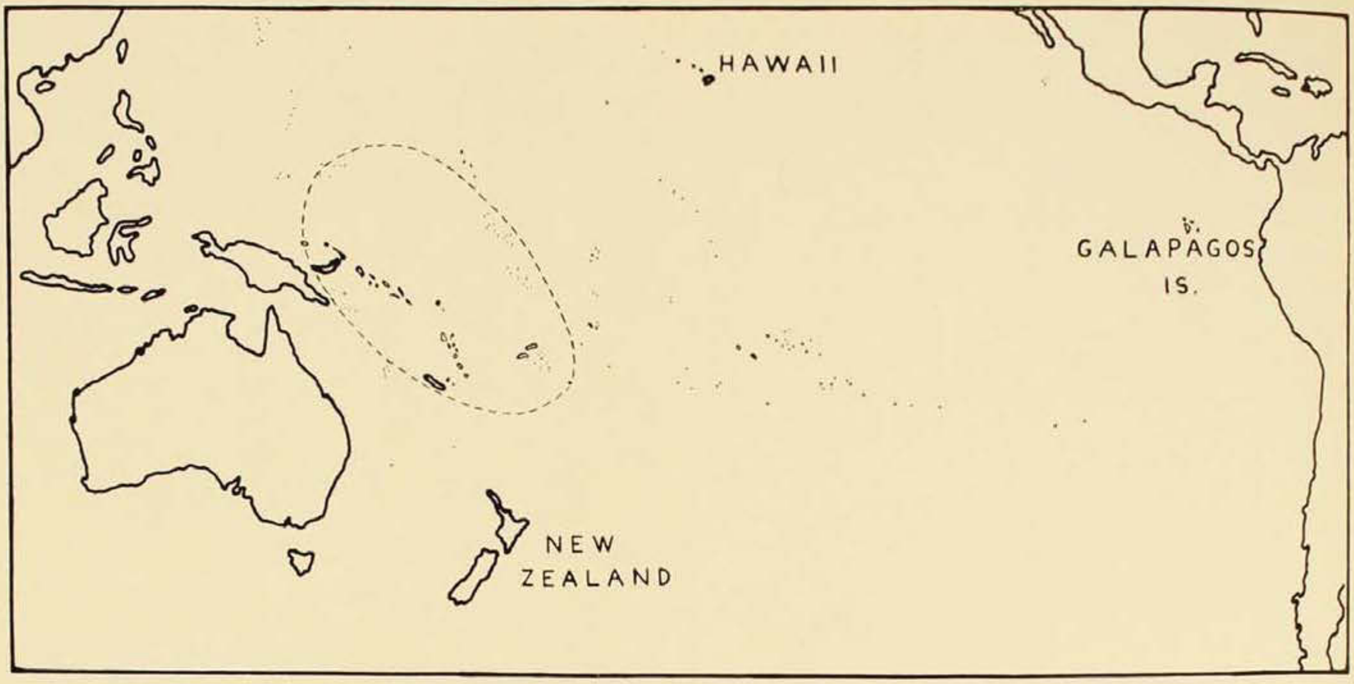
The first vertebrates, which were jawless armoured fishes, arose during the Ordovician geological period, and from them the true jawed fishes evolved in the following period, the Silurian. These radiated into the sharks and bony fishes in the Devonian.

The Amphibia, which today are represented by frogs and toads, arose from air-breathing, fresh-water Devonian fishes, and were the first vertebrates to colonise the land, though they had to return to the water to breed.

Reptiles evolved from the amphibians during the Carboniferous, and became the dominant land animals of the Mesozoic era. Their ability to lay shelled eggs which could develop out of the water allowed them to become fully terrestrial.

Birds evolved from fast-running reptiles during the Jurassic, and the earliest forms retained many reptilian features, such as teeth and long bony tails.

During the Jurassic, a group of reptiles gave rise to the mammals, which remained small and insignificant until the Cretaceous, when they began a spectacular radiation after the extinction of the large dominant reptiles of the Mesozoic.



This map shows the positions of the Galapagos and Hawaiian Islands, and of the island area (in the ellipse) used in the article in a comparison with Australia.

The Role of Islands in Evolution

By ALLEN KEAST

Illustrated by Wendy Manwaring

MAN has always recognised that animals fall into a vast number of distinct entities, each characterised by common structure, size, behaviour and way of life. These—the species—breed and are fertile only within themselves.

So distinct are species that, throughout history, it has not required any stretch of the imagination to believe that each is a separate divine act of creation, constant and not subject to change. Though prior to, and during, the early part of the 19th century one or two writers had suggested that species might, in fact, be evolving units, such suggestions commanded virtually no attention.

It was this world that Darwin entered and, with his lucid thought and painstaking analysis, produced, once and for all, the proof of evolution. And it was an island archipelago, the Galapagos, some 600 miles to the west of South America, visited when on the voyage of the *Beagle* in 1837, that started him on his study of evolution. Thus, he has written (Darwin's Diary, 1837): "In July opened first note-book on 'Transmutation of Species'. Had been greatly struck from about month of previous March on character of S. American fossils—and species on Galapagos Archipelago—These facts origin (especially latter) of all my views."

