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THE AUTHORS OF THE SEVERAL PAPERS ARE SEVERALLY RESPONSIBLE FOR THE SOUNDNESS OF THE OPINIONS GIVEN AND FOR THE ACCURACY OF THE STATEMENTS MADE THEREIN.

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Art. I.—*Preliminary Notes on the Monchiquite Dykes of the Bendigo Goldfield.*

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(With Plate I.).

[Read 14th December, 1911].

Introduction.

The following notes are the result of an unfinished study of the dyke rocks occurring at Bendigo.

References to the rocks are not very numerous among the literature of this gold field, which is mostly contained in Professor Gregory's Bibliography of the Economic Geology of Victoria (1). They are only occasionally mentioned throughout the publications of the Victorian Mines Department, except in Mr. Dunn's monograph (2) where they are treated at some considerable length, and in Dr. Howitt's petrographical report (3). Elsewhere they have been referred to by Mügge (4) in a review of Dr. Howitt's paper, and by T. A. Rickard in his descriptive papers on the Bendigo field published in the Transactions of the American Institute of Engineers. Rickard (5) has given special treatment to the dykes in his paper on the Origin of the Gold-bearing Quartz of the Bendigo Reefs, Australia. In this paper he gives a number of sketches illustrating the relations ot the dykes to the strata. One of these, which is incorrect and deservedly criticised by Argall (6) as being inconsistent with Rickard's stated facts, has recently been copied into Malcolm Maclaren's book on Gold (6) as figure 127. The papers by Argall resulted in the discussion on Rickard's work.

Very little work has been done on these dykes within the last sixteen years, and at the beginning of the present year it was thought that a study of these rocks and their relation to the distribution of gold could be profitably commenced.

General Relations.

The dykes, which are locally always termed "lavas," have been injected into the folded ordovician sediments of the Bendigo field. Mr. Dunn (2) has pointed out that the dykes are found along the course of every anticline, and not in the synclines, and that they are not continuous along the whole length of the anticlinal axes at the surface. The course of a lava upward is irregular, and as it rises through the different levels of a mine it wanders at times both east and west of the actual "centre country," but is seldom far away. So regularly do the lavas follow the centre country that they have been of great service to the Geological Survey in the mapping of these anticlinal axes, and Mr. H. S. Whitelaw (7) has tabulated the surface characteristics of the lavas which are always decomposed and recognised by (1) the trench or gutter caused by their weathering more easily than the walls of the adjoining country rock, (2) their more stable decomposition product, the magnesium carbonate, which at the surface occurs in thin nodules or veins, and (3) the peculiar opaline aspect often induced in the quartz of a reef with which they have come in contact.

Observed in one anticline they are frequently found to branch into two or more lava streams which may or may not junction again at higher levels. At the New Christmas shaft, situated on the Christmas anticlinal axis at Kangaroo Flat, six lavas are met in one small crosscut of 94 feet, revealing the existence of quite a network of streams.

In thickness they average from 9 inches to 12. Three-inch seams are not uncommon, and they range down to thin threads which may die right out. Mr. Dunn (2) records a 5-foot lava in the Great Britain Mine. The south shaft of the New Christmas Mine contains a lava 6 feet thick. A 12-foot lava was supposed to exist in the Bird's Reef Mine, Kangaroo Flat, but has been found to be in part sandstone, and is only 5 or 6 feet thick.

The trend of these dykes, north and south, is remarkably persistent. and they form a parallel system of the "plateau region" type. The parallelism is made particularly noticeable by its coincidence with the direction of strike of the rocks. With this parallelism we do expect to meet them in anticlines rather than synclines, for anticlines are always in a state of relative tension to the synclines, and, therefore, suffer fracturing in the relief of crustal stresses in preference to the synclines. The coincidence of the strike of the rocks and the dykes means that the same kind of crustal stresses have been involved in the folding of the rocks, and in the injection of the igneous material. The main earth movements resulting in the folding have resulted from pressure from easterly and westerly directions. The rock stresses which were relieved by the injection of the dyke material, and which no doubt result in rock fracturing, in part, have developed at a later date from the same direction. I think this instance forms a good Victorian example of Harker's principle of the intimate connection between igneous action and crust movements (8), especially if we agree with T. C. Chamberlain that earth movements are inheritances, and likely to be continued in the same manner at different periods of the earth's history.

The cross-courses on the field which have displaced the anticlines and the slides have resulted from movements distinctly minor to the main ones, and Mr. Dunn has spoken of dyke material filling the cross fractures, but I have not been able to verify this.

In such a parallel system of dykes as this, which has originated from the same magma, we might expect the dykes to communicate across the anticlines at different levels in the crust of the earth. The only possible instance of this that came under my notice was in the Koch's Pioneer Mine, Long Gully (Garden Gully line), where a lava comes from the west at the 1200-foot level, and continues through the upper levels to the surface, but is not found in the lower levels.

The metamorphism of the intruded series by the dykes is extremely slight. Apart from the peculiar appearance sometimes seen in the quartz reefs, noticed above by Mr. Whitelaw, the only evidence I can record is the presence of sillimanite crystals in quartz associated with a lava obtained from the Ironbark Mine.

The penetration of these thin parallel sheets, persistent for miles in length, through a thick series of folded sedimentary rocks, is a fact which is impressive. It has astonished previous observers, and caused Rickard (5) to propound a fanciful theory of dyke intrusion based on an unproved statement that the mobility of the lava is due to superheated steam and not to intense heat. Such was rightly attacked by Argall (6) Mr. Dunn (2) is inclined to imagine the presence of explosive forces. There is little to be gained at present by speculation. The mechanics of dyke intrusion is a difficult subject and one little known. It can therefore be well left to a later date.

The question, too, has been raised as to whether these dykes were channels of supply for lava flows at the surface. Rickard was quite sure that they were, because he erroneously connected the monchiquites with the newer basalt, but Mr. Dunn thought probably not. It is not uncommon to find a dyke stream fading out in the upper levels, and an instance was recently noticed in the Koch's Pioneer Mine, where the top of the dyke was largely a mass of sulphur. The presence of sulphur now implies the presence originally of sulphurous gases which were unable to escape through a vent. In this connection it may be remembered that large black biotite crystals are to be found in the lava in places like Jones's shaft, New Chum line (2), and the Victoria Consols Mine. Small biotites are sometimes seen in the sections of rocks from the other mines. The formation of biotite as a mineral is now known to require either the presence of a " mineraliser " like water vapour, or pressure. Mineralisers would have escaped and the pressure would have been established with the existing surface at the time of intrusion. This helps us to think that these dykes were independent and self-contained intrusive bodies. Yet on the other hand the nearest petrographical allies of these rocks in Victoria, e.g., the King's Quarry rock at Macedon (11), have resulted in very small flows, and any small flow at Bendigo could well have been denuded away.

Petrology.

Chemical Characters.

A rock sample from the Central Red, White and Blue Mine, Sheepshead line, was analysed. This sample was taken from the thicker of the two lavas which occur within a few feet of each other in a small crosscut at the 318-foot level. This rock was chosen because it was found to be very fresh. The analysis made is in general similar to that made by Mr. Frank Stone, quoted in Dr. Howitt's paper (3), of a sample of the New Chum lava in Lansell's 180 Mine.

	I.	II.
SiO_2	40.92	39.32
Al_2O_3	11.34	17.53
TiO_2	6.57	—
Fe_2O_3	.54	3.07
FeO	12.96	9.12
CaO	9.28	10.38
MgO	7.78	8.00
K_2O	1.94	3.04
Na_2O	3.27	2.44
MnO	.13	—
P_2O_5	.51	—
CO_2	2.82	Moisture 2.20
H_2O-	.64	5.10
H_2O+	1.77	
	100.47	99.20

I. Dyke, Central Red, White and Blue Mine, Sheepshead line. Analyst, F. Stillwell.

II. Dyke, Lansell's 180 Mine, New Chum line. Analyst, F. Stone

The Sheepshead line is immediately east of the New Chum line, and these analyses tend to emphasise the minor variations that can be noted microscopically in various samples of the Bendigo monchiquites. The Sheepshead lava is relatively more acid, though at the same time it is a fresher rock. The high titanium content finds expression in the highly titaniferous augite, and the abundance of ilmenite. The low silica percentage, moderately low alumina, moderately high alkalies with soda predominating over potash, high lime, ferrous iron and magnesia are the chemical features of the monchiquite group of rocks.

Petrographical Characters.

Central Red, White and Blue Rock, 318-foot level. (Plate I, Fig. 1). This rock in the hand specimen is dense, bluish-black, and very hard. Porphyritic crystals of olivine can be seen, and also occasional white vesicles filled with calcite.

Microscopically, it is extremely dense. Occasional very large olivine crystals are found which are more or less completely serpentinised. Smaller olivine phenocrysts are common, and are for the most part relatively clear and unaltered. These fresh olivines from the 318-foot level are remarkable when one considers that the olivine usually seen in the Bendigo rock sections is very much altered, even at the deepest levels of the Victoria Quartz Mine, 4614 feet.

Augite is perhaps the most abundant mineral. It is a purple, titaniferous variety, and faintly pleochroic. A brown prismatic hornblende is present in a much smaller amount than augite. It is strongly pleochroic, and is distinguished from biotite mainly by its oblique extinction. The angle between the prism faces can only sometimes be seen.

Ilmenite is extremely abundant in small crystals distributed evenly throughout the rock. Microlites of ilmenite are also abundant. Thin, colourless rods of apatite are discernible in the ground mass.

The ground mass when unaltered is clear, colourless and isotropic. Its refractive index is higher than that of xylol (1.4912) and not much different from that of a sample of cedar oil (1.5090). The ground mass is therefore a glassy residuum, and not analcite. Not only does the material serve as a general ground mass for the whole of the rock, but it appears as well here and there in irregularly-shaped areas which, containing an excess of brown hornblende, form light-coloured patches in the rock. These are obviously the acid residuum remaining after the crystallisation of the bulk of the magma. In part the ground mass is found to be not absolutely isotropic and to show polarisation colours up to iron grey and grey white. This condition is most evident in some of the segregated patches when in addition a curious perthitic intergrowth with ilmenite is evident. It is here found to pass out into occasional basic felspar laths, and the assumption is that the remainder of the crystallised ground mass is felspar.

Vesicles in this rock are filled mostly with a carbonate, probably calcite. The carbonate could well be dolomite, especially as rhombs of this carbonate have been seen in sections from the rocks from other mines. Occasionally rods of a fibrous carbonate, arragonite or fibrous calcite, can be seen under the high power lining the edge of some of the vesicles. Rods of a fibrous zeolite, probably natrolite, are present. Analcite, in small isotropic cubes, has also been seen. Chalcedonic silica is present as a secondary mineral, and also crystallised silica as quartz. A vesicle filled with quartz is rimmed with a network of green prismatic crystals showing high polarisation colours and oblique extinction. Pleochroism, if any, is extremely faint, and the mineral looks like epidote, but has not got the extinction angle of epidote.

These characters, combined with its high basicity and chemical composition, and its mode of occurrence as a dyke, are sufficient to place the rock among the monchiquites. The felspar is too insignificant in quantity to displace it from this monchiquite group.

Dr. Howitt (3) has described a dyke rock apparently similar to the above, from Lansell's 180 Mine, on the New Chum line, and named it limburgite. Mügge (3) in a review of Dr. Howitt's paper, suggested that the name monchiquite should be used to agree with the mode of occurrence, and the name limburgite should be reserved for very basic lava flows. This is the proper interpretation of the terms, and therefore we may call our type rock monchiquite.

An examination of a number of sections of lavas from other mines reveals the same general characteristics of the monchiquite group, with minor variations. A complete comparison is not possible, because the lavas are so frequently decomposed. This decomposition is in no way proportional to the depth below the surface, as shown by the Central Red, White and Blue rock. Further, the decomposition, once started, is surprisingly rapid. A lava, exposed only for six months at 2600 feet in the Koch's Pioneer was found to be crumbling in part, though quite dry. In the Pearl Mine a lava exposed some thirty years along the roof of a disused drive at 130 feet, has rotted sufficiently to form a linear heap of mullock along the floor of the drive.

In spite of this, fresh rocks, suitable for microscopical examination, were obtained from a number of places, and the following notes may be made: Specimen No. 14, Lansell's 180 Mine, No. 2. The sample was obtained from the 400-foot level, about 30 feet south of the shaft. This mine is situated on the Sheepshead line, and adjoins the Central Red, White and Blue Mine. Three branches of the lava are present in this mine, while there are only two in the other. In this rock olivine has been more abundant, but is now completely serpentinised. Augite is present in two generations. The large augites are nearly colourless and sometimes zoned, sometimes with hourglass structure. The small augites form the same kind of network as in the Central Red, White and Blue rock. The hornblende is present in about the same proportion, but the ilmenite is relatively much less abundant. The colourless ground mass is in small proportion, but appears in the same residuum as patches, crowded with hornblende and ilmenite microlites. Vesicles are more developed, and this is always noticeable with the further decomposition of the rock as recorded by Dr. Howitt. Many of these have an inner core of green amorphous silica, rimmed with calcite, and the alteration is sometimes repeated.

Specimen No. 9, 3827-feet, Victoria Quartz Mine. The complete alteration of the olivine in this rock is very noticeable, and the ground mass is perfectly isotropic. This New Chum dyke was found to be very decomposed down to 1300 feet in the Pearl Mine, and very hard again in the Catherine Mine, Eaglehawk. Here the rock is similar to that in the Victoria Quartz Mine, but the vesicles are far more abundant, and many of them contain rims of a coarse fibrous carbonate, probably calcite.

Specimen No. 31, 1868-feet, Johnson's Reef Mine, No. 1. This is the Garden Gully lava, and here it is very dense, and the colourless ground mass is scarcely perceptible. Ilmenite is scarce, vesicles are numerous, and many are curiously lined with pyrite. The same dyke at the Clarence United Mine contains an average amount of ilmenite. Natrolite is well developed in the vesicles of this rock. The natrolite is prismatic, positive in sign, with straight extinction and low polarisation colours At the Koch's Pioneer Mine, the Garden Gully lava is not so fresh, but a section of a 2-foot dyke shows it to be relatively coarse. Olivine is completely serpentinised. Large augites are present, some of which have a core of inclusions. Ilmenite and hornblende are present in average proportions. Small biotites are noticeable. The ground mass is in general not isotropic, and consists mainly of a low polarising mineral. This is probably original felspar, but may be secondary, and developed during the alteration of the rock.

The rocks from the places above mentioned come within the monchiquite group, from which the following deviate:—

Specimen No. 7, Goldfield's Mine, No. 1. The Goldfield's No. 1. is an abandoned shaft at the southern end of the Nell Gwynne line of reef. The specimen was obtained from the dump, and was a piece of a thick lava met in sinking the shaft at the depth of about eighty feet. The first glance under the microscope shows the rock to be generally similar to the true monchiquites. Olivine phenocrysts are partly fresh, and only partly serpentinised. There is only one generation of augite. The ilmenite is very abundant and hornblende is present. Biotite is present in relatively large crystals. The feature of the rock is that the ground mass is perfectly clear and colourless, and not isotropic. A large vesicle is present in the slide, and contains a little biotite and a great deal of calcite, and these are mixed with a mineral which is apparently identical with the true ground mass of the rock. Here it is found to possess cleavage, and an extinction of three or four degrees. It is untwinned and the polarisation colours are never above greyish-white. It is biaxial and positive, and has a refractive index less than that of oil of cloves (1.5333). Its appearance is that of a felspar, and its refractive index is that of orthoclase and anorthoclase. In addition it has in some places an appearance suggestive of very fine lamellar twinning, and one is therefore inclined to call it anorthoclase. It is probable that the chemical composition of the rock is not far different from the Central Red, White and Blue type, where the soda is in excess of the potash, and this assists the determination as anorthoclase. The presence of this anorthoclase (?) base distinguishes the rock from the typical monchiquites.

Specimen No. 5, Forbes Carshalton Mine. The specimen was obtained from the dump heap without any knowledge of its depth in the mine. The locality is more than one mile north of the Goldfields No. 1 shaft. Like the Goldfields' rock this rock is generally similar to the monchiquites. Olivine is mostly serpentinised, and the augite is present in two generations. Hornblende and ilmenite are perhaps in smaller proportion than in the typical monchiquite. These minerals are all set in a ground mass of felspar laths. The felspar shows lamellar twinning, and the lamellae give extinction angles up to 35 degrees, which determines it as labradorite. This felspar is present in much the same proportion as the isotropic material in the type monchiquite. In addition it appears on the segregation patches similar to the light coloured, acid residual areas in the monchiquite. Clearly this felspar has been the last mineral to crystallise during the consolidation of the magma, and in this respect it is certainly analogous to the isotropic material of the monchiquite.

The felspar of this rock and of the Goldfields No. 1 indicates that they belong to the camptonitic variety of lamprophyre. The Forbes Carshalton specimen is more of a true camptonite than the Goldfields No. 1 sample, with its alkali felspar. It seems to be very similar to a rock found at Balwyn, which occurred as a small flow. This has been described by Messrs. Chapman and Thiele (10) as a limburgite.

The examination suggests that the labradorite and anorthoclase are but further stages in the crystallisatiaon of the monchiquite magma. The distribution of each as a base for the other minerals is very similar, and their relative proportions are much the same. This, combined with the minute amount of felspar in the monchiquite itself, suggests the passage from the true monchiquite through the Goldfields No. I. type to the Forbes Carshalton type. The specific gravities of the two last-named are greater than the specific gravity of the Central Red, White and Blue type. This is in accordance with the suggestion because the specific gravity of a glass is always less than that of the mineral which would result from it.

Specimen No. 38. One Tree Hill Mine. (Plate I., Fig. 2). This specimen was collected by Mr. Whitelaw, and was obtained from a now inaccessible part of the One Tree Hill Mine, two miles to the S.S.W. of Bendigo. The One Tree Hill anticlinal axis is some distance to the east of the main lines of reef. In the hand specimen it is a hard, greenish rock with shiny flakes of mica. Microscopically, the rock is much altered and of porphyritic character. The outstanding phenocrysts are those of an originally well crystallised mineral, which is now completely altered to brownish unrecognisable material, though here and there small patches have only gone as far as chlorite and calcite. Some of these well bounded sections are eight-sided, and indicate original augite. Others are six-sided, and by their prism angle indicate original hornblende. No unaltered augite or hornblende is present. Plagioclase felspar occurs sparingly as crystals which are not much altered. Phenocrysts of biotite with ragged edges are common, with pleochroism varying from a deep brown to a very pale straw colour. It has undergone considerable alteration to chlorite. Some crystals of biotite have undergone internal bleaching, the iron having been leached from the centre, and concentrated in a ring which now gives a dark border to an interior of chlorite and calcite. Quartz is abundant, and the chlorite and calcite extremely so. Ilmenite occurs scattered in very small crystals, and apatite is also accessory in fine needles.

The rock is a typical mica lamprophyre, and, if placed in Rosenbusch's classification, it would be termed kersantite.

The specific gravities of these rocks were determined from small fragments, and found to be:—

Central Red, White and Blue sample - - -	2.95
Forbes Carshalton sample - - - - -	2.99
Goldfields No. I. sample - - - - -	3.05
One Tree Hill sample - - - - - -	2.78

Age of the Bendigo Dykes.

The dykes include ordovician sediments, and are certainly post-ordovician. South of the Big Hill tunnel, a monchiquite dyke cuts a granitic dyke. The granitic dyke is probably associated with the Harcourt granite, and the monchiquites are probably post-devonian. At Kangaroo Flat a dyke is found cutting through a glacial conglomerate. If this conglomerate is part of the derrinal series, and of permo-carboniferous age, the dykes must be later than permo-carboniferous. Further than this the stratigraphy of the Bendigo district cannot help one, for no later geological period has left its record except in some tertiary and recent river gravels.

No structural evidence is forthcoming, though there is a possibility that the relations of the dykes to the series of earth movements that have affected the Bendigo field may be found and co-ordinated in time with general movements throughout Victoria.

For further help we must therefore depend on the less convincing petrological evidences. Rickard (5) looked upon the monchiquites as part of the newer basalts. The monchiquites, however, are quite different from the newer basalt type, and are even more basic than the older basalt series.

The nearest petrographical allies are found in some limited ultra-basic lava flows in the Macedon district, e.g., King's Quarry type. Professor Skeats and Mr. Summers (11) have placed these flows near the top of Macedon series of tertiary igneous rocks. They have suggested the existence of a sub-alkaline magma beneath the whole of Victoria in tertiary times, and progressive differentiation from it has produced first the alkaline rocks and later the basic rocks. If this is correct and the King's Quarry type is a differentiation product from this magma, then the monchiquite dykes may well be its differentiation products also, because the monchiquite itself is a sub-alkaline rock. This analogy suggests that the monchiquites are of mid-kainozoic age.

Monchiquites are known to occur in a similar manner in other parts of Victoria.

Correlative evidence may therefore be produced in the future, but till then the balance of evidence, such as it is, leans towards the conclusion that these dykes were intruded in mid-kainozoic times.

Relation of the "Lavas" to the Gold Distribution.

Only a study over an extended period of time can throw much light on this question. Concrete cases, nowadays, of lavas in contact with rich gold-bearing stone are rare, and many such instances must be found and examined before the problem can be thoroughly discussed. Instances were probably not so rare during the earlier history of the field when all the development work was in the shallower levels, and it is more often the miner of the old days who asserts that the lava exerts an influence on the gold. There can be no doubt that such belief would be assisted by the presence of the lavas in centre country, and the lavas have been followed as guides to the unrecognised centre country. Such is obvious in mines like the Pearl, where drives in each successive level have been started on the lava.

My contribution to this question is the record of observations in the Ironbark Mine, Long Gully. Here, in sinking a winze in the centre country of the Sheepshead line from the end of a crosscut about 700 feet long at the 480-foot level, a lava was found to split into two branches, each about ten inches wide. The branches opened to about four feet, and then continued more or less parallel. The lavas are the dark, dense characteristic monchiquite, with streaks and segregations of olivine altered to serpentine. The enclosed space was filled with quartz. The winze was down twenty-seven feet at the time of my first visit, and the quartz across its full width showed galena, blende, and pyrite with just occasional colours of gold. Scattered through the milk-white quartz were dark fragments of the country rock, angular in shape, of all sizes, and with definite, unabsorbed boundaries found in fissure filled reefs. Between this reef and the dykes there is thoroughly brecciated material, consisting of pieces of slate, reef quartz and lava. Some of the quartz has lost the milky appearance and become vitreous, and there are greenish patches near the lava pieces coloured by the serpentinous material. This material is typical breccia, mineralised, and very rich in gold.

Pieces broken from right in the side of both lavas showed gold. Mr. Rogers, the manager, gave me a piece of the eastern of the two branches, showing a coarse shot of gold quite obviously detached from any quartz whatever. Examination with a pocket lens showed that the rock immediately around the gold was different from the main mass of monchiquite.

A thin slice of this rock, cut through visible gold a little distance from the one coarse shot, was prepared, and revealed the fact that the rock actually containing the gold itself was a piece of breccia set in the dyke material. The bulk of the gold is mixed with dark, opaque material, which looks decidedly carbonaceous. This dark patch also contains small pieces of a white micaceous mineral, calcite and slaty material. One fragment of gold is detached from the opaque material and set in a lump of fine sandstone, but has several veins of secondary calcite leading up to it. The whole is surrounded by fragments of micaceous slate and sandstone. These fragments have apparently been caught up by the lava in its intrusion, and cemented well into the lava during consolidation. The detached fragments of lava in the breccia indicate earth movements subsequent to the consolidation of the lava. These may have followed the consolidation immediately, resulting from the same rock stresses involved in the intrusion itself.

A thin slice (Plate I., Fig. 2) of another specimen of the contact material was prepared, cut transversely to the contact, and through visible gold. This section clearly shows crustification parallel to the direction of the lava. The gold in the hand specimen could be distinctly seen lying between crustified bands for a length of about four millimetres before the slice was cut. Under the microscope, pieces of slate, galena, and opaque material are seen between the crustified bands. Mixed with the opaque matter and also with the galena is gold. As before, the opaque matter looks decidedly carbonaceous. This crustification clearly shows that mineral-bearing siliceous and calcareous solutions have traversed the side of the lava, subsequent to the lava. The presence of carbonaceous material suggests that it was the precipitant of the gold.

Connected with this is the fact that the bulk of the gold is in the brecciated material, which would itself certainly provide the easiest passage for solutions. This is evidence which points to the conclusion that the gold is secondary, meaning by this that the gold is subsequent to the reef, that the gold has been deposited elsewhere first, from there removed, and re-deposited in this breccia, and that therefore there has been secondary enrichment in this particular spot.

A drive was opened to the south from this winze for about a hundred feet, and a second winze is being sunk. In this winze the lavas are six feet apart, but the whole of the space between is not filled with quartz. It is in part slate, and the reef, about three and a-half feet wide, pursues a wavy course downwards. Occasional colours of gold, I was informed, are seen throughout the reef, but the brecciated material seemed to be absent. The reef in this winze is not nearly so rich as the No. I. winze, and this erratic distribution supports the conclusion of secondary enrichment.

The lavas may influence the gold distribution in the following ways:

(1) The heat accompanying the intrusions may stimulate the flow of the underground solutions involved in the formation of the quartz reefs.

(2) The lava sheets may act as an impervious barrier to the transverse passage of such solutions.

(3) The lavas may form drainage channels for the vertical passage of such solutions.

(4) The dyke material may act as a precipitating agent to the gold carried by traversing solutions.

If the lavas are of the late geological date indicated by the petrological evidence, the first of these methods has had no effect on the primary deposition of the gold. Observations where the dykes cut through reefs at the deeper levels, as at 2300 feet in the Catherine Mine, Eaglehawk, and at 2600 feet in the Koch's Pioneer, Long Gully, are all negative, yielding no evidence of any influence on the gold distribution. Such influence would be noticeable, if anywhere, in the deepest levels, where the heat and stimulation would be greatest and it is becoming generally recognised that the deeper reefs are not so valuable as the shallower reefs.

