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War conditions having rendered it impracticable to hold an Ordinary Meeting on February 9th, 1942, the Paper for that date was circulated to subscribers and is here published, together with the written discussion elicited.

WHAT THE ANIMAL FOSSILS TELL US.

By Douglas Dewar, Esq., B.A., F.Z.S.

GREAT is the variety displayed by the animal world. About a million different species now exist, all of which, according to the theory of organic evolution, are descendants of one or more kinds of microscopic organisms devoid of eyes, ears, mouth, nose, limbs, bones, shells, digestive tube, liver, heart, lungs, gills, kidneys, blood or blood vessels.

Prima facie, this theory is improbable, because, first it involves the origin of all the above organs from undifferentiated protoplasm, followed by prodigious transformations; secondly, despite the great diversity of the animal world, every species is a member of one or other of a few sharply-marked-off groups, each of which is constructed on a different plan.

However, we are not entitled to reject the theory on purely *a priori* grounds. We have to consider the evidence adduced by its supporters. We have to abide by the testimony of the fossils, which provide the only means of deciding whether the theory is true or false. Fossils are the remains of animals and plants embedded in the crust of the earth, or products of these, or marks left by them in the rocks. Billions of these fossils exist, and hundreds of thousands of them have been dug up by man, representing thousands of different species, many of which still exist, but most of which are extinct.

In a short paper it is impossible to survey even briefly the fossils known to us, but it is possible to show how the known fossils furnish a crucial test of the tenability or otherwise of the theory of organic evolution.

There exist to-day, and this is true of the past, a number of animals of peculiar form, sharply marked off from all others. If,

as the theory of evolution postulates, each of these be the modified descendant of an ancestor of a generalised type, then each must have a line of ancestors intermediate in form between it and the last of its generalised ancestors. Thus, among mammals, whales, sirenia (sea-cows), seals, bats and kangaroos differ much in form from the ordinary four-legged land mammals from which, *ex hypothesi*, they are descended. *Mutatis mutandis*, this applies to such peculiar types as turtles, pterodactyls (extinct winged reptiles) and ichthyosauruses (extinct marine reptiles) among reptiles; frogs and toads among amphibia; and butterflies, dragonflies, spiders and scorpions among invertebrates. Fossils have been found of all the above peculiar animals, hundreds of them in the case of whales, seals and turtles, scores of them in the case of all the others; but not a single fossil has been found of any species of animal intermediate in form between any of them and its supposed generalised ancestor. Each of these peculiar animals appears in the rocks unheralded, exhibiting all the characters that mark it off sharply from all other kinds of animal.

Although everyone is familiar with the appearance of most of the animals named above, only a zoologist can appreciate fully their differences from supposed generalised ancestors. Accordingly, for the benefit of those who are not zoologists, let me mention some of the differences in the case of whales. These have neither hind legs nor a pelvis, and their fore-limbs are jointless paddles or flippers. At its base the fish-like tail is as thick as the body, and it tapers off to end in a great fin; the tail, by moving up and down, propels the body through the water. Like fishes, whales have no neck and, as they breathe by lungs, they have to come to the surface whenever they take in fresh air, and in order that this may be necessary only at fairly long intervals, the whole respiratory system differs in several respects from that of a land animal. The whale lacks a covering of hair or fur, and, to enable it to keep its temperature above that of the surrounding water, the body is protected by a thick layer of blubber. Further, in order that the young may be born and suckled under water, both they and the mother are provided with special adaptations. I contend that it is impossible for any kind of land animal to have become changed into a whale by a series of slight modifications that took place in successive generations, and I have repeatedly challenged transformists to describe feasible ancestors in the middle stages of the supposed trans-

formation. But, assuming that such changes did take place, it would mean that the line of ancestors linking the first whale to its last quadrupedal land ancestor would include at least thirty types of animal,* each of which differed sufficiently from its immediate predecessor and successor for it to be deemed a different genus. Nor is this all. The whale order—the Cetacea—exhibits much diversity, and is split up into three sub-orders: the Archæoceti (now extinct), the Odontoceti, and the Mystacoceti. The Archæoceti, while fully adapted to life in the sea, differed in many ways from living whales. Unlike the latter, they had two sets of teeth (milk and permanent), differentiated into incisors, canines, pre-molars and molars. The teeth of the Odontoceti are quite different from those of the Archæoceti; there is only one set of them—the permanent set, and these are all of one type; and instead of having 36 teeth, like the Archæoceti, some dolphins have over 200, while the Narwahl has only one tooth, which projects forwards and may be from 6 to 18 feet long. If, then, the Odontoceti be derived from the Archæoceti, both the original sets of teeth must have been lost, and then a new set of undifferentiated teeth must have been grown, and this new set, unless developed separately in each genus, must have undergone, after development, changes leading to all the types of the teeth in the Odontoceti; in any case, at least five different genera of intermediaries linking the two sub-orders must have existed in the past. The Mystacoceti, or whalebone whales, have no teeth, and so are incapable of masticating their food. Although some of them are the biggest mammals in existence (the Right Whale may be as much as 70 feet long), they feed on small animals such as shrimps, crabs, molluscs and