Islands are of importance in the study of evolution in three ways.

Firstly, several archipelagos, in the wonderful examples they contain of the formation of new species, provide living demonstrations of evolution. Evolution also occurs, of course, on continents, but much of our basic knowledge of species formation has been derived from islands.

Secondly, islands have functioned in the preservation of ancient and specialised forms of life that have been exterminated elsewhere. New Zealand is an example of this, with its unique reptile, the Tuatara (the last survivor of an order that disappeared from the fossil record 100 million years ago), its primitive frog *Leiopelma* (2-3 species) and its giant flightless moas (which took the place of large herbivorous mammals and were probably exterminated by the Maoris). Madagascar is another example, with its various lemurs, relict iguanids, and pelomedusid turtles. Australia (monotremes, marsupials, lungfish, the shrimp *Anaspides*) though a continent is, after all, also an island.

Thirdly, in the safety and isolation of islands it is not uncommon for animal species to undergo a special "degenerative" form of evolution not seen on continents. In this, the body may become over-large in size, as in the extinct dodo of Mauritius, and birds may lose their power of flight, as in various Pacific rails, teal ducks on sub-Antarctic islands and the cormorants on the Galapagos. A word of explanation is necessary here. Physiological and anatomical studies have confirmed that body form and body size are no accident but are a compromise between conflicting demands. A large body, for example, may be the most efficient from the viewpoint of heat conservation and energy output relative to food intake. But, if we may again use a bird as our example, the constant peril of predation and fluctuating food supplies necessitate its remaining fairly small and agile and being able to fly well. On islands, as we shall see, because of the smaller number of species competition with others for food is much reduced and there are few, if any, predators. Changes in body form can occur along quite different lines.

Darwin's Findings

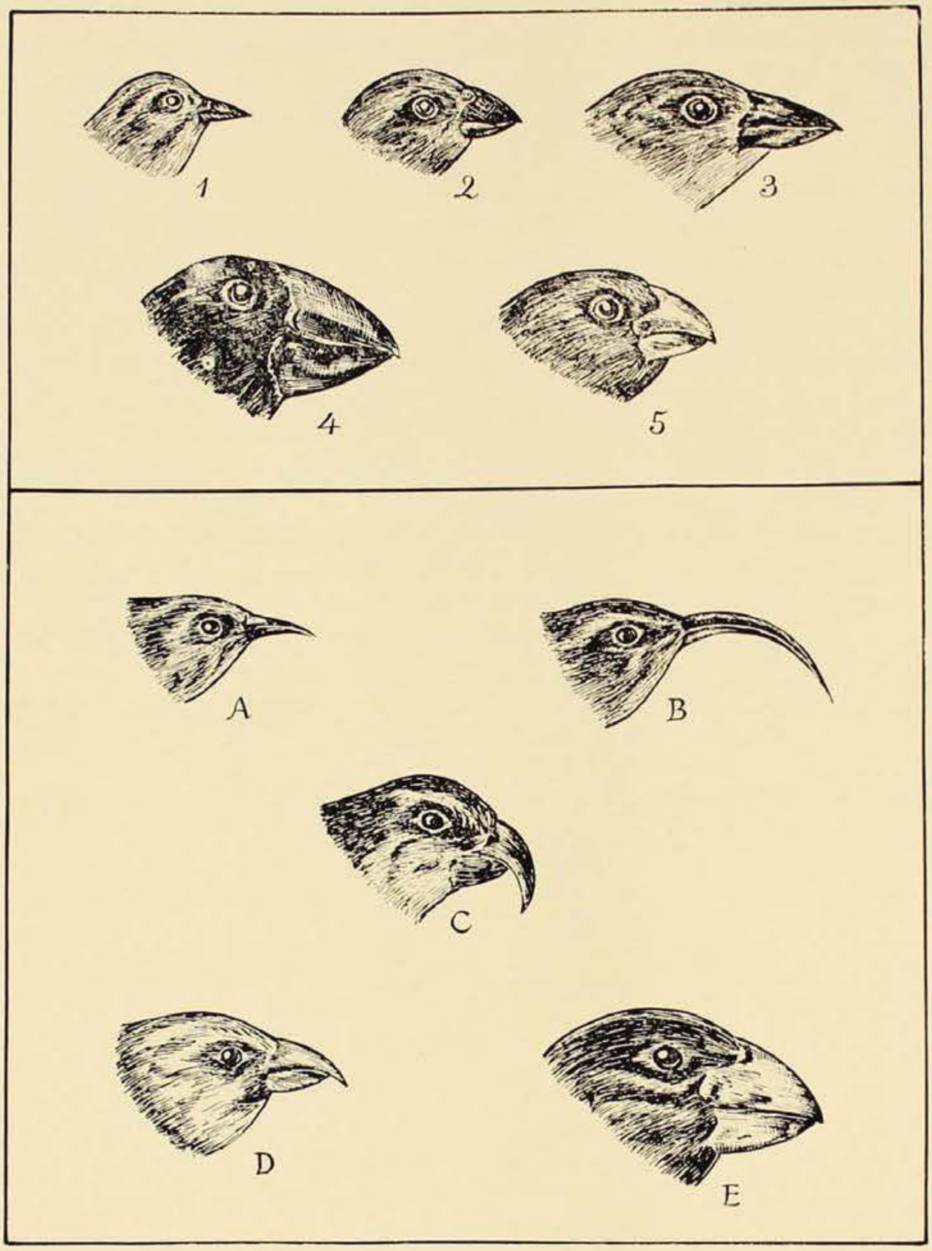
To appreciate properly the role islands have played in the development of scientific knowledge one must review the initial thoughts and subsequent findings of Darwin with respect to the Galapagos. He was surprised to find that the Spanish residents could tell, by body form, scale shapes and general size, from which island any tortoise came. That is to say, the tortoises varied racially from island to island. The Galapagos animals as a whole, though unique and unlike those from anywhere else, were undoubtedly South American in character. Other island groups, he noted, likewise had faunas closest to those of the continent nearest to them. The number of species on the Galapagos (and on all other islands) was materially less than in any area of equal size on a continent. There were great "gaps" in the island fauna, and it was unbalanced. Many of the commonest animal groups on the nearest mainland were absent. The Galapagos lacked frogs, and the only furred animals were a bat and a rodent. Reptiles and birds were the commonest groups, the former apparently taking the place of mammals elsewhere. Most amazing of all, one group of closely-related birds, finches of the family *Geospizinae*, had "radiated out" to fill a whole series of different roles, niches that were occupied by distinct families of birds on the continents. Thus, there were a warbler-like, insect-eating finch; finches with long bills that ate cactus or took plant food from the ground, and seed-eating finches with heavy bills for crushing seeds. The evidence was consistent with only one explanation—that the ancestors of only a few groups of animals had ever succeeded in reaching the islands. There they had thrived, changed, developed races on the different islands, and finally radiated out into a whole range of forms specialised for a wide series of ways of life.

