Palæontological Evidence of Australian Tertiary Formations.

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[*Read before the Royal Society of N.S.W.*, 5 *September*, 1877.]

At a recent meeting of this Society I read a paper on "Australian Tertiary Geology," on which I proposed to prepare at some future time a complete list of our described Australian Tertiary fossils. This task has occupied a good portion of my leisure since, but it will be yet some time before it is completed, as I have been induced by Prof. Tate to delay the publication until some work he has in hand on some of our Tertiary Gasteropoda is published. In the course of its preparation the question of the age or position of our Tertiary formations has come very prominently before me. I do not mean to say that I have been able to arrive at any very definite conclusion on the subject, for a comparatively certain or permanent conclusion may be very distant from us; but I think the Palæontological evidence has never fairly been collected together—the data are scattered in various publications, and I think I can hardly do better than group them, so that the facts may be seen and their weight better appreciated. My knowledge of some of the beds and most of the fossils, and of the existing fauna, extends over many years, and it may be as well for me to try to arrange them, as a help to others who may come after me.

I said in my former paper that it was not easy to judge by the percentage system, as our knowledge of the existing fauna is so imperfect, yet I think, upon consideration, that the imperfection of this knowledge has been exaggerated. We do know a great deal of the Mollusca, the Echinodermata, the Polyzoa, and the Brachiopoda; for the Echini alone we may say our knowledge cannot be much extended; the Corals, too, have been tolerably well worked out. So that after all there is quite material enough to form an opinion. Well, then, my object is to show in this paper what that material is, and what its affinities are. With this view, I shall examine what fossils we have in our Tertiary rocks which are still existing, and what differences there are (if any) between their present habitats and their former ones. I shall next inquire what are the extinct fossils, which are found elsewhere as fossils, and where they are found. I shall then inquire into the relations of those fossils which have no living or

fossil representatives elsewhere. This inquiry means, Where do we find anything *like* our fossils? The solution of these questions, as far as our knowledge goes, will materially help to clear the ground of at least some of the obscurity which at present rests upon it.

But, before I do this, I must define what I mean by our Tertiary formations. I do not mean the raised beaches, or the more recent Pliocene formations. The evidence of all these is clear and unquestionable. I mean only the great Tertiary formation which extends, with the interruptions I have already described, from the river Murray to Gipps Land, and from Tasmania some distance inland in South Australia. In this formation there are many subdivisions, as I have already indicated, and some no doubt are much older than others. They are spoken of as one formation by European geologists; but the Pliocene of Italy, the Miocene of Vienna, Touraine, and Malta, and the Eocene of Paris and London, are not more widely separated than the Murray and Tasmanian beds, the Muddy Creek, Western Port, Onkaparinga, and Australian Bight. I shall deal principally with the Tertiary rocks which are represented in Victoria, in the south-eastern district of South Australia, and North Tasmania. There are various subdivisions in these rocks. They have been generally classed as Cainozoic by Professor Duncan, the learned President of the Geological Society. They are variously regarded as Lower Miocene and Pliocene by geologists in Australia. A succession is established by the Victorian Geological Survey, and to this I may say that I adhere: regarding the Tasmanian beds as the equivalents of the Muddy Creek and Geelong formations, and regarding the Mount Gambier limestones and the Polyzoan beds at Cape Otway as the uppermost of the series.* As I am not in a position to say anything of the fossils of the Aldinga beds and those of the Australian Bight, I must not be understood to include them in this examination; but I may state that it is probable that the Bight strata are the equivalents of the Murray cliffs, and I regard the Aldinga formation as lower than anything we have in Victoria or South Australia.

I now proceed to examine the recent species found as fossils in our Cainozoic rocks. I may include generally the far greater portion of the *Foraminifera*. I am not aware that many purely extinct forms have been discovered. They are tertiary in character. Knowing the wide vertical and horizontal range which these species have, we must not expect any conclusive evidence from them; and even if we would, they have never been carefully examined. *Amphistegina vulgaris* is very abundant in the Muddy Creek beds, and of large size. The following were determined

* Prof. Tate thinks he has reasons for believing that the Mount Gambier limestones are older than the Muddy Creek and Geelong beds.

for me by Professor Rupert Jones, many years ago:—*Polymorphina lactea, Textularia pygmea, T. agglutinans, Globigerina bulloides, Cassidulina oblonga, Rosalina Bertholetiana, Rotalia ungeriana, R. Haidingeri, R. reticulata, R. rotula.* There are no *Nummulites* or any of the characteristic forms of our Eocene beds.