* Anyone who visits a museum and compares the skeleton of any land mammal with that of a whale will appreciate that the conversion of the skeleton of a land mammal gradually into that of a whale would involve at least 30 intermediate genera. Almost every bone of the body would have to be modified in form; the bones of the face and jaw to be greatly lengthened, and the nose bones to become very small; the nasal canals to become almost vertical; all the bones of the ear to be much modified; the neck vertebræ to become very short. The change of the fore-limb from a walking leg to a paddle involves the shortening and thickening of all the long bones, and the joints at the elbow and wrist ceasing to exist. Extra joints have to be formed in some of the digits, the ribs have to become movable on the backbone and the breast bone. As to the hind part of the skeleton, the vertebræ have to become flattened, to grow expanded transverse processes, and to lose the interlocking processes of their arches so as to become freely movable. All the bones of the pelvis and hind legs have to disappear, and to be replaced by two small arc-shaped bones, which serve to stiffen the genital orifice.

medusæ. The huge mouth is just a trap to catch these small animals. The lower jaw may be as much as 16 feet long, 7 wide and 12 deep, affording, as has been well said, sufficient space for a jolly-boat and her crew to float in! Instead of teeth, these whales have baleen plates, which hang like curtains from the roof of the mouth. There are about 600 of these plates, arranged in two longitudinal rows; each plate is thick and solid at the insertion in the jaw, and is split at the extremity into a number of hair-like fringes. Some of these plates are 11 feet broad at the base, and are more than 10 feet long. As the whale rushes along under water with open mouth, it engulfs much water and the animals floating in it. When its mouth is full the jaws close, and thus drive out the water in the mouth, and, during the passage of this, the animals in it become entangled in the baleen plates and then swallowed.

These whales are supposed to be derived from toothed whales. If this happened gradually, at least six ancestral genera must have existed in which the teeth were in as many intermediate stages between the toothed and the baleen-plated whales.

The Sirenia, like the whales, are fully adapted to life in the sea, but the two types differ in so many respects that no one thinks they are derived from the same land ancestor. Thus, *ex hypothesi*, there must have existed in the past as many Sirenian as Cetacean intermediaries. If derived from land ancestors, seals must have had as ancestors at least eight intermediate genera, bats at least 20, and kangaroos three such.

The fact that not a fossil of any intermediate ancestor of any of the above mammals has been found, or of any intermediate ancestor of any of the other peculiar types cited above, is fatal to the theory of organic evolution unless a satisfactory explanation can be given in accordance with the theory, because, as Darwin says, "by my theory innumerable transition forms must have existed." He then asks, "Why do we not find them embedded in countless numbers in the crust of the earth?" and replies: "I believe that the answer mainly lies in the record being incomparably less perfect than is usually supposed" (*Origin of Species*, 6th edn., p. 34). This is the only explanation transformists are able to give to-day. In support of this contention they assert, first, that it is only in exceptional circumstances that a dead animal becomes fossilised, and secondly, it often happens that, after a fossil has been laid down, the sediment in which it is embedded is eroded away, so that the fossils in the

sediment are destroyed or washed out to sea. These assertions are true, but they do not adequately explain the lack of intermediate or transitional fossils. It is commonly said that only one in a million dead animals becomes fossilised. This is a guess; the percentage is too high for animals that lack hard parts and too low for those that have shells. But let us assume that one in a million of the animals that have shells or internal skeletons becomes fossilised, and compare this figure with the immense numbers of animal populations. Consider the house fly, which is cosmopolitan; its total population must run into many thousands of millions. But the house-fly population is small compared with that of most small marine animals. According to the authors of *The Science of Life*, where the waters of the Elbe are slowed down on entering the estuary, over ten million minute crustaceans are to be found in every cubic yard of water, and in the same river below Hamburg about 27,000 bristle worms may inhabit one square foot, and in other parts of the Elbe about 7,000 of the tiny bivalve mollusc *Sphærium* occur per square foot. In England and Wales 300,221 cwt. of cockles and 37,760 cwt. of mussels were landed in 1925. Both these species have a wide distribution. The edible mussel (*Mytilus edulis*) occurs on both sides of the Atlantic as far south as Morocco; it also occurs in the Mediterranean. Its habitat is near the low-tide mark, and some mussel beds cover several acres and contain millions of individuals. The annual catch of shrimps in England amounts to some 850,000 gallons, that of the U.S.A. to 70,000,000 lbs., that of Japan to 40,000,000 lbs. These three catches represent some 60,000 million individuals. Here are the weights, in thousands of tons, of various fish brought to the United Kingdom in 1929: mackerel, 14; hake, 27; whiting, 31; plaice, 35; haddock, 154; cod, 182; herring, 422. These are taken from only a small part of the range of each fish. In addition to the 422,000 tons of herring taken to the United Kingdom, about 311,000 tons were taken to Norway, Holland, Germany, Denmark and France. At an average weight of $\frac{1}{2}$-lb. per fish, these catches of herrings represent over 5,000 million individuals. Generally speaking, the larger the size of an animal, the smaller its population; but the populations of most big animals are immense. According to Mr. J. Colman (*Journal of Animal Ecology* (1937)), in the Newfoundland seal hunt from 150,000 to 200,000 are caught annually. During the season 1928–29, 13,514 whales were

caught by three British and eleven Norwegian whaling companies.