If the second method operated, one would expect enrichment only on one side of a lava, cutting through a reef, and I have found no evidence in this direction.

The third method is one which I venture to suggest in explanation of the above Ironbark occurrence. The evidence points to the circulation of gold-bearing solutions subsequent to the reef, and to the lava. The evidence is not sufficient to decide whether the solutions came from above or below. Circulation of solutions may operate throughout the whole field, but for enrichment it is necessary that :—

(1) The solutions should traverse the dyke channel.

(2) The solutions should be gold-bearing.

(3 The solutions should meet material which will precipitate the gold.

Only where these three conditions meet will enrichment result. Enrichment will thus not necessarily result when a decomposed dyke meets a quartz reef or spur. If the enriching solutions are travelling downwards, enrichment is only likely in the shallower levels of any mine.

The fourth possible method is suggested by the example recorded by Mr. Dunn (2) in the Hercules and Energetic Mine, where a quartz spur cut through the dyke, and is rich in the dyke and poor on each side. No evidence has been produced to show how the dyke could possibly so operate.

In concluding this paper I should like to acknowledge the invaluable assistance of Mr. T. W. Ross, B.M.E., Assistant Inspector of Mines, in gaining for me access to the mines, and of Mr. H. S. Whitelaw and the members of his staff, and by no means least the unfailing courtesy of the mining managers. In the laboratory I have been much indebted to Professor Skeats and Mr. Summers, M.Sc. To Mr. H. S. Grayson I am especially indebted for the preparation and staining of rock slides.

Summary.

The dykes of the Bendigo goldfield are intruded into folded ordovician rocks. They form a parallel system with a parallelism coincident with the strike of the rocks. They occur along the course of each anticline, and in the mines are always approximately in the centre country. At the surface they are always decomposed and soft.

Specimens of fresh lava were obtained from several of the mines. These were examined, and one was analysed. The rock was found to be highly basic, and a member of the monchiquite group. The monchiquite was found to pass into camptonitic varieties at the Forbes Carshalton Mine, and at the Goldfields No. 1 shaft. A kersantite is recorded from the One Tree Hill Mine to the south-west of Bendigo.

The age of the rocks can only be determined by petrological analogy, and is considered to be probably mid-kainozoic.

The relation of the lavas to the distribution of the gold is discussed. Evidence has been obtained in the Ironbark Mine to suggest the secondary deposition of the gold. Gold is found more abundantly and irregularly in thoroughly brecciated material than in the adjoining

reef quartz. Some of this gold was examined microscopically in thin section, and was found to be in crustified bands along the side of the lava. Hence the lavas are believed to influence the deposition of gold only in so far as they provide drainage channels for the flow of secondary mineralising solutions.

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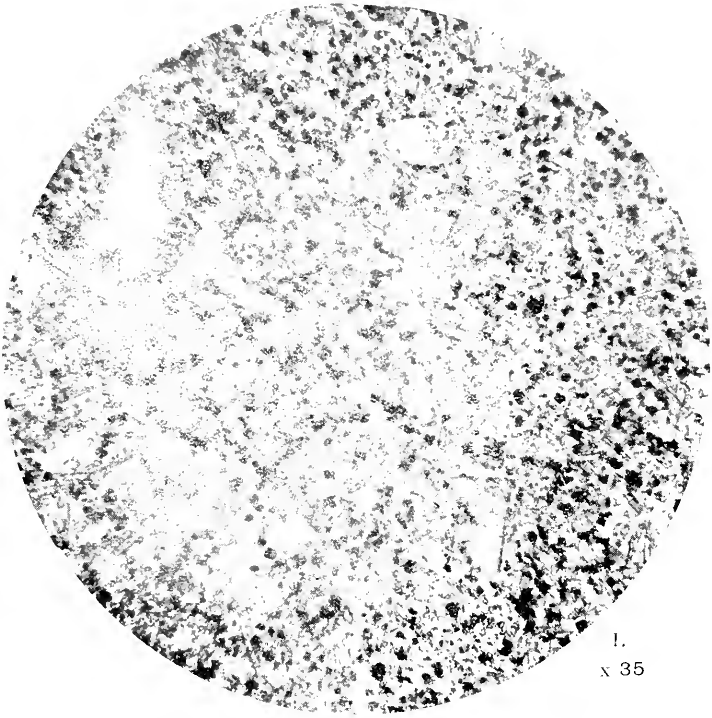
DESCRIPTION OF PLATE I.

Fig. 1. Monchiquite; 318-foot level, Central Red, White and Blue Mine, Bendigo. × 35.

Fig. 2.—Kersantite; One Tree Hill Mine, Bendigo. × 25.



I.
x 35

II.
x 25

[PROC. ROY. SOC. VICTORIA, 25 (N.S.), PT. I., 1912.

ART. II. *The Introduction and Spread of the Cattle Tick (Boophilus annulatus, var. microplus), and of the Associated Disease Tick Fever (Babesiasis) in Australia.*

BY J. A. GILRUTH, D.V.Sc., M.R.C.V.S., F.R.S.E.

[Read 14th March, 1912.]

Australia, although a large portion of its local area is situated within the tropical belt, is happily free from almost all those protozoan diseases which affect the domesticated animals in tropical regions elsewhere. For this she has to thank not quite so much the foresight of her administrators, as her insular position, the fact that no domesticated animal is indigenous, and above all, the fact that all her importations have been derived almost solely from the original home of her people, namely, Great Britain.

Nevertheless, there are at least two specific diseases present in Australia, both affecting cattle, and both the cause of considerable pecuniary loss to stockowners, either directly or indirectly, and these are diseases which are unknown amongst British stock. The diseases in question are "Tick Fever" or "Redwater" (*Babesiasis*) and the so-called "Worm Nodules," due to the parasite *Onchorcerca gibsoni*, which is dealt with in another paper.

Tick fever is not found all over Australia. It is rare in the southern States, and has not yet appeared far south of the tropical border. The evidence all points to its greater prevalence the further north stock are pastured.

Now, as the Australian tick fever is not present amongst the British herds which have formed the basis of our Australian herds, it is highly incumbent on us to ascertain exactly how it came to be introduced, or at least the most probable sources of introduction. But to do so one must first of all consider which countries are most likely to have been in a position to affect Australia in such a manner.

So far as I can gather there are no official records of stock importations ever having been made through any ports other than the main ports of the southern part of the continent and Queensland. At these ports there has been almost from the earliest days of settlement a more or less satisfactory system of inspection and quarantine, and the most cursory official examination could have hardly failed to detect the tick parasite, which is a necessary agent in the natural transmission of tick fever. Had its presence been overlooked in any instance, one is safe in concluding that it would have been heard of primarily in one of the southern districts. But we hear of its appearance first in the northern parts of the tropical regions, far away from known ports of cattle entry.

One is therefore impelled to the conclusion that the disease must have entered by way of the northern littoral, unless indeed it be assumed that the same tick parasite affects indigenously the native fauna, for which assumption there is absolutely no evidence. Irresistibly we are compelled to look to the countries lying north of Australia as the possible source of original infection.

The nearest territory whereon cattle are husbanded is the Dutch Indies. There we know that the tick is a common parasite among the native cattle, and that although these cattle exhibit a great natural immunity to the blood-parasite (*Babesia*), the true cause of tick fever, which is transmitted by the tick, yet imported non-immune cattle are very susceptible, at least in the Straits Settlements adjacent, and unless special precautions are adopted, are almost certain to succumb in considerable numbers. The same conditions obtain in other tropical countries lying farther north.

Our nearest neighbour has, therefore, this tropical disease of cattle. But we are separated from her by hundreds of miles of sea, communication is infrequent, and besides, there are no official records of the importation of cattle therefrom to Australia. If it can be shown that live cattle have been imported notwithstanding, the position becomes clear. If not, it seems obvious that other agencies must be looked for, and that if this disease has been introduced by unknown means, other and perhaps more to be dreaded tropical animal maladies may be introduced in the future; indeed, they may be at the present moment existing to some extent in our northern areas.

The buffalo naturally offered a possible solution. It is well known that the Governors of the British settlements at Melville Island and Port Essington (about 1826 and 1828) imported the mud or swamp-buffalo from Timor, and Johnston and Cleland have drawn attention to the fact that the Governor of the Port Essington settlement was also empowered to import cattle from the Netherlands Indies, though they could find no record of this having been done.

Since their introduction to Port Dundas by Sir Gordon Bremmer in 1824, the buffalo have spread all over Melville Island; and since their introduction to the mainland at Port Essington they have gradually spread southward along the swampy plains near the sea-coast to within a few miles of Port Darwin. A few have wandered inland, but chiefly bulls which have left the main herds, one or two being occasionally seen as far as the Roper and even the McArthur Rivers.

During my visit, thanks to the kindness of Mr. W. Lawrie, I had an opportunity of examining a number of fresh buffalo hides, besides a buffalo killed for my examination, and no ticks were detected thereon, although these animals were running on land where the cattle were badly tick-infested. Again in Melville Island I was enabled through the courtesy of Messrs. Robinson and Cooper to examine buffalo immediately after slaughter, and buffalo hides, and can testify to the freedom of these animals, at least at the time of my visit, from cattle ticks or other tick infection. This, it must be admitted, is in accordance with the experience of buffalo hunters generally.

Others, it is true, have assured me that they have actually seen the tick on the buffalo, and while not being in a position definitely to contradict these statements, I am inclined to the opinion that the large louse (*Haematopinus* sp.) which constantly affects these buffalo, may, in a cursory examination, have been mistaken for ticks; that they have been so confounded by some I am certain.

It should be here observed that about 1886, Indian buffalo (two cows and one bull) were brought to Port Darwin by the agency of the Government, with the intention of establishing the Ghi (or buffalo butter) industry. Some of the descendants of these buffalo may still be seen being employed as beasts of burden. They also are apparently tick-free, and in any case were introduced subsequent to the known appearance of redwater or tick fever in the north.

I think, therefore, the buffalo may be held guiltless of the charge of introducing the cattle disease in question, the chief reason being that to-day he is unaffected with the necessary skin parasite, even when grazing on the same land as badly-infected cattle.

The result of my enquiries, however, abolishes any necessity for assuming any other agent in the introduction than the live bovine animal itself. Through the kindness of Mr. J. Campbell, late Secretary of Agriculture, Sydney, I have been able to procure a copy of a despatch, being a report on the Port Essington Settlement, addressed to the British Government by Captain Everard Home, dated from H.M.S. "North Star," 19th April, 1843. Captain Home furnishes a description of the settlement at that date, and states, *inter alia*, "of stock they have one English cow and a bull, two Indian heifers and two cows, about 50 goats, and a few fowls. . . . There are besides 6 working oxen and 30 buffaloes and pigs, the property of the Government." That the descendants of these Indian cattle are still on the Coburg Peninsula is vouched for by Mr. E. O. Robinson, Mr. H. W. H. Stevens, Mr. R. J. Cooper, Mr. C. Freer, and others, who have traversed the country buffalo shooting, etc. The evidence is, however, that these cattle, unlike the buffalo, have not spread, and have never reached country occupied by station cattle. But that they would originally bring with them cattle ticks is almost undoubted.

Unfortunately at the time of my visit to Darwin there was no means enabling me to reach Port Essington, so that an examination of the descendants of the original cattle, interesting and important as such an examination would have been, was impossible.

But that this importation alone would not account for the spread of ticks through tropical Australia I am convinced, for the reason that the natural spread of ticks is by cattle, and rarely by other agencies. We may look to another and later importation of Brahma cattle as in all probability the true source of our trouble. Mr. H. W. H. Stevens, who was at that time connected with the British Australian Cable Company, informs me that in August, 1872, the settlement at Darwin, then Palmerston, being short of meat, the Company's vessel, the "Investigator," landed from Batavia twelve native cattle (eight cows and four bulls), and that some of these escaped. Some time after they were mustered by Mr. Stevens and taken to the Adelaide River, where they bred up to six or seven hundred head. This is confirmed by Mr. W. S. Stretton, Collector of Customs at Darwin, who was present at their landing, and who, in fact, afforded us the first definite information regarding this important fact. Furthermore, that Brahma cattle must at one time have been imported there I can personally testify, for on the Adelaide River I saw their crossbred descendants, amongst which was one old cow that might readily have passed as purebred Brahma. Mr. Lawrie, the owner of the station, very kindly had two of these crossbred Brahmas shot for me. They were well covered with ticks, and exhibited a large number of worm nodules, in the usual regions. As corroborative evidence incriminating this importation, what I have been able to ascertain regarding the appearance, and early spread of tick fever in the north is important. For this information I am largely indebted to Mr. Alfred Giles, who has been in the Territory for forty years, and has a diary covering the whole period, and to Mr. W. Lawrie, who has been for thirty years intimately connected with the live stock and meat trade, and to official records.

The first cattle to reach the northern part of the Territory were brought from Queensland overland *via* the Roper River in 1872 by Mr. D'Arcy Wentworth. The mob consisted of about 400 head, which were taken to the Peninsula opposite Port Darwin, and ultimately all slaughtered for beef. There is no evidence that any of these cattle were affected with redwater or other serious disease.

The next cattle to arrive was a mob of fat bullocks from the Macdonald Ranges, brought by Mr. T. Nelson in 1876, and owned by Mr. Abbott, a Port Darwin butcher. There is no history of redwater or ticks. Messrs. Giles arrived at the Katharine River in 1879 with 2000 cattle and 12,000 sheep for the purpose of stocking land acquired by the late Dr. W. J. Brown, of Adelaide. At that time both ticks and redwater were unknown in that district.

Redwater first apears to have been noted at Glencoe, distant 104 miles from Darwin by rail, about the years 1880-1. About this time a mob of cattle arrived at Glencoe from Queensland, and a large percentage soon succumbed to redwater. Mr. Lawrie bought a number to take to Port Darwin, but 50 per cent. died before reaching there. Subsequent arrivals at Glencoe experienced a like mortality. Gradually the disease and the ticks spread southward. About 1886, 150 head of cattle arrived from Newcastle Waters, at Katharine, where delivery was taken by Mr. A. Giles, who was to travel them north. Between there and Glencoe nearly 50 per cent. died from redwater. By 1887 the disease had spread to the Roper River, and by 1890 to the McArthur, being manifested chiefly, if not solely, in cattle travelling through from Queensland.

In the official reports presented to the South Australian Parliament from the Northern Territory, the earliest mention of redwater is in that of the Resident dated 1st January, 1886 which contains the statement that "of 3000 Wave Hill cattle passed to the westward, hundreds died of redwater." In the report of 1st July, 1886, these losses are again referred to, and also in some notes by Mr. A. Giles, then resident at Springvale, near the Katharine Station, who states that ticks on cattle and horses appeared here for the first time in any number this season, arguing a recent invasion of the district. In the report of 1st January, 1887, redwater is definitely referred to as a "serious disease." That its prevalence had previously been well known to settlers is indicated by a statement in the first report of a stock inspector, who stated that redwater "continues to be the *bête noir* of drovers from Queensland *via* the Roper River." Henceforth the disease assumes an increasing importance in these official reports for several years. In that of January, 1899, considerable space is devoted to its ravages, and Mr. H. W. H. Stevens affords some valuable information: "The first cattle that I know of to show redwater were Mr. C. B. Fisher's mobs that came along the Roper during the dry weather. . . . Out of 1700 we took delivery of in August, 1882, fully 400 died on arrival on the Glencoe run." He then fixes the locality where the trouble begins as "from the junction of the Hodgson River with the Roper River along the Roper west and north-west as far as its head, and in the neighbourhood of the King and Katharine Rivers for a few miles." He mentions three mobs from different parts, Gregory Downs, Queensland, Limmen Bight, Northern Territory, and Newcastle Waters, Northern Territory, which suffered a loss of from 20 to 30 per cent. from passing through the infected country. Yet Mr. A. Giles, then at Springvale on the Katharine, states the disease in cattle is unknown there, a position quite easily understood in the light of present-day knowledge.

In the next official report, 1890, the significant statement occurs: "It is generally stated that redwater (so-called) does not attack acclimatised or Territory-bred cattle." The chief complaint throughout is that overlanded cattle travelling from Queensland especially, alone exhibit the symptoms of the disease, and die therefrom. To-day, when the full nature of the disease is understood, these circumstances are not at all surprising. By 1891 the report shows that cattle coming from Queensland generally become affected between the McArthur and Roper Rivers, which proves that the disease was gradually spreading backwards towards the Queensland border along the stock routes.

It must be remembered that at this time, and, indeed, prior to the publication by Smith and Kilborne in 1893 of the records of their exhaustive experiments, the relationship between redwater and ticks was not appreciated. It will be understood therefore that the spread of the visible parasite, the tick, was not associated in the public mind with the specific and deadly disease redwater. Ticks always appear in a new district for some time before there is any definite occurrence of the disease redwater, and indeed their multiplication may be so gradual that, beyond "tick worry," especially where the land is sparsely stocked, as in the Northern Territory, the majority may become gradually immune to the specific blood parasite, the actual cause of redwater, conveyed by the tick.

That ticks and consequently the disease redwater or tick fever originally reached Queensland from the Northern Territory, the reports of the officers of the Queensland Department of Agriculture leave no doubt. About 1894 Mr. C. J. Pound, Government Bacteriologist, was commissioned by the Government to visit the Gulf district, and report on the so-called "redwater" disease, which was just then commencing to devastate some of the station herds.

From the exhaustive enquiries made by Mr. Pound, he arrived at the conclusion that the disease was introduced into the Gulf country from the Northern Territory by cattle tick-infested, but themselves redwater immune, brought to Queensland as the result of the establishment of boiling-down works at Burketown and Normanton. (Queensland Agricultural Journal, June, 1907, Vol. XVIII., pt. 6, p. 283.)

The whole of the evidence which I have been able to secure from official and private sources, although varying slightly in detail, as is to be expected, points to the gradual advancement of the disease redwater, which we know to-day to be tick-borne, and tick-borne only, from the point of its original and earliest appearance Glencoe Station, some hundred miles south of Darwin. This is exactly what might now be assumed *a priori* would happen given the introduction of ticks by the Brahma cattle, which were turned out near Port Darwin in 1872. They were taken to the Adelaide River, where they rapidly multiplied.

During the wet summer months when the lowlying coastal lands are swampy, some, if not all, would seek higher and drier grazing lands inland. Being unable to cross the Adelaide, they would keep to the left bank, some in straying would ultimately reach and mingle with the nearest station cattle at the time, which would be those of Glencoe. Thus they would gradually, but surely, carry the ticks, and so infest the land with the eggs and larvae. These larvae, though by virtue of gradual infection of station cattle they might not seriously affect them with the blood parasite, would almost certainly seriously affect fresh non-immune arrivals that would suddenly be attacked by numbers of the skin parasites, and thus the appearance of redwater amongst the Queensland cattle reaching Glencoe about 1880-1881 seems sufficiently accounted for. Not all these cattle would succumb to the fever. Many would be but slightly affected; others would recover, though possibly be left as useless. Such travelled cattle, when they leave the mob, naturally tend to return over the route they have traversed, and seek their original home. In this way the tendency would be for the ticks to become carried further inland and backwards gradually towards the Queensland border, as we see was the case. The whole evidence, although circumstantial, incriminates the importation of Asiatic cattle by the British-Australian Telegraph Company in 1872 as the actual agent of the introduction of ticks (*Boophilus annulatus* var. *microplus*) and tick fever (*Babesiasis*) to Australia. As against the likelihood of the Cable Company's importation of Batavian cattle having introduced ticks, I must quote Mr. H. W. H. Stevens's assurance that during the voyage these cattle were daily washed with sea-water, and that no ticks were observed on them during the voyage and on their arrival. This may be so, but so far as the sea-water baths are concerned they would not destroy living ticks, judging by experience of the application of much more potent solutions, and everyone with experience of these parasites knows how easy it is to overlook them when but comparatively few are present. Writing me in regard to this subject, Mr. Stevens states: "Although there was a small mob of English cattle depastured at the Jungle 12 miles from Darwin, belonging to the Government, I never heard any reference to ticks, nor did I see them on these cattle up to the year 1875. We had also milch cows and other stock in the settlement, but it was not until some years later, say 1880, that any trouble from tick was experienced." This is additional proof that ticks were not originally in the Territory. Such cattle were not mixed with the Brahmas, and probably the infection reached Darwin itself by a circuitous route from the native herd on the Adelaide River.

Briefly my reasons for suspecting this importation of cattle as the introducers of ticks and redwater to Australia are as follows:—

1. All cattle in the Dutch Indies are more or less affected with ticks, although naturally immune to redwater.

2. This is the only importation of native Eastern cattle which have been able to cross with station cattle.

3. These cattle we know travelled inland as far as the Adelaide River.

4. It is more than likely some of their progeny would gradually reach from there the main stock route from the South to Darwin.

5. This point would be somewhere about Glencoe.

6. At Glencoe about eight years after the introduction of these Eastern cattle, redwater as an epidemic and serious disease first appeared in Australia.

7. The disease redwater only affected travelling non-immune cattle on reaching Glencoe.

8. The evidence strongly points to the gradual spread of ticks and redwater to other parts of the continent along the stock routes from this point, by cattle which had been sick and recovered, tending to travel backwards in the direction of their original home, and in this way disseminating the ticks.

[Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. I., 1912.]

Art. III.—*Further Observations on Onchocerca gibsoni, the Cause of Worm-nodules in Cattle.*

By J. A. GILRUTH, D.V.Sc., M.R.C.V.S., &c.,

AND

GEORGINA SWEET, D.Sc.

[Read 14th March, 1912.]

Since the publication last year by the Commonwealth of Australia of our previous paper on *Onchocerca gibsoni*, several lines of external evidence have become available, bearing on the original home and host, the history of its occurrence and geographical distribution in Australia, and the means of transmission of this parasite, etc., so that it seems desirable that the information should be made public, together with a record of the results of series of experiments undertaken to elucidate the life history.

Historical.

Evidence obtained by J.A.G. during the late expedition to the Northern Territory most strongly corroborates previous statements by others and ourselves that there is a gradually increasing extent of infection by *Onchocerca gibsoni*, the further north the cattle are reared: that is, the further away from the ordinary ports of stock introduction in the south and east. From the information available at the time of their writing (1910, p. 99) Doctors Cleland and Johnston considered that the buffalo, imported into Australia from Timor in 1826-8, was the originating host, though, as shown by ourselves later (1911, pp. 2 and 34), it was at least highly likely that the Timor cattle imported about 1824 and 1840 into the Port Essington settlement were the true original hosts. However, an opportunity was available to J.A.G. of examining a number of buffalo, the descendants of those introduced by Sir Gordon Bremmer in 1824 to Port Dundas, and later to the mainland. These have spread from Port Essington southwards over the swampy plains to very near Port Darwin. These buffalo, so far as his experience goes, are all unaffected with *Onchocerca*, but all the cattle depastured on the same country are more or less affected—indeed, the greatest extent of infection yet seen was in a steer killed at Port Darwin, the region of the brisket showing at least a hundred nodules—so that, although experience is limited as regards the buffalo, it seems almost certain that had the buffalo imported at the early dates given above been the original and natural hosts, their descendants would be at least as badly affected as the cattle, if not more affected. Were these "worm nodules" at all prevalent in buffaloes, it is certain their presence would be known to some of the buffalo hunters, who invariably remove the briskets along with other parts of the flesh for food. During the past 30 years 100,000 buffalo hides have been exported from Darwin, so that it is unreasonable to suppose that the parasitic nodules would have been entirely overlooked in all these animals. Certainly the Indian Ghi buffalo, imported about 1886 by the South Australian Government to Port Darwin itself, cannot be responsible for the original introduction of this parasite to Australia, for even were these nodules known in them, such nodules had been discovered in Australian cattle long before this. Further enquiries, however, elicited the fact that cattle have been imported from a different source altogether. Captain Everard Home, writing from H.M.S. "North Star," 19th April, 1843, reported to the British Government in a despatch on the Port Essington Settlement, among other things, that there were at that date "1 English cow and a bull, and 2 Indian heifers and 2 cows, . . . besides 6 working oxen and 30 buffaloes." Further, numbers of careful observers among those who hunt buffalo on the Coburg Peninsula are positive that the descendants of these Indian cattle are still there, though, unlike the buffalo, they have not spread across the swampy plains down to the cattle station country. But it seems at least highly probable that they were responsible for the introduction of *Onchocerca*, not only from a comparison of the date of their entry, and that of the discovery of the nodules in Australian cattle, and the wide distribution of the parasite, but also in the light of a well-considered statement by Mr. S. L. Symonds, Government Veterinarian of the Federated Malay States, that the only animal in which he has ever found the *Onchocerca* nodules in those States was an old Indian bullock, the native animals and the buffalo being free.

It must be realised, however, that, if the intermediate host of *Onchocerca gibsoni* be a tick, as some have suggested, or a louse, as we ourselves suggested, and considered very probable from general evidence in our previous paper, since these ecto-parasites can only be conveyed any distance by means of their hosts, the ancestors of the Indian cattle now on the Coburg Peninsula could not be incriminated, for, as already stated, these cattle have never become mixed with the station herds. Assuming, however, some blood-sucking insect such as a biting fly to be the intermediary host, then the possibilities of transference over considerable distances must be admitted. A thorough investigation of the descendants of the Indian and British cattle now on Coburg Peninsula will therefore prove extremely interesting, and it was a matter of great regret that owing to absence of transport, it was impossible to make such an examination as was intended. It is hoped, however, that at an early date such an opportunity may present itself to test the infection or otherwise of these Indian and British cattle. In view of the statement recently made to us by Dr. de Blieck, Director of the Veterinary Laboratory and Veterinary School at Buitenzorg (Java), that tumours similar to those of *Onchocerca gibsoni* are quite common in Java cattle, it may yet be found that our original inference was correct, viz., that the Timor cattle, introduced some time between 1824 and 1840 into Port Essington, were the responsible agents of introduction.