Darwin's findings on the Galapagos are consistent with our now vastly-extended knowledge of island life. Archipelagos continue to yield basic information on evolution, and Darwin's Galapagos have been visited again and again.

The Hawaiian Islands have been found to provide an even more striking case of ecological radiation than the Galapagos. Here the birds are the sicklebills (*Drepaniidae*), the ancestor of which came from North America. Some of the surprising novelties in bill-form acquired in their new home are shown in Fig. 2. The food of these species (which are divided now into several genera) has been summarised by Dean Amadon. It is given in the caption to Fig. 2.

Formation Of Species On Islands And Continents: A Comparison

New animal species are now known to be formed by the following series of steps: (a) Part of a species becomes isolated from the parent by establishing itself on a remote island, or by the break-up of its habitat. (b) During a prolonged period of isolation it gradually changes in general appearance, in its genetic make-up, and in habits and ecology, the last-named in association with



Figs. 1 and 2: The Galapagos finches and the Hawaiian sicklebills provide an excellent example of the radiation by members of a single family to fill ways of life occupied by distinct groups on continents. This is a living demonstration of evolution. Fig. 1 (*Above*): Some Galapagos finches, derivatives of a single ancestral type that established itself from South America: (1) The warbler-like *Certhidea olivacea* (food, mainly small insects from leaves and twigs, some nectar). (2) *Camarhynchus parvulus* beetles, etc., from twigs and holes in wood). (3) *Geospiza scandens* (soft pulp of cactus, seeds). (4) *Geospiza magnirostris* (seeds, fruits, buds. (5) *Camarhynchus crassirostris* (vegetarian tree-finch). Fig. 2 (*Below*): Some Hawaiian sicklebills, derivatives of an ancestor that established itself from North America: (A) *Loxops virens* (food, general—insects, nectar, berries). (B) *Hemignathus obscurus* (insects from cavities in fern stems and bark, some nectar). (C) *Pseudonestor xanthophrys* (wood-boring beetle larvae, obtained by tearing open the burrows). (D) *Psittirostra psittacea* (fruits, berries, vegetable matter). (E) *Psittirostra kona* (nuts, hard seeds).

the changed conditions in its new home. (c) Finally, the changes become so great that it can no longer successfully interbreed with the parental type. At this stage it is a new species. We can, of course, only know this in those few cases when the two stocks happen to come together again, i.e., have the opportunity of interbreeding. Isolated populations of animals that are different from those elsewhere can be referred to as "intermediate stages" in the speciation process. They are forms with the "potential" of developing into new species. Geographic isolation is essential during the formative period as, otherwise, there would be back-crosses with the parent and divergence could never take place.