Turning now to the Polyzoa, we must say in this case also that a careful examination is wanting. A *Retepora*, very nearly allied to *R. monilifera*—if not identical with it—is common at Mount Gambier, so is the existing *Salicornaria sinuosa* (Hassal), and *Cellepora pumicosa* (Busk). Some of the *Escharidæ* have been doubtfully referred to existing species; but it must be remembered that by far the larger portion of our living Australian Polyzoa are of families which would inevitably be destroyed ere they could be entombed in our rocks. They are jointed with horny joints in a single or multiple series of cells, and these horny joints would rapidly perish, and thus cause the destruction of the whole. It is among the *Lepralia* that I should look for the most important results, for these are well preserved, and are abundant in the living and fossil states, yet neither have received much attention. I am somewhat familiar with the various forms of *Membraniporæ* living on our southern coasts, and I have carefully searched for fossils like them at Mount Gambier, but without success. If ever there were a field where a careful observer might make most useful researches and extend our knowledge, this is one. It is, I may say, quite untrodden, and the facility with which the study could be approached, and the beauty of the forms to be dealt with, ought to make it equally attractive. As far as my own observations extend, I should say that we have but a small portion still existing of those which were likely to become fossils.

Referring to the corals, because that is the order which is most convenient, for I need hardly state that in point of organization they rank below the Polyzoa, it is singular that, while the Mount Gambier formation abounds in Polyzoa, Corals are almost entirely absent. In fact, I can remember none except a rare cast of *Placotrochus* occasionally. But at Muddy Creek, Geelong, and Table Cape, Tasmania, they are numerous. Now the existing forms among all these localities are only four in number, namely, *Flabellum candeanum, F. distinctum, Deltocyathus italicus*, all Edw. and Haime, and a new species of the genus *Sphenotrochus*, which I have named *Sphenotrochus variolaris*. The first is a well known form in the Red Sea and off the coast of Japan; the second occurs at Japan and in the Miocene fauna of Touraine. Both these localities are tropical, and very different from the condition under which the same corals would have to exist were they flourishing in Australia in the localities where they are found as fossils. *Deltocyathus italicus*, Edw. and Haime, is another species

which still exists, that is to say a variety of it, but in the Carribean Sea, and it is also found in the Miocene formation of Europe. *Sphenotrochus variolaris* is only known hitherto on the east coast, and is rare. Now, out of about forty described fossil forms, and probably as many more undescribed, four existing is a very small proportion, and this let it be remembered only in very remote and tropical countries, and under totally different conditions, that is to say, surrounded by a totally different fauna from that which surrounds them now. We have in Australian seas at present about thirty forms of coral known as living, but hardly more than three of them are included in our Tertiary formations.

I will now deal with the Echini of the same beds. We have twenty-four well characterized species described from our Australian fossils. This probably includes two described by me in 1865, and described again by European palæontologists who had not seen my work, namely, *Echinolampas Gambierensis*, subsequently named *E. ovulum* by Laube, and *Brissiopsis Archeri*.* See *Proceedings Philosophical Society, Adelaide*, 1865. Out of this number we have only three living species—*Echinanthus testudinarius* (Gray), *Echinarachnius parma* (Gray), *Schizaster ventricosus* (Gray). The first is a species with rather a wide range, being generally an Indian Ocean (Red Sea inclusive) and Pacific species, being found also at California. It is commonly tropical, but not at all uncommon at Port Jackson. In all my examinations of collections and specimens, extending over many years, I have never seen it from the south-west of Australia, or near where it is found as a fossil now. *Echinarachnius parma* is found, we may say, all over the world. I have seen specimens from almost every part of the coast, though it is more common within the tropics. *Schizaster ventricosus* is said to be Australian, but I have never seen a well authenticated specimen from Australia. It is not common in New Caledonia and some of the tropical islands of the Pacific. Thus we see, of our three living species, one is not now Australian; and, of the other two, one is not found in the same localities; and all are more properly tropical species, though they are sometimes found outside it.

Referring now to the Mollusca, we find the same paucity of living forms, and nearly all with a different habitat. As far as we know, the fossils still living are *Limopsis Belcheri*, *Pectunculus laticostatus* (Lamck.), *Corbula sulcata* (Linn.), *Cylichna arachis* (Quoy and Gaim), *Fissurella concatenata*, Crosse, *Ancillaria mucronata* Sby, *Liotia lamellosa*, mihi, *Dentalium lacteum*, *Limopsis aurita*, Sassi, *Trivia europea*, *Liotia discoidea*, Reeve, *Eulima subulata*, Donovan, *Syrnola bifasciata*, *Natica polita*,

* It appears that there is a peripetalous fasciole on this fossil, which removes it to the genus above named. I had described it as *Hemiaster*.

mihi. Of these, *Fissurella concatenata*, *Natica polita*, *Cylichna arachis*, *Liotia discoidea*, *L. lamellosa*, and *Syrnola bifasciata*, still are found living on the east coast of Australia, and near the beds where they are, found fossil; but they are not common, with the exception of *Cylichna*, which has a wide range. The European shells are perhaps more open to question. I would not like to give their identification as more than probable. The other shells are found now in very different places. *Corbula sulcata* occurs on the coast of Africa within the tropics, *Limopsis Belcheri* at immense depths off the Cape of Good Hope, *Pectunculus laticostatus* in New Zealand, but both the latter are found in St. Vincent's Gulf and N. Tasmania. We see thus that the proportion of living species is very small, not eight per cent., and that of these so few are found in the same localities and the rest so variously scattered that we can conclude nothing as to the habitat except that some of them are found in warmer seas, and only one in colder, that is *Pectunculus laticostatus*. *Dentalium lacteum* is an Indian shell. It is doubtful if *Ancillaria mucronata* was not described from a fossil. I have never seen a living specimen.