The importation of Javan native cattle to Port Darwin in 1872 which, as is shown elsewhere, is considered to have been the source of the introduction of the cattle tick (*Boophilus annulatus* var. *microplus*) and of tick fever, may also have introduced the "worm-nodules," yet they could hardly have been the first source of introduction, seeing we have circumstantial evidence of the appearance of these nodules in Queensland at least 40 years ago. It may be noted, however, that the crossbred descendants of those Brahma cattle, when examined, all show more or less *Onchocerca* infection.

General Characters of the Nodules.

In some animals recently examined *post mortem*, the proportion of nodules situated in the deep pectoral muscles was much less than had previously been noted, while in the thigh they were very few in number, and then were situated close alongside the head of the femur. In each case they were more numerous on the right side than on the left. Two cases are here given of two cows from the same district in North Queensland, and kept here under exactly similar conditions (*vide infra*) for 6 and 8 months respectively, B having been killed two months later than A.

	A (5 year old cow).	B (3 year old cow).
Total number of nodules - -	47 (19L, 28R)	15 (6L, 9R)
Number of nodules in thigh - -	0	3 (1L, 2R)
Number of nodules containing eggs and living larvae - - -	22	4
Number of nodules containing intraparasitic parasites - -	10	4
Number of nodules degenerate -	15	11

The proportion of nodules in B, containing degenerate parasites, is more typical than in A, and undoubtedly a marked diminution in size of the nodules took place during the months the cows were under constant observation, as determined by frequent manipulation.

We have previously noted the fact that amongst the large number of nodules which we have examined, the female parasite was either in a stage of complete development liberating living larvae, or the nodules contained degenerated parasites; in other words, no immature parasite has ever been found in a nodule. With these two cows for a period of 6 and 8 months there was absolutely no possibility of reinfection. Many of the nodules could be felt under the skin, and as a number of these subcutaneous nodules were found *post mortem* to contain living *Onchocerca* liberating living larvae, it must be assumed that they had been continuously liberating such larvae during the whole period, for as the male lies continuously alongside the female, there is probably continuous fertilisation of the latter.

We have in the previous paper indicated the probability that infection of the bovine takes place during its early years (1st and 2nd) alone. Corroboration of this was obtained by J.A.G. and Dr. Breinl when in the Northern Territory; on one station, the station on which the steer with a hundred nodules had been bred and fattened, an opportunity was obtained of carefully examining two very old bullocks. In one, only one small nodule, and that containing a living parasite, could be discovered; in the other, a few small, circumscribed, thin, circular or oval dense fibrous masses about $\frac{1}{2}$ to $\frac{3}{4}$ inch were found adhering firmly to the muscular fascia. Section showed a calcareous centre. Judging from the invariable infection with living *Onchocerca* of younger cattle on this station, two conclusions seem fairly obvious—1st, there is little, if any, reinfection after a certain age; and 2nd, the tendency is for the nodules to become greatly diminished and ultimately disappear.

Intermediary Host.

As indicated in our previous communication there are several possibilities with regard to the intermediate host, which we have already shown must be present, though, as there stated, the evidence then available appeared to point to a biting insect, and especially the louse, as being the responsible agent.

Since then, experiments at that time in progress have been completed, the investigations in the Northern Territory above referred to have been made, and several other series of experiments have been carried out with the object of testing conclusively whether the infection may be brought about by direct contact, by intermediation of the soil, or by either of the lice normal to the cow, and as to whether perchance an adult worm or the larvae may leave a nodule and infect the same or other animal, thus rendering an intermediary host unnecessary.

1.—*Direct Infection.*

To test so far as possible whether any intermediate host be necessary, a well-formed nodule containing a living parasite was removed from a cow containing a fair number of nodules, and transplanted, under all proper conditions of asepsis, etc., to the subcutaneous tissue behind the shoulder of a calf born and reared at the Institute. Eight months later this animal was killed. The nodule was found firmly adherent to the skin, flattened and somewhat smaller in diameter than previously, and surrounded by an intimate capsule of diffuse new connective tissue, which covered it so effectually that it would have been quite overlooked had not the exact spot of the transplantation been known. The parasite was dead, and calcified in pinhead areas. Evidently, therefore, as might be expected, the parasite will not live in other than the individual host in which it has developed, and probably cannot leave the nodule once the latter is formed, and so re-infect the same animal or pass out and infect another. Also, the larvae from this living nodule had every opportunity and sufficient time to infect the new host, and to form nodules, since well-formed nodules have been found in 6-8 months old calves, so that any possibility of direct infection without the intermediation of another host is negatived, as one would have expected.

2. *Intermediation of Soil.*

A quantity of earth from a cow-yard in North Queensland, wherein badly infected cows rested every night, was imported here. It was examined very carefully for any sign of larvae or adult *Onchocerca*, both before and after moistening, and after incubating for some days, with negative results.

The soil was spread evenly over a deep layer of ordinary soil in a pen in which a young locally-bred calf was placed. The pen was a warm one, and the soil was kept moist for some time after deposition. Seven months afterwards, the calf was killed and most carefully examined, and showed no trace of nodules, or of adult parasites in any part of the body, or of larvae either in the blood or in the subcutaneous areolar tissue, glands, muscles, or intermuscular tissue of the brisket; so that, at all events in this case, where all the conditions were as favourable as they could possibly be, infection by intermediation of the soil alone, is absolutely negatived.

3.—*Intermediation of the Louse and Infection by Direct Contact.*

A calf referred to in the previous paper, to which lice had been artificially transferred after being allowed to feed on a restricted area inoculated with numerous larvae, died some nine months after transference of the lice, but showed no sign of nodules either in the brisket or on the thigh, and no filarial parasites at all.

Two cows, each containing a considerable number of nodules, were imported to Melbourne from North Queensland, and placed in two separate pens. They were examined very carefully at different times on and after arrival for ectoparasites, with negative results. A locally-bred 6-months-old calf was placed with each cow, each calf carrying numbers of *Trichodectes scalaris* (*Haematopinus vituli* and *H. eurysternus* not being then available), these being also found later on the cows. A large number of *H. vituli* and some *H. eurysternus*, and a large quantity of their eggs were later placed on each cow, especially just over the nodule region. Large numbers of each kind of louse were examined for larvae up to and about 5 weeks after they had been placed on the cows, and at intervals later, but always with negative results. That the worms in some at least of the nodules were living was shown on arrival by excision of one of a large group lying under the skin, living larvae and eggs being numerous. The blood of the animal was examined during the operation, but no larvae could be detected. Nor were any larvae or intraparasitic parasites found in the sediment in saline fluid in which this living nodule had been kept at blood heat for some time.

Fluid aspirated after several blisterings in various ways, was examined at different times after the oedema had been produced, both on the same day and on the succeeding day, but in no case were larvae to be found.

Further numerous examinations were made of the blood at all hours of the day and night for larvae, but none could be found even after considerable quantities had been centrifuged, and a very large number of smears, both thick and thin, examined in many ways.

It is well to remember that embryos of *Onchocerca volvulus*, which forms similar subcutaneous tumours in natives in West Africa, have not yet been found in the blood of infected natives; as Brumpt (p. 457) very naturally suggests, they may in that case pass into the blood intermittently, or at certain times when the patient has not been examined.

As stated above, we (and we believe others also) have made exhaustive examinations at all hours of the day and night. There is, however, one possibility. Lingard (p. 22) has found in the blood of horses in India, affected by *Filaria equina* (?) and *Filaria* sp., that comparatively few embryos are present in the blood between July and September, and may be even absent after that date. They were more numerous between December and June, being most generally present from April to September, during the hot and rainy seasons. This supports the suggestion we have already made to the effect that a seasonal periodicity may be found in *O. gibsoni*.

After an interval of 5 months, the calf in one of the pens mentioned above was killed (as the result of an accident), and showed no sign of *Onchocerca* anywhere. Two months later the other calf, which had been in habitual contact with the second cow, was killed, and also showed no evidence of either free *Onchocerca* or of nodules.

From these experiments, therefore, one may infer that neither direct contact nor apparently the intermediation of *Haematopinus vituli* or *H. eurysternus* or *Trichodectes scalaris* (though this latter would hardly be expected to act as such an agent) can act as a means of transmission of *Onchocerca gibsoni.*

This apparent failure of direct contact and of the louse to act as intermediary agencies in the spread of *O. gibsoni* is extremely interesting in the light of what has been stated earlier in this paper concerning probable introduction of the parasite in Indian cattle, since as there stated, distribution from the Indian cattle originally introduced, if they were the original hosts, could hardly have taken place other than through the agency of a flying and biting insect, though there are, as pointed out in our previous paper (p. 27) several difficulties in respect to this means of transmission.

As regards the apparent absence of embryos from the blood, and the suggested impossibility of transmission therefore by a blood-sucking insect, we may note that Brumpt (p. 457) does not hesitate to suggest in the exactly similar case of *O. volvulus* that a specific fly *Glossina palpalis* is the distributing agent.

It may be remarked that proof of the intermediation of any flying insect will be impossible without rigorous methods of experimentation, and even then will be extremely difficult. So numerous are the native animals, birds and marsupials, carrying microfilaria in their blood-streams, that only insects bred in a laboratory can be used, and they must be forms belonging to the North of Australia, since those found in the southern States are possibly impotent in this respect, while for this and other reasons, including climatic conditions, the experiments must be done in the North, with cattle bred preferably in Tasmania, so as to avoid all possible infection previous to experimentation. The practicability of, and arrangements for, experiments along these lines are now under consideration, and facilities for the same have been asked for from the Federal Government.

From the scientific point of view it is undoubtedly true that complete proof as to the intermediate host would be valuable, but from the practical point of view, we do not anticipate that the results would be of any material value. We have shown that every probability points to the intermediary host being a fly; we have also shown previously that in the northern parts of Australia all cattle are more or less affected. When one reflects, therefore, that over the greater part of Northern Australia where worm-nodules are prevalent there are no fences, that the cattle on the average do not nearly number 1 per 100 acres (often over large areas not 1 per 1000 acres), and the impossibility of coping effectually with tick fever in such countries, where the intermediary host, the tick, is well known and cannot fly, the remoteness of practical means of prevention is evident.

In contradiction, it may be urged that certain biting insects have been eliminated from certain districts in the world; but these have been insects restricted to certain habitats such as watercourses, etc., and we have previously shown that cattle from the driest areas are often as seriously affected as cattle from wet districts, and that even areas chiefly supplied by artesian water, are not by any means immune. Nor so far as is yet determined by the evidence available at freezing works, etc., is there any natural circumstance other than latitude, which specially favours infection.

This does not mean that we suggest that scientific investigation should be discontinued, but that the stockowner and exporter can hardly expect an extermination of the parasite.

We desire to thank Dr. W. Stapley, Mr. Norman MacDonald, and Mr. H. R. Seddon, all of the Melbourne University Veterinary Institute, for their assistance at various times in the above experiments.

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Art. IV.—*Australian and Tasmanian Coleoptera Inhabiting or Resorting to the Nests of Ants, Bees and Termites.*

SUPPLEMENT.

By ARTHUR M. LEA.

(With Plate II.)

[Read 11th April, 1912.

Probably at no period in Australia has so much attention been paid to insects, occurring in the nests of ants, as during the last five years. The result has been that new and remarkable forms have been obtained in abundance. But, as immense districts of Australia have never been explored for insects of any kind, it is certain that large numbers remain to be discovered, and probably the numbers of insects now known to occur in the nests of ants will be more than quadrupled.

The fact that I am now able to add eight new species of *Chlamydopsis*, of which six were certainly taken since the paper of which the present one is a supplement was read (July, 1910), is sufficiently indicative of the perseverance with which these anomalous beetles have been looked for.

It is also a curious fact that (at any rate in the temperate parts of Australia) the guests are more numerous in the cooler parts of the year, and some completely disappear during the summer months, when the ants themselves are more active. This fact may have something to do with the paucity of specimens taken by collectors whose holidays are usually of the briefest during the spring and autumn months.

An asterisk * is prefixed to species previously noted.

Ants.

Additional species of ants now known to act as hosts of beetles are:—

Acantholepis Froggatti, Forel.
Camponotus claripes, Mayr.
Ectatomma Mayri, Forel.
Iridomyrmex itinerans, Lowne.
Odontomachus coriarius, Mayr.
Orectognathus antennatus, Smith.
Polyrhachis ammon, Fabr.
Polyrhachis hexacantha, Er.
Stenamma longiceps, Smith.

Ponera lutea, Mayr.

Ectatomma socialis, Macl.

There are before me four, evidently co-type specimens, of an ant from Mr. Masters's collection; they were placed with four specimens of the beetle *Tmesiphorus formicinus*, and labelled Mundarlo, with the name *Ectatomma socialis*, the original collector and the original locality. The name is, as I previously suspected, a synonym of *Ponera lutea*.

Iridomyrmex glaber, Mayr.

I received this name from the Department of Agriculture at Washington for the species previously referred to as *Colobopsis Gasseri*. I have not been able as yet to check the names of ants with the original descriptions, although I hope to do this later, meanwhile having to take the names on trust. The species is an important one from a coleopterist's point of view, as it is common, widely distributed, and the host of many species of beetles.[1]

The true *C. Gasseri*, I am now given to understand, is a rather scarce species, having its nests in old fences, stumps and hollow trees, and from whose nests I have never taken an inquiline of any sort. Nor is it even close in appearance to *I. glaber*.

Previously the name *I. glaber* was received for a moderately common species from New South Wales, with long and fairly numerous setæ scattered about. The name struck me as a most inappropriate one, but it appears now that the identification was incorrect.

Carabidae.

Nototarus australis, Chaud.

In his catalogue Wasmann records this species as from ants' nests.

**Philophlaeus myrmecophilus*, n.sp. (Plate II., Fig. 1.)

♂. Reddish-flavous, appendages and elytral vittae somewhat paler; elytra piceous, the margins narrowly paler, each with a longitudinal vitta commencing near the base and extending to about one-fifth from apex; pygidium and sides of under surface more or less piceous. Lightly clothed with short and somewhat golden pubescence, sparser on head and on middle of prothorax and of under surface than elsewhere; with a few setiferous punctures.

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1 The species previously listed as occurring with this species of ant are: *Falagria Fauveli*, p. 122; *Polylobus colobopsis*, p. 128; *P. intrepidus*, p 129; *Dabrosoma pubescens*, p. 135, *Ctenisophus morosus*, p. 155; *C. impressus*, p. 155; *Articerus auriflous* p. 164; *A. curvicornis*; p. 165; *Scydaemnus colobopsis*, p. 181; *S. Dareyi*, p. 182; *Anisotoma myrmecophila*, p. 189; *Rodwayia minuta*, p. 196; *R. orientalis*, p. 196; *Bothrideres tibialis*, p. 210; *Anthicus glaber*, p. 225.

Head moderately large, with moderately dense and somewhat rough but not large punctures, much smaller about base than elsewhere, with a setiferous puncture at the side of, and another just behind each eye. Antennae extending to about basal third of elytra. *Prothorax* about twice as wide as long, apex regularly and fairly strongly emarginate; front angles strongly, the hind ones widely and evenly rounded; median line distinct to apex, but interrupted and terminated before base; sides rather widely flattened, with three setiferous punctures, of which the median one is distinctly nearer the subapical than the subbasal one; disc feebly transversely wrinkled, and with a setiferous puncture on each side; with small punctures scattered about, but rather dense and irregular where the margins begin. *Scutellum* subtriangular, with moderately dense punctures. *Elytra* at base wider than widest part of elytra; sides gently rounded and dilated to beyond the middle; with distinct but not deeply impressed striae, the interstices of somewhat uneven widths, and with dense clearly defined punctures, third with four larger setiferous punctures, ninth (the marginal interstice) with an almost regular row of larger punctures. *Pygidium* with dense but somewhat irregular punctures. *Under surface* with rather sparse punctures. *Legs* not very long, front tarsi with three basal joints densely clothed on lower surface, the fourth less noticeably so, middle tarsi with basal joint rather densely clothed about apex. Length 8 mm.

Hab.—Tasmania: Sheffield, Chudleigh, from nests of *Iridomyrmex glaber* (A. M. Lea).

In size and appearance much like *quadripennis* and *Sydneyensis*, but prothorax with emargination of apex more even, and basal angles completely rounded off.

On each elytron, the vitta at the base is confined to the fifth interstice; it immediately dilates so as to include the fourth, at about the basal third it extends to part of the third and sixth, at about the middle it occupies only the third and fourth, and it then contracts so that at its apex it is only on part of the third.

Although not described, a specimen of this species was previously noted (these Proceedings, 1910, p. 122) as having been taken from an ant nest; as since then I have taken another specimen in the same way, it is to be presumed that the species naturally occurs with ants.

Adelotopus ipsoides, Westw.

On sending a specimen of this species from Geelong Mr. Davey wrote:—"Recently I opened an old established nest of *Iridomyrmex nitidus*, and it contained a fair number of this species; they were quite covered by the ants, but they did not appear to be eating them."

Adelotopus scolytides, Newm.

A specimen of this species was recently taken at Rhyndaston (Tasmadia) from a nest of *Iridomyrmex glaber*. The beetle was completely covered by a mass of ants, but the ants were not attacking it.

Illaphanus Stephensi, Macl.

Mr. Davey sent a specimen of this species as from a nest of an *Iridomyrmex* at Panmure (Victoria). I had myself taken specimens from under a stone amongst ants,[1] but thought they were there by accident. This, however, was probably not the case. Mr. Davey, on being written to for information as to how he captured his specimen, wrote: "The *Illaphanus* was crawling along a drive with the ants when I took it."

I have recently taken two specimens of the species, under a stone, close to a nest of *Pheidole Tasmaniensis* at Dunorlan (Tasmania)[2] and another at the side of a nest of a species of *Monomorium* at Spreyton, and another at the side of the nest of a jumper ant (*Myrmecia*) at Evandale Junction.

Illaphanus Macleayi, Lea.

The types of this species were taken under a stone that covered a nest of *Orectognathus antennatus*. At the time it was considered that they were only casually with the ants, but this may not have been the case.

Staphylinidae.

Polylobus piceosobrinus, n.sp.

Piceous; prothorax and abdomen obscurely paler; legs, palpi and base of antennae flavous. With rather dense and very fine pubescence, longer on abdomen than elsewhere.

Head rather rounded; eyes scarcely projecting. Antennae extending to base of prothorax, lightly inflated towards apex, third to tenth joints transverse, eleventh conical, about as long as three preceding combined. *Prothorax* moderately transverse, front angles strongly rounded, sides thence oblique to base, which is gently rounded; with minute punctures. *Elytra* about once and one-third the width of prothorax, sides feebly, but shoulders strongly rounded, sides about one-fourth longer than suture; with dense minute punctures. *Abdomen* feebly decreasing in width to apical third, thence strongly to apex. Length, $1\frac{1}{2}$, to apex of elytra $\frac{3}{4}$ mm.

1 A small black species, from memory either *Iridomyrmex glaber*, or another species of *Iridomyrmex*.

2 It is now first recorded from Tasmania.

Hab.—Victoria: Geelong, from a nest of *Ectatomma metallicum* (H. W. Davey).

The prothorax is dark, but not black, but regarding it as such it differs from *colobopsis* in having the head small, the prothorax with sides oblique to base instead of rounded and antennae longer, etc. Regarding the upper surface as not entirely black, it would be associated with *Tasmaniensis*, from which it differs in having the prothorax less transverse and darker, and the abdomen not paler at the base than in the middle.

Polylobus brachypterus, n.sp.

Of a rather dingy flavous, head and fifth and part of sixth abdominal segments infuscated. With very fine and short pubescence.

Depressed. *Head* rather longer and less rounded than usual, with small punctures. Antennae lightly incrassated, extending to base of prothorax; third to tenth joints transverse, eleventh subconical, scarcely longer than two preceding combined. *Prothorax* very little wider than long, angles rather strongly rounded, sides and base feebly rounded; punctures indstinct. *Elytra* no longer than prothorax and scarcely wider; punctures indistinct. *Abdomen* parallel-sided to apex of sixth segment. Length, $1\frac{1}{2}$, to apex of elytra $\frac{3}{4}$ mm.

Hab.—Tasmania: Evandale Junction, from a nest of *Pheidole conflicta* (A. M. Lea).

A thin pale species, with exceptionally short elytra, that appear too small to cover wings. Although the colours are somewhat as in *pallidominor*, the species is very distinct from that one, being narrower, prothorax less transverse, elytra much smaller, abdomen parallel-sided to apical segment, antennae slightly stouter, etc.

A specimen from Bagdad, from a nest of *Ectatomma metallicum*, probably belongs to this species, but is rather paler (perhaps from immaturity) and smaller.

Polylobus tenuis, n.sp.

Of a rather dingy flavous: head, antennae (base excepted) and elytra flavous brown; fourth, fifth and part of sixth abdominal segments darker, sometimes almost black. With very fine, short, pale pubescence.

Head rounded, punctures very indistinct, eyes moderately prominent. Antennae passing base of prothorax; first joint moderately long, but slightly shorter than second and third combined, these subequal, fourth to tenth transverse, eleventh subconical, as long as two preceding combined. *Prothorax* moderately transverse, sides and base rather strongly rounded; punctures very minute. *Elytra* lightly transverse, scarcely wider than widest part of prothorax, and very little longer, sides straight and slightly longer than suture; punctures dense and very small. *Abdomen* long, thin and parallel-sided to apex of sixth segment. Length, 3, to apex of elytra 1; variation in length, 2½—3 mm.

Hab.—Tasmania: Railton (from nests of *Ectatomma metallicum* and *Iridomyrmex glaber*), Stanley (in tussocks at summit of "Nut"), Hobart (in tussocks and fallen leaves), Mount Wellington, Parattah, Launceston, Stonor (A. M. Lea), Victoria, Geelong (from a nest of *Iridomyrmex nitidus*), (H. W. Davey); New South Wales: Glenfield (from a nest of *E. metallicum*), National Park (amongst rotting leaves), Tamworth (Lea).

A narrow shining species, in general appearance close to *Homalota chariessa*, but prothorax without the "four large punctures just before the middle on the disc" of that species. The prothorax is sometimes scarcely paler than the elytra, but is usually conspicuously paler.

Polylobus quadratipennis, n.sp.

Of a rather bright flavous red, elytra and metasternum darker, middle of abdomen still darker. With dense pubescence rather longer than usual in the genus, the sides, except of abdomen, where they are dense, with a few short hairs.

Head with sides much less rounded than usual; with very small punctures. Eyes fairly large and prominent. Antennae rather stout, passing base of prothorax, fourth and fifth joints feebly, the sixth to tenth strongly transverse, eleventh almost as long as three preceding combined. *Prothorax* about as long as wide, sides and base gently rounded, punctures small and more or less obscured by clothing. *Elytra* quadrate, about one-fourth wider than prothorax, and distinctly longer; with small and moderately dense punctures.. *Abdomen* rather narrow and parallel-sided, with strong margins to near apex; punctures fairly dense and distinct, except at tips of the segments. Length, 2¾, to apex of elytra 1¼ mm.

Hab.—New South Wales: Barraba, from a nest of *Pheidole* sp. (F. A. Rodway).

The elytral punctures from some directions appear to be transversely or obliquely confluent. It is distinctly stouter than most species of the genus occurring with ants.

Polylobus apianus, n.sp.

Flavous-red, in places deepening to blood-red, legs, palpi and base of antennae paler; a large rounded spot on each elytron, and fourth and fifth abdominal segments black. With short pale pubescence, the sides, especially of abdomen, with fine hairs.

Head more transverse than usual; punctures fairly dense and clearly defined. Eyes fairly large and prominent. Antennae rather lightly thickened towards apex, not extending to base of prothorax; fourth to sixth joints feebly, seventh to tenth moderately transverse, eleventh briefly subconical, about as long as ninth and tenth combined, and slightly but distinctly wider. *Prothorax* about once and one-half as wide as long, front angles strongly rounded, sides thence oblique to base, which is almost truncate; punctures as on head. *Elytra* moderately transverse, about one-fourth wider than prothorax, and along suture about one-third longer, longer at sides; punctures slightly sparser and more clearly defined than on prothorax. *Abdomen* almost parallel-sided, and with strong margins to near apex; punctures fairly dense and clearly defined. Length 2, to apex of elytra 1 mm.

Hab.—New South Wales: Sydney, from a wild nest of the domesticated bee (C. Gibbons).

The spot on each elytron is moderately distant from the suture, rather nearer the apex than the base, fairly large, and from above appears almost round, but from the side is seen to be transverse, and almost touching the margin. The middle of the prothorax appears to be vaguely infuscated.

Polylobus apiciniger, n.sp.

Bright flavous, antennae (base excepted) somewhat darker; head, apex of elytra, metasternum and fifth abdominal segment black. Pubescence very indistinct; except at sides of abdomen.

Head rather short; eyes fairly prominent. Antennae somewhat incrassated to apex, scarcely extending to base of prothorax. *Prothorax* twice as wide as long, rather strongly (for the genus) convex, sides rounded and increasing in width to base, which is gently rounded. *Elytra* almost twice as wide as long, distinctly longer and wider than prothorax; punctures obscured by clothing. *Abdomen* moderately but decidedly decreasing in width to near apex, and then strongly to apex itself; margins comparatively feeble. Length $1\frac{1}{3}$, to apex of elytra $\frac{2}{3}$ mm.

Hab.—New South Wales: Otford, from a nest of *Ectatomma metallicum* (A. M. Lea).

A small robust species, in general remarkably like a very small specimen of *acceptus*, but differing essentially in the prothorax; in *acceptus* the sides of that segment are evenly rounded, with the base no wider than the apex, and considerably narrower than the elytra; in the present species its sides are also rounded, but they are considerably wider at the base than at the apex, with the consequence that they appear to be subcontinuous with those of the elytra. In the shape of the prothorax it agrees with *Tasmanicus*, but that is a much larger species, with much stronger punctures, etc. The black at apex of elytra is slightly dilated to sides, so that there it occupies about two-fifths of the length, at the suture it occupies about one-third.