As so much of our basic knowledge of species formation has been derived from archipelagos, it may now well be asked whether or not the process is the same on continents. On continents, as noted, there is a vastly greater number of species, which belong to many major groups, and there are no areas of sea to function as isolating barriers. The answer is that the process is exactly the same basically, though things are more complex and a detailed analysis is necessary to reveal the full circumstances. For one thing, much of the continental variation is continuous. For example, instead of there being a large-bodied population on one island and a small-bodied one on another, they may be in the south and north of the continent, with a whole series of intermediate-sized forms between. There is no physical isolation, the extremes are connected, and a new species cannot develop. It was this observation of the commonness of clines, as they are called, that falsely led one geneticist (Richard Goldschmidt, 1940) to suppose that evolution did not proceed on continents in the way that it did on islands.

In recent years a study has been made of the formation of new bird species on the Australian continent. Bird species do not occur haphazardly over the landscape, but are specialised for life in the different kinds of forest and terrain. Some live only in humid tropical rain forest, with its dense leafy canopy and trailing vines. Others are to be found mainly in sclerophyll forest—the luxuriant type, with undergrowth, that occurs near the coastal cities of the east. Other species are restricted to savannah woodland, and others to mallee, grassland or desert. The all-important factor breaking up the distribution of these, and leading to isolation and divergence, has been found to be gaps in the special habitat of the various species. Most often this is a tongue of dry country or desert, extending through from interior to seaboard. For example, the arid Nullarbor Plain at the head of the Great Australian Bight (a barrier that dates from at least the onset of generalised aridity 10,000-50,000 years ago) isolates eastern and western forms in a large number of forest species.

As has been noted, the different ecological roles are typically occupied by representatives of *distinct groups* on continents. In Australia almost all the nectar-feeding birds belong to the honeyeater family (Meliphagidae), the species of which typically have somewhat elongated bills for taking nectar. The heavy-billed grain-feeders are, mostly, the finches (Ploceidae) or parrots (Psittacidae). The Muscicapidae, the members of

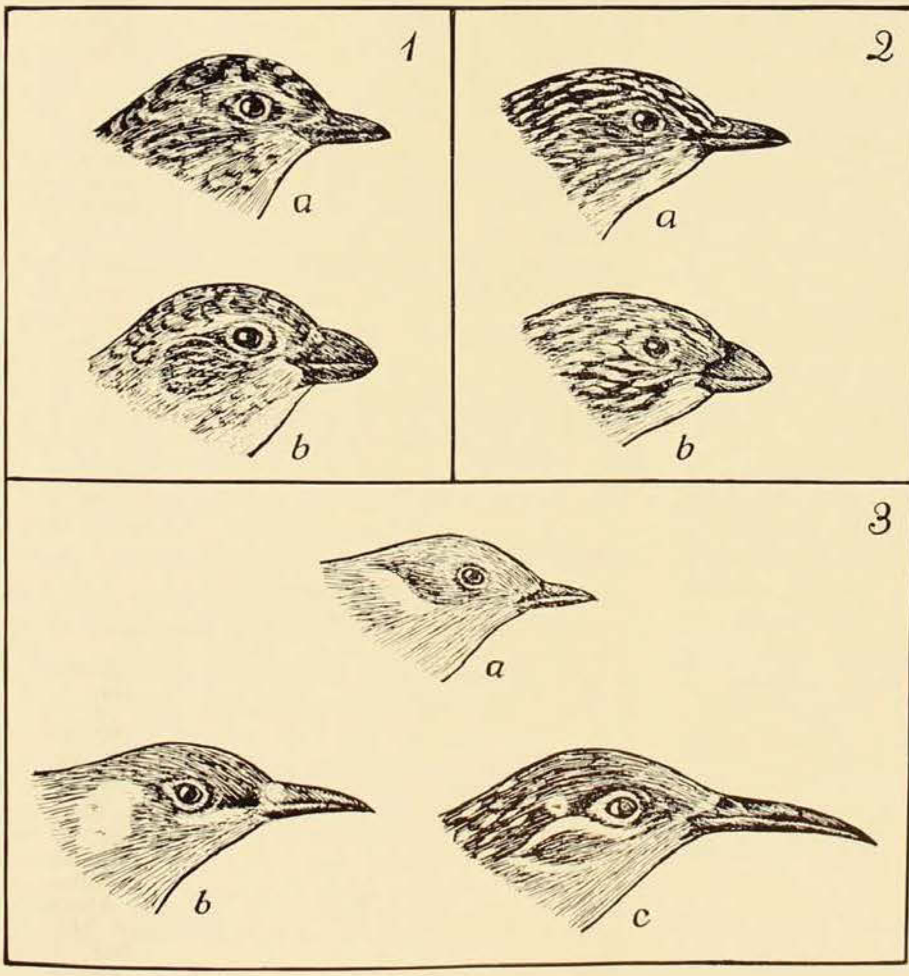


Fig. 3: Some examples of marked difference in bill-form within genera on the Australian continent: (1) *Turnix* (quails): (a) *T. maculosa* (generalised type of bill suitable for both insects and small seeds). (b) *T. velox* (heavy bill of seed-crushing type). (2) *Amytornis* (grass-wrens), with the species (a) *A. textilis* and (b) *A. goyderi* similarly adapted. (3) *Meliphaga* (honeyeaters): (a) *M. fusca* (mainly insects from leaves and twigs). (b) *M. notata*. (c) *M. chrysotis* (elongated bill-type of the somewhat specialised nectar-feeder; in one species such a bill is used to obtain insects from crevices in the bark).