On the whole then, the living species are not eight per cent. of the actual number described. We have about 120 described mollusca (including Brachipoda), nearly thirty Echinoderms, about forty Corals, and say twenty Polyzoa. But of the sethere are not twelve in existence. This according to European standards would place our Tasmanian and Muddy Creek beds on a level with or even below the Upper Eocene; and if from this estimate of living species we reject the three recent Echini which are found in the Murray beds, but not in the beds mentioned above, we shall bring our percentage still lower.

I now address myself to the question of those fossils which are found in Australia in other Tertiary formations elsewhere. In the Polyzoa we have only one, which is the living species *Saliconaria sinuata* referred to above. Our Corals are represented sparsely in other strata. *Deltocyathus italicus*, Edw. and Haime, occurs in the Miocene of Europe, *Conotrochus M'Coyi* in the older Pliocene of Sicily, and *Balanophyllia cylindracea*, Mickelotte, in the Miocene of Tortonia. Few of our urchins are found among the fossils of other formations besides those which still exist, as I shall show further on. *Echinarachnius parma* was found by Mr. Darwin in a Tertiary deposit at Patagonia, whose age has not been determined. Among the mollusca there is scarcely any identity or at least no very satisfactory identity with extinct species in other deposits.* At first sight many of our fossils have been referred to forms found in Tertiary deposits of Europe and America, but

* *Limopsis aurita*, Sassi, is not uncommon in our lowest beds. *L. insolita*, Sby and Hutton, is, according to Prof. Tate, a synonym.

in the end sufficient differences have been perceived to cause them to be regarded as distinct. In nearly every case these identifications have been with well known Miocene or Eocene forms. We may however take what Professor M'Coy has called the "mimetism" of our Volutes in the oldest of our Tertiary rocks as instances of at least quasi-identity with well-known Eocene forms of Europe. Some of our fossil Brachiopoda are extremely like described species from the Malta Miocene, but we have the very best authority, that of Mr. Davidson, for regarding them as distinct. Prof. Tate thinks that the Brachiopoda have no affinity with the Italian forms, though there is a similitude in some species. He looks upon them as unique in facies.

I shall now proceed to examine the question of the relations of our Tertiary fossils, that is to say, failing complete resemblance or identity, what fossils do they resemble the most, and what is the geological horizon to which those fossils belong? In dealing with this question, I must say a few words on what is generally recognized as the Mesozoic facies which the Australian fauna possesses. Unless we estimate this beforehand, we might be led astray as to the character of our extinct Tertiary fauna. And it is also necessary to refer to it to pursue another inquiry of considerable interest, which is—Do we find in our Tertiary rocks stronger and stronger Mesozoic resemblances as we go down, so that our present fauna may be said to be what is left of a very slow extinction of the Mesozoic fauna?

I need not dwell upon the evidence of our existing fauna, which is familiar to every naturalist; still I may say that it has been somewhat overstated. In the marine fauna it is slight; in the mollusca I know of nothing except our possessing some species of *Trigonia*. These are, however, very distinct from the Secondary forms. In the Tertiary beds we have three species. Two are like our existing species in trifling particulars (*T. acuticostata*, and *T. Howittii*—M'Coy), and one is very much like the middle Secondary forms (*T. semiundulata*—M'Coy). A very remarkable instance of a surviving ancient form, which is even palæozoic in character, is found in a large *Pleurotomaria* (*P. tertiaria*, M'Coy). *In the Aldinga beds of South Australia, which I think will be found older than any Tertiary beds of Victoria or Tasmania, and perhaps even passage beds between our Tertiary and Secondary rocks, we have learned through the careful researches of Professor Tate, that *Salenia* and *Belemnites* still exist. Now *Salenia* is a cretaceous form, and I need hardly dwell on the significance of such fossils as *Belemnites*; yet they were associated with truly characteristic fossils belonging to our Australian Tertiary deposits.

But, while so much has been said about the Mesozoic aspect of our Australian fauna, very little has been made of the Miocene

* There are two species of *Pleurotomaria* still living in the West Indies.

aspect of our natural history—yet it is very marked. Attention has been already called by European botanists to the similarity between the plant remains of Miocene age in Europe and the present flora of Australia. The common corals now living in Australia are Miocene fossils of Touraine, Mayence, &c. Our *Conocyathus sulcatus*, E. and H., is very common at Port Jackson. For my own part, I am not very certain about the identity; but the corals are extremely close in any case, and of such marked and peculiar characters, that their occurrence in remote places, and separated by so great an interval of time, is very singular. *Conocyathus sulcatus* is very Turbinolian in its aspect, with four cycles of costæ and only three of septa; the second and third of the latter uniting like many Eocene Turbinoliæ, but with pali and no columella. If we bear in mind the survival of European Miocene forms amongst us, of course it very much weakens the inference that might be drawn from any identity of species between our Tertiaries and beds in Europe whose horizon is well known.