**Polylobus semiopacus*, Lea.

Recently taken in numbers at Otford and Sydney[1] in nests of *Ectatomma metallicum.*

**Polylobus pallidominor*, Lea.

Mr. Cox has sent a second specimen of this species from a nest of *Iridomyrmex rufoniger.* I have also 20 specimens that were taken in flood débris on the Nepean River by Mr. A. J. Coates.

**Polylobus Daveyi*, Lea.

A single specimen of this species was taken near Adelaide, by Mr. Griffith, from a nest of *Ectatomma metallicum.*

**Calodera cuneifera*, Lea.

Mr. Davey has sent three specimens from Geelong and Ararat, as having occurred in nests of a species of *Iridomyrmex.*

**Myrmedonia clavigera*, Fvl

Recently taken near Hobart from a nest of *Iridomyrmex glaber.*

Homalota trigonae, n.sp.

Black, shining; elytra piceous-brown; legs, palpi and basal joints of antennae somewhat paler. With very short ashen pubescence, longer on abdomen than elsewhere; sides with a few short hairs.

Head convex, moderately transverse; punctures very indistinct. Antennae not very thin, just passing base of prothorax; first joint as long as second and third combined, fourth to tenth transverse, eleventh subconical, almost as long as ninth and tenth combined. *Prothorax* almost twice as wide as long, sides and base evenly rounded; with a puncture on each side of the middle at about one-third from the base, and with much smaller and dense but rather clearly defined punctures. *Elytra* slightly wider than prothorax, and slightly wider than long; with small, dense, clearly defined punctures. *Abdomen* as wide at apex as at base, the sides very feebly increasing in width to middle; margins strong. *Legs* rather long. Length 2¼, to apex of elytra 1 mm.

Hab. New South Wales: Sydney, from a nest of *Trigona carbonaria* (C. Gibbons).

1 Now first recorded from the mainland.

In general appearance close to *parens*, but antennae shorter and stouter, and prothorax very decidedly transverse, its sides more strongly and evenly rounded, and disc with two conspicuous punctures. Also close in appearance to *Calodera cuneifera*, but readily distinguished therefrom by the apical joint of antennae. From some directions an extremely faint median prothoracic line is visible.

Homalota curvicauda, n.sp.

Black, shining; antennae and palpi brownish; legs (coxae excepted) flavous, femora paler than tibiae and tarsi. Rather densely clothed with short ashen pubescence, a few hairs on apical sides of abdomen.

Head rather strongly convex, sides rather strongly rounded, eyes not at all prominent; punctures indistinct. Antennae rather thin, extending almost to middle of elytra, first joint distinctly shorter than second and third, these moderately long, fourth and fifth subglobular, sixth to tenth transverse, eleventh subconical or almost wedge-shaped, slightly longer than ninth and tenth combined. *Prothorax* about once and two-thirds as wide as long; sides gently, the base very feebly rounded; with dense and small, but clearly defined punctures. *Elytra* scarcely wider than widest part of prothorax, and with slightly larger punctures, moderately transverse. *Abdomen* with strong margins, and parallel-sided to near apex; punctures dense and small, becoming very small posteriorly. *Legs* rather long and thin. Length $3\frac{1}{4}$, to apex of elytra $1\frac{1}{3}$ mm.

Hab. Tasmania: Chudleigh, Railton, a single specimen at each place from a nest of *Iridomyrmex glaber* (A. M. Lea).

The Railton specimen when alive had its tail cocked over its back and touching the base of its elytra, and when first seen had much the aspect of a flea. In general appearance close to the preceding species, but antennae paler, legs much paler, elytra darker, prothorax without the two larger punctures, etc.; the sides of the prothorax are more rounded than in *Calodera cuneifera*, and the legs are much paler.

Homalota myrmeciae, n.sp.

Head and elytra black, prothorax, third, fourth and fifth segments of abdomen, and the metasternum dark brown, base and apex of abdomen and antennae of a rather dingy flavous, legs paler. Pubescence very short and fine.

Head moderately transverse, sides rounded, eyes fairly prominent, a shallow depression between them; punctures indistinct. Antennae rather thin, extending to about middle of elytra; first joint distinctly shorter than second and third combined, these moderately long, fourth to tenth each about as long as wide, or feebly transverse, eleventh subconical, slightly longer than ninth and tenth combined. *Prothorax* depressed, distinctly wider than head, about once and one-half as wide as long, sides angularly dilated at apical third, thence oblique to both base and apex; punctures scarcely visible. *Elytra* slightly wider than prothorax, and along middle about as long, but distinctly longer at sides, punctures dense and very minute. *Abdomen* with strong margins, the sides feebly inflated to about middle, punctures slightly stronger than on elytra. *Legs* moderately long and thin. Length 2½, to apex of elytra 1 mm.

Hab. Victoria: Lal Lal, from a nest of a species of *Myrmecia* (H. W. Davey).

The angularly dilated prothorax renders this species very distinct.

Conosoma lateripenne, n.sp.

Testaceous-brown, hind angles of prothorax, most of elytra and apical parts of abdomen somewhat paler, legs and antennae almost flavous. Rather densely clothed with short pale pubescence; elytra with a few long black hairs on each side; abdomen with two fascicles of black hairs at its tip.

Head with almost invisible punctures. Antennae moderately stout, not extending to base of prothorax. *Prothorax* about once and two-thirds as wide as long; punctures minute, dense, and more or less concealed. *Elytra* slightly narrower than, and about the length of prothorax, apex gently incurved to middle: punctures slightly more noticeable than on prothorax. *Abdomen* regularly decreasing in width to apex. Length 3, to apex of elytra 1⅓ mm.

Hab.—Victoria: Sea Lake, from nest of *Iridomyrmex nitidus* (J. C. Goudie).

In general appearance rather close to *rufipalpe*; but the long hairs at the sides of the elytra (there are four on each side) distinguish from that species, and from all others known to me except *myrmecophilum*, from which it is distinguished by being rather narrower, somewhat different in colour, and without long hairs at sides of prothorax and abdomen.

**Conosoma myrmecophilum*, Lea.

Mr. Davey sent two specimens of this species from Geelong[1] (Victoria); without any indication, however, as to how they were obtained. Subsequently he sent another from a nest of *Iridomyrmex nitidus*.

Quedius cuprinus, Fvl.

Mr. Davey has taken a specimen of this species from a nest of *Camponotus nigriceps* at Geelong.

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1 It is now first recorded for E. Australia.

Scopaeus interocularis, n.sp.

Brownish-flavous, legs and palpi paler: four basal segments of abdomen, except margins, infuscated; fifth slightly infuscated about base, and feebly infuscated between eyes. With very short pale pubescence, longer at sides and apex of abdomen than elsewhere.

Head, including mouth parts, subquadrate; with dense minute punctures. Antennae extending almost to base of prothorax; first joint stout, about as long as three following combined, second to tenth subequal, eleventh not much longer than tenth. *Prothorax* slightly narrower and slightly longer than head, subovate, apex produced; a shallow depression on each side of base marking off the base of a very feeble longitudinal elevation; punctures as on head. *Elytra* parallel-sided, scarcely longer than wide, the width of prothorax, and with slightly larger punctures. *Abdomen* feebly increasing in width to apex of fifth segment, thence decreasing rapidly to apex. *Legs* not very long; femora rather stout. Length 3, to apex of abdomen 1½ mm.

Hab. New South Wales: Sydney, from a nest of *Iridomyrmex* sp. (A. M. Lea).

In size and shape much like *S. dubius* and *S. oricollis*, but very differently coloured.

Lithocharis camponoti, n.sp.

Bright flavous red, appendages somewhat paler, apical two-fifths of elytra, and basal two-thirds of upper surface of fifth abdominal segment black. Clothed with short depressed pubescence; sides with a few short hairs, becoming longer and denser towards and at apex of abdomen.

Head, including mandibles, slightly longer than wide, sides almost parallel behind eyes, between them the derm somewhat flattened; with dense minute punctures. Antennae extending to base of prothorax, first joint about as long as second and third combined, each of these a trifle longer than each of the others to tenth, eleventh subconical, about half as long again as tenth. *Prothorax* with front almost the exact width of head, and the angles right-angles; sides gently decreasing in width to base, with basal angles rounded; punctures much as on head. *Elytra* just perceptibly longer than wide, the width of head, basal and apical angles rounded, sides parallel, apex slightly oblique to middle; punctures small but more distinct than on prothorax. *Abdomen* parallel-sided or gently increasing in width to beyond the middle, thence rapidly decreasing to apex, fourth segment distinctly longer than third, fifth longer than third and fourth combined. *Legs* not very long; femora stout. Length 2¾, to apex of elytra 1½ mm.

Hab. New South Wales: Otford, from nests of *Camponotus aeneopilosus* (H. W. Cox and A. M. Lea).

Apparently close to *cincta*, but abdomen not entirely pale, elytra with dark part at, instead of before, apex, and punctures not as described. The dark part at the apex is sometimes slightly cut into along the suture. There are about three hairs on each side of the head, four or five on each side of the prothorax, and about the same on elytra; they appear, however, to be easily abraded.

**Glyptoma myrmecophilum*, Lea.

A specimen of this species was recently taken under rotting bark of a fallen log at Ulverstone.[1]

**Oxyteius micropterus*, Lea.

Mr. Davey has taken two specimens of this species from a nest of *Camponotus nigriceps* at Lal Lal (Victoria).

Pselaphidae.

In addition to the species now recorded I have taken a very minute[2] specimen of this family from a nest of *Iridomyrmex glaber* in Tasmania. It is blackish with pale appendages, and is apparently without a medio-basal prothoracic impression; the head, however, has a rather deep groove on each side, the two conjoined in front, and these combined with an elongated form would appear to exclude it from *Eupines*. As it is a female it appears undesirable to propose a new genus for it.

Narcodes ectatommae, n.sp.

♂. Of a dingy reddish brown, abdomen blackish, club infuscated. Clothed with short, subsquamose clothing, mostly stramineous, but variegated in places (notably on abdomen) with sooty.

Head large; with three shallow impressions, of which the deepest one is in front; base gently incurved to middle, and produced on each side behind the eye; each margin near apex with a small subconical projection, indistinct from some directions. Antennae moderately long, first joint stout, as long (when viewed from the sides) as second and third combined, third distinctly longer than second or fourth, ninth distinctly longer than eighth, about as long as wide, tenth larger, eleventh truncate-ovate, slightly longer than ninth and tenth combined. *Prothorax* decidedly transverse, apical half with flattened and dilated sides, which are obtusely bituberculate (the hind tubercle

1 Now first recorded from Tasmania.

2 It is just perceptibly larger than *Limoniates australis*, the smallest known species from Australia.

very obtuse) in middle towards base with a moderately large fovea, thence to apex feebly ridged, each side with a rather large and shallow fovea. *Elytra* very short and dilated posteriorly, each with sutural stria strong and dorsal wide and deep at base, and strong to beyond the middle, where it rather abruptly terminates. *Abdomen* large, with wide margins; under surface gently concave along middle. *Metasternum* gently concave along middle, each side with a feeble ridge terminating in an obtuse tooth posteriorly. *Legs* rather short and stout; front trochanters strongly dentate, the tooth itself with a smaller one on its hind margin; front femora with a small acute subbasal tooth. Length $2\frac{3}{4}$ mm.

Hab.—Tasmania: Railton, in a nest of *Ectatomma metallicum* (A. M. Lea).

The size is larger than that of *N. nigriventris*, the head is larger and wider across apex, the prothorax has the sides more suddenly and angularly inflated, and its medio-basal fovea and the elytral striae are deeper. From both sexes of *N. varia* it is readily distinguished by the sides of the prothorax.

On the whole of the upper surface there are more or less dense punctures, but these are more or less concealed until the clothing has been abraded. From some directions the sides of the elytra towards the apex appear to be feebly notched.

Ctenisophus nigropiceus, n.sp.

♂. Blackish-piceous; appendages of a rather dingy red. With very short pale pubescence, giving the upper surface a greyish appearance.

Head wide; with two large but rather shallow inter-ocular foveae. Antennae comparatively short, second joint slightly stouter than first and, from above, apparently slightly longer, third to seventh small, eighth, ninth and tenth about as long as wide, subequal, eleventh about as long as ninth and tenth combined, and a trifle wider. *Prothorax* feebly transverse, widest at about apical third, sides thence oblique to base; with a rather large medio-basal fovea. *Elytra* distinctly transverse; each with sutural stria distinct, the dorsal rather wide towards base, and elsewhere very narrow but clearly defined. Under surface of fourth segment of *abdomen* with a shallow subtriangular impression, indistinct from most directions, whilst from others each of its walls appears to be tipped by a minute tubercle. *Legs* comparatively short (for the genus). Length $1\frac{1}{4}$ mm.

Hab.—Victoria: Geelong, from a nest of *Iridomyrmex*, sp. (H. W. Davey).

Readily distinguished from all previously described species by its dark colour; the tip of the abdomen and the prothorax are not quite as dark as the rest of the upper surface. The four apical joints of antennae are rather more than half the total length: the eighth is very little longer than the ninth.

**Ctenisophus morosus*, Raffr.

Mr. Griffith has taken this species in Tasmania from nests of *Ectatomma metallicum*: and I have taken three from a nest of *Polyrhachis hexacantha.*

Ctenisophus vernalis, King.

Dr. Ferguson has taken sexes of this species from a nest of termites (*Eutermes*, sp.) at Narromine.

**Ctenisophus impressus*, Sharp.

Mr. Griffith has taken near Adelaide a specimen of this species from a nest of *Ectatomma Mayri.*

Tmesiphorus hoplocephalus, n.sp.

♂. Reddish castaneous, elytra, tarsi and palpi paler. With moderately dense short pubescence, tip of elytra rather densely clothed, a fascicle of golden hairs on each side of base of head.

Head with two small inter-ocular foveae, front longitudinally impressed between antennary ridges, a small acute conical tubercle or spine behind each eye; densely punctate all over. Antennae moderately long; third to eighth joints transverse, ninth subquadrate, much wider than eighth, and almost as long as three preceding combined, tenth about as large as ninth, scooped out on one side, eleventh lop-sided, and about once and one-half as long as tenth. Palpi with a strong spine on each of the second and third joints, the apical joint strongly produced on one side and acutely produced at apex. *Prothorax* slightly longer than wide, sides widest at about apical third, thence incurved to base; with a small medio-basal fovea, and a larger but shallower one on each side; punctures as on head. *Elytra* lightly transverse; each with dorsal stria, rather wide on basal half and scarcely traceable beyond the middle; with clearly defined punctures, not as dense as on prothorax. *Abdomen* with a strong narrow carina on each side of the second and third segments; lower surface with a very feeble depression in middle of second and third segments. *Trochanters* unarmed; front tibiae excavated in middle of inner surface. Length $2\frac{3}{4}$ mm.

Hab. New South Wales: Narromine, from a nest of white ants (E. W. Ferguson).

The head is armed behind each eye somewhat as in *T. termitophilus*. In shape it is much like *T. ponerae* and *T. formicinus*, but the head and club are different. *T. brevicornis* is without the golden basal fascicles, and has much shorter antennae. It is perhaps closest to *T. Kingi* of all the described species, but the elytra have the sulcus on each side much less pronounced, the front tibiae different, and the ventral impressions of different shape and much shallower.

From some directions the front tibiae appear to be scooped out in the middle or bidentate. The eleventh joint of antennae is obtusely produced on one side, and its lower surface is gently concave, the tenth has a small tubercle on one side of its apex.

DAVEYIA, n.g.

Head transverse, bifoveate: a wide thin flange margining each eye. Eyes small, prominent, coarsely faceted. Antennae moderately long, ten-jointed, first rather large, second smaller, the others to ninth small and submoniliform, tenth large. Palpi large, first joint concealed, second rather long and angular, third subtriangular, with several projections at outer edge, each of which has a clubbed hair, fourth much smaller than third and also with projections, its apex with a thin spine or stout seta. *Prothorax* feebly transverse, sides angularly dilated in middle. *Elytra* short, dilated posteriorly. *Abdomen* about as long as prothorax and elytra conjoined, second, third and fourth segments large, with wide margins. *Metasternum* moderately long. *Legs* rather long and unarmed; trochanters large; femora stout; tibiae rather thin, slightly dilated towards apex; tarsi thin, first joint small, second and third rather long; claws small and thin.

The species described below at first resembles a small flattened *Ctenisophus*, but is readily distinguished from that genus, and from all others, by its remarkable palpi and flanges. The latter are wide and very thin, convex on the upper and concave on the lower surface; they are attached to the head partly directly, and partly to the lower surface of the eyes, so that each appears as a remarkable canthus. From above, the flanges appear to completely margin the lower surface of the eyes; their hind inner margin appears to be fringed with fine setae. There is nothing much like them in any described Australian genus except perhaps a vague remnant in some species of *Tmesiphorus*. A distant approach, however, is made by a foreign species, *Ctenotillus costatus*:[1] which Raffray at the time of description referred to the vicinity of *Tmesiphorus*, but later[2] placed closest (of the Australian genera) to *Leanymus*. The palpi[3] of *Daveyia*, however, are very different to those of *Ctenotillus*, and I

1 Raffray, Ann. Soc. Ent. Fr., lxv., 1896, Plate II., Fig. 5.
2 In his monograph in Wytsman's Genera Insectorum, p. 367.
3 It is very difficult to manipulate the palpi, as they snap off almost at a touch.

have seen nothing figured at all like them: the subapical joint has a number of stout hairs, that from some directions appear to be simple, but from others knobbed, and in some lights they look much like the sticky hairs of some species of *Drosera*.

The genus evidently belongs to the *Tyrini*, and for the present may be placed in the vicinity of *Tmesiphorus*. It is with very great pleasure that I dedicate it to such an energetic examiner of ants' nests as Mr. Davey.

Daveyia mira, n.sp. (Figs. 2 and 3.)

♂. Reddish castaneous, elytra and eye flanges somewhat paler. Clothed with short whitish pubescence, moderately dense at tip of elytra, and base of abdomen on under surface.

Head (including flanges) almost twice as wide as long, with two fairly large submedian foveae. Antennae extending to base of prothorax, surface of first, second and tenth joints somewhat uneven. *Prothorax* slightly wider than long, sides strongly and angularly dilated in middle; with a large medio-basal isolated fovea. *Elytra*, across apex, about one-third wider than long; sutural stria on each distinct, the dorsal represented by a short basal groove. *Metasternum* transversely excavated at middle of apex. *Abdomen* with under surface regularly convex, the fifth segment semi-circularly emarginate. Length, 1–$1\frac{1}{5}$ mm.

♀. Differs in being slightly larger, legs somewhat shorter, and abdomen with the fifth segment straight at apex.

Hab.—Victoria: Geelong and Portland, in nests of *Iridomyrmex itinerans* (H. W. Davey).

Under a fairly high power the head appears to be covered with small round flattened granules, and rather less distinct ones are to be seen on the prothorax and elytra. From some directions the metasternum of the male appears to have its median excavation extending its whole length, but from others it appears to be apical only, as in the female. Mr. Davey obtained numerous specimens in the nests and their vicinity, and some of the specimens sent were mounted as slides in Canada balsam.

**Pselaphus flavipalpis*, Lea.

There are five specimens of this species in the British Museum from Townsville; two are males, and differ from the females in having the middle of the second ventral segment with a slight longitudinal ridge at its apex. The metasternum is less convex, and about the apex is somewhat excavated.

**Pselaphus geminatus*, Westw.

There is a specimen of this species in the Macleay Museum from South Australia.

Margaris imperialis, Schfs.

In his catalogue, Wasmann states that this species is myrmecophilous. The only specimen I have seen was obtained in flood débris.

Hamotopsis auricomus, Lea.

Mr. Davey has taken five specimens of this species from nests of *Amblyopone australis*.

Eudranes carinatus, Sharp.

The type of this species was taken from an ants' nest by Commander J. J. Walker.

Rybaxis ectatommae, n.sp.

Bright castaneous, legs (knees excepted) and palpi somewhat paler. With short, pale pubescence, interspersed, especially on abdomen, with some longer hairs.

Head highly polished; with a (for the genus) rather small and partly open fovea close to each eye, frontal impression shallow. Antennae rather long, first joint apparently (when seen from above) no longer than second, but really (when seen from the side) distinctly longer, third to sixth rather small, seventh larger, eighth slightly smaller than seventh but larger than sixth, ninth and tenth small, eleventh subovate, apex pointed, about as long as three preceding joints combined. *Prothorax* moderately transverse, widest at about apical third; with a small medio-basal fovea, indistinctly connected along base with a comparatively small fovea on each side. *Elytra* about as long as wide; each with sutural stria distinct, dorsal distinct at base, but not traceable beyond middle; epipleural furrow absent, but marginal stria distinct; punctures small but fairly distinct. *Metasternum* rather shallowly impressed. *Abdomen* somewhat flattened along middle. *Legs* rather long and apparently unarmed. Length, $1\frac{3}{4}$ mm.

Hab.—New South Wales: Blue Mountains (E. W. Ferguson), Otford, from a nest of *Ectatomma metallicum* (A. M. Lea).

In size and general appearance close to *R. 5-foveata*, but antennae and prothoracic impressions different. The inflation of the seventh and eighth joints is not very strong, but is such that they are noticeably larger than the preceding or following ones. The two specimens before me appear to be males, although they have no distinctive sexual features on the under surface and legs.

Rybaxis villosa, n.sp.

♂. Of a rather pale, dingy castaneous, tarsi and palpi paler. Indistinctly pubescent, but with numerous distinct and rather long hairs.

Head with a moderately large, round, deep, partially open fovea close to each eye, with a rather shallow impression in front. Antennae with first joint longer and slightly wider than second, third to eighth small, ninth slightly larger, tenth distinctly larger than ninth, eleventh ovate, apex pointed, distinctly wider than tenth, and about as long as four preceding combined. *Prothorax* feebly transverse, widest slightly in advance of middle: with a feeble, isolated, medio-basal fovea, towards base on each side with a fairly large fovea. *Elytra* about as long as wide, each with sutural stria distinct, the dorsal foveate at base, but not traceable to middle; epipleural furrow very short and indistinct. *Metasternum* excavated at middle of apical third. *Abdomen* flattened along middle of under surface, each side towards base with a small tubercle behind the coxa. *Legs* rather long and apparently unarmed. Length $1\frac{1}{3}$–$1\frac{1}{2}$ mm.

♀. Differs in having metasternum less impressed, abdomen convex along middle of under surface, and without tubercles, and legs and antennae somewhat thinner.

Hab. New South Wales: Otford, from a nest of *Ectatomma metallicum* (H. W. Cox), from a nest of *Stenamma longiceps* (A. M. Lea), Sydney (Macleay Museum).

A small species with long straggling hair, especially on the elytra, where it is more noticeable than in the preceding species.

Rybaxis tibialis, Raffr.

R. bryophila, Lea.

M. Raffray's name was published in 1909, and consequently, not being noted in the Zoological Record, was unknown to me at the time I named *R. bryophila*, which is a synonym of it. Raffray's figure shows the tenth joint of the antennae as longer than in any of the numerous specimens I have examined.

A single male of this common moss species was recently taken from a nest of *Iridomyrmex glaber*.

Rybaxis 5-foveata, Raffr.

Mr. Gibbons sent a specimen of this species as having been taken, at Hornsby, from a wild nest of the hive bee.

**Eupines flavoapicalis*, Lea.

Recently taken from a nest of *Eutermes*, sp., at Sydney.

Eupines indistincta, Lea.

A male of this species was recently taken, at Latrobe, from a nest of *Ectatomma metallicum*.

**Cyathiger punctatus*, King.

A specimen before me was taken by Mr. George Masters at Petersham (the original collector and one of the original localities), and it can, I think, be fairly regarded as a co-type.

Its metasternum, not mentioned by King, is concave in the middle, with a strong curved ridge or carina slightly inwards from, but marking the outlines of each of the hind coxae, the carina at the highest about its middle, so that from the side it appears as a conical tubercle or tooth. The under surface of the abdomen is largely concave, each side of the concave portion being bounded by a line of obtusely pointed tubercles, forming the ridge mentioned by King. The club is decidedly concave on its upper surface, but the hollow is neither shining nor very deep.

Cyathiger simulator, n.sp.

♂. Reddish-castaneous. With very minute pale pubescence.

Head moderately large, rather feebly convex; densely punctate; a shallow depression between eyes (which are small and prominent), and another between antennae. Antennae stout, first joint almost as long as second and third combined, but from above apparently the length of second, second to fifth transverse, of equal length, sixth the same length but more rounded, seventh as large as head, subreniform, convex on lower surface, hollowed out and highly polished on upper surface. *Prothorax* feebly transverse, sides widest at about apical third; punctures as on head; with a very small median subbasal fovea, and a slightly larger one on each side. *Elytra* about as long as wide, sides gently rounded, without striae; punctures rather coarser than on prothorax, but otherwise the same. Upper surface of *abdomen* apparently not segmented, evenly rounded; punctures as on prothorax; lower surface with apical segments appearing within a slight subcircular depression, basal segments with a large depression conspicuously bounded on each side by a ridge or row of obtuse tubercles. *Metasternum* largely excavated in middle, and on each side of depression with a large, acute and slightly curved tooth. *Legs* long and thin; trochanters obtusely dentate; front femora minutely denticulate, middle femora with a small subbasal tooth, concealed from most directions; hind tibiae bent downwards in middle, and somewhat longer than the others; tarsi terminated by a single claw, the basal joint large. Length $1\frac{1}{4}$ mm.

Hab.—New South Wales: Otford, from a nest of *Stenamma longiceps* (A. M. Lea).

At once distinguished from *punctatus* by the club; this is larger, of somewhat different shape, and much more hollowed out[1] with the hollow highly polished; from above it appears as a thin hollow shell. The metasternal depression is bounded on each side by ridges or carinae; of these there is one on each side, commencing at the middle coxa, and extending to the middle, when it turns back so as to become V-shaped; at its end it meets a similarly forked carina, the point of meeting being marked by an acute recurved spine or tooth, below this there is a smaller tooth; in *punctatus* the sculpture is on a smaller scale and less complicated.