As to land animals, by observations on certain of their roosts, I estimate the population of the common crow of India (*Corvus splendens*) to be about 75 million. Coming to mammals, the populations of some species of bat are enormous. F. Ratcliffe states (*Flying Fox and Drifting Sands*) that some of the roosts of the large fruit-eating bats (*Pteropus*) in Australia hold hundreds of thousands of these animals, adding, " not so long ago a few must have exceeded the million mark." Here are the figures of the number of skins sold at the fur auctions in London during the year 1927 in thousands : beaver, 52 ; musquash, 491 ; fox, 640 ; skunk, 1,660 ; Australian opossum, 1,668 ; mole, 1,961 ; squirrel, 3,203 ; fur seal, 22 ; American opossum, 2,431 ; Persian lamb, 970 ; marmot, 558 ; nutria, 21 ; white hare, 1,085 ; mink, 121 ; Russian ermine, 214 ; stone marten, 39. In addition to the London auctions, there are other large ones at New York and Leipzig, and smaller ones at Montreal Winnipeg, Paris, Seattle and Edmonton.

The population of some species is far greater than that of others. The size of the population of a species depends upon its range and its density. Take, for example, the 15 species which constitute the teal genus (*Nettium*). The common teal (*N. crecca*) extends over the whole of Europe, Asia and North Africa, while at the other extreme is *N. albigulare*, which is confined to the Andaman Islands ; the population of the former is many millions (2,720 were shot on one lake in Kashmir in one season), while that of the Andaman teal is only a few thousands. Speaking generally, few species have a population of less than 500,000, and few genera one of less than three million. The populations of some species are renewed every year ; nearly all are renewed in less than every twenty years. If the average population of a given species is 500,000 and is renewed every 20 years, $2\frac{1}{2}$ million individuals live in 100 years, 25 million in 1,000 and 150 million in 6,000 years. On the time scale adopted by many zoologists, most species exist for fully one million years, and this would make the total population of this species 25 thousand million. If only one in a million of these is fossilised, in all 25,000 fossils of the species should be laid down in the course of its existence. Thus, *a priori*, every species having a shell, skeleton or hard parts should leave in the crust of the earth many fossils, and a genus which comprises a number

of species should leave very many. This conclusion is confirmed by the immense number of fossils known to exist, especially of smaller animals. Some rocks are composed almost entirely of the remains of marine animals ; thus, one cubic inch of limestone contains more than a million fossils.

We must, however, bear in mind that some of the fossils laid down eventually get destroyed. This happens when the sediment in which such fossils are buried suffers erosion by the action of wind and rain. In such case the eroded detritus is carried away, usually by water, and deposited elsewhere to contribute to the formation of a new rock in which fresh fossils are laid down. The fossils originally buried in the eroded part of a rock are either re-deposited elsewhere or destroyed as the result of exposure to wind and rain. But the number of fossils destroyed in this way, though great, represents only a fraction of the total number of fossils laid down. It may be that all the fossils laid down of some species (and even of some genera) of which the range never becomes extensive may be destroyed, but it is doubtful whether this has ever happened in the case of a family or larger group.

But we must distinguish between the completeness of the record of the fossils and that of our knowledge of it. Our knowledge of the record is at present far from complete. Apart from rocks at the bottom of the ocean and under ice in the Polar regions, many countries have been very little explored geologically. This being so, we have to ascertain, if we can, whether or not our knowledge is sufficient to render the non-discovery of the transitional fossils cited above a fatal objection to the evolution theory—in other words, sufficient to render it almost certain that the necessary transitional forms never existed. I think it is possible to do this by applying certain tests.

One test is to ascertain the percentage of existing species and genera of which fossils have been found. If fossils of all the species or genera of any class of animals have been found, obviously the fossil record and our knowledge of it is complete in the case of that class ; if, on the other hand, the percentage is very small, then either the record, or our knowledge of it is, or both are, very incomplete.

About twelve years ago the late G. A. Levett-Yeats and myself ascertained this in the case of living genera of mammals. In order to reduce our task to reasonable dimensions, we selected as our unit the genus as the term was understood thirty years

previously, before systematists developed the mania of species-splitting. Thus we had to deal with 664 genera, which have now been split up into several thousand. A short account of the results of our enquiry is to be found in Vol. LXIV of the *Journal of the Transactions of the Victoria Institute*. Since the publication of that paper fossils have been found for the first time of 16 living genera of mammals, showing how our knowledge of the fossil record is increasing, and rendering it necessary to alter the figures in it.‡

Here are the up-to-date totals :—

MAMMALS.