which have short (often broad) bills with bristles at the side, are the insect-eaters, and so on. Nevertheless, when a detailed study is made it is found that, within a few groups, there are examples of closely-related species developing different bill-forms. Three of these are shown in Fig. 3. Both in the quails (*Turnix*) and grass-wrens (*Amytornis*) there are species with a somewhat long, generalised type of bill, and another with a heavy, grinding, grain-feeding bill. Amongst the honeyeaters (Meliphagidae) many species have short, generalised bills not unlike those of flycatchers, and feed mainly on insects from the leaves and twigs, with some nectar. The most specialised nectar-feeders have very long, narrow bills (e.g., the Spinebill, *Acanthorhynchus*), while one species, *Melithreptus validirostris*, of Tasmania, has a long, heavy bill, like that of a tree-creeper, which it uses for getting insects from cracks in the bark. Examples of three different types of bill, within the genus *Meliphaga*, are shown in the figure.

To complete the comparison between continent and archipelago, an island area of equivalent size in the south-west Pacific has been chosen (Map). Though Australia has 535 species of land and fresh-water birds, only 53 occur both on the continent and in the island sector of the area. The number of isolated forms that have diverged from the parental type is about 200 in the archipelago area and 40 on the continent. So there is much greater opportunity for forms to become isolated, and to differentiate, on islands than on a continent. Further investigation reveals that many of these forms are relatively more distinct than their continental counterparts in colouration, colour-pattern, relative colouration of the sexes and in length and shape of appendages (bill, tail, etc.). Compared to the Galapagos and Hawaii, the closer proximity of these Pacific islands to Australia and New Guinea has enabled many more species to invade and spread through them. Once established, however, these populations have settled down and started to differentiate, just as they have in the Galapagos and Hawaii. This, too, bears out the greater isolating influence of areas of sea.

One could extend the review of the role of islands in evolution to a discussion of the factors accelerating ecological and genetic changes on the individual islands within an archipelago. This somewhat speculative field, however, lies beyond the scope of the present article.

Book Review

RANGATIRA (THE HIGH-ONE): A Polynesian Saga. By N. B. Tindale and H. A. Lindsay. Illustrated by D. F. Maxted. Rigby Ltd., Adelaide, 1959; 208 pp.

This book is a fictional story, based on known scientific information, of the peopling of New Zealand by the Polynesians. A settlement on a lonely and remote island, finding its population expanding too greatly for its resources, has its problem solved by an old Polynesian mariner, of chiefly rank, who is blown ashore. He directs the building of a sea-going canoe, upon which 30 of the fittest people sail away to find a new land.

The book is a well-written and entertaining account of their hazardous voyage and subsequent settlement in New Zealand. A glossary of Polynesian words, customs and beliefs is added, and the illustrations aptly demonstrate the incidents and customs described.

The authors, who are a professional anthropologist and a journalist, respectively, have found in this book and in their contribution on the peopling of Australia, an interesting way of presenting scientific knowledge, particularly for school children.

F. D. McC.

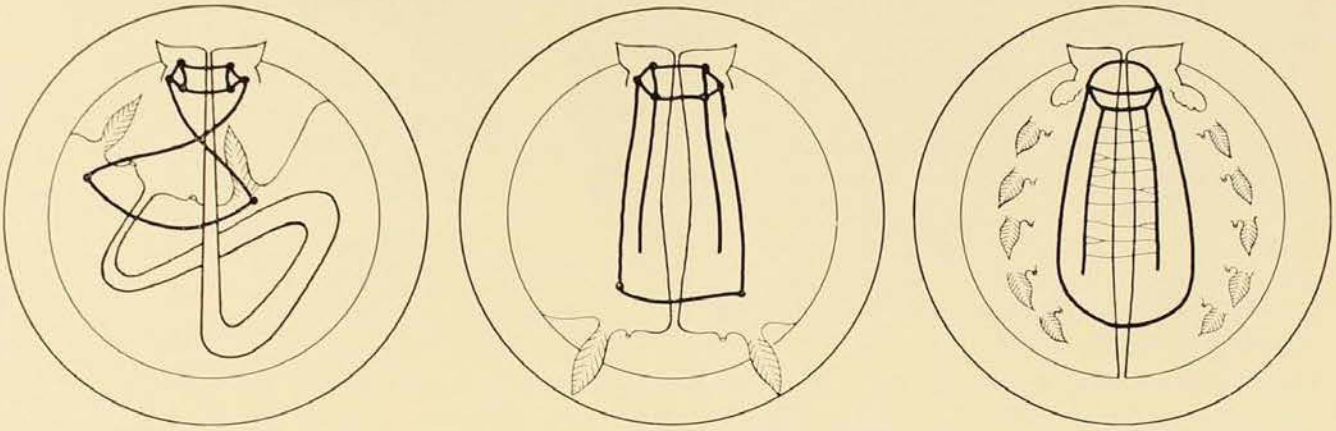
BOOK RECEIVED.—Men were My Milestones: Australian portraits and sketches, by A. H. Chisholm (Melbourne University Press, 1958). Price, 27s. 6d.