The specimen obtained (in September) remained motionless for a little while after the covering stone was removed. It then started to move slowly, but as soon as touched folded its appendages together, much as do the species of *Diplocotes*.

Euplectops ectatommae, n.sp.

Bright pale castaneous, abdomen very little darker; appendages almost flavous. Rather densely clothed with very short pubescence.

Head moderately transverse; a large fovea on each side, not quite closed in front and meeting in front; base distinctly notched in middle. Antennae rather thin, almost extending to base of prothorax; club three-jointed, ninth and tenth joints rather small, although larger than the preceding ones, eleventh ovate, apex obtusely produced. *Prothorax* rather lightly transverse, sides rather strongly rounded at apical third, thence decreasing in width to base; near base with a strong transverse impression, slightly dilated in middle, and foveate on each side; median line rather short and shallow, not extending to apex or subbasal impression. *Elytra* parallel-sided, slightly longer than wide, subsutural and dorsal striae commencing at base in small foveae, the dorsal striae scarcely traceable to middle; punctures indistinct. *Abdomen* slightly longer than elytra, very feebly increasing in width to apical fourth; second segment with a small transverse basal tubercle, second to fifth subequal in length. *Legs* moderately long. Length $1\frac{1}{4}$ mm.

Hab.—New South Wales: Sydney, from a nest of *Ectatomma metallicum* (A. M. Lea).

A small narrow parallel-sided species; fairly close to *depressicollis*, but larger, more parallel-sided, cephalic impressions more pronounced, those on the prothorax not the same, etc.; *basalis* is more convex and polished, antennae shorter and club stouter, etc.; *ziczac* has much stronger impressions and *bryophilus* very different clothing.

From some directions the cephalic impressions appear to be closed

1 Somewhat as in Raffray's figure of the club of *C. Simoni* from Borneo; Rev. d'Ent. 1895, Pl. 2, fig. 21.

in front, but from others they are seen to be only shallower there, and they really meet in front, so that combined they appear to form a short broad Λ, with a raised Λ immediately behind.

Plectusodes pubescens, n.sp.

♂. Reddish-castaneous, appendages somewhat paler. Densely clothed with very short pale pubescence.

Head rather wide; each side with a wide depression, meeting in front, and deepened posteriorly so as to be almost foveate; base distinctly notched, the space in front of notch elevated in the form of a wide Λ. Antennae thin, slightly passing base of prothorax, second to eighth joints small, ninth and tenth larger but scarcely forming part of a club, eleventh elongate-ovate, apex rather acutely produced. Palpi very small. *Prothorax* feebly transverse, depressed; sides rounded in front, apex wider than base, near base strongly transversely impressed, the impression foveate at each side and subfoveate in middle; median line fairly deep, but not extending to apex or subbasal impression; with small dense punctures. *Elytra* slightly longer than wide, slightly wider than widest part of prothorax, sides gently rounded, dorsal stria on each distinct at base, but scarcely traceable to basal fourth; with small dense punctures. *Abdomen* about the length and width of elytra, parallel-sided to near apex; under surface with a large shallow impression on apical segment. *Legs* rather long; front trochanters subtriangularly dentate. Length $1\frac{1}{2}$ mm.

Hab.—New South Wales: Sydney, from nests of *Ectatomma metallicum* and *Polyrhachis ammon* (A. M. Lea).

Close to *breviceps*, but narrower and with denser although still short pubescence. From the sides and from certain other directions the metasternum of that species appears to be sulcate throughout its length, but in this species the surface is scarcely visibly impressed along the middle. The prothorax is also less inflated than in *breviceps*.

From some directions the head appears to be conspicuously bifoveate. Judging by the abdomen and trochanters the three specimens before me are all males.

Plectusodes cavifrons, n.sp.

♂. Bright reddish-castaneous, appendages paler. Rather sparsely clothed with very short pubescence, interspersed with a few longer but not very conspicuous hairs.

Head wide; with a wide impression in front, curved round at sides and foveate close to each eye; base distinctly notched, the space in front of notch in the form of a wide elevated Λ. Antennae moderately thin, just passing base of prothorax, first joint very little larger than second, second slightly larger than third, third to tenth small, the ninth and tenth slightly larger than the eighth, but not forming part of a club, eleventh ovate, slightly longer than ninth and tenth combined, its apex acute. Palpi very small. *Prothorax* as long as wide, moderately convex; sides strongly rounded, base much narrower than apex; near base with a strong bisinuous impression, somewhat expanded in middle and terminated at each side in a strong fovea; median line short and feeble; punctures very indistinct. *Elytra* about as long as wide, base wider than prothorax, sides feebly dilated posteriorly, apex incurved to middle; sutural stria on each narrow and commencing in a very small fovea, the dorsal represented by a distinct impression at base only; punctures very indistinct. *Abdomen* the width of elytra and somewhat longer, rather strongly convex on upper surface, and slightly flattened along middle of lower surface; apical segment with a median impression. *Metasternum* depressed along middle of apical half. *Legs* moderately long; hind trochanters obtusely dentate. Length $1\frac{3}{4}$ - 2 mm.

Hab.—Tasmania: Chudleigh, Kindred, Dunorlan, from nests of *Iridomyrmex glaber*.

In appearance fairly close to the preceding species, but larger, more brightly coloured, differently clothed, narrower and less depressed, punctures smaller, etc. From *breviceps* it differs in being larger, narrower and more convex. In general appearance it is somewhat like *Euplectops carinatifrons* and *E. villosus*, but the median line of the prothorax is feeble and isolated.

The base of the prothorax appears to be rather suddenly narrowed, and the sides in front of the lateral foveae appear to be almost tuberculate; the median line is shallow and scarcely visible from some directions, and is traceable neither to the apex, nor to the subbasal impression, but it is somewhat variable individually. The five specimens before me appear to be all males.

Mesoplatus, two species.

Mr. C. Gibbons took a specimen of this genus in a wild nest of the domesticated bee near Sydney; it is unfortunately a female, so is not now described. Another female of the same species, also from Sydney, is in the Macleay Museum.

Mr. H. W. Cox took a specimen of an allied species, also unfortunately a female, from a nest of *Stenamma longiceps*.

Limoniates camponoti, n.sp.

Pale castaneous, abdomen slightly darker, appendages flavous. Very finely pubescent.

Head moderately transverse, notched in middle of base; each side with a strong oblique groove, the two meeting in front. Eyes moderately prominent. Antennae not extending to base of prothorax; basal joint fairly stout, third to eighth rather small, ninth and tenth rather small, but forming part of club, eleventh subovate, as long as three preceding combined. *Prothorax* moderately transverse, depressed, widest at about apical third, each side near base with a strong curved impression, the two meeting in middle, their junction subfoveate; each side with a longitudinal impression, invisible from above, distinct towards base, but disappearing before apex. *Elytra* subquadrate, shoulders slightly raised; base with a few small foveae; dorsal striae scarcely traceable beyond base; punctures minute. *Abdomen* as wide as elytra, and slightly longer; parallel-sided to near apex. *Legs* moderately long. Length, 1 (vix) mm.

Hab.—New South Wales: Sydney, from a nest of *Camponotus claripes* (A. M. Lea).

Close to *subterraneus* but club different: dorsal striae of elytra shorter and less impressed. In general appearance it is close to *Euplectops depressicollis*, but is rather smaller, with the cephalic and prothoracic impressions different.

Articerus Griffithi, n.sp.

♂. Reddish castaneous, appendages scarcely paler. Elytra with short stiff golden setae, abdomen sparsely clothed but with a conspicuous fascicle on each side of base.

Head densely punctate; without a longitudinal impression. Antennae very wide and flattened, basal third subtriangular, thence scarcely diminishing in width to apex, which is truncate and with an elliptic outline. *Prothorax* strongly transverse, sides widest near apex, thence oblique to base, with a large but rather shallow medio-basal fovea; punctures not quite as dense as on head. *Elytra* moderately transverse, sides lightly dilated posteriorly; sutural striae distinct; punctures clearly defined, coarser at base than elsewhere. *Abdomen* transversely excavated at base, where the sides are distinctly constricted, the excavation scarcely produced backwards at each side; under surface depressed along middle. *Metasternum* largely excavated, the wall on each side of excavation with a distinct triangular tooth. Front *trochanters* rather obtusely armed; hind coxae with a large triangular curved tooth; femora moderately stout; tibiae inflated towards apex. Length $1\frac{2}{3}$ mm.

Hab.—South Australia: From a nest of *Iridomyrmex* sp. (H. H. D. Griffith).

Close to *A. excavipectus*, but metasternum of male still more largely excavated[1] with the walls of the excavation angular or dentate on

1 The excavation commences quite close to the base instead of about the middle.

each side of the middle, prothorax with medio-basal fovea smaller, elytra without impunctate spots, and the teeth of the hind coxae even larger and somewhat curved.

The females of the two species are much alike, but when placed side by side certain differences of degree (as in size of prothoracic fovea and width of head) can be noted; although these are of such a nature that it would be inadvisable to identify a specimen as either *excavipertus* or *Griffithi* from the female alone, although the males are readily distinguishable by the metasternum.

**Articerus nitidicollis*, Raffr.

Mr. Davey has taken two males that belong to this species; they agree perfectly with the description, except that the antennae are not twice the length of the head, but in this respect they agree with the figure accompanying the description. The species differs from *constrictiventris* in having the prothorax much more polished, with a shallow transverse subbasal impression suddenly deepened at its middle. The excavation on the upper surface of abdomen is transversely suboblong, and with the constricted parts of its walls less triangularly encroaching.

Hab.—Victoria: Portland, in a nest of *Iridomyrmex rufoniger*.

**Articerus Mastersi*, Lea.

There is a specimen of this species in King's collection (now in the Australian Museum) standing under the name of *angusticollis*; it differs, however, from the description and figure of that species in being considerably smaller, the prothorax decidedly transverse (in the figure of that species the prothorax is drawn as longer than wide), the antennae shorter and stouter, and the abdominal excavation totally different.

Mr. Davey has recently taken specimens in nests of *Iridomyrmex gracilis* at Ararat, and Mr. T. S. Hall sent me another that was taken at Castlemaine, and mounted in Canada balsam many years ago. Mr. H. H. D. Griffith also has recently taken sexes of the species at Adelaide.

The male differs from the female in having a spine marking the apex of a ridge on the front of the prosternum, its metasternum is terminated by an oblique acute spine, the under surface of the abdomen is excavated. The front trochanters are spinose, all the tibiae are inflated at apex, the front pair terminated by a small spine, and the middle pair by a curved hook; the hook and the tarsus combined from some directions appear like a small claw.

**Articerus Pascoeus*, Sharp.

The British Museum sent seven unnamed specimens of this species for examination; but they certainly belong to *Pascoeus*. In the male the fovea on the upper surface of the abdomen is produced backwards at the middle, but is more or less rounded, in the female it is subangularly produced backwards.

The species is very close to *Mastersi*, and I am unable to define any character to distinguish the females. But the males differ in the front of the prosternum; this being armed in *Mastersi*, and unarmed in *Pascoeus*.

**Articerus dentipes*, Lea.

Mr. H. H. D. Griffith has taken, at Adelaide, nine specimens of this species in nests of a small ant. The female (previously unknown) differs from the male in having the metasternum regularly convex and unarmed, the abdomen convex on under surface, and the legs thinner and unarmed.

**Articerus irregularis*, Lea.

A male before me, taken at Glenfield, from a nest of *Iridomyrmex gracilis*, appears to represent a variety of this species. It differs from the type in being slightly smaller, in the fovea of the under surface of abdomen much smaller and deeper in proportion, and the subbasal impression on each surface of the antennae less noticeable. Mr. H. W. Davey has recently obtained a female at Geelong. It differs from the male in having the under surface of abdomen and the metasternum regularly convex, and its legs unarmed. The lop-sidedness of the antennae is also less pronounced, although quite distinct.

**Articerus constricticornis*, Lea.

The male has the under surface of abdomen with a wide shallow depression towards the base, and the tibiae more inflated towards the apex.

Hab.—New South Wales: Roper Creek.

Articerus cylindricornis, Raffr.

A. cylindricornis, Lea, n.pr.

M. Raffray's name was published in 1909, consequently his paper was not included in the Zoological Record by the time my own name was published (1910). There is no need to change my name, however, as the species is the same as M. Raffray's, and his specimens were almost certainly taken by Mr. Goudie, from whom I also first received it.

**Articerus curvicornis*, Westw.

Recently taken near Sydney from nests of *Iridomyrmex rufoniger.*

**Clavigeropsis Australiae*, Lea.

A second female of this species was taken under a stone, from a nest of *Iridomyrmex gracilis* at the side of the George's River at Glenfield (New South Wales).

Mr. Cox has also taken the species in the Illawarra district. And there is a specimen in the British Museum labelled as from Queensland.

PAUSSIDAE.

**Anthropterus brevis*, Westw.

Recently taken from nests of *Camponotus aeneopilosus* and of *Ectatomma metallicum.*

SCYDMAENIDAE.

Scydmaenus imparidus, n.sp.

Bright castaneous, head and prothorax somewhat darker than elsewhere, palpi and tarsi flavous. Upper surface glabrous except for some sparse clothing at sides of prothorax and a fascicle on each side of base of head.

Head moderately transverse, not bilobed between antennae. Eyes very small and not prominent. Antennae rather long and thin, second joint longer than third, seventh slightly longer than sixth; club four-jointed, eighth joint not much longer, but about twice the width of seventh. *Prothorax* slightly longer than wide; base with three shallow foveate impressions, all connected by a shallow depression. *Elytra* at base no wider than base of prothorax, somewhat obliquely dilated to the middle (where the width is twice that of the prothorax), thence rounded to apex. *Legs* rather long and thin; hind coxae rather distant. Length $1\frac{3}{4}$ mm.

Hab.—South Australia: Port Lincoln (J. J. Walker).

The type was given to me by Mr. C. French, as having been taken by Commander Walker, from the nest of a short, thick, stinging ant.[1]

The antennae are rather longer than in the following species, and in others having the elytra glabrous, the size is larger, and the elytra are more strongly narrowed to the base, so that their middle is about twice the width of their base.

On close examination a few minute setae may be seen towards the base of the elytra, but they are so few and indistinct that I think the elytra could quite fairly be regarded as glabrous.

1 A sample of the ant did not accompany the beetle.

I have not described the elytral punctures of this and of all the following species of the genus, as they are so extremely faint and sparse as to be scarcely, if at all, visible. On the head and prothorax they appear to be always absent or at least invisible under a Coddington lens.

Scydmaenus bifascicnlatus, n.sp.

Reddish-castaneous, elytra (suture excepted) somewhat paler; appendages still paler (almost or quite flavous); metasternum almost or quite black. Upper surface glabrous except for rather dense, dingy hairs at sides of prothorax; and a distinct fascicle on each side of base of head.

Head transverse, rounded between antennae. Eyes small and rather prominent. Antennae moderately long and rather thin; club conspicuously four-jointed. *Prothorax* about as long as wide; each side of base with a distinct fovea, the two connected by a transverse impression. *Elytra* wide and depressed; base distinctly wider than base of prothorax; sides rounded and increasing in width to about the middle, thence decreasing in width to apex. *Legs* moderately long; hind coxae not close together. Length $1\frac{1}{4}$ mm.

Hab.—Victoria (Macleay and British Museums): Geelong, from nests of a small variety of *Ectatomma metallicum*, Portland (H. W. Davey).

Smaller than *glabripennis*, differently coloured, and with the club somewhat smaller; the outlines, however, are almost exactly the same. Also close to *Daveyi*, but larger, prothorax more densely clothed at sides, head wider and more conspicuously fasciculate on each side of base, and elytra wider, with the apex more rounded. *Ectatommae*, an inquiline of the same species of ant, is about the same size, but is of a dingier colour, with shorter antennae and very different clothing.

The metasternum varies in colour from black to no darker than the elytra; two specimens, probably immature, are almost entirely flavous. On several of the specimens there are very faint remnants of pubescence about the base of the elytra, but they are so extremely faint, that the elytra could quite fairly be regarded as glabrous, as they certainly are in some specimens.

The impression connecting the basal foveae of the prothorax together appears rather shallow and feeble from some directions, but from others it appears to be quite deeply impressed but rather narrow; as results the foveae themselves, according to the points of view, appear either widely separated, or almost touching.

Scydmaenus incerticornis, n.sp.

Castaneous, elytra diluted with flavous about apex, but suture somewhat darker; legs and part of abdomen of a rather dingy flavous, but tarsi and palpi paler. Elytra with distinct and suberect clothing, but rather sparse and not very long; prothorax rather sparsely clothed, even at the sides, middle of disc glabrous; head sparsely clothed, the fascicle on each side of base small and loosely composed.

Head lightly transverse, feebly impressed between antennae. Eyes small and prominent. Antennae thin and moderately long; club rather indistinctly four-jointed. *Prothorax* slightly longer than wide, more convex than usual; with two small foveae near base, and some distinct punctures almost at extreme base; each side with a strong oblique impression, which is invisible from above. *Elytra* moderately long, at extreme base no wider than prothorax, sides obliquely dilated to near the middle, and then rounded to apex. *Legs* rather long; hind coxae moderately separated. Length, $1\frac{1}{3}$ mm.

Hab.—New South Wales: Sydney (Macleay Museum), from nests of *Ponera lutea* and of *Stenamma longiceps* (A. M. Lea).

In size and general appearance fairly close to *Paramattensis*, but antennae decidedly thinner, prothorax with different impressions, and no darker than elytra, the latter rather narrower at base, and with shorter clothing. *Colobopsis* is about the same size, but is flatter, wider, and with the sides of the prothorax very differently clothed. *Ectatommae* is dingier, with the club stouter, and elytra much more sparsely clothed. *Duplicatus* is slightly smaller, more sparsely clothed, and with the eighth joint of antennae larger, in proportion, then the seventh. *Microps*, also occurring with *Ponera lutea*, has much smaller eyes, and is otherwise different.

The eighth joint of the antennae is about midway in width between the seventh and ninth, and is slightly shorter than the ninth, so that while it appears best to regard it as belonging to the club, this might almost fairly be regarded as three-jointed, or at least with the joints of subcontinuous width. The seventh is almost exactly the shape of the sixth; the eleventh is about as long as the two preceding combined. The prothoracic foveae are feebly connected with the lateral impressions, but are completely isolated from each other. Scattered about the extreme base are some large punctures, a few of which might almost be regarded as small foveae.

A specimen given to me by Mr. Cox, and taken by him in the Illawarra district, from a nest of *Stenamma longiceps* differs from the type in having the prothoracic foveae less conspicuous (from some directions they appear to be altogether absent), the elytral clothing decumbent, and the antennae somewhat stouter. Quite possibly, however, it represents a new species.

Scydmaenus insigniventris, n.sp.

♂. Black; base of prothorax and the elytra (suture widely infuscated) castaneous, antennae somewhat paler; legs almost, the tarsi and palpi quite flavous. Elytra with sparse and moderately long stramineous hairs; clothing on head and prothorax somewhat shorter and darker, on the latter becoming dense on sides, and on the former forming a feeble fascicle on each side of base.

Head (excluding neck) distinctly transverse, flattened between antennae. Eyes of moderate size and very prominent. Antennae long and thin; club four-jointed. *Prothorax* slightly wider than long; base with a strong transverse impression, with a foveate expansion at each end. *Elytra* moderately long, somewhat depressed, base slightly wider than prothorax, sides evenly rounded and widest across middle. *Abdomen* with fourth segment conspicuously armed. *Legs* moderately long; hind coxae rather distant; femora stout, especially the front pair. Length $1\frac{3}{4}$ mm.

Hab.—Tasmania: Devonport, from a nest of *Ectatomma metallicum*, Stanley, in tussocks at summit of "Nut" (A. M. Lea).

The type has its neck exposed, and this is seen to be castaneous. The antennae at a glance appear to have the joints subcontinuous in width, but the seventh, although distinctly longer and wider than the sixth, is less than half-way in width between that joint and the eighth; the eleventh is not much shorter than the ninth and tenth combined. The prothorax has two rather large transverse foveae, connected together by a short impression, but they could quite fairly be regarded as expanded portions of the impression. Each side also is obliquely impressed, but the impression is invisible from above, and, as in many other species, is more or less obscured by clothing.

The fourth segment of the abdomen, towards each side, has a long, and somewhat obtuse, reddish tooth, projecting backwards at an angle of about 45 degrees; each is about half the length of the hind tibiae, and the two are connected basally by a semitransparent, membranous flap, that is thickened in the middle, causing an appearance as of a much smaller median tooth.

**Scydmaenus glabripennis*, Lea.

There are two specimens of this species in the Macleay Museum from the Tweed River, and five in my own from the Clarence.[1]

**Scydmaenus colobopsis*, Lea.

Recently taken from nests of *Amblyopone australis*.

A specimen from Dunorlan, from a nest of the original ant, differs from the types in being considerably darker, almost piceous.

A specimen from an unnoted ants' nest at Sea Lake[2] sent by Mr. Goudie, differs from the types in having the impression at base of prothorax narrower across the middle, but I can find no other distinctions.

1 Now first recorded from the mainland.

2 Now first recorded from the mainland.

**Scydmaenus castaneoglaber*, Lea.

Dr. Ferguson has taken a specimen of this species on the Blue Mountains[1] from a nest of *Ectatomma metallicum*. Its eyes, by their colour alone, are indistinguishable from the rest of the head, and the right club is almost black, the left being normal; these, however, appear to be individual aberrations.

**Scydmaenilla pusilla*, King.

In October, 1910, specimens of this species were taken from nests of *Ectatomma metallicum, Ponera lutea, Stenamma longiceps, Acantholepis Froggatti*, and a species of *Monomorium*.

**Scydmaenilla constricta*, Lea.

Four specimens were recently taken at Glenfield, New South Wales, from a nest of termites. There is also a specimen in the Macleay Museum from Gayndah.

Heterognathus myrmecophilus, n.sp.

Bright castaneous, somewhat darker about junction of prothorax and elytra. Upper surface with not very dense, but almost evenly distributed pale pubescence.

Head moderately long and convex. Eyes small, and latero-frontal, but not very prominent. Antennae rather long, passing middle coxae, eight basal points subcylindrical, the others forming a rather narrow club. *Prothorax* rather strongly convex, distinctly longer than wide, sides rather strongly rounded but becoming oblique towards base. *Elytra* more than twice the length of prothorax, not much wider at base, but fully twice as wide across middle; sides rather strongly and obliquely dilated to near middle, and then rounded to apex. *Legs* long; hind coxae widely separated; femora subclavate. Length 2 mm.

Hab.—Tasmania: Marrawah, Latrobe, from nests of *Amblyopone australis* (A. M. Lea); Victoria: Lal Lal, from nests of same species of ant (H. W. Davey).

About the size of *carinatus*, but prothorax not carinated and tenth joint of antennae decidedly smaller. Longer, wider and more convex than *gracilis* and antennae longer. Also close to *Scydmaenus optatus* (which is probably a *Heterognathus*), but larger, with decidedly thicker antennae, which have the club three—instead of two—jointed. The ninth joint of the antennae properly belongs to the club, although its base is no wider than the apex of the eighth, but it is distinctly

1 Now first recorded from the mainland.
2 Now first recorded from the mainland.

longer, with the apex distinctly wider; the tenth is about once and one-half the length of the ninth, but at base scarcely wider, although increasing in width to apex; the eleventh is subconical, about once and one-half the length of tenth and near base slightly wider.

There are some very small punctures on the prothorax and elytra, but they are almost concealed by the clothing. The apical segment of the abdomen (on five specimens before me, probably all males) is large, with its hind margin semicircular, so that the three preceding segments are conspicuously narrowed across their middle. The middle trochanters each have a small acute tooth, projecting inwards and slightly forwards, but owing to its position it is not easily seen.

**Phagonophana latipennis*, Lea.

There is a specimen of this species in the Macleay Museum from Rope's Creek, and Dr. Ferguson has two from the Blue Mountains.[1]

**Phagonophana macrosticta*, Lea.

Two specimens from South Australia, in the British Museum, belong to this species but differ from the types in having the dark markings considerably reduced in intensity; this, however, is a common variation between Australian and Tasmanian specimens.

A third from Victoria labelled "*Kingi?*" in Dr. Sharp's writing also belongs to the same species and has the markings still more reduced. The species, apart from markings, may be readily distinguished from *Kingi*, by its femora being much less clavate; the clothing and antennae are also different.

Trichopterygidae.

Rodwayia hirsuta, n.sp.

Pale reddish castaneous, appendages slightly paler. With pale, and, for the genus, long pubescence.

Head with outline continuous with that of prothorax, about twice as wide as long. *Prothorax* rather strongly convex, about once and one-half as wide as long, sides strongly rounded, hind angles produced backwards to clasp elytra. *Elytra* about as long as prothorax, and at base not as wide, gently decreasing in width to apex, which is widely rounded. Intercoxal process of *prosternum* moderately notched at apex. *Femora* very flat and compressed. Length, $\frac{2}{5}$ mm.

Hab.—New South Wales: Otford, three specimens from a nest of *Stenamma longiceps* (A. M. Lea).

In size resembling *R. ovata*, but readily distinguished from all others of the genus by its comparatively long pubescence; under a compound power the hairs look like coarse bristles. With a Cod-

1 Now first recorded from E. Australia.

dington lens each hair can be picked out when the insect is viewed from the side; in the others of the genus this cannot be done owing to their extreme shortness. The prosternal process is rather more parallel-sided than in *orientalis*, and rather more deeply notched at apex, although less so than in *minuta*.

Although Mr. Cox and I examined many nests of the ant named, no more than the three specimens described were obtained; from a close-by nest to that from which they were taken, Mr. Cox obtained several specimens of *R. ovata*, and these represent our total captures of *Rodwayia* in its nests in New South Wales.