TABLE I.

Name of Order.	No. of genera now living.	Percentage of which fossils have been found.
Primates	40	42·50
Insectivora	36	50·00
Edentata	13	60·00
Rodentia	157	63·06
Carnivora (Fissipedia)	55	66·66
Do. (Pinnipedia)	9	77·78
Hyracoidea	1	100·00
Proboscidea	1	100·00
Perissodactyla ...	3	100·00
Artiodactyla	61	79·03
Cetacea...	29	73·17
Sirenia	3†	66·66
Chiroptera	215	19·07
Monotremata	3	100·00
Marsupialia	39	41·03

† Including Rhytina.

‡ In order to bring up to date the list of living genera of mammals of which fossils have been recorded, on page 143 of Vol. LXIV of the *Journal of Transactions of the Victoria Institute*, the following additions should be made :—

* Denotes not known earlier than the Pleistocene.

Primates—*Cercocebus.

Insectivora—*Notiosorex, Soriculus, Parascalops.

Rodentia—*Petromys, Phenacomys, *Heterocephalus (Cryptomys), *Mystromys, *Heteromys, *Microdipodops (also Apodemus, inadvertently omitted, should be added, and Dactylomys struck out, as this is a synonym for Cannabatomys).

Ungulata, Artiodactylla—*Hydropotes, *Budorcas.

Carnivora, Fissipedia—*Crossarchus (also Otocyon and *Thalarctos, inadvertently omitted).

Cetacea—*Rachianectes.

Chiroptera—Hipposiderus, Miniapteris and *Megaderma.

TABLE II.

Types of Mammal.	No. of genera now living.	Percentage of which fossils have been found.
Volant	215	19·07
Marine	41	75·61
Land	408	60·54
Total	664	48·06

TABLE III.

Continent.	No. of genera of land mammals now living.	Percentage of which fossils have been found.
Europe	48	100·00
Asia	134	72·06
Africa	145	53·79
North America ...	71	94·44
South America ...	86	72·09
Australia	48	45·83

Two features of the above figures are the low percentage of living genera of bats of which fossils have been found, and the considerable variation in the percentages of continents. The first shows that flying animals are less liable than other kinds to meet with accidents, such as being drowned in floods, which result in fossilisation, indicating that the fossil record may be incomplete in the case of such creatures. The second illustrates the different extent to which the various continents have been explored by fossil-hunters, showing that our knowledge of the record of mammals in Europe and North America is extensive, and rather poor in the case of Africa and Australia.

As more work is done outside Europe the percentages for the other continents are likely to grow until they reach 100.

One cause of the low bat percentage is: most bats are confined to tropical and sub-tropical areas, *i.e.*, those that have been least explored geologically. Only five genera occur in the British Isles, and fossils of all these have been found, as have those of all living European genera. It may well be that eventually fossils will be found of all the 215 living genera of bats. Probably the only animals of which the fossil record is incomplete are those that lack shells, teeth, skeletons, or other hard parts. This is indicated by the figures I have compiled, showing the extent to which fossils have been found of genera of molluscs now living in the United Kingdom and in its coastal seas :—

TABLE IV.

Class of Mollusc.	No. of genera now living.	Percentage of fossils recorded.
I. Lamellibranchiata (bivalves)	67	100·00
II. Gastropoda—		
Polyplacophora ...	1	100·00
Prosobranchiata ...	79	96·20
Opisthobranchiata ...	57	19·30
Pulmonata	25	76·00
Scaphopoda ...	2	100·000
III. Cephalopoda ...	11	27·30
Total	242	73·97

The low percentage in the case of the Cephalopoda is due to the fact that the only hard part of these is the readily-decomposable "cuttle bone." In the case of the Opisthobranchs. only 16 of the 57 genera possess shells. Of these, fossils of 11 have been found; in three of the remaining five the shell is minute.

As to the six genera of Pulmonata, of which I have no fossil record; two are about one-tenth of an inch long, one is about one-fourth of an inch, one has no shell, the minute shell of one is as thin as paper, while one seems to be confined to Co. Kerry, Ireland.

Consider the import of the evidence afforded by the statistics of the mammalian fossils. As fossils of 73·17 per cent. of living genera of Cetacea have been found, if whales be derived from land mammals, fossils ought to have been found of about 21 of the 30 genera of what we may style pro-Cetacea, *i.e.*, intermediaries between the first Cetacean and the last of its land ancestors, also some fossils of collaterals of these transitional forms. In addition, fossils should have come to light of some six genera of Cetacea interlinking the three sub-orders of this group.

Moreover, fossils ought to have been found of over a score of genera linking the Sirenia with a land ancestor, five or six genera linking seals with their land ancestors, and at least 20 connecting the bats and three connecting the kangaroos with ancestors that walked on all-fours.