Historical Society's Visit to Museum

About 60 members of the Royal Australian Historical Society made an afternoon visit to the Australian Museum on Saturday, July 25. They were welcomed by the Director, Dr. J. W. Evans, in the Hallstrom Theatre, where a talk on the Museum's early history was given, illustrated by slides. The visitors were conducted through the Museum's galleries by the Curator of Fishes, Mr. G. P. Whitley, and the Curator of Molluscs, Dr. D. F. McMichael. They also visited the board room to see the portrait of Alexander Macleay (reproduced in The Australian Museum Magazine, Vol. VII, No. 10, September, 1941) and the old wedgwood medallions of Banks and Solander.

Neopilina—A Molluscan Missing Link

By DONALD F. McMICHAEL



These diagrams illustrate the structure of (left) a simple gastropod, showing "torsion"; (centre) the hypothetical ancestral monoplacophoran suggested by paleontologists; (right) the living *Neopilina galatheae* Lemche. The heavy black lines show the central nervous system.

Drawn by David Rae.

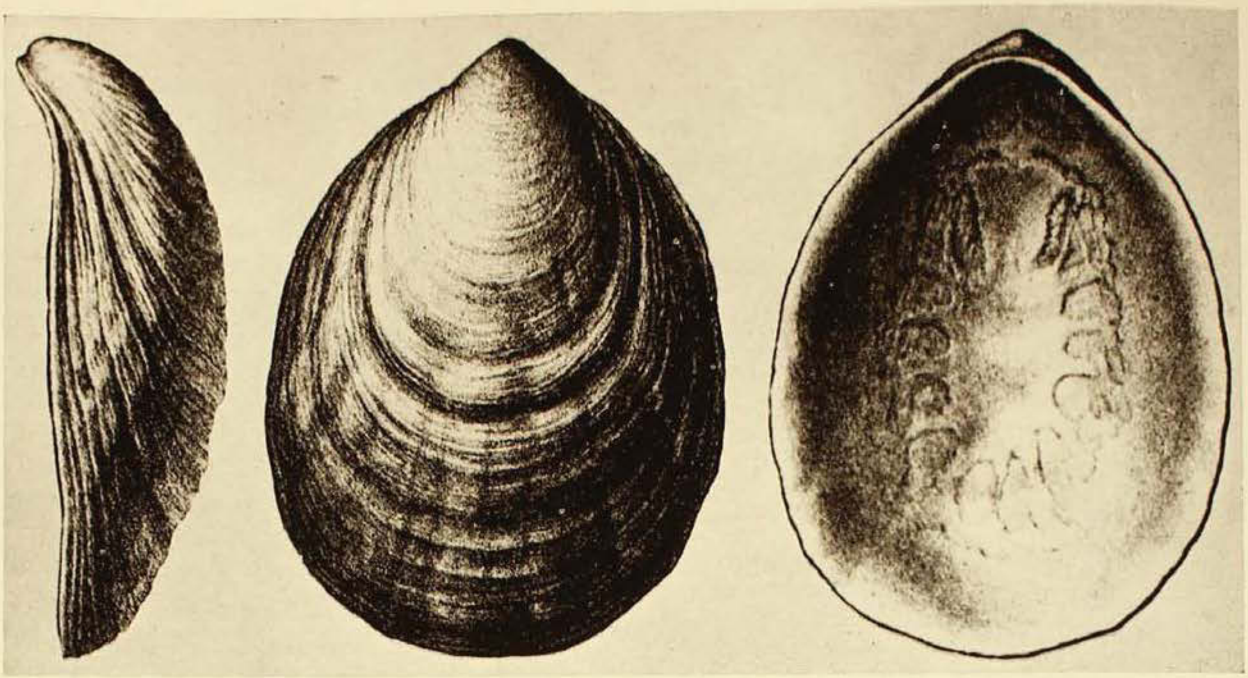
THE great debates of the last century which raged around the Darwin-Wallace theories of the evolutionary origin of plants and animals had some remarkable consequences for zoology. Not the least of these was the close re-examination of the animal world in a search for living creatures which might prove to be intermediate in structure between two or more of the sub-divisions of the animal kingdom. These so-called "missing links" were the object of a good deal of scorn by those opposed to the theory of evolution. The phrase was not one widely used in zoological circles, but it was quickly adopted by popular writers and especially used for those creatures which in any way linked man with the primates.

None the less, there is a great deal of value in this phrase, for if evolution is to account for the bewildering variety of animal types then there must have existed a whole host of species which, in one way or another, were intermediate stages in the evolution of the various groups. The lack of more than a few known living or fossil animals which were truly intermediate in structure between one group and another has always been a stumbling block to the defence of the theory of evolution. Consequently, any new discovery which could help to bridge the structural gaps between the major groups of animals is of the utmost importance to the zoological world.