Speaking of the corals generally, we have more affinities with Miocene forms than any other formation; but a few genera are common to both Eocene and Miocene formations. We have no truly Eocene forms such as *Turbinolia*, which are found in the Eocene beds both of Europe and America; neither have we among the many Foraminifera such characteristic fossils as Nummulites; but we have certain American genera which have seldom been found, as far as I am aware, above the Eocene. I shall shortly describe in the Transactions of this Society some few very characteristic Eocene genera of America, and one *Ceratotrochus* (*C. fenestrata*), which is both Miocene and Eocene, as it is both American and European. The commonest of our corals in the Muddy Creek is undoubtedly *Deltocyathus viola*, Woods and Duncan; and of this Professor Duncan says it has a greater resemblance, as far as shape is concerned, to the *Pleurocyathi* of the German Oligocene; but it is a true *Caryophyllia*,* and therefore not in the same sub-division of the Caryophyllian sub-family. Hitherto only one member of the genus has been found in either the Indian, Southern, or Pacific Oceans; there is a new species, *C. Australis*, whose diagnosis will shortly appear in a monograph of our living Australian corals which I am preparing for the Linnean Society of New South Wales. No other species has been found in our fossil deposits, though the individuals are very abundant, which is an anomalous fact, and one not in keeping with the evolution theory. The genus best represented in the number of species, and probably in individuals as well, is *Balanophyllia*. "These," says Professor Duncan, "give a very Falun-

* I have placed this in another genus (*Deltocyathus*) as it departs in many important details from *Caryophyllia*.

nian and Crag facies to the Australian corals as a whole, especially as there are no recent species in the seas around." But I don't think that we are quite without the recent species, as far as I can judge from an examination of many undescribed forms in the Australian museums. I believe there are undescribed species in the Sydney Museum from Port Jackson, and another, if I am not mistaken, in the Macleayan museum, from the East coast further north. Dr. Duncan adds—" Forming a large proportion of the fossil fauna, the *Balanophylliæ* stamps the deposits with a definite character as regards the depth at which they occurred, and this is rendered almost certain by the bathymetrical disposition of the genera *Caryophyllia*, *Flabellum*, *Placotrochus*, *Sphenotrochus*, and *Amphihelia*. The northernmost Faluns (Miocene) contain vast quantities of *Balanophylliæ* (not of species) a *Flabellum*, a *Sphenotrochus*, and there, as in the Australian Tertiaries, every gradation of sea depth, from the abyss to low spring tide mark, is represented by species." (*Quart. Jour. Geol. Soc.*, 1870, *p.* 310.)

With reference to this I must remark that our corals have been collected from beds widely apart, and evidently deposited under different conditions. That where *Caryophylliæ*, *Sphenotrochi*, and *Flabellum* occur we have few or no *Balanophylliæ*. There are few at Muddy Creek, and none at Table Cape in Tasmania. But we have in place of them in the latter place, remarkable species of branching or reef-forming corals; all the others enumerated being solitary, turbinate, and for the most of the genera free. Such forms as *Dendrophyllia*, *Heliastræa*, and *Thamnastræa*, make their appearance in Tasmania, all indicative, in the manner in which they are found, of a deep warmer sea than in Tasmania. Professor Duncan has called in question my opinion that the sea was also a deep one, but I think he misunderstood my meaning. These fossils, no doubt, *grow* in a sea of a few fathoms, but they did not grow where they are found, but are evidently brought from a distance. They are associated with organisms generally found at least in a moderately deep sea, and this is the origin of my opinion. The *Thamnastræa* (*T. sera*, Dunc.) is a very peculiar form of early Mesozoic alliances; in fact, it closely resembles a form from the Lower Oolitic of England (*T. Walcotti*, Duncan). It might, indeed, have been washed out of some older rocks; but there are other specimens, and no other oolitic forms with it. It is, however, always found very much worn and much older in appearance than the accompanying fossils. The *Heliastræa* (*H. Tasmaniensis*, Dunc.) is quite fresh, and unlike the other. It is of a genus of which other Tertiary species exist, but this species has remarkable affinities with an Indian cretaceous fossil (*H. cortica*, Stol.) from the Ootatoor rocks. (See *Prof. Dunc., Q. Jour. Geo. Soc.*, 1876, *p.* 343.) Both these genera had, as before observed, Tertiary representatives, but *Heliastræa* cul-

minated in the Miocene period, while *Thamnastræa* became rare, or died out in the Eocene. I have lately discovered another Mesozoic form in *Smilotrochus*, of which I believe no other Tertiary species has been hitherto found.