As fossils of turtles are abundant in the rocks from the time of their first appearance in the Triassic period, a large number of fossils ought to have been found of genera transitional between them and their supposed shieldless ancestors; and this is true to a rather less extent of the Pterodactyls, the Ichthyosaurs and the other peculiar types cited above. The fact that not a single fossil has been found of any of these hypothetical intermediaries renders it almost certain that such intermediaries have never existed.

Another method of testing the degree of completeness of the fossil record and of our knowledge of it is to take a continent, and compare the number of genera of any class of animal now living on it with the number shown by the known fossils to have existed on it at various points of time in the past. Some years ago I made such an enquiry in respect of the genera of mammals now living, and those known to have lived, in Europe and North America. The results of this enquiry were published on page 131 of Vol. LXIV of the *Transactions of the Victoria Institute*. Owing to discoveries since made, these figures need to be brought up to date. I have not been able to do this completely, owing to war conditions; but, thanks largely to recent papers by Dr. G. C. Simpson and Mr. G. L. Jepsen, I have been able to augment the numbers of the early Tertiary mammalian fossils of North

America, also to add to those of the latest periods of both continents. Here are the figures thus amended :—

TABLE V.

Number of genera of non-volant land mammals known to have lived at various stages of the Tertiary and in the Quaternary of Europe and North America.

Stage.	Europe.	North America.
Lower Palæocene ...	14	32
Middle Palæocene ...		68
Upper Palæocene ...		58
Lower Eocene ...	24	73
Middle Eocene ...	38	69
Upper Eocene ...	68	37
Lower Oligocene ...	80	58
Middle Oligocene ...	41	44
Upper Oligocene ...	43	57
Lower Miocene ...	52	51
Middle Miocene ...	59	35
Upper Miocene ...	82	52
Lower Pliocene ...	88	42
Middle Pliocene ...	48	18
Upper Pliocene ...	47	30
Pleistocene	68	108
Now Living	48	72

Thus, the known fossils tell us that at most stages the number of genera of mammals was larger in Europe than it is to-day, and in most periods not much smaller in North America. That the genera now living are fewer than in the Pleistocene seems to indicate that the recent Ice Age caused the extinction of many mammals. The low figures for some stages may mean that in these comparatively few deposits holding mammal fossils were laid down, or that some deposits have not yet been examined, or that something led to the extinction of numbers of genera of mammals. It has been objected that, since many zoologists estimate the duration of the Tertiary period at from 50 to 60 million years, each of the stages in the above list represents three or four million years, and it is ridiculous to compare such a space of time with a single instant. Even if this estimate be accepted, the objection has little substance, because more than

80 per cent. of the genera listed are shown by their fossils to have lived in more than one of the stages of the table; so that if each of these stages were sub-divided into a million, every sub-division would contain more than four-fifths of the number given in the table. The above figures demonstrate that in the case of the mammals of Europe and North America, the fossil record of the Tertiary cannot be described as "exceedingly fragmentary." In some epochs it seems to be nearly complete as regards genera and higher categories. Thus G. C. Simpson, who is a transformist, writes (*The Fort Union of the Crazy Mountain Field and its Mammalian Faunas* (1937), p. 69): "Knowledge of the general composition of the Middle and Upper Palæocene mammalian faunas of North America as a whole may now be considered very good. It is probable that we have representatives of almost all the orders and families and a large majority of the genera that occurred on this continent during that time. The combined area representated by collections is now very considerable, of the order of 1,000 square miles of actual collecting territory, representing many times that in the ranges of sampled faunas. The environmental variety represented is apparently great, for the sediments yielding mammals of these ages are of very different sorts, many genera are represented by several well-defined species in each, and inferred habits of the various known mammals include almost every possible terrestrial habitus. The collecting areas certainly were part of a unified North American land mass in the Palæocene, extending more than 1,200 miles north and south, and were probably central in that land mass, ideally situated for a representative sample of the whole North American fauna."

The testimony of the fossils of the Middle and Upper Palæocene periods is of vital importance in connection with the theory of evolution, because in the period that followed immediately—the Eocene—several orders of mammals make their first appearance in the rocks—the carnivora, odd-toed ungulates, even-toed ungulates, bats, proboscidians, and eight other orders now extinct; also the rodents, of which the earliest known fossils occur quite at the close of the Palæocene. If these orders evolved from other orders, fossils of these latter or their immediate descendants ought to be abundant in Palæocene rocks; but no such fossils have been found. Evolutionists have to admit that the Eocene orders of mammals did not evolve in North America or in Europe. It is, or used to be, thought that the evolution

took place in Asia, and the new orders spread from that continent to Europe and North America. Recent discoveries in Mongolia, however, are unfavourable to this theory, because, to quote G. L. Jepsen (*Proceedings of the American Philosophical Society*, (1940), p. 293), "as an evolutionary incubator, however, Asia has been disappointing, because few, if any, of its known fossils clearly represent forms ancestral to those of other regions."