The phylum Mollusca, which includes the true shell-fish, such as snails, clams and the pearly nautilus, as well as many apparently shell-less creatures like slugs, squid and octopus, is one of the major sub-divisions of the animal kingdom. It is a very successful group, for shells are found in the very oldest fossiliferous rocks of Cambrian age.

Molluscan Characteristics

Among the many specialised characteristics of the molluscs are the presence in most of them of a radula, the peculiar horny, many-toothed feeding organ which is not found in any other group; the presence of a calcareous shell (sometimes reduced or absent), secreted by the mantle, which is a fleshy dorsal fold of the body enclosing a cavity in which lie the gills; the lack of any



A fossil monoplacophoran shell from Sweden, showing the symmetrically arranged muscle scars.

After Lindstrom.

trace of segmentation—that is, the subdivision of the body into a series of similar segments, as in the annelid worms and the arthropods. There are many other characteristics, including the nature of the blood-circulatory system, the excretory organs, the nervous system, the foot and the larval stages, which help to distinguish this large group of animals.

Some of these characteristics are shared in common with other phyla of animals, but the molluscs were considered to be quite well characterised by the total combination, and especially distinguished by the radula, the shell and the lack of segmentation. For example, many marine molluscs possess a special larval stage known as the trochophore larva, which is a minute free-swimming larva with tufts and bands of cilia and a simple gut. A similar larva is found in the annelids, or segmented worms which are marine, such as the polychaete beach-worms. The body cavity of the molluscs is similar to that found in the other phylum of segmented animals, the Arthropoda. It consists of a *haemocoel*, which means that the cavity is filled with the animal's blood. This blood flows directly back to the heart, and is not confined to a discrete set of veins and arteries as in the vertebrates. This open type of blood circulatory system is also found in the Arthropoda. The true coelom (which forms the body cavity in the vertebrates and also in the worms) is very much reduced in the molluscs, being represented only by the tiny cavities of the pericardium, the gonads and the excretory organs.

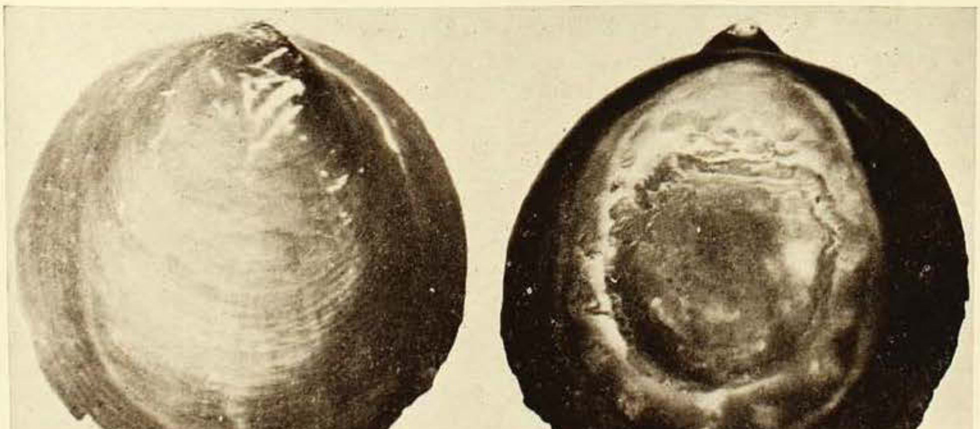
Because the annelid worms, the arthropods and the molluscs share a number of characteristics in common, these three great groups have always been considered to have evolved from a common ancestral stock. However, the mollusca differed in one very important way from both these other phyla, and that was in the lack of body segmentation. The molluscan body was not divided into units, and there seemed to be no trace of any series of organs which might indicate that segmentation had been lost during the evolution of the group. The one exception was the chitons, or coat-of-mail shells, which had a series of eight shells along the back and very many gills in a row down either side. These were about the simplest of the known molluscs, and it was thought that the series of shell plates and the many gills had been acquired secondarily and did not represent a primitive segmentation, because the rest of the body did not show any signs of segments.

In 1951, the Danish research vessel "Galathea" brought to the surface from the ocean depths, 3,500 metres down, a few small limpet-like shells which were set aside for further study. Early in 1957, the zoological world was astounded to learn that these creatures were segmented molluscs, missing links between the Mollusca and the annelids and arthropods. They were named *Neopilina galatheae* by the Danish scientist Henning Lemche, who recognised that the new animals were living representatives of a group which had previously been known as fossils in the early Palaeozoic rocks of Cambrian to Lower Devonian age. The group was believed to have become extinct about 250 million years ago! One of the best known of these fossils was the genus *Pilina*, and Lemche's name for the new discovery means "new Pilina". These fossils were small limpet-like shells which differed from true limpets in the arrangement of the muscle scars that mark the inside of the shells. The true limpets have a single horseshoe-shaped scar, but these fossils have a series of symmetrically arranged muscle scars in pairs down either side of the shell. The astonishing thing about *Neopilina* was that not only the muscles, but also the gills, excretory organs, body muscles and nervous system, all showed signs of serial arrangement—that is, of segmentation.