Antillia lens (Dunc.) is another anomalous form, with Mesozoic alliances and a genus with no living form, except one in Batavia, and of which a specimen was lately brought down from Darnley Island by the Chevert Expedition, and is now in the Macleayan museum. The genus is well represented in the West Indian Miocene, and in the Sindhian, Travancore, and Arabian Miocene. It is not at all uncommon in the Brighton beds, but there is no other species, and it has no living or fossil representative in these latitudes now.

The general facies of our Australian Tertiary corals is therefore Lower Tertiary, between Eocene and Miocene, with strong Mesozoic alliances. If we separate the different species according to the locality in which they occur, we should find that the Eocene forms predominate in the Tasmanian, Muddy Creek, and Schnapper Point formations, while the Miocene forms are more common in the beds at Spring Creek, sixteen miles south of Geelong, and Portland Bay, Western Victoria.

With regard to the *Echini*, a very interesting paper has recently appeared on the subject from Professor Duncan (*Quarterly Journal Geological Society*, 1877, *p.* 42.) He says that this order, as represented in our rocks, "is very remarkable as a fossil fauna. The presence of such genera as *Temnechinus*, *Echinolampas*, *Pygorhynchus*, and *Eupatagus*, gives a Nummulitic (of Europe and India) facies to the fauna, whilst the Cretaceous aspect is presented by the genera *Catopygus*, *Holaster*, *Micraster*, and a *Rhyncopygus*, with the Ananchytic looking apex." He adds, "that the general facies of the whole is older than is warranted by the geological position." (p. 68.) I cannot well understand what is meant by the "geological position," for that is at present undecided. It must be remembered, on the one hand, that we have in our Australian fauna a genus closely allied to *Temnechinus* (*Temnoplerus toreumaticus*, Klein), and I have found a true *Temnechinus* in very recent Tertiary beds from New Guinea associated with recent fossils, notably *Peronella decagonalis*, Lesson. On the other hand, the difference between our living species and the species of the same genera which are fossil is very marked. There is a very great difference between our living *Lovenia elongata* and the fossil *L. Forbesii*. But I have strong reasons for believing that *L. Forbesii* possesses a true peripetalous fasciole, in which case it would be a *Breynia*, and very closely allied to our living *Breynia Australasiæ*, Gray. *Maretia anomala*,* Duncan, is

* Professor Duncan mentions this genus as West Indian, but this is probably a misprint for East Indian Islands.

a form which is retained in the genus in spite of its having a lateral fasciole, but this does violence to the classification to some extent. There is no such band visible on *M. planulata*, which is not known to naturalists as an Australian species, but which I find is not at all uncommon at Port Jackson and on the east coast. The species is a variable one, the specimens at Port Jackson are smaller, paler in colour, and with much more salient and conspicuous large spines, so that I think we may consider Professor Duncan's species as perhaps a variety. It was found at the mouth of the Sherbrook River in W. Victoria, very far removed from the present habitat. *Monostychia Australis* is another of the forms closely allied to the existing *Arachnoides*, of which two other species are described by Professor Duncan. The genus of *Monostychia* must be abandoned, according to the same author, because it is founded on a mistaken appreciation of the reproductive system and on the position of the periproct. With regard to this I may say that since seeing Professor Laube's monograph I have examined forty or fifty specimens of *Arachnoides placenta* from various localities. I find it a very variable species. The position of the periproct is the most uncertain feature. It is very infra-marginal and marginal. *Psammechinus Woodsii*, Laube, is said to be a form closely allied to our *Echinus magellanicus*, of which Agassiz states that he received two specimens from Australia. It is nearer to a species recently described by me from Darnley Islands *(E. Darnleyensis)*.* There are four species of *Eupatagus* described from our Tertiary beds, all differing but not very considerably from *E. Valenciennesii*—Agas., which is a common living form on the east coast, especially at Port Jackson. *Leiocidaris Australiæ* is a representative of *Dorocidaris papillata*, which is of world-wide distribution; but I am not aware that it has ever been found in Australian seas.

Altogether the facies of our *Echinodermata* is somewhat recent, and in some respects related to past periods of the earth's history. In those respects in which it relates to the past it is at least of early Tertiary affinities, with strong Mesozoic alliances. Its relation to the recent fauna, with only one or at most two exceptions, is to inhabitants of remote localities in Australia and of much warmer seas.