In order that Table V may furnish all the information available as to the number of genera existing in each of the stages into which the Tertiary Epoch has been divided, I have arrived at the total in each stage by including (1) all genera of which fossils have been found in rocks laid down in the stage, and (2) genera of which fossils have not been recorded from those rocks, but which have been recorded both from the stage that immediately preceded and that which immediately followed this stage; for example, if fossils of a particular genus have been recorded from rocks of the Upper and Lower Miocene periods, but not from those of the Middle period, I have included the genus in the Middle Miocene list. On this account I have been charged by evolutionists with wrongly including in my list for various periods fossils which have not been found in them. This is on a par with rebuking me because I assert that Jones was alive in 1939, although I did not actually see him in that year, and base my assertion on the fact that I saw him in 1938 and 1940!

The reason why transformists have attacked Table V is that it demonstrates that the fossil record is not very fragmentary in the case of the mammals that existed in the Tertiary and Quaternary periods. For example, we know that to-day 48 genera of mammals are living in Europe, and the fossils show that 59 genera were living on this continent in the Middle Miocene. If the latter figure represents only a small fraction of the number that actually existed, say 10 per cent., that would mean that in the Middle Miocene 590 genera lived, as opposed to the 48 of to-day. I doubt if anyone believes this to be the case. Do evolutionists realise that if the fossil record be very fragmentary, then some facts revealed by the known fossils are fatal to the theory of organic evolution? These facts are first that, instead of making their first appearance in the rocks in the form of a single species or genus, as the theory requires, large animal groups usually appear in the rocks unheralded, and in the form of several genera. Thus the earliest-known fossils of the Cetacea and the Sirenia date from the Middle Eocene; but instead of

only one genus, or at the most two genera of each, as the evolution theory requires, having been found in the Eocene, fossils of six genera of Cetacea and five of Sirenia have been found. This is bad for the evolution theory; how much worse if these be only a small percentage of the genera then existing!

For my part, I am satisfied that in the case of animals having hard parts, the fossil record is not very fragmentary, and that transitional forms from generalised to highly specialised types never existed, and that is why fossils of such have not come to light.

The question has been put to me: If no fossils have been found transitional between such peculiar types as the Cetacea and their supposed generalised land ancestors, how is it that zoological text-books cite instances of fossils intermediate between the various classes of vertebrates, such as the Ictidosauria linking reptiles and mammals, *Archæopteryx* linking reptiles and birds, *Sauripterus* and *Ichthyostegis* linking fishes with amphibia? The answer is: these alleged intermediaries are nothing of the kind; so far as our knowledge of it goes, every fossil cited as intermediate between two classes belongs indubitably to one or other of the two classes it is said to link. The most that can be said of each is that it is the member of its class most like members of another class. To prove this in the case of all the alleged intermediaries would involve writing a small book. All I can do here (and that by exceeding the approved length of papers for this Institute) is to deal with one alleged intermediate briefly, and in as simple language as possible. It must be a case of *ex uno disce omnes*.

Let us consider the Ictidosauria which are said to be intermediate between the class Reptilia and the class Mammalia. In fact, they are true reptiles.

Mammals are sharply marked off from reptiles by a number of characters. Most of these are (1) physiological, *e.g.*, the main product of excretion is urea in mammals, uric acid in reptiles; the blood of mammals is maintained at a constant temperature, that of reptiles is not; or (2) appertain to the soft parts of the body, *e.g.*, mammals have a single aorta, reptiles have two aortæ; mammals have mammary glands, reptiles have not.

As characters of these kinds are not fossilised, in determining whether a fossil is that of a mammal or a reptile we have to rely on the skeleton or hard parts.

The most important skeletal differences between mammals and reptiles are :—

(1) In reptiles the drum of the ear is connected with the tympanum by a single rod-like bone, known as the columella ; in mammals the connection is by a series of three bones, called the stapes, malleus and incus, because in shape they resemble respectively a stirrup, a hammer and an anvil.

(2) In every reptile the articulation of the lower jaw with the skull is not direct, but through the intervention of a bone called the quadrate ; in every mammal the articulation is direct—there is no quadrate bone.

(3) In every reptile each half of the lower jaw is composed of six bones ; of these the largest is called the dentary, because it bears the teeth ; the others are the splenial, coronoid, angular, supra-angular and articular ; the last is so called because it is the bone that articulates with the quadrate. In every mammal each half of the lower jaw is composed of only one bone.

(4) In all reptiles the ankle joint is between the two rows of ankle bones ; in all mammals it is at the root of the toes.

(5) and (6) There are differences between the breast- and hip-girdles of reptiles and those of mammals.

When, then, we find a fossil of which we are in doubt as to whether it is that of a reptile or a mammal, we have to observe all the above characters in it ; if these are all reptilian, it is clearly a reptile, and clearly a mammal if these are all mammalian. Should, however, the fossil have some characters intermediate between those of a mammal and a reptile, such as two bones in the middle ear, or two, three, four or five bones in the ramus of the lower jaw, then we must regard it as intermediate, and may fairly put it in a class of vertebrates intermediate between the reptilia and the mammalia.