**Rodwayia orientalis*, Lea. (Fig. 4.)

Recently (September and October, 1910), about Sydney, Otford, etc., Mr. Cox and I saw thousands of specimens of this species in nests of the green-head (*Ectatomma metallicum*). In some large nests, not uncommonly hundreds were in sight at the same time. Mr. Davey has also taken the species at Lal Lal (Victoria).

In addition to the previously recorded species of ants, it is now known to occur with *Amblyopone australis*, *Polyrhachis hexacantha*, *Camponotus aeneopilosus*, *C. nigriceps*, *C. claripes*, *Myrmecia pyriformis*, *Myrmecia*, sp., and *Iridomyrmex*.

The elytra of some specimens seem more pointed than on others, but this is probably due to shrivelling at the sides. The prothorax also appears larger on some specimens than on others, but this seems due to its base being more extended over the elytra. The colour also is slightly variable in intensity of shade.

**Rodwayia minuta*, Lea.

Specimens of this species are usually taken from amongst the eggs and larvae of the ants.

Numerous specimens from Sydney differ from Tasmanian ones in being a trifle larger, and rather more densely clothed; but as there appear to be no other distinctions they probably represent a variety only.

**Rodwayia ovata*, Lea.

Recently taken by Mr. Cox and myself from nests of *Stenamma longiceps* at Otford; Mr. Davey has taken it at Lal Lal and elsewhere in Victoria from nests of *Polyrhachis hexacantha*, *P. Froggatti* and *Polyrhachis*, sp.

Chlamydopsis.

Of this remarkable genus sixteen species are now known to me, and seven others (including *Orectoscelis*) have been described. Species have now been taken in all the Australian States, and it is probable that many more will yet be taken, as all are extremely rare. *Formicicola* was originally taken by the late Rev. R. L. King in nests of *Camponotus aeneopilosus*; Mr. Foggatt has taken it in nests of the same ant, and I also have so taken it, but only one specimen, although dozens of nests of that ant were specially examined for the beetle. Mr. Davey has now taken eleven specimens of *longipes* in nests of *Ectatomma metallicum*, and Mr. H. H. D. Griffith and I have taken it in nests of the same species of ant at Port Lincoln. Recently I obtained another species, *ectatommae*, with that ant, and Mr. Hacker has taken a specimen of *glabra* in company with it. Mr. Davey took three of *tuberculata* in nests of *Iridomyrmex rufoniger*, and Mr. Gibbons one of *epipleuralis* with another species of *Iridomyrmex*. Mr. Goudie, Mr. Davey and I have each taken (*carbo*, *granulata* and *pseudocephala* respectively) a single specimen in nests of *Pheidole*. The hosts of the other species are not recorded, but, as will be seen, the beetles occur in the nests of at least four genera of ants, and they probably occur with others. They have also been taken from August to January.

Those known to me may be tabulated as follows:—

A. Prothorax with a strong double process in front.
- *a.* Process considerably overhanging head - - *carbo*, Lea.
- *aa.* Process feebly overhanging head
  - *b.* Elytra granulate but with very indistinct punctures - - - - - *granulata*, n. sp.
  - *bb.* Elytra not granulate but with clearly defined punctures - - - - - *pseudocephala*, n. sp.

AA. Prothorax without such a process.
- B. Hind legs fully twice the length of the body - *longipes*, Lea.
- BB. Hind legs much shorter
  - C. Prothorax with a very strong discal tubercle - *tuberculata*, n. sp.
  - CC. Prothorax without such a tubercle.
    - D. Prothorax without narrowly upturned margins
      - *c.* Shining - - - - - *glabra*, Lea
      - *cc.* Opaque - - - - - *opaca*, n. sp.
    - DD. Prothorax, at least in front, with narrow upturned margins.
      - E. Elytra without conspicuous striae on disc.
        - *d.* Elytra with distinct punctures on disc - - - - *variolosa*, Lea.
        - *dd.* Elytra without such punctures.
          - *e.* Prothorax with conspicuous net-like punctures - - - *excavata*, Lea.
          - *ee.* Prothorax with feeble punctures at most
            - *f.* Elytra tipped with rather long hairs - - - *cavicollis*, n.g.
            - *ff.* Elytra with sparse and very short setae at tip - - *formicicola*, King.

EE. Elytra with conspicuous striae on disc.
F. Prothorax with dense but rather small punctures - - - *epipleuralis*, n. sp.
FF. Prothorax with conspicuous net-like punctures.
G. Elytra about scutellar region with a highly polished non-striated space.
g. Clothing of epaulettes very short and almost hidden - *striatella*, Westw.
gg. Clothing of epaulettes very conspicuous - - - *reticulata*, Lea.
GG. Elytra about scutellar region strongly striated.
H. Such striae transverse - *ectatommae*, n. sp.
HH. Such striae curved - - *latipennis*, n. sp.

Since the above table was prepared I have examined the four species described by the Rev. T. Blackburn;[1] they are all very singular insects.

Sternalis.—This species belongs to the group whose other members are *carbo*, *granulata* and *pseudocephala*.

Comata.—This species has highly polished prothorax, striated at the sides, and elytra with fascicles of extraordinary length arising from the epaulettes.

Pygidialis.—This species has the hind body margined with a conspicuous row of small teeth, and the prothorax with three acute carinae, which, although not in contact with each other, divide the disc, as it were, into three large areolets.

Inaequalis.—The body parts of this species are somewhat like those of *longipes*, but the epaulettes are of different shape and differently clothed, the hind legs are considerably shorter, with their tibiae compressed and inflated, and the club of antennae considerably larger.

Chlamydopsis tuberculata, n.sp.

Dark reddish brown; margins of prothorax and all appendages somewhat paler, abdomen (basal two-thirds of first segment excepted) still paler. Prothorax with a few stiff setae, py- and propygidium with denser and shorter setae, two golden-red fascicles within each shoulder.

Head somewhat rounded between antennae, feebly convex; with small granules. Antennae when at rest completed fitted into cavities; first joint large and somewhat boomerang shaped; last joint about half the size of first, the intermediate joints small. *Prothorax* moderately transverse, apex narrower than base, sides thickened and strongly raised, base and apex narrower and less strongly raised;

1 He has also an apparently undescribed species from Queensland.

disc with a large median tubercle, feebly double at its tip: with numerous small distinct punctures. *Elytra* subquadrate, coarsely and irregularly punctured; shoulders notched out; with a strong subbasal depression ending outwardly at the base, and supplied on each side of scutellar region with an oblique ridge, the depression without punctures; epipleurae with more regular sculpture than discs. *Under surface* smooth, shining and almost impunctate; metasternum feebly impressed along middle. *Legs* long, tibiae inflated. Length $1\frac{3}{4}$–$2\frac{1}{4}$ mm.

Hab. Victoria: Ballarat, from a nest of *Iridomyrmex rufoniger* (H. W. Davey).

A small species readily distinguished from all others of the genus by its very conspicuous median prothoracic tubercle.

The legs are sometimes infuscated in parts. The fascicles project obliquely forwards; they are both small, but the inner one is considerably larger than the outer one on each shoulder. At a glance the elytra appear to have square shoulders, but the spaces where the true shoulders should be are excised; the false shoulders are smooth and impunctate at their tips. The tibiae are compressed and inflated, with their outer edges rounded but not angular, as in others of the genus, although from some directions the front pair appear somewhat angular towards the base. The tarsi are fitted into grooves in the tibiae, the tibiae into the femora, and the front legs into prothoracic grooves.

The three specimens sent by Mr. Davey (two have been returned to him as co-types) are apparently females, as each has a process (apparently an ovipositor) with two inner projections, extruded from the tip of the abdomen.

Chlamydopsis cavicollis, n.sp.

Of a uniform dark chestnut-brown, with rather straggling stiff yellowish setae; absent from greater portion of pronotum and depression and sides of elytra; near shoulders with conspicuous golden fascicles.

Head between antennae about as long (to mouth parts) as wide, flat, finely shagreened; with small but distinct punctures. Antennae when at rest completely fitted into cavities. *Prothorax* fully twice as wide as the sides are long, but along middle about one-third longer than sides; these almost straight and strongly raised, front margin sinuous and strongly raised, but somewhat thinner than sides; disc gently undulated and finely shagreened. *Elytra* decidedly wider than prothorax, apices widely and separately rounded; near base with a wide, transverse, shining, irregular depression, which is continued to each side, where it emerges as a narrow curved slit, but is partly concealed by the fascicles; about scutellar region with an obtuse elevation on each side, each shoulder from above appearing as a raised, narrow, curved epaulette, at its tip almost meeting a strong projection from the side; between each epaulette and the middle is a large obtusely triangular elevation, strongly elevated to its tip. In parts shagreened and towards apex with small (setiferous) granules. Epipleurae with distinct striae converging to subhumeral slit, the upper parts polished and without striae. *Under surface* shagreened and in places with irregular punctures. *Prosternum* with a narrow deep stria, commencing close to each coxa, and curved round so as to terminate at the extreme base at the shoulder. *Metasternum* with a narrow median line. *Legs* long and thin. Length $4\frac{1}{2}$ mm.

Hab.—New South Wales: Sydney (type in Macleay Museum).

A large species very unlike any previously described; the strongly raised prothoracic margins cause the disc to appear concave.

The fascicles on each elytron are four in number, two are directed forwards and two backwards, so that they meet or irregularly cross at their tips: the outer are smaller than the inner ones, and each is separated from its fellow by a distinct gap. The legs are all longer than the entire body, the hind pair being the longest; the tibiae are not strongly inflated or angular, but the front pair are somewhat dilated on each side of the tarsal groove. The front femora are too long to be received into the (rather shallow) prothoracic grooves.

I have not attempted to manipulate the antennae of the type, as they are completely fitted into their receptacles; the first joint appears large and about twice as long as its greatest width; the club is only partly concealed, and apparently can be extruded even when the first joint is at rest.

Chlamydopsis ectatommae, n.sp.

Black; appendages chestnut-red. With a few short pale stiff setae scattered about; a small and somewhat golden fascicle or pubescent membrane overhanging each depression towards the base.

Head somewhat rounded; with large, round, shallow punctures or areolets. Antennae large, first joint with similar punctures or areolets to those of head, curved, its outer edge somewhat grooved, club subcylindrical, lightly curved, almost as large as first; intermediate joints combined much shorter than first, or club. *Prothorax* moderately transverse, sides incurved to middle; margins not narrowly elevated, but apex gently raised, disc convex; with punctures or areolets as on head. *Elytra* about as long as wide; towards base with a large depression, which towards each side becomes vaulted and does not touch the sides, about base with a feeble elevation on each side; shoulders raised into feeble epaulettes, each marked off inwardly by an oblique impressed line. With conspicuous longitudinal striae, except in depression, where they are transverse, and about shoulders, where they are somewhat irregular. Epipleurae striated throughout, the striae more or less converging to a subhumeral space. *Pro-* and *mesosternum*, base and sides of metasternum, parts of abdomen, py- and propygidium, and under surface of front legs, with sculpture as on head. Metasternum, with a narrow median line. *Legs* rather long; tibiae strongly inflated, the inflated parts suddenly cut off towards the base, so as to appear strongly angular. Length $2\frac{1}{6}$ mm.

Hab. New South Wales: Gladesville, near Sydney, from a nest of *Ectatomma metallicum* (A. M. Lea).

A black species in general appearance close to *striatella*, but with conspicuous transverse striae about the scutellar region; the epaulettes are also somewhat different.

The depression, instead of being continued to the epipleurae, as in some other species, terminates some distance from each side, in a large, deep cavity or fovea, above which is the small fascicle. The outer walls of the cavities for the antennae are very thin, and when looked down into appear of a rather light reddish brown; from outside, however, they appear almost black. The front legs are entirely received into excavations, when their sculpture appears to be as that of the prosternum.

Chlamydopsis latipennis, n.sp.

Dark reddish brown, in places almost black; shoulders and appendages paler. With very short, sparse and irregularly distributed setae; subhumeral depressions with short, stiff, golden fascicles.

Head and antennae much as in preceding species, except that the large punctures or areolets are somewhat larger, and that the club is slightly larger than the first joint. *Prothorax* about twice as wide as long, sides gently incurved to middle and not raised, apex sinuous and distinctly raised, except in middle, where the elevation is but slight, disc strongly convex, but scarcely tuberculate in middle; with punctures or areolets as dense as on head, but more oval in shape. *Elytra* slightly wider than long, sides gently rounded towards base with a large and (for the genus) rather shallow depression, which towards each side becomes somewhat irregular. Shoulders each appearing as a feeble epaulette, and marked off inwardly by a deep and almost straight line. *Pro-* and *mesosternum*, and py- and propygidium with sculpture as on head, except that it is finer. Metasternum with a narrow median line, with large round punctures about middle, a row of punctures margining each middle coxa and fairly coarse punctures at sides; elsewhere smooth and almost or quite impunctate. Abdomen with irregular punctures, those on middle of first segment as on middle of metasternum. *Legs* long and thin. Length, 3 mm.

Hab.—N.W. Australia (type in Macleay Museum).

The prothoracic punctures are larger than in any other species known to me.

There are four small but distinct fascicles on each side of the subbasal depression, two being directed forwards and two backwards, the outer ones are slightly larger than the inner ones; there also appear to be remnants of others. The depression itself, from above, appears to be in three parts, a median space as in other species (except that it is somewhat shallower, with the subsutural elevations less noticeable) and a large round foveate space, interrupted by fascicles, nearer the side than the middle of each elytron. The elytra about the shoulders have sculpture much as on the head; on the basal part of the depression the surface is mostly smooth, but about its middle the punctures appear curved, and then to near the apex as very elongated ones or broken striae; about the apex they curve round, becoming wider than long. The epipleurae are smooth (much as if cicatrised) in a line with the subbasal depression, and towards this space all the punctures or irregular striation appear directed. Parts of the under surface are finely shagreened. The hind legs are about the length of the entire body, the others are somewhat shorter; the front femora are not fully receivable into excavations; the tibiae are angular towards the base (the hind pair less noticeably than the others) and thence to apex each has a narrow flange, but the flanges are only of such a width that the greatest width of the tibiae is about equal to the width of the tip of the femora.

Chlamydopsis epipleuralis, n.sp.

Chestnut brown; in places somewhat infuscated. With moderately long golden setae, absent from pronotum.

Head with numerous large shallow punctures or areolets. Antennae with first joint large, strongly curved inwards and strongly angular outwardly, with punctures or areolets as on head; club elongate-ovate, much smaller than first joint, and scarcely as long as intermediate joints combined. *Prothorax* about thrice as wide as the sides are long, sides gently incurved to middle and feebly elevated; apex more noticeably elevated, and directly from above, its median half straight but thence oblique to sides; disc moderately convex; surface with dense and very shallow punctures or very small areolets; a rather small depression or shallow fovea on each side near base, the two equidistant from each other and from the sides. *Elytra* slightly longer than wide; towards base with a large depression, breaking out at the sides on the upper edge of the epipleurae; a wide, feeble, transverse elevation on each side of the scutellar region. Each shoulder in the form of a raised epaulette, obtusely notched at its apex and sculptured as on head: separated from the rest of elytra by a deep, straight line; inwards from this line a raised subtriangular space, with its tip close to the tip of the epaulette, the two points almost meeting two points of each elytron behind them, between which portion of the subbasal depression appears as a fovea. *Under surface* shagreened, and with sculpture, except that it is finer, as on head. *Metasternum* with a narrow median line. *Legs* long: tibiae strongly inflated, the inflated parts suddenly angular, and rapidly decreasing in width at about the basal third. Length $2\frac{3}{4}$ mm.

Hab. New South Wales: Hornsby, from a nest of *Iridomyrmex*, sp. (C. Gibbons).

In general appearance fairly close to *formicicola*, but the prothorax with more distinct and different punctures (much as in *variolosa*) the subscutellar and subhumeral elevations somewhat different, and the striation alone will readily distinguish the species from *variolosa*.

The club, though large, is considerably smaller than in others of the genus. The upper surface of the elytra is marked by fine longitudinal striae (except towards the base); but on the epipleurae the striae are deep, and are all directed towards the outer edge of the subbasal depression. Although when seen directly from above the apex of the prothorax appears in straight lines, when viewed directly from behind it appears to be gently sinuated or lobed. The front femora are too long to be received into the rather shallow prosternal excavations. The hind tibiae are somewhat longer than the others, but are in other respects much the same. I cannot see any distinct fascicles or membranes within the subhumeral depressions, but there appear to be remnants of such.

var. *Mastersi*, n. var.

A specimen, from South Australia, in the Macleay Museum, appears to represent a variety of this species. It differs in being slightly larger (3 mm.); elytral striation much more distinct; prothorax with the apex, as viewed from behind, more lobed, and its punctures rather deeper; punctures of under surface more clearly defined, and py- and propygidium with fine pubescence in addition to setae. On its prothorax there are four small darkish spots, placed, as it were, at each corner of a square; on the type the basal ones are not distinct, as the whole of the basal fourth is infuscated.

Chlamydopsis pseudocephala, n.sp.

Chestnut-brown, in parts slightly darker; appendages slightly paler. With short, pale, stiff setae, nowhere very dense, but denser on pygidium than elsewhere. A small fascicle or pubescent membrane within each subhumeral depression.

Head, between antennae and mouth parts, about as long as wide, very feebly concave; with deep distinct punctures. *Prothorax* moderately transverse, sides lightly incurved to middle; median half of apex strongly and obliquely raised, with summit bilobed, the lobes strongly divided down middle, and separated from each side by a narrow triangular groove, which is open in front and closed behind, rather nearer the base than apex; densely punctate and shagreened, but about base with punctures only. *Elytra* subquadrate, each shoulder deeply and obliquely sulcate, the sulcus opening out posteriorly, so that each side of the base appears elevated, and each side behind the sulcus still more elevated, with moderately dense and clearly defined punctures along middle, becoming smaller and sparser towards sides; a very fine stria each side of suture. *Under surface* with dense and usually clearly defined punctures, but becoming very dense on prosternum; middle of prosternum with a narrow deep groove. *Legs* short and wide. Length $1\frac{3}{4}$ mm.

Hab.—Tasmania: Latrobe, from a nest of *Pheidole Tasmaniensis* (A. M. Lea).

The smallest of the genus. There were not many ants in the nests whence the type was taken, and when in the nest it looked remarkably like a head of one of the soldiers, amongst a small group of whom it was noticed. It evidently belongs to the same section of the genus as *sternalis*, but is considerably smaller than that species, prothorax not bisinuate at sides and elytral punctures not mixed with striae.

The median apical half of the prothorax is strongly elevated in two lobes, the lobes marked off behind by a deep impression and in front by a conspicuous impression, so that they appear as two tubercles, straight and touching on their inner edges, and rounded on their upper and outer edges. The punctures are so dense across the middle of the prothorax that they cause its surface to appear opaque.

On account of the minute size of the type, I did not venture to prise out the antennae, of which only the large basal joint of each (which is somewhat curvilinearly triangular in shape) and the tip of the club is visible. The legs are completely fitted into receptacles on the under surface, and these also were not prised out; they are short and wide, the tarsi entirely concealed, the tibiae (as visible) slightly wider than the femora, curved outwardly and apparently not angular; the tip of each of the hind femora just cuts into the elytral margin.

Chlamydopsis granulata, n.sp. (Fig. 5.)

Colour and clothing as in preceding species.

Head with central portion subcircular, gently concave with distinct punctures. Basal joint of antennae large, triangularly dilated in middle, club elongate-ovate, about half the size of basal joint, the intervening ones small. *Prothorax* as in preceding species, except that the frontal elevations are stouter, have their outlines more rounded, and that the excavation behind them is larger. *Elytra* as in preceding species, except that the punctures are very small, and indistinct, and that the surface is granulated posteriorly, and subgranulated elsewhere. *Prosternum* with punctures as on pronotum, the middle deeply grooved. *Metasternum* with distinct but not very large punctures, the punctures becoming much smaller and somewhat sparser on basal segment of abdomen. *Tibiae* strongly dilated, the four front ones angular towards base, the others rounded. Length, 2¼ mm.

Hab.—Victoria: Geelong, from a nest of a species of *Pheidole* (H. W. Davey).

Closely allied to the preceding species but larger, elytra with scarcely visible punctures, the surface granulated, and punctures of metasternum and basal segment of abdomen not of even size and considerably smaller. It is possible that the specimen should be treated as representing a variety of the preceding species, rather than as distinct, but the differences in the elytral sculpture are so pronounced, that it appears best to regard the differences as specific. In some lights, vague remnants of elytral striation are visible.

Chlamydopsis opaca, n.sp.

Black, opaque; sides of prothorax, sides of elytra at basal third, their epipleurae, abdomen and appendages of a more or less dingy red. Glabrous.

Head vertical, face slightly concave and with small punctures. Each basal joint of antennae about as large as exposed portion of head: somewhat triangular in shape, inner edge bisinuate, outer gently rounded, and upper notched. *Prothorax* feebly convex, about twice as wide as long, margins not thickened and very feebly raised, outlines somewhat angular; surface finely shagreened and with numerous small punctures. *Elytra* subquadrate, sides feebly undulated; with a strong, narrow, transverse impression at apical fourth, with a narrow golden membrane on front edge of impression, occupying the median third of each elytron; an oblique line from each shoulder almost to the membrane; surface finely shagreened and with dense and rather coarse punctures, becoming finer at base, sides and apex;

epipleurae wtih dense minute punctures, and with fairly numerous larger ones. *Prosternum* smooth and shining in front, but elsewhere shagreened. Metasternum shagreened and densely and finely punctate; with a narrow median line. *Abdomen* highly polished except parts of the sides, and most of the middle of the basal segment, which is shagreened and with rather coarser punctures than on metasternum. *Femora* wide; tibiae angularly dilated from base to basal third, and then rounded to apex, all wide, but the hind pair wider and less angular than the front pair. Length $4\frac{1}{2}$ mm.

Hab.—New South Wales: National Park (W. Du Boulay).[1]

Closer to *glabra* than to any other described species, but upper surface shagreened and opaque, elytra with conspicuous punctures, the transverse subbasal impression narrower and more parallel-sided, its dilated portion narrower, with a faint line running in from each shoulder (not a trace of this is in *glabra*) suggesting the position of the epaulettes of other species, epipleurae with conspicuous punctures and the under surface opaque, except front of prosternum and most of abdomen. The outlines as given for *glabra*, however, are exactly as in this species. The type has the head completely retracted within the prothoracic cavity, and, fearing injury, no attempt was made to force it out.

**Chlamydopsis formicicola*, King.
**C. striatella*, Westw.
**C. inquilina*, Lewis.

Mr. Lewis recently wrote to me of these species:—

"*C. formicicola*, King, differs from *striatella*, Westw., by being darker[1] in colour, less quadrate in form (the elytra being longer), by the thorax being acutely angulate at the anterior angles, and the surface is less opaque and less distinctly granulate, by the elytra having the two elevations behind the scutellum much less oblique and somewhat acutely pointed at their ends. The elevations in *striatella* are somewhat short, distinctly divided in the middle, oblique, and end on each side obtusely. *C. inquilina* differs from both species by being nitid, and the thorax is much less transverse, and is parallel laterally, the edges in front and at the sides being uniformly and more strongly elevated, the elytra also have the elevations behind the scutellum perfectly transverse, not oblique, and they are longer and acute at the ends, and there is scarcely any discernible median partition. The legs of *inquilina* are more robust, a character

1 A son of the Du Boulay who took the first described species of the genus.

1 This is evidently an error, as *formicicola* is more or less reddish, and *striatella* was described as piceous-black. My own specimen of *striatella*, from the type locality (Swan River), is considerably darker than the type of *formicicola*; but as Mr. Lewis wrote that his specimen of *striatella* was from New South Wales, it seems possible that his identification of that species was not correct.

especially obvious at the bases of the tibiae and the median angles of the tibiae are all less acute. My specimens of *inquilina* and *striatella* are from Liverpool, New South Wales. I think that the elevations on the elytra behind the scutellum are likely to afford good specific characters should many more species be brought to light."

**Chlamydopsis longipes*, Lea.

Of this species, Mr. Davey recently wrote to me:

"I made a fine haul of *C. longipes* the other day, took three in the one nest under a stone, one a small specimen, and two large ones; you might not think it (judging by their legs), but my experience is that they are very difficult to spot, they seem to favour nests built under pieces of ironstone, and when they are at rest with their legs all tucked away, they have a remarkable likeness to the nodules on this stone, and all I have taken have always been on ironstone with the green ants."[1]

Mr. Davey has taken the species at Ararat, a fresh locality.

**Chlamydopsis glabra*, Lea.

There is a specimen of this species in the Queensland Museum. It differs from the type in having the elytra rather more conspicuously punctured (much less conspicuously than in *opaca*, however), and the prothorax of a dingy red, with the edges narrowly black, and the middle of the base obscurely piceous.

It was taken by Mr. Hacker at Brisbane, under a stone, from a nest of *Ectatomma metallicum*; and in sending it he wrote:—"It did not attempt to escape, but kept turning round and round in the same place; and, when it did move, it had a curious jerky run different to any other beetle I've seen."

NITIDULIDAE.

Brachypeplus inquilinus, n.sp. (Fig. 6.)

Dark piceous-brown: sides of prothorax, base of elytra and all the appendages reddish. Upper surface with very short and rather indistinct pubescence, prothorax and elytra distinctly fringed with short setae: under surface with distinct and somewhat golden pubescence.

Head about twice as wide as long, a distinct impression towards each side on clypeal suture; with dense and rather small, but clearly defined punctures. Antennae scarcely longer than head; first joint stout, about as long as three following combined; club subcircular.

1 *Ectatomma metallicum.*

Prothorax less than twice as wide as long, wider at base than at apex, the sides flattened, with the flattened parts narrowed to apex; punctures on disc much as on head, but becoming slightly coarser towards sides. *Elytra* slightly wider than prothorax, distinctly wider than long; distinctly but not strongly striated, the interstices densely punctate. *Abdomen* with basal segments fully as wide as elytra; upper surface with punctures as on head, under surface with similar, but more or less concealed punctures; third, fourth and fifth segments each with a shallow depression on each side, third about as long as first, twice as long as second, slightly shorter than fourth, and much shorter than fifth. *Legs* short and stout. Length 4 mm.