I shall have to deal more generally with the mollusca in treating of their alliances. I hasten in the first place to correct an erroneous impression, conveyed in my last paper read before this Society. I there stated that Australian genera, as the term is understood, were almost entirely absent. I overlooked the fact that I myself have described a new *Cominella* from the Tasmanian beds; and since then Professor Tate has just informed me

* Proc. Linnean Soc., N. S. Wales, Sept., 1877.

that he has found a *Phasianella* and an *Elenchus*. I referred to the *Thalotia*, which I said was doubtful. I think that we must still conclude that our present Australian fauna is not the fauna that we find even generically represented in our Tertiary fossiliferous formations. Naturalists have been accustomed to regard Australia and New Zealand as one province, but this gives rise to a misconception of the molluscan fauna of both localities. Several common New Zealand forms are totally absent from Australia, and New Zealand is singularly deficient in Australian forms. We have only a small *Struthiolaria*, which is rare, and on the east coast only, and we have no *Rotella*, which is a characteristic New Zealand genus. The differences would be too long to enumerate here, but they are at least sufficiently marked to prevent the two places being grouped as one province. As to species, it is quite the exception to meet with instances where they are common to both. We have far more which are common to Australia and the Philippines. But still the differences are great between those two provinces. The facies of our Lower Tertiary molluscan fauna is in a general way Philippine, but it is true only in the sense in which we may say that the facies of the Lower Miocene and Upper Eocene is Philippine. We meet with some existing forms there which represent the fossil fauna of both places, and the genera and general habit of the shells suggest many resemblances. But I repeat that this is only in a general way; for once we try to reduce this to some definite facts, we find that the resemblance is only general and will not bear the test of strict comparison. The truly Australian recent genera may be said to be *Phasianella*, *Elenchus*, *Bankivia*, *Macroschisma*, *Parmophorus*, *(Scutus)*, *Risella*, *Amphibola*, *Trigonia*, *Chamostræa*, *Anatina*, *Myodora*, *Myochama*, *Crassatella*, *Cardita*, *Circe*, *Cypricardia*, *Venus*, *(Chione)*, *Anapa*, *Mesodesma*, *Panopœa*, *Solenella*, *Spirula*, *Fasciolaria*, *Trophon*, *Pleurotoma*, including *Drillia* and *Daphnella*, *Voluta*, *Mitra*, *Ancillaria*, *Tornatella*, *Trochocochlea*, *Siphonaria*, *Cominella*, *Fusus*, *Liotia*, *Adamsia*, *Crossea*, *Siphonalia*, *Purpura*, *Triton*, and a peculiar trifoliate kind of *Murex*. None of these genera are entirely restricted to Australia, but some are only found in its neighbourhood as far as Japan or the Philippines; while one or two—such as *Solenella*, *Bankivia*, and *Trophon*—reappear at remote places. Thus, Dr. Carpenter reports a solitary *Bankivia varians* among the Mazatlan shells. *Anatina* and *Crassatella* are small characteristic genera. Both are found at the Philippines. *Phasianella* is found at the Philippines as well, and so the list might be continued. But of the above genera we have very few among our fossils. *Crassatella* is one which is common, and so is *Liotia*. *Voluta* and *Mitra* are common and varied; *Cardita* also does not seem scarce, and that common form of *Venus* which is recognized as a subgenus named *Chione* by some authors. A *Venus* very like

V. lammellata exists, but with decidedly specific differences. Our fossil *Pectens* are not at all like our recent forms, but are peculiar—one *P. foulcheri*, nobis, is spinous, *P. yahlensis*, nobis, is finely imbricated, *P. corioensis* is delicately striated, *P. coarctatus** and *P. gambierensis*, nobis, are both coarsely granular; in all of which particulars they differ much from our recent species. *P. yahlensis*, according to Professor M'Coy, so nearly resembles the well-known German Miocene species, *P. Hoffmani*, Goldf., as to be easily mistaken for it; but the valves are both alike in the German fossil, while they are different in the Australian. *Cypræa, (Aricia) gigas* is a very peculiar and large species, differing very much from any form fossil or recent, while *Trivia avellanoides* can scarcely be distinguished from *Trivia avellana* of the British Oligocene, and is very like *T. affinis* of the French Miocene and British Lower Pliocene. The genera best represented in our Lower Tertiary deposits are *Pleurotoma*, *Cerithium*, and *Turritella*. I have carefully compared all our species with a very complete series of the Vienna and French Miocene forms, but find that the resemblances are only remote. There is a far greater similarity between them and those of the Paris basin, but still it is not very close. None of our lower Tertiary *Cerithiadæ* have been described. There is a *Spondylus* (*S. gaderopoides*, M'Coy), which is exceedingly close to *S. bifrons*, Munster, of the Miocene of Westphalia. *Haliotis ovinoides*, M'Coy, and *H. Mooraboolensis*, are both forms with strong resemblances to *H. ovina* and *H. Roei*, Gray, respectively, both of North Australia.