Let us apply these tests to the known fossils of the Ictidosauria. Unfortunately, we know nothing of the legs of these animals, and very little of the pectoral and hip girdles ; but we do know the skull and lower jaw, and, fortunately for diagnosis, half the main skeletal differences between the reptiles and mammals are exhibited in these. In the Ictidosauria all these three features are entirely reptilian. Why, then, do Dr. R. Broom and his followers deem the Ictidosauria to be intermediate between the reptiles and mammals ? Because, although admitted by all to be reptiles, they exhibit in the skeleton some mammal-like characters. In this connection we must remember that the

reptiles now living are but a small remnant of a great class of animals which were far more diversified than mammals are; some attained a length of 100 feet; some were taller than a giraffe. Mammals seem to have been absent in most localities in which fossils of these reptiles have been found; they took the place of mammals, and had many of their habits. To facilitate the seizing and devouring of large quarry, the teeth of some, like those of most mammals, were differentiated into incisors, canines and molars, and, to give them the necessary agility, the legs, instead of being asplay in the standing posture as in most reptiles, were vertical, as in mammals, so that the body of the animal when standing was raised well above the ground. These mammal-like reptiles exhibit so much diversity that they are divided up into several orders and sub-orders. It is among these that evolutionists seek for ancestors of mammals. They are collectively known as the Theromorpha or Anomodontia, or Therapsida. Dr. Broom writes of them (*The Mammal-like Reptiles of South Africa and the Origin of Mammals* (1932), p. 330): "In considering the various orders and sub-orders of the mammal-like reptiles it will be observed that we have a most varied assemblage of animals, from little forms as small as a mouse to others larger than a rhinoceros. The differences in structure are greater than those found among mammals, and if we only knew mammals by their bones we might readily have classified them as forming two orders and a number of sub-orders of the Therapsida."

This passage shows, first, how little information the fossils give about the soft parts of animals, and, secondly, that there is plenty of fossil material from which to select the reptile from which mammals are supposed to be derived. Despite this, no one dares to name any of these mammal-like fossils as the ancestor of the mammals.

The best the transformist can do is to name the group from which he thinks the mammals are derived. The order most in favour is that having the teeth most like those of mammals—the Theriodontia. Of the families that compose this order, Dr. Broom and his followers consider the Ictidosauria the most mammal-like, and they assert that one of these must have given rise to the mammals. Broom's reasons for this belief are briefly: the quadrate bone is small, and in the lower jaw the dentary is very large and occupies three-quarters of the jaw, the other bones of the jaw being small and lying in a groove of

the dentary. This is what he has to say about the supposed conversion of an Ictidosaurian into a mammal (*Op. cit.*, p. 315): "The changes that converted them or one of them into a mammal may have been a change of diet. The snapping jaw had to be converted into a masticatory jaw, and as the quadrate became more or less fixed to the squamosal (*i.e.*, the bone in the skull on which the quadrate articulates), it kept with it the articular and other little bones of the jaw, and the dentary became comparatively free and formed a new hinge with the squamosal. The small bones, no longer moving with the jaw, became modified as parts of the auditory apparatus. . . . The changes by which the articular became the malleus, and the angular became the tympanic (the bone encircling the ear to which the ear drum is attached in mammals), in my opinion originated after the small bones had left the jaw, and can be fairly easily imagined."

In less technical language, some reptile is supposed to have scrapped the original hinge of its lower jaw and replaced it by a new one attached to another bone. Then five of the bones of the lower jaw are supposed to have broken away from the biggest bone. The jaw bone to which the hinge was originally attached is supposed, after being set free, to have forced its way into the middle part of the ear, dragging with it three of the lower jaw bones, which, with the quadrate and the reptilian middle-ear bone, formed themselves into a completely new outfit. The rest of the lower jaw bones, having no work to do, vanished! While all this was in progress a complicated structure—the Organ of Corti, peculiar to mammals and their essential organ of hearing—developed in the inner ear. This organ comprises, *inter alia*, some 3,000 arches placed side by side so as to form a tunnel. Dr. Broom does not suggest how this organ arose, nor does he say how the incipient mammals contrived to eat while the jaw was being re-hinged, or to hear while the middle and inner ears were being reconstructed.

The above changes appertain only to the skeleton of the head, and are insignificant in comparison with those that must take place in blood system, digestive tube, breathing apparatus and body covering before the reptile can become a mammal.

Verily, as Mr. Field remarks, "the evidential standards of modern evolutionist science represent probably the lowest point in intellectual degeneration reached by civilised man in the past two thousand years."

Written Communication.