Hab.—New South Wales: Hornsby, from a wild nest of the hive bee (C. Gibbons).

In general appearance somewhat like a very wide specimen of *basalis*, but much less parallel-sided, the pale markings of elytra occupying much less of the base (they scarcely pass the tip of the scutellum), and nowhere touching the suture. The clothing also is somewhat different. The lateral fringes of the prothorax and elytra are quite conspicuous, although less so than in *auritus*. The scutellum appears very distinct on account of being darker in colour than the base of the elytra.

Brachypeplus blandus, Murray.

Mr. C. Gibbons also took two specimens of this species from a wild nest of the same bee.

Carpophilus planatus, Murray.

Mr. Gibbons took a specimen of this species from a nest of *Trigona carbonaria*.

**Pria rubicunda*, Macl.

Three specimens recently taken by Mr. Davey from a nest of *Iridomyrmex nitidus*.

TRETOTHORACIDAE.

**Tretothorax cleistostoma*, Lea.

Mr. Hacker has taken numerous specimens of this species in nests of a second species of ant, *Odontomachus coriarius*.

CUCUJIDAE.

Cryptamorpha delicata, Blackb.

A specimen, apparently representing a variety of this species, was taken at Railton (Tasmania) from a nest, built amongst stones, of a small form of *Ectatomma metallicum*, some distance from the nearest tree. It moved quite rapidly amongst the ants, and I think its presence there was not at all accidental.

The specimen differs from the typical form of *delicata* in having the elytra more or less stained with piceous; the base and apex are less stained than elsewhere, but the shades of colours are not sharply limited.

Byrrhidae.

**Microchaetes scoparius*, Er.

Mr. Davey has taken two specimens of this species from a nest of *Ectatomma metallicum*. A specimen previously sent by him as from a nest of a species of *Camponotus* probably belongs to the species, but is too abraded for certainty. I have taken one of the species myself, from a nest of *Ponera lutea* near Sydney.

Ptinidae.

Polyplocotes castaneus, n.sp.

Bright castaneous: prothorax somewhat darker. Middle of sterna and basal segment of abdomen with dense, and somewhat golden pubescence; rest of abdomen and prothorax very sparsely pubescent, elytra glabrous.

Head strongly transverse; eyes rather acutely projecting. Antennae passing base of prothorax, first joint stout and subgranulate, the others shining, second, third and fourth each about as long as wide, fifth slightly shorter, sixth and seventh still shorter, eighth about as long as sixth and seventh combined, and distinctly wider, its apex truncated and base rounded, ninth narrower than eighth, and a little more than half its length. *Prothorax* slightly longer than wide, sides rounded in front and constricted near base; near base strongly transversely depressed, the depression terminated in a fovea on each side; densely and more or less longitudinally strigose, with a few punctures scattered about. *Elytra* ovate, strongly convex; base truncate and each side with four small deep impressions; with regular rows of small punctures, the interstices each with a series of still smaller punctures. Three basal segments of *abdomen* rather large, their sutures obliterated across middle, with fairly numerous punctures. *Legs* rather long. Length, 2 mm.

Hab.—N.W. Australia: "Sharp's Collection" (type in British Museum).

The latero-basal foveae of the prothorax are of considerable size, but invisible from above. From some directions the elytra of the type appear to be covered with regular rows of large punctures; but from others these are seen to be watery-looking marks only, such as occur in many specimens of *Cordus hospes*; from most directions they are invisible. The head in front of the antennae is quite invisible from above, is strongly sculptured, and (in the type) has the mandibles resting between the front coxae.

In general appearance close to *Diplocotes Howittanus*, but antennae nine-jointed only. Westwood regarded *Diplocotes* as distinct from *Polyplocotes* on account of the typical species having the antennae eleven-jointed; but two species of the former genus are now known to have ten-jointed antennae; and so, later on, it will probably be considered advisable to unite the two genera, and to regard the species having nine, ten or eleven jointed antennae, as belonging to sections only.

Paussoptinus dolichognathus, n.sp.

Castaneous, knees slightly infuscated. Very sparsely pubescent; but sterna between coxae with dense, whitish pubescence.

Head about thrice as wide as long, front gently bisinuate; with dense, partially concealed punctures. Eyes prominent and apparently acute. Mouth parts produced so as to appear like a flattened rostrum. Antennae large and wide, their bases almost touching; first joint large, its front edge strongly curved, second very small and quite concealed from above, third to ninth each much wider than long, the joints slightly increasing in size to ninth, tenth about as long as eighth and ninth combined, its apical edge incurved to middle. Palpi concealed. *Prothorax* slightly longer than wide; base wider than apex, sides dilated to basal third (but not dentate), then narrowed to near base, and then dilated to base; across basal third strongly impressed, the impression slightly dilated in middle, but not foveate, densely, conspicuously and more or less longitudinally strigose. *Elytra* subovate, strongly convex; base narrow and with eight small foveae; feebly striated, the interstices finely strigose, and with scarcely visible flattened granules. *Legs* rather long and flattened. Length $3\frac{1}{4}$ mm.

Hab.—C. Australia: Killalpanima (Rev. H. J. Hillier).

The type and only specimen known to me has been returned to the British Museum It differs from *laticornis* in having the antennae with one joint less, the apical joint much larger and of different shape, mouth almost rostrate, prothorax differently impressed and unarmed, etc. *Brevipennis* (unknown to me) is described at having the antennal joints differently proportioned, the prothorax with a profound basal fovea, and its sides tridentate, etc.

Looking straight at the face below the antennae, there appears to be an acute ridge on each side marking off a strong depression; in the middle is an acute, narrow Ω-shaped elevation, with a small tubercle between its tips. Then the mandibles commence: they are very curiously shaped, truncated at apex, with their tips crossing. The whole of the projecting parts are rather more than two-fifths of the total depth of the head.

TENEBRIONIDAE.

Hyocis cancellata, Lea.

Mr. Davey has taken a specimen of this species from a nest of *Pheidole*, sp.

Hyocis nigra, Blackb.

In examining the contents of the nest of a mound building species of *Iridomyrmex* at Ulverstone I obtained nine specimens of this species.[1]

Cardiothorax aeripennis, Blackb.

Recently at Otford Mr. Cox obtained two specimens of this species, singly, from nests of *Stenamma longiceps*; and I obtained two from another nest of the same kind of ant.

LAGRIIDAE.

**Lagria formicicola*, Lea.

Dr. Ferguson informs me that he has taken and seen numerous specimens of this species in nests of *Ponera lutea*: in several nests there were at least 20 specimens of the beetles.

XYLOPHILIDAE.

Xylophilus alpicola, Blackb.

Three specimens obtained from nests, near Sydney, of *Ponera lutea*.

BRENTHIDAE.

**Cordus hospes*, Germ. (Fig. 7.)

In October, 1910, in examining some nests of *Iridomyrmex nitidus* at Glenfield (New South Wales), I saw thousands of specimens of this beetle. In parts of the nests they were clustered so thickly together, that from a space, a square inch in extent, several dozens could have been taken. The ants moved freely about them without in any way interfering with them. The beetle also occurs in nests of *Stenamma longiceps* and of *Iridomyrmex itinerans*.

1 Now first recorded from Tasmania.

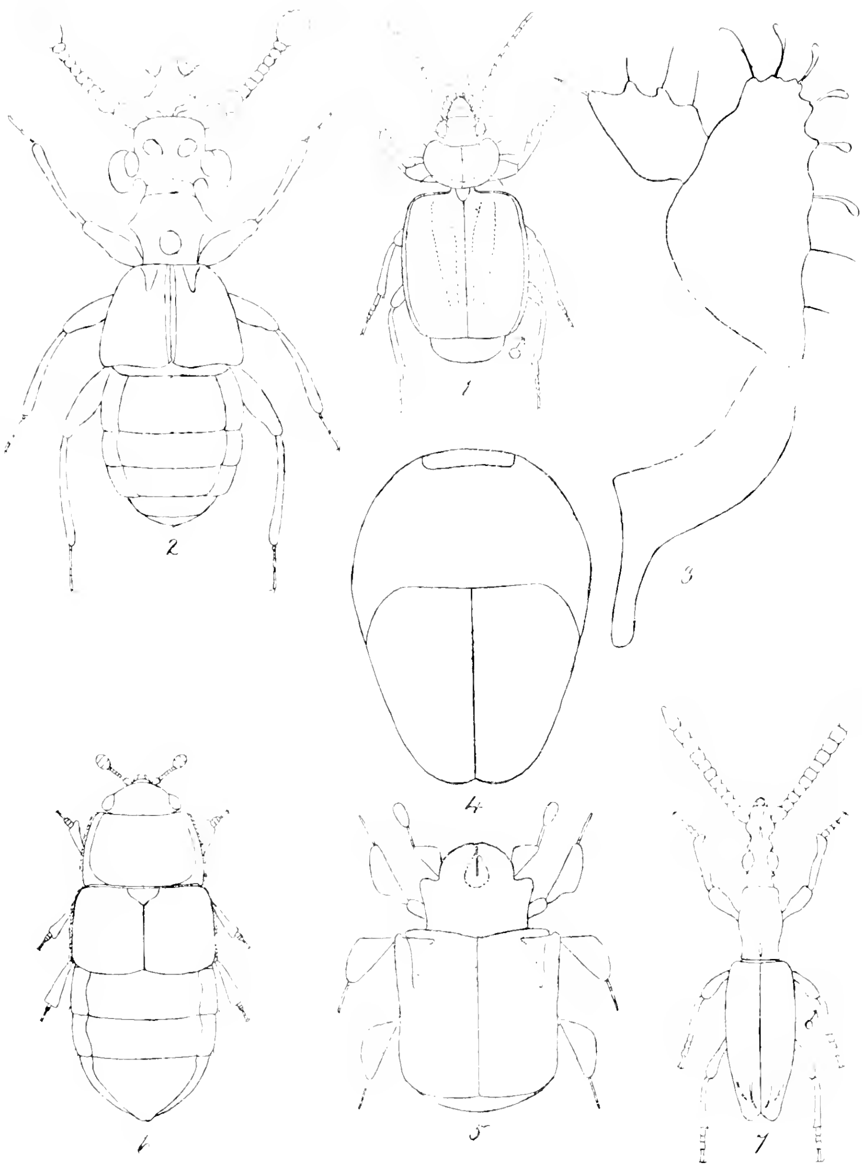
COCCINELLIDAE.

Rhizobius hirtellus, Crotch.

A specimen of this species was taken near Hobart from a nest of *Iridomyrmex glaber*, where it was feeding on mealy bugs (*Dactylopius*, sp.).

EXPLANATION OF PLATE II.

Fig. 1. Philophlaeus myrmecophilus, Lea.
2. Daveyia mira, Lea.
3. Daveyia mira, Lea, palpus.
4. Rodwayia orientalis, Lea.
5. Chlamydopsis granulata, Lea.
6. Brachypeplus inquilinus, Lea.
7. Cordus hospes, Germ.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Art. V.—*On a new Holothurian of the Genus Taeniogyrus found in Port Phillip Bay.*

By E. C. JOSHUA.

(With Plates III. and IV.).

Read 11th April, 1912.

Taeniogyrus allani, sp. nov.

The *Chiridotinid* of which a description follows was first dredged by Mr. J. M. Allan, near Geelong, and was subsequently found by myself near Williamstown.

Description.—Tentacles ten, peltato-digitate, pigment spots at base.

Size.—8 centimetres in length, breadth about 6 mm.

Colour.—Carmine in life, in spirits white.

Calcareous deposits, consisting of wheels, sigmoid bodies, and rods. The wheels are principally confined to the three dorsal interambulacra and are grouped in round and irregularly-shaped papillae, except at the anterior and posterior ends, where they are thickly disposed all round the body. They have six spokes connecting with a peripherally hexagonal rim, the inner margin of which consists of alternate serrated convexities and unserrated smaller concavities. One side of the hub of the wheel is closed by a six-rayed plug, the other is open and surrounded by a dentated margin. The sigmoid bodies are scattered singly at fairly regular intervals and roughly at right angles to the axis of the body; they occur equally in all the interambulacra. The rods are confined to the margins of the tentacles and to the intertentacular web.

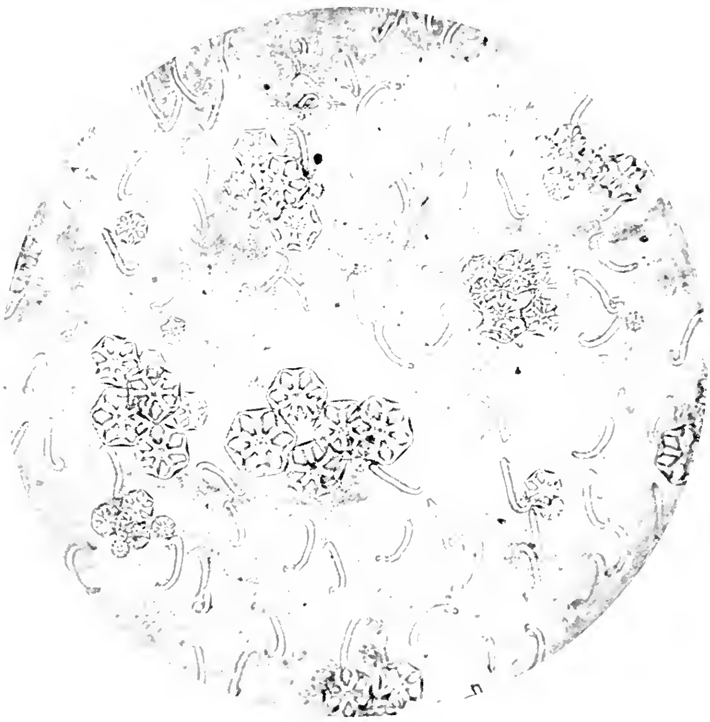
Habitat.—On mud banks, in from 5 to 10 fathoms, Port Phillip Bay.

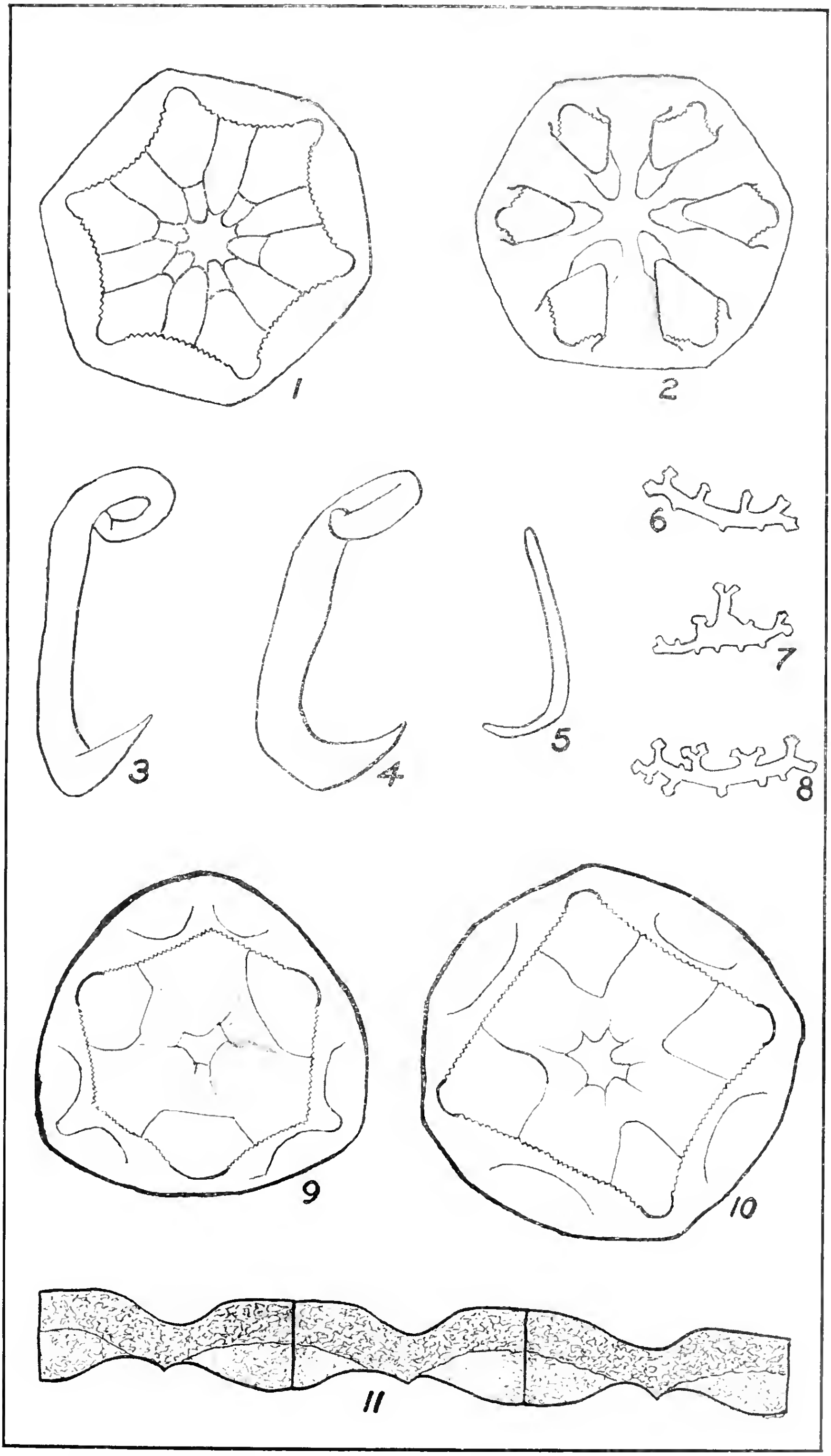
Anatomy.—Genital glands: Two, single, unbranched, sexes separate.
Alimentary canal: Contorted axially.
Polian vessel: Single.
Stone canal: Apparently absent.
Calcareous ring: Consisting of ten pieces.

Two mounted specimens of an animal, which Mr. Allan declares to be identical with the present species, were sent by that gentleman to the President of the Royal Microscopical Society, London, who in turn submitted one of them to Professors R. Koehler and C. Vaney of Lyons. Prof. Vaney identified the specimen as *Trochodota* *dunedinensis*, Parker (1). In November, 1910, I was fortunate enough to obtain a number of specimens of the same animal near Williamstown, and a careful examination convinced me that I was dealing with a different species from the above-mentioned. The accepted classification of the sub-family *Chiridotinae*, to which both *dunedinensis* and the present species belong, is that of Ostergren (2), who bases his arrangement on the presence or absence of calcareous deposits, and their disposition in the integument. Hubert Lyman Clark (3) in his monograph on the Apodous Holothurians gives a key to the genera and species comprised in the sub-family, and adopting a suggestion of Semper's (4), he establishes the genus *Taeniogyrus* to include those forms in which the wheel ossicles are collected in papillae; the genus *Trochodota*, Ludwig, being characterised by the wheels being scattered singly. The present species has the wheels definitely aggregated, and could not therefore be placed in the genus *Trochodota*, therefore further to consider its identity with *T. dunedinensis* is perhaps superfluous; it may, however, be pointed out that a comparison of the description and figures of the wheels of *dunedinensis* with that given by myself of that of the present species, shows marked variation. *T. allani* further differs in having but two genital tubes, as opposed to several in *T. dunedinensis;* and in having a contorted alimentary canal as opposed to the straight one of Parker's species. Its differentiation from its congener *Australiana*, Stimpson (6), and *T. contorta*, Ludwig, is fairly definite, and is rendered easier in the case of the former from the fact of the species having been reviewed by Clark (3). We have unfortunately no description of the wheel of *Australiana*, but as regards the distribution of the sigmoid ossicles, Clark confirms Stimpson's original observation, that they are in definite papillae; in *T. allani* they are invariably scattered. The genital tubes of *T. Australiana* are distinctly branched; in *T. allani* they are unbranched; size, colour and habitat are also different.

From *T. contorta*, it differs in the structure of the wheel ossicle. I am relying on Theel's (7) figure for this, as I could not get access to Ludwig's original paper. *T. contorta* has twelve tentacles. *T. allani* ten; *T. contorta* has branched genital glands, *T. allani* unbranched. *T. contorta* is viviparous (8), and though I have opened many specimens of *T. allani*, I have been unable to note this peculiarity in it.

Although I have pointed out above the error of Professor Vaney's diagnosis, I think it but fair to state that I think it was almost certainly due to the fact that he was furnished with an incomplete specimen; the slide submitted contained in reality only about 2 cm. of the anterior end of the animal. In this portion the aggregation of the ossicles into papillae is not definite, and unless the wheels were

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closely examined, their difference in structure from that of *T. dunedinensis* might not be detected. Even if noted, it might be regarded as having only varietal significance: whilst, of course, such a specimen would be quite useless for noting any peculiarities of the internal anatomy.

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DESCRIPTION OF PLATES.

Plate III.

Photo-micrograph of portion of dorsal integument of *Taeniogyrus allani*—to show arrangement of wheel ossicles in aggregations, and sigmata scattered, . . . × 60.

Plate IV.

Fig. 1—Wheel ossicle. Outer aspect. Actual size, .20 mm.
2—Wheel ossicle. Inner aspect. Actual size, .20 mm.
3, 4, 5—Sigmoid ossicles. Actual size, .14 mm.
6, 7, 8—Tentacle ossicles. Actual size, .10 mm.
9, 10—Abnormal wheel ossicles. Actual size, .18 mm.
11—Calcareous ring. Enlarged.

Proc. Roy. Soc. Victoria, 25 (N.S.) Pt. I., 1912.]

Art. VI.—*The Occurrence and Development of Cervical Ribs in Man and some of the Mammals that have abandoned Quadrupedal Progression.*

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[Read 11th April, 1912].

Cervical ribs have acquired such a prominent place in modern surgery that practical as well as scientific reasons demand that the causes controlling their formation should be investigated. The observations and deductions that are put forth in this paper are the outcome of my enquiry into such causes, and they form an extension of the abstract published in the Australian Medical Journal, August 19, 1911.

The endeavour has been made to discover not only the influences that cause the development of cervical ribs, but also the hostile conditions that suppress rib growth and destroy rib structure.

It will be shown that cervical ribs develop in the human neck because the lungs have migrated towards, and encroached on, the neck; and, from the conditions associated with general rib development, the deduction is drawn that cervical ribs form in the human neck in response to impulses that are generated in the organism which has been and is being excited by the presence of lung in the neck.

Classification of the Principal Stages in the Evolution of Cervical Ribs.

(1) The primary development of rib-structure in the neck-area.
(2) The suppression of neck rib-structure.
(3) The secondary development of cervical ribs.

The primary development of ribs in the neck-area is illustrated by the structure of fish.

The suppression of cervical ribs can be studied in the following structures:—

(a) The cervical rib-stumps of crocodiles.
(b) Costal processes as they occur in the mammalian neck.

Neck rib suppression is further evidenced by the absence of costal processes from the seventh cervical vertebra of the quadrupedal mammals. The absence of these costal processes shows that the rib-structure which is associated with the seventh neck bone may, under the influence of the neck flexion that occurs in the quadrupedal mammals, suffer extinction.

The development of cervical ribs in the mammalian neck may be either partial or complete.

(a) Partial in the short cervical ribs that do not reach the sternum, as seen in dugongs and man.

(b) Complete in the sternal cervical ribs of the manatee and in the occasional sternal cervical ribs of man.

Function of Ribs.

Ribs are stiff and resilient. The uses to which these qualities are put by the animal economy constitute the functions of ribs.

Fish-ribs stiffen the body and protect viscera, but they possess no respiratory function.

In the chameleons, the sphenodon, and other lizards possessing a low grade of neck development, cervical ribs are continuous with the ribs of the body-cavity, their function being to protect viscera and to assist respiration. In snakes the cervical ribs are greatly developed and their function is locomotory. The cervical rib-stumps of the crocodile afford muscular attachments, and they confer some degree of rigidity upon the neck.

The costal processes of mammals are too small to interfere with the freedom of the movement of the neck, and they serve merely for muscular attachments. The main function of the thoracic ribs is associated with respiration, and the rib development that occasionally takes place in the mammalian neck is also intimately associated with the lungs. Therefore

Cervical Ribs of Mammals are of Respiratory Function.

Cervical ribs have been variously described: Keen, in 1907, referred to them as "congenital anomalies"; Andrews, in Keen's Surgery, calls them "deformities." Purves Stewart records that Oppenheim regards cervical ribs in the human neck as the "stigmata of degeneration." Here and there cervical ribs are regarded as examples of atavism, but the majority of medical men regard them as vestiges.

The term "congenital anomaly" can only be used in a very restricted sense because science cannot regard any natural condition as anomalous. The word "deformity" conveys no idea as to what causes the development of cervical ribs. The expression "stigmata of degeneration" throws no light on the cause of cervical ribs, but as the development of cervical ribs in mammals is associated with degenerative changes in the neck, the term is useful.

Considerable confusion seems to exist about vestiges and cervical ribs. It is as well to preface the remarks on this subject by quotations from Morris's Human Anatomy and Arthur Keith's Human Embryology and Morphology.

Morris says:—"The costo-transverse foramen is very characteristic of a cervical vertebra. It is bounded internally by the pedicle, posteriorly by the transverse process, which corresponds to the transverse process of a thoracic vertebra, anteriorly by the costal process, which corresponds to the rib in the thoracic vertebra, and externally by the costo-transverse lamella.

"The transverse process (of the seventh cervical vertebra) is massive; the costal element of the process is very small, but, on the other hand, the posterior or vertebral part of the process is large, and becoming more like the transverse process of a dorsal vertebra. The costo-transverse foramen is the smallest of the series and may be absent. Occasionally the costal process is segmented off and constitutes a cervical rib."

Keith says:—"Vestigial Ribs: Although the ribs are only fully developed in the dorsal region, yet a representative, a costal element, is present in every vertebra."