I do not enter at any length into the question of the resemblances of our older Tertiary *Brachiopoda*. Their strong Miocene analogies have been pointed out by many authors, but not the Miocene of France or Austria so much as the Maltese Miocene, where the resemblances, in a few instances, have led to the species being mistaken for one another. The Maltese Tertiary formations have a peculiar facies of their own which merits some notice from all Australian palæontologists. They are described at some length in the *Annals of Nat. Hist.* for July, 1864, by Dr. Leith Adams, and the *Brachiopoda* in the same paper by Mr. Thos. Davidson. He says the Maltese Islands, which extend about 29 miles, all belong to one series, and are to be considered portion of an early Miocene equivalent to the Hempstead beds of England, which was regarded by Sir Chas. Lyell as Upper Eocene. The formations are sedimentary and marine, with a horizontal stratification, and are all conformable. The greatest thickness above the sea level is about 800 feet. Those who wish to study these strata,

* As the name *P. coarctatus* was applied to a fossil figured by me which I thought was identical with a European species, I now propose the name of *P. stenos* for the same shell, as it has not been described, and is not *P. coarctatus*.

which certainly throw some light on our Tertiary beds, will find the following references useful:—"*On the Geology of the Maltese Islands, with Notes on the Fossils by Prof. E. Forbes, Proc. Geol. Soc. Lond., vol.* 4, *p.* 225." "*On Fossil Echinoderms from Malta, &c., by Thos. Wright, M.D.: Ann. Nat. Hist., Feby.* 1855, *p.* 101; also *Fossil Echinoderms of Malta, by Wright: Jour. Geol. Soc. for* 1864, *vol.* XX, *p.* 470." These deposits are very rich in fossils, and the strata are divided into five groups, each of which is distinguished by peculiar organisms. They are so like our Australian deposits that I enumerate them:—1. Coralline limestone; 2. Yellow sand; 3. Clay; 4. Calcareous sandstone; 5. Hard cherty flintstone. The *Echinodermata* are the most abundant and characteristic fossils. Judging from the figures of Wright, there are few that resemble our fossil species except *Echinolampas Deshayesii*, which is in no way distinguishable from my *Echinolampas Gambieriensis*, which I think is the one described by Laube as *E. ovulum*, and considered by him a distinct species from the Maltese form, *Pygorhynchus Vassali*, Wright, and another which is regarded as identical by Professor Duncan. Dr. Wright considered it as resembling *Catopygus fenestratus* from the upper chalk of Belgium, and differing but slightly from *Nucleolites* (*Pygorhynchus*) *subcarinatus* of the Middle Tertiaries of Bünde. Professor Duncan remarks that the genus is essentially tertiary, but Forbes described one which is probably a *Cassidulus*, from the Indian cretaceous. The numerous species have been found in Eocene and Miocene deposits of Malta, America, and Jamaica. *Brissus oblongus*, Forbes (see Wright, *Ann. Nat. Hist.*, vol. 15, 2nd series, p. 184), is not to be distinguished from our existing *Linthia Australis*, Gray. The only difference is the number of pairs of pores, and this depends upon age. There are also a few pairs of pores instead of a single row on the actinal anterior ambulacra. It would be interesting to find that some Eocene or Miocene forms of Europe which are not to be found in our contemporaneous rocks survive in the existing fauna here. There are not wanting facts which would support this view—it certainly is the case with the corals. *Linthia Australis* sometimes attains a very large size, but generally it is found of the dimensions given by Dr. Wright. The Maltese *Spatangus ocellatus*, Defranc, is extremely like our *Lovenia Forbesii*, Woods and Dunc., but they belong to different genera. I question, however, whether the mere absence of a visible fasciole is a sufficient distinction, considering how very easily when there is no depression such a mark disappears. It is very rare to see the internal fasciole on our fossil, but it seems to me that even from Wright's figures (*Journal Geological Society*, vol. 20, pl. 21, figure 1) there are evidences of such a mark. I should infer it from the atrophy of the apical pores of all the petals. I commend this to the attention of palæontologists in England who can refer to the specimens.

To sum up all the evidence which has been gathered on this subject, we may say that our Tertiary formations probably range through all the various Miocene periods which are represented by different deposits on other portions of the globe. We may certainly conclude that the whole of the central parts of South Australia, the north of Tasmania, and the Islands of Bass' Straits, were under the sea during that epoch. There is quite sufficient evidence to show that we have Tertiary rocks of a lower horizon than the Miocene. I conclude this from the small percentage of recent species, the relations of the fossils, and the general facies.