Dr. Arthur P. Kelley, M.A., Ph.D. wrote: I think Mr. Dewar's contention is justified that there can be no scarcity of fossilised animals which existed in great numbers, such as the skunk, but it could be argued that the critical species proving evolution, the missing links, might have existed in such few numbers that none chanced to be fossilised. Then, how can we be sure that a given species, even though represented by a great many individuals, is sure to be preserved in the rocks in numbers?

Author's Reply.

Some zoologists take the line suggested by Dr. Kelley. Thus Cuénot contends (*L'Adaptation*, p. 371) that the lack of fossils linking the various groups of animals leads us to conclude that the forms connecting the great groups have all been *very localised, composed of very few individuals* having unspecialised organs; since these had not an extensive range they found it difficult to exist, and when they had given birth to the ancestors of the great groups these ancestral forms were rapidly eliminated.

The following considerations expose the weakness of this argument:

1. We are confronted by not a score or so of "missing links" but of thousands—whole chains of links. We know of more than 3,000 familes of animals, living and extinct, having shells or skeletons, each of which the transformists believe to be derived from a different family; all the members of each of these families are thus supposed to be descended from a single ancestor, from a genus that gave birth to a family.

2. We know thousands of genera which have persisted through several geological periods—many existing genera lived in the Palæozoic period, and none of these have thrown off varieties which gave rise to new families.

3. The geological record shows that many short-lived genera have left abundant fossil remains. Consider the Equidæ, the horse family. This appears suddenly in the Eocene period in the form of four genera and about a score of species. Since then 20 new genera and about 250 new species have appeared, all of which, except the genus Equus, are extinct. These short-lived genera have yielded a

vast number of fossils, tens of thousands of which are exhibited in our museums. Although the fossils known to us of the genus Eohippus are confined to North America and the early part of the Eocene period, this genus has left in the rocks fossils of 13 species. We have found fossils of 45 species of the living genus Equus, the earliest of which occurs in the Pliocene period. It is true that horses are more readily fossilised than are most mammals, but we have found fossils of 30 species of Elephas (elephant) which does not appear until the end of the Pliocene period, while the monkey genus Macacus, although arboreal, has yielded fossils of more than a dozen species.

Thus, these supposed ancestors of familes of which no fossils have been found must, one and all, have been endowed with two peculiarities : that of producing ancestors of new familes, and that of possessing shells or skeletons composed of materials so transient as to have become decomposed very shortly after burial !

As I have taken the horse family as an example, let me say that the various pedigrees set forth in text-books purporting to derive Equus from Eohippus are examples of wishful thinking. None of the known thousands of fossils of three-toed horses seems to be ancestral to the one-toed Equus. Transformists have to try to find an ancestor for this animal. Mivart, Nicholson, Lydekker, Schmidt and Cuénot cite Hipparion as the ancestor : T. H. Huxley, Wallace, Marsh and Arambourg favour Pliohippus : H. G. Wells, J. Huxley and W. D. Matthew plump for Plesihippus, while the more cautious J. A. S. Watson is of opinion that the one-toed horse of to-day is derived from some ancestor of which a fossil has yet to be discovered !

Dr. Kelley asks : How can we be sure that a given species, even though represented by a great many individuals, is sure to be found in the rocks in numbers The answer is : the evidence is that the majority of animals having hard parts leave fossil remains ; nevertheless we cannot be sure that any given species will leave such remains, but we are sure that of a hundred species, taken at random, a considerable proportion will do so. The absence of fossils of all these supposed ancestors makes it certain that such ancestors never existed.

War conditions having rendered it impracticable to hold an Ordinary Meeting on January 26th, 1942, the Paper for that date was circulated to subscribers and is here published, together with the written discussion elicited.

LET THERE BE LIGHT: A COMPARISON OF GENESIS i, 3–5, *AND JOHN* i, *WITH ROOT-MEANINGS OF CERTAIN VERY ANCIENT WORDS.*

By A. Cowper Field, Esq.

IN the account of the Creation with which the Old Testament opens, we read (Gen. i, 3–5): "God said, Let there be Light: and there was Light. And God saw the Light, that it was good: and God divided the Light from the darkness. And God called the light day, and the darkness He called night. And there was evening and there was morning, one day" (thus our 1611 version, as revised 1885).

And St. John's Gospel commences, "In the beginning was the Word, and the Word was with God, and the Word was God. The same was in the beginning with God. All things were made by Him, and without Him was not anything made that hath been made. In Him was life, and the life was the Light of men. And the Light shineth in the darkness; and the darkness apprehended it not" (the 1611 version, as revised 1881).

Clearly, these two passages are complementary to each other; in some way mutually explanatory. The purpose of this Paper is an attempt in some degree to elucidate the underlying connection between them, and for this purpose first making use of other references to "light" and "the Light" in Holy Scripture, and then adducing certain facts, ideas and implications gathered from the study of archæology, and from much delving into the scanty remains (all too scanty, one must regretfully admit) of the oldest records of human speech now available.

And we are further handicapped in our comparative study of these passages by the difficulties inherent in any attempt to translate words so pregnant with *underlying* conceptions and