Some years before the discovery of *Neopilina*, palaeontologists had become very interested in the fossil shells related to *Pilina* because of their paired muscle scars. They had recognised that these were the shells of a very primitive type of mollusc, rather closely related to the chitons, but differing in that they had only a single shell. The palaeontologists placed them in a separate Class, the *Monoplacophora* (meaning single-plate), as opposed to the chitons or *Polyplacophora* (many-plates). They also recognised that these monoplacophorans differed from the true limpets (members of the class *Gastropoda*) in one particularly significant way. This was that the monoplacophorans did not undergo the curious twisting of the body organs known as torsion, which is characteristic of the gastropods. This torsion causes the gills, the anus, the excretory openings and the mantle cavity opening of the gastropods to come to lie at the front of the animal, just behind the head. As a result, there is a tendency for the animal to become rather asymmetrical, with only one gill and one kidney and excretory duct, and with a twisted nervous system. And it is for this reason that the limpets have only a single muscle scar, instead of the pair present in the larva. This twisting takes place during the development of the larva, and the organs which start off paired, degenerate as development proceeds.

Hypothetical Ancestor

From a study of the paired muscles of the fossil monoplacophoran shells, the palaeontologists supposed that these primitive creatures still maintained the symmetrical arrangement of the body organs and did not undergo torsion. They



Neopilina ewingi: Left, the shell seen from above; right, the living animal seen from beneath.

Photo.—Ruth D. Turner.

pictured a hypothetical ancestral animal with the mantle cavity opening behind, the nervous system untwisted, the anus posterior, and the gills at the back of the animal. The illustration on page 133 shows the twisted structure of a gastropod, compared with the symmetrical structure of the monoplacophorans as imagined by the palaeontologists. Beside these two is a drawing of the living *Neopilina*, and it is quite obvious that in nearly every way the structure of *Neopilina* is similar to the hypothetical ancestor created by the palaeontologists. The only significant difference is that the gills of *Neopilina* are arranged in a series down either side, instead of being just a pair at the posterior end of the animal.

Since the "Galathea's" discovery the American research ship "Vema" has found another living species, *Neopilina ewingi*, and a photograph of this animal has been lent by Dr. Ruth Turner, of Harvard University. *Neopilina* has a rather plain, limpet-shaped shell, just over an inch in length and a little less across. The animal has a large circular foot, though it has been suggested that it does not creep along on this foot like the limpets, but probably lies on its back and feeds by making currents which carry small particles of food to its mouth. Along each side of the foot are five or six gill-like structures, which possibly serve to make the water currents for feeding. The animal has a distinct head and mouth, and the gut contains the characteristic molluscan radula, as well as a crystalline style, an organ found in most bivalve molluscs and some gastropods.

Fossil monoplacophorans have been reported from most areas of the world, including Australia. The species illustrated is from Sweden, and shows the series of muscle scars which first attracted attention to these ancient shells. Probably quite a lot of fossil limpet-like shells will turn out to be monoplacophorans when they are re-examined. Both the known living species have been found in the deep-water trench off the west coast of South America, but perhaps we will find them one day off the Australian coast.

Meanwhile, another link in the chain of evidence for evolution has been forged, and our knowledge of the animal world has advanced another step. *Neopilina* is shown in the Australian Museum's "These Are Invertebrates" exhibit; and scientists throughout the world are busy re-writing their textbooks to include these no-longer-missing links.

Notes and News

"Black Swan" Film

The Australian Museum's seven-minute, 16mm., educational sound and colour film, "The Black Swan," was televised by the Australian Broadcasting Commission's Channel 2 on October 9. The Commission intends to televise it again. The New South Wales Education Department has bought copies of the film for use in school biology classes. The film, which shows some details of the life of a pair of Black Swans found nesting on a lake near Pitt Town, N.S.W., in 1957, was made for screening to school pupils visiting the Museum.

Sea-snakes

The Australian Museum has received six Yellow-bellied Sea-snakes (*Pelamis platurus*) from members of the public in response to its recent appeal for specimens of sea-snakes for its research collection. One came from Bunbury, Western Australia, and the others from New South Wales.

Harmful Marine Animals

The Australian Museum will participate in an international congress on life-saving techniques to be held in Sydney in March, 1960. One section of the congress will be devoted to the study of harmful marine animals, and the Museum will co-operate with an exhibit of sharks, sea-snakes, poisonous and venomous fishes, stinging invertebrates and harmful molluscs.

"Glass Eels"

The Australian Museum's Department of Fishes has acquired a number of "glass eels", or the *Leptocephalus*-larva stages of eels. They were found by Mr. Phillip Colman washed up on Collaroy Beach, near Sydney, in December, 1954; July and September to December, 1958, and April, September and October, 1959. They are probably the young stages of marine, not freshwater, eels. An exhibit of the life-history of freshwater eels is being prepared in the Museum.

Royal Zoological Society

Mr. Gilbert P. Whitley, Curator of Fishes at the Australian Museum, has been elected President of the Royal Zoological Society of New South Wales for 1959-60.