It is also evident that our fossils are with very few exceptions such as we only find at present in much warmer seas. This fact, which all palæontologists are agreed upon, joined to the discovery of certain reef-building kinds in Tasmania, has led to a most interesting discussion recently at the Geological Society of London, when the President, Dr. Duncan, suggested that it might be accounted for by supposing an alteration in the earth's axis. This was further suggested might be accounted for by a shifting of the earth's crust on a fluid and molten mass. It seems to me, however, of very little real service to science to make such speculations. They rest on such slight inferences that they are readily overturned, and really give us no insight into the question. If I might venture to offer an opinion to men so much more qualified than myself to judge, I should say that the theory is too much for the facts. If anything altered the axis of the earth, so as to place, let us say, Tasmania within the tropics, we should expect to find a tropical marine fauna as well. But do we find this? On the contrary, the species are those of a warm sea for the most part; but were we to find such a fauna in a warm sea, we should be equally puzzled to account for the presence of certain species and for the absence of others. Another remarkable peculiarity about our older fossil shells is, that they are thin and fragile, and with the exception of a few species they are anything but substantial. Now, I need hardly remind any one acquainted with the marine molluscan fauna of the tropics, how the first thing that strikes one is the solid and substantial nature of the shells, and for the most part the thickened character of the ornamentation, enamel, &c. Certainly our Lower Tertiary fauna is not a tropical or even a subtropical one. All that we can say is, that certain species which are found still living now inhabit the tropics, while others remain where they are, and generally very many of the genera are now to be found in a warmer climate. It is very remarkable to find specimens of reef-building corals; but we can hardly assert under what conditions they lived, since they are so very different from the reef-builders of the present day. I suppose it is hardly attempted to account for the reef-building corals

which we find in the British coral rag (oolitic), for instance, by climatical conditions alone. It seems to me that we are too imperfectly acquainted with the circumstances which govern the migration of species at present to be able to apply even generally any reasoning to such facts as those before us. Climate alone will not account for them. Indeed, we have nothing very cogent to urge against those who might read the facts in another way, that is by saying that species which now live in warm seas were formerly inhabitants of temperate or even cold waters.

In conclusion, I may remark that throughout the whole of Australian Tertiary palæontology we find a certain peculiar character, which is often distinguished by its almost capricious variation from well-known types of the other hemisphere. I remember hearing a distinguished naturalist remark that he was astonished when he first came to Australia to find so many of the birds "wrong." That is, I suppose, that they seemed by their peculiarities to stray outside the rigid definitions of genera, and sometimes unite the characters of two or more. This certainly must arise from our having formed our systems too artificially from our limited experience. It was natural to suppose that the study of organisms in remote countries would widen our knowledge, and cause us to widen our conception of nature's plan. What we called the Australian "abnormalities" are in reality the shortcomings of our systems of natural history. Thus, we find a *Maretia* with a lateral fasciole, and certain other peculiarities in our *Echini* which would be very difficult to enumerate without entering too much into detail. In the corals the relations of the septa and costæ are most peculiar and exceptional. According to Edwards and Haime, costæ are modified or extra-mural septa. They ought, therefore, to correspond with the septa, and so they do generally. But there are exceptions—such as *Stephanophyllia* and *Micrabacia*—where they alternate with them. In *Dasmia*, one of the costæ corresponds to three septa. But in the Australian species everything is exceptional. We have alternating costæ and septa, and in *Ceratotrochus fenestratus*, mihi, we have the triple septa to one of the costa as in *Dasmia*, besides many other differences. We have also *Dendrophyllia epitheca*, that is to say with a thick epitheca, *Flabellum* with basilar radiciform appendages of *Sphenotrochus*. In the *Volutes*, of which mention has been made, we have always a swollen pullus at the apex, and this often forms the only mark of distinction. In *Voluta strophodon*, M'Coy, there is no difference appreciable from *Volutilite spinosus* and *V. depauperatus* of the Upper Eocene of Europe except the apex (See *Prod. Palæontology of Victoria, Dec. IV. p.* 25). I might extend these instances very considerably; but a very slight acquaintance with the fossils themselves will furnish abundant instances.

There can be no doubt that these observations on the fossil fauna might be much amplified, were our knowledge of the marine fauna of Australia more complete. Each day, however, adds to this knowledge, which is very different now from what it was when I first came to the Colony, twenty-three years ago, when such an estimate as I have made would have been impossible. It is to be hoped, however, that what I have thus far noted may be of use, and will give an impetus to the inquiries which are being prosecuted now on every side of Australia.

NOTE.—While these sheets were passing through the press, Prof. Tate informs me that he thinks he has found stratigraphical evidence showing the Muddy Creek beds to be above the Murray cliffs, and the latter as contemporaneous with the Mount Gambier limestones. These questions can hardly be decided without a careful survey. My paper professes to deal with the palæontological evidence only. Prof. Tate's zeal and industry in the matter gives hope of a speedy solution of many of these problems.

DISCUSSION.

The Chairman conveyed the thanks of the Society to the Rev. Mr. Woods for his very valuable paper.

Mr. WOODS said he desired to add that in making these investigations one difficulty he had experienced was that in our colonial museums there were no characteristic recent marine faunas represented. He meant to say that if he wanted, in any museum in Melbourne, Adelaide, Tasmania, or New South Wales, to find recent marine fauna as a means of comparison, he should look in vain for any such collection, and students must be without the instruction such a collection would give. He wished to make this known; and he thought that members of the Society ought to make this matter their first care. If he wanted to obtain in any colonial museum a collection of recent echini, or corals, or shells, he would be unable to find it. This was a matter which museums ought to give their best attention to. Such a collection would be a most useful acquisition.