"The costal process of the seventh cervical, usually represented by a mere vestige, may develop into a rudimentary or even a fully formed rib."

It is difficult to accept this teaching of Keith, because it contains an error somewhat akin to the exploded idea that cranial bones are modified vertebrae, for he confuses the costal process, which is a reduced rib, with the costal rudiment, from which all ribs must develop.

The formation of costal processes is shown in the monotremes; there, in the *Platypus*, the rib-stumps are separated from the vertebrae by joints, but in the *Echidna* these joints are more or less indistinct and the rib tissue is becoming confluent with the neck bones. In the higher mammals these joints have entirely disappeared and the suppressed ribs remain as costal processes or rib vestiges. Costal processes are vestiges of ribs because they mark the remains of pre-existing cervical ribs. Mammalian cervical ribs are developments because they appear in positions which have been occupied either by ribs that have become extinct, or by costal processes, ribs that have become vestigial. Cervical ribs are developed ribs, and the development varies from slight to full. A developing, or a developed, structure is not a vestige, nor is a vestige a rudiment, nor is the costal process the costal rudiment. The term "costal element" that is frequently used, can refer to but one thing, and that one thing is the costal rudiment, from which all rib tissue, suppressed and developed, must arise. Costal processes express suppression, by hostile movement, of rib tissue; cervical ribs express rib development over lung tissue that has migrated into the neck.

If cervical ribs be developed costal processes, as Keith claims, cervical ribs should be devoid of joints and appear as buttresses of bone fused with the transverse process and body of the vertebra, even when quite small cervical ribs are jointed. The difference between costal processes (vestigial ribs) and cervical ribs is the difference between suppression and development. The greatest likeness that can be claimed between them is they may both arise from a rib rudiment, which by no means makes them one and the same thing.

Atavism.

In order that the association of atavism with cervical ribs may be reviewed, it is necessary to pass back through the mammals where cervical ribs were absent, through the monotremes and later reptiles where cervical ribs occur, back to the early reptiles, where cervical ribs had persisted from the fish-type; and then to show that the germ plasm as it passed through successive stages of evolution has retained the hereditary power to form cervical ribs, and that this power, though possessed, has been held in subjection until quadrupedal progression has been abandoned and the adoption of some other form of progression has made it possible for cervical ribs to form. This much is necessary to the belief in atavism in spite of latter-day criticism, with its pruned version as to what atavism is. The interpretation of the theory of atavism has been altered and contracted from the widest limits to the narrowest confines. To many present-day pathologists the word atavism connotes:—"The appearance in an individual of normal or pathological characters which are wanting in the parents, but were present in the grandparents or great-grandparents." (Ziegler.)

These ideas are embodied in the Mendelian law, and if the word atavism is only to be thus used, it should become obsolete, as it leads only to confusion.

As an example of atavism, Bland-Sutton wrote:—"The attainment of a functional condition by parts normally suppressed is well illustrated in the case of man by supernumerary ribs."

When going into detail, Sutton displays unfamiliarity with the neck bones, for he says:—"Supernumerary ribs attached to the lumbar vertebrae are more instructive than those in the neck."

He is also in error when he says:—"In many birds and reptiles all the cervical vertebrae bear ribs," whereas many birds, particularly ostriches, show large vestigial neck ribs. Owen in 1866 had correctly written:—"In the cervical vertebrae of birds the pleurapophysis, if present, is confluent with the neural arch."

Gegenbaur refused to accept the old ideas of atavism and laid it down that:—"Atavistic parts do not belong to forms palaeontologically or systematically far distant."

Sutton, who accepted Gegenbaur's restrictions, grouped atavistic phenomena into two classes:—(1) "The attainment of functional condition by structure normally suppressed." (2) "Reversion of organs and tissues to an original type."

Although Darwin had no difficulty in understanding the extinction of species, he realised that he was unable to understand the extinction of organs and structures. The following quotations from Darwin's writings bear out this point:—"It is most difficult always to remember that the increase of every creature is constantly being checked by unperceived hostile agencies, and that these agencies are amply sufficient to cause rarity and finally extinction."

"There remains, however, this difficulty after an organ has ceased being used, and becomes in consequence much reduced, how can it be still further reduced in size until the merest vestige is left; and how can it be finally quite obliterated? It is scarcely possible that disuse can go on producing any further effect after the organ has once been rendered functionless. Some additional explanation is here requisite which I cannot give."

The theory of atavism does not fit the evolution of cervical ribs; the old idea takes us back to the early lizards and fish, the modern idea to the quadrupedal mammals, and the new idea is distinctly Mendelism.

The destruction of neck ribs can be traced from the fish through the reptiles and monotremes until in the mammals they become small and confluent with the neck bones. From the quadrupedal mammals through some of those mammals that have abandoned quadrupedal gait, notably man and sirenia, cervical rib development may be traced from small undeveloped cervical ribs that appear only occasionally in the dugong, to fully formed cervical ribs that occur constantly in the manatee.

The point of greatest interest in relation to mammalian cervical ribs is the seventh cervical vertebra; a careful study of this bone shows that ribs undergo not only suppression, but that they also undergo extinction, for when the seventh cervical vertebra is without costal processes, it is evident that the rib vestiges have disappeared and that the ribs, which in an earlier stage of evolution belonged to this bone, have become extinct.

It seems a process of narrow reasoning which admits the origin of new species, but refuses to admit that new structures may be evolved. The denial of the appearance of new structures seems to be the basis of the theory of atavism.

Where ribs develop in sites that have been previously occupied by vestiges of extinct ribs, new rib-forming impulses have arisen which are of a different character to those impulses that have suppressed neck-ribs and formed rib-vestiges, or to those that have brought about the extinction of rib.

Darwin did not fully grasp the relationship that exists between organs, structures and species. It is apparent that structures and organs form the parts of the species; and it follows that that which applies to the whole must apply to the part. Species are admitted to suffer extinction through hostile influences, and therefore it must also be admitted that structures and organs may likewise suffer extinction by the same means.

Bland-Sutton wrote:—"Much that is fanciful and speculative is mixed up with the subject of atavism," and a study of neck ribs compels the endorsement of this remark, for it is a fanciful idea that regards mammalian cervical ribs as atavistic to the ribs in the neck area of fish.

Mammalian cervical ribs develop in association with respiration, fish ribs are unassociated with lung, therefore mammalian neck ribs and ribs in the neck-area of fish are not teleologically related, for they are each utilised for a different purpose. It will be shown that cervical ribs are late developments in the mammalian neck, which development is due to the impulses that are occasioned by the encroachment of lung into the neck.

The costo-transverse foramen is absent from the seventh vertebra in most quadrupedal mammals that have well defined neck curves; and usually associated with the absence of this foramen is the lack of costal processes. The absence of costal processes from this bone would appear to be determined by the fact that their presence would hamper the range of what in quadrupedal animals is an extensive neck movement occurring in this position. The seventh neck bone of such animals has been submitted to extinction of its rib vestiges by the hostile effect of neck flexion upon a thoracic base that has been made firm by the lateral pressure of the weight of the body. Occasionally in true quadrupeds, the costal processes on the seventh cervical vertebra are not suppressed on both sides. We have found this abnormality in the racehorse "Traquair," and Dr. Dodd, of the Sydney University, writes me that he also has a specimen of the same abnormality, that is, the costal process of the sixth neck bone is suppressed on the same side as it is developed on the seventh. Sisson, Veterinary Anatomy, page 33, records similar abnormalities. This change of position of the costal process is clearly compensatory, and it is probably due to the impulses that cause these horses to lead off the gallop from the same foot.

The extinction of the costal processes from the seventh vertebra by the flexion of the neck seems to clear up the point which puzzled Darwin, how structure may become extinct. The costal processes of the seventh neck bone disappear before hostile conditions that are sufficiently hostile to suppress them to extinction. We have evidence that the costal processes of the seventh vertebra are suppressed to extinction by the flexion of the neck; and this fact shows a reason for the extinction of definite structure and it goes to prove that structures and species are controlled by the same law. If it be admitted that species and structures are controlled by the same law, it follows that cervical ribs in mammals represent a new type of rib situated in the same positions as ribs that have suffered extinction; and, therefore, they are not atavistic structures but new developments.

If it be admitted that mammalian cervical ribs are atavisms, then it must be admitted that extinction of rib-structure is a throw-back to the invertebrates.

A brief account of some of the hostile influences that have assailed cervical ribs, reduced them to vestiges, and finally caused their extinction will be dealt with in the body of this paper.

Impulses.

Smith-Woodward writes thus (Ann. Nat. Hist. xviii., 1906, page 312):—

"Throughout the evolution of the organic world there has been a succession of impulses, each introducing not only a higher state of life, but also fixing some essential characters that have been variable in the grade immediately below."

From this quotation it does not seem clear what an impulse is. Does it represent the action of environment on the organism, or the reaction of living tissues to external conditions from which results the generation of impulses? These two things are very different; one ignores the re-action of tissues and the other regards it as an essential factor. In dealing with neck tissues it seems impossible to ignore the biological factor and to explain the evolution of the neck by physical conditions alone. For instance, there is a general belief that "continued pressure causes atrophy, and intermittent pressure hypertrophy," and yet the necks of porpoises and whales that are submitted to intermittent pressure show atrophic changes. These neck tissues react to the impulses which the biological factor in reaction with external conditions generates.

In this paper it will be assumed that the evolution of the neck is controlled by impulses that are generated by the reaction of the tissues to external chemical and physical conditions. These impulses determine change and stability in animal tissues and under their influence it will be shown that fixed-type may be destroyed and new tissues arise.

The Evolution of the Neck.

Mammalian neck evolution may be studied in the *Schnapper*, *Ceratodus*, *Trachysaurus rugosus*, *Varanus varius*, *Crocodilia*, *Platypus*, *Echidna* and *Mammalia*.

In many fish dorsal and ventral ribs occur; the former extend between the muscles and the latter stiffen the walls of the body-cavity. Some seem to use the words dorsal and ventral to the parts of a mammalian rib, the rib proper being termed the dorsal rib and the costal cartilage the ventral; this use is still more commonly adopted in describing avian ribs. There also seems to be an ill-defined tendency on the part of some writers to assign to vertebrae the power of laying down ribs. As all the bones of the body are formed in response to impulses it follows that vertebrae and ribs come alike under the influence of the impulse. As the body requires new bone, fresh centres of ossification undoubtedly develop; and, as movement becomes necessary, joints appear.

In the schnapper and haddock the heart occupies a position in the gill-area, and ribs are in the area that ultimately in reptiles, birds and mammals becomes the neck. Fish are neckless, a state which is marked by ribs extending to the head. Fish are propelled by the thrust of the tail and this force is transmitted through the body mainly by the vertebrae, but the ribs serve to stiffen the body and thus to prevent loss of propelling power.

The neck is formed by the passage of the pectoral girdle, which strips the neck-area of its ribs; or, to be more exact, the passage of the girdle is associated with the denudation of the neck of its rib tissue. From the fact that fish are neckless, and that limbed vertebrates have necks, it is apparent that the evolution of the neck becomes necessary as the limbs are evolved. A neck is of no use to a fish and a formed neck in marine animals has the effect of diminishing speed and making steering difficult. As the limbs were evolved they descended the neck, and as they descended they became larger and stronger, and as the limbs became larger and stronger the neck proportionately developed. The pectoral girdle provided the means whereby the fore-limbs were carried down the neck, and with them the heart, from the gill-area to the thorax, these migrations becoming necessary as more perfect land progression was essential to the animal. As the girdle passed down the neck, the cervical vertebrae were denuded of their ribs, to a greater or less extent, according to the activity of the neck movements.

The fore-limbs of *Ceratodus*, the lung-fish of Queensland, though only slightly developed, are somewhat larger than the fore-limbs of pectoral fins of ordinary fish. It seems most probable that the slight increase in size of these puny fore-limbs is the result of impulses that have resulted from contact with mud. Ribs are present in the neck area and throughout the remainder of the body cavity.

The *Menopome*, which Owen describes on page 48, vol. I. of the 1866 edition of Comparative Anatomy, shows some limb and neck development. Small ribs occur throughout the body and neck of this amphibian.

Trachysaurus rugosus, compared with *Ceratodus*, shows a great development of the pectoral girdle, a development which expresses the construction of a bony carriage that is used to convey not only the fore-limbs down the neck as they progressively develop, but also the heart from a position of threatened danger to one of secured safety, that is from the throat to the chest. In this lizard the pectoral girdle embraces the heart in what corresponds to the gill-area, beneath the neck, and spreads itself over and above the cervical ribs. As the pectoral girdle bears the heart and fore-limbs down the neck, the cervical ribs are reduced to rib-stumps, a condition that is remarkably well shown in the crocodile. *Trachysaurus* has poor powers of progression, its limbs being small and its neck undeveloped. It is an interesting animal because it shows the early stages of the migration of the heart from the gill-area to the thorax, during which migration the left recurrent laryngeal nerve is caught about the aorta and dragged into the thorax.

The Tuatara lizard, *Sphenodon punctatus*, shows partial suppression of the ribs of its neck, therein agreeing with that rib suppression which is seen in the more common lizard.

Varanus varius is as active a lizard as *Trachysaurus rugosus* is sluggish. It has a long neck containing six cervical vertebrae; its heart has left the pectoral girdle and become an occupant of the thorax, and its pectoral girdle shows signs of atrophy. In the crocodile the pectoral girdle undergoes further atrophy, and the posterior portion is retained to form the coracoid bones. The narrowing which the girdle undergoes, in being transformed into the coracoids, enables the seventh vertebra to perform neck movements; and thus the seven cervical vertebrae that characterise the mammalian neck, are established.

This is a critical time in the evolution of the mammalian neck, for at this stage the body is elevated for raised quadrupedal progression. The impulses that accomplish this great change etch into the mammalian neck its very fixed characters.

The neck of the crocodile bears fourteen cervical rib-stumps, made up of seven pairs;-the first and second pairs are long because the pectoral girdle only caught their tips in its span of the ventral and lateral aspects of the neck. The neck of *Varanus* bears less rib tissue than the crocodile, and this difference expresses the greater movement of the neck that the *Varanus* exercises in comparison with the crocodile.

According to the activity of the neck movements, the denudation of the cervical ribs that occurs as the pectoral girdle passes down the neck, is more or less complete. The stiffness of ribs in the neck prevents free neck movement. The cervical ribs stiffen the neck, therefore those impulses that set up active neck movements in association with limb progression are destructive to cervical ribs.

Coracoid Bones.

These bones maintain the fore-limbs on the lateral aspects of the body in positions that are favourable for swimming and for flight, therefore they occur in amphibians, reptiles and birds. As the body was lifted for mammalian quadrupedal progression, the lateral position of the fore-limbs gave place to the ventral position, and the space occupied by the coracoid bones became needed, and was later occupied by the limbs. In the impulses that established raised quadrupedal progression, destructive hostility to the coracoid bones existed and the coracoids are now to be seen as vestiges on the mammalian scapula.

Vestiges are often referred to as being capable of development, and in this connection it may be pointed out that the flying-fox, fox-bat of *Pteropus*, a mammal that has acquired the ability to make sustained flight, has not redeveloped its coracoids.

The coracoid bones of birds and reptiles cross the sternal ends of the first ribs, and to avoid collision of bone with bone, the sternal ends of the ribs are fibrous. In this connection it is to be noted that Keen, in the American Journal of Medical Science, shows a plate of a human cervical rib that had a very definite fibrous end. The significance of Sibson's fascia remains to be explained; a careful investigation of this structure is likely to establish between cervical rib development and Sibson's fascia a close relationship, for it seems probable that this fascia is the forerunner of a cervical rib.

The fibrous nature of the sternal ends of the first ribs in reptiles and birds lends a yielding character to the junction of neck and chest, whereas the bony first ribs of mammals give a rigidity to the boundary between neck and thorax. In many birds and many reptiles the coracoid bones migrate backwards and establish eight and more neck bones, and as they go back they imperil rib-end after rib-end, which becomes removed by the associated impulses. In this way the long necks of birds and reptiles are apparently formed.

Extinct Sea Lizards.—The *Ichthyosaurus* had cervical ribs. The *Plesiosaurus* had a long neck and no ribs on the first seven bones: it may be inferred that *Plesiosaurus* was slower in the water than the *Ichthyosaurus*, and that it first developed its long neck on swampy land, after which it became aquatic.

Elevated Quadrupedal Reptiles.—The *Brontosaurus* had both a long neck and tail, each of which contained many vertebrae. It had attained a mode of progression that has some resemblance to mammalian quadrupedal progression. It would seem that these extinct reptiles were not lifted from the ground by their limbs when seven neck bones had been formed, and that body elevation in their case only occurred after many neck bones had already been established.

Fixed Mammalian Neck-type.—This is characterised by seven neck bones devoid of cervical ribs, associated with a definite type of neck curvature that is more or less marked. This type was established by the mammalian body being lifted up from the ground by the limbs when seven neck bones had been formed, an event that was accompanied by the suppression of the coracoid bones.

Monotremes. The monotremes show neck structures transitory between reptilian and mammalian type; the platypus, that lives mostly in the water, has relatively larger coracoid bones than the echidna, that lives on land and mostly in soil. It would seem that the approximation of the limbs to the ventral aspect to allow of burrowing operations has been inimical to the coracoids. The echidna has better fore-limb development and greater neck curvature than the platypus. The straighter neck of the platypus contains cervical rib-stumps, whereas the rib tissue in the curved neck of the echidna is less of the nature of rib-stumps and more of the nature of costal processes.

The echidna shows rib-stumps merging into costal processes; therefore the suppression of ribs into costal processes can be traced, but I am unable to find evidence supporting the prevalent idea that costal processes develop into cervical ribs, the term "costal process" being taken as synonymous with vestigial ribs and not with the costal rudiment. The echidna shows that under the impulses that raise the body from the ground the curvature of the neck becomes established, and the rib-stumps disappear into the costal processes.

The first ribs of the monotremes differ from those of reptiles in being attached to the sternum by bone; they differ from mammals with which they are classed, in having between the sternal rib and the true rib an intermediate rib. The first ribs of monotremes are more rigid than the first ribs of reptiles, but they are less rigid than the first ribs of mammals. In this connection it may be pointed out that in ruminants a diathrodial joint occurs between the ribs and the sterna cartilages, which joint does not upset the fixed neck type, but it serves to illustrate the fact that impulses may determine the formation of joints in parts of the body in which joints do not usually occur.

Neck curvature is practically absent from lizards and crocodiles: it is slightly marked in the platypus, and more so in the echidna; it reaches its highest development in the mammals, such as llamas and antelopes. The neck curves of birds do not occur in definite places as they do in mammals, these definite neck curves being due to the weight-carrying qualities and length of the fore-limbs, and also to the length of the neck. The neck must be of sufficient length to enable the animal to gather its food.

The weight of the head suspended at the end of the neck has set up impulses that have developed the ligamentum nuchae to conserve the muscle energy of the muscles of the neck. The elastic ligament always exerts its force in definite directions, and it is a prominent factor in producing the definite neck curves of mammals. In man the ligamentum nuchae is poorly developed, and his neck curves are practically lost.

When it is remembered that fish and snakes have cervical ribs, that the crocodile has seven pairs of rib-stumps, that the *Varanus* is almost without rib tissue, and that quadrupedal mammals are entirely free from cervical ribs (except vestiges), it becomes apparent that neck mobility, when associated with quadrupedal progression, is hostile to neck ribs.

No quadrupedal mammal normally has cervical ribs. No mammal that habitually carries part of its body weight on the pectoral limbs varies from seven neck bones. All mammalian cervical ribs and all mammalian variations from seven cervical vertebrae, occur amongst those mammals that have abandoned quadrupedal progression, such as *Bradypus, Porpoise, Manatee, Dugong* and *Man.*

Quadrupedal mammals remain true to neck type because they perform those neck and limb functions which the mammals were evolved to perform. Mammals that have abandoned quadrupedal progression may show destruction of the fixed mammalian neck type, but all such animals do not vary from fixed type. Those that are variant have been submitted to impulses of a hostile nature; great stability of type occurs when the neck has to operate from a thorax that has been made rigid by the impulses that are associated with supporting the weight of the body above ground; and conversely, the type is less fixed when the thorax is not made rigid by such impulses. In the quadrupedal mammals, the transmission of the weight of the body from the sides of the ribs through the great serrated muscles to the scapulae, and thence through the limbs to the ground, narrows the cephalic end of the thorax by lateral pressure; this narrowing of the thorax, which is splendidly shown in the skeletons of the horse and giraffe, drives the lungs towards the loins and keeps the apices of the lungs behind the anterior border of the first ribs.

The apices of the lungs above the first ribs, the normal anatomical position in man, constitutes a divergence from the normal mammalian position of lung. Ribs unaffected by pressure are curved, probably because between curved ribs the maximum amount of lung may collect. Be that as it may, the fact stands that the first ribs are the most curved ribs in the human body, and that the first ribs of the horse are the straightest in its body. The first ribs of men are practically never fractured, because no strain is thrown on them; the first ribs of the horse are frequently fractured by the strain thrown on them by the weight of the horse's body, and also by the load superimposed by man. The bearing of these facts on cervical ribs is that straight first ribs prevent the lung passing into the neck, whereas curved first ribs permit the passage of the apices of the lungs into the neck, and when lungs gain the mammalian neck, ribs develop over them as the occupation of the neck becomes more extensive.

Marsupials.—All these animals, including the extinct *Diprotodon australis*, are true to mammalian neck type. The kangaroos have acquired a mode of progression that has led to atrophy, from disuse of the pectoral limbs and upper thorax. Owing to the inclination of the body being submitted to great changes, a good degree of neck curvature exists; mostly the body is tilted downwards and forwards, and it is erect for only brief periods; thus the lungs occupy the position that is normal to quadrupedal mammals, and they are not induced to migrate, as they do in man, towards the neck.

The lungs of the kangaroo do not encroach upon the neck, therefore cervical ribs do not occur in these animals.

Xenarthra. The neck structures of the animals of this order afford an interesting and difficult study, interesting because of the variation of type that occurs in the sloths, difficult because abundant material for comparison is hard to get.

The extinct *Megatherium* was true to type, and therefore it is probable that all the animals belonging to this order were originally of ordinary mammalian type.

The dermal armour of the *Armadillo* has prevented movement between the bones of the middle of the neck, and they are fused into a rod of bone: this fact suggests that as the necessity for joints departs, they disappear.

Bradypus, or three-toed sloth, has been compelled to lengthen its neck to afford the head a wider range of browsing circumference. As a result of the impulses generated by its hanging and browsing habits, the first and second thoracic vertebrae have lost their ribs, and thereby these back bones have been converted into neck bones. The animal spends its life hanging body downwards from the branches of trees, and under the impulses resulting from this mode of life, the fixed mammalian type has been broken down, and the rigidity of the anterior thorax has given place to adaptations that have extended the movements of the neck to the thoracic region. In this mammal it is observed that under the necessity for elongating the neck the first and second thoracic vertebrae are added to the neck, which is not according to the mammalian rule. The giraffe has elongated its neck, but it has done so under the control of a strictly quadrupedal gait and consequently its neck is composed of seven cervical vertebra, according to the law which holds the mammalian neck true to type. The three-toed sloth, therefore, shows destruction of the fixed mammalian type, and therefore conclusively proves that fixed type must, when impulses change and assail its fixed characters, yield up its stability, become plastic and change into aberrant type. This fact shows that the law of evolution, like the law of gravity, is ever operative: the evidence which the three-toed sloth offers in this direction is augmented by every mammal that has changed from the fixed mammalian type.

Choloepus.—There is considerable diversity of opinion as to the number of neck bones that are in the neck of the two-toed sloth. Owen describes seven bones, Thomson six, and Wiedersheim writes thus of the ribs of mammals:—"The cervical ribs in nearly all cases unite completely with the vertebrae, and a vertebrarterial canal is thus formed. The last cervical rib may be well developed and may articulate with the corresponding vertebra (*Choloepus Hofmanii*)."

This diversity of opinion may be due to the different species of two-toed sloths varying from one another, as do the two genera of the order *Sirenia*, or to variations within the species itself, as occurs in man.

The three-toed sloth has a short, thick body which is suspended by short, thick limbs; the body is too short to sag in the middle of the back, and it consequently hangs straight in the horizontal. The two-toed sloths have long, narrow bodies and long limbs, and when suspended in what would produce a horizontal position in the three-toed sloth, the animal presents a long U, with the middle of the back at the lowest part, and the head in a position that is more or less erect. The two-toed sloth has a body and limbs that are long and lithe enough to gather its food without the neck elongation that has occurred in the three-toed sloth, and in its peculiar position, together with the fact that it has abandoned quadrupedal gait, it would not be surprising if dissection should reveal that its lung has risen into the neck and cervical ribs have formed.

The three-toed sloth is said by Wiedersheim to have cervical ribs upon the seventh neck bone. A skeleton of this animal in the Melbourne Museum does not show them, and Owen, who went very carefully into the question, only depicts rib-stumps on the eighth and ninth bones. But it is not surprising that Wiedersheim has found cervical rib structure in the three-toed sloth. In the normal mammals, costal processes are absent from the seventh bone, and this permits flexion of the neck on the chest, an extensive movement where neck curvature is great. As the *Bradypus*, by its peculiar gait, abolished the curvature of its neck, it may have become necessary to stiffen up the seventh bone to harmonise it with the sixth above and the eighth below, so that the neck may be of proper strength in its various parts.

Clavicles and Flight.—The *Pteropus* or flying-fox, or fox-bat, is a mammal that has acquired the power to fly, yet its neck type is true to mammalian characteristics. This stability of type appears to be due to several causes; this animal walks on the ground in quadrupedal fashion, and not after the manner of birds, on the pelvic limbs; and in developing its air-planes it has had to do without the great help that birds derive from the coracoid bones, consequently those changes that occur in birds through the presence of the coracoid bones, are not to be seen in the flying-fox. Although the clavicles of the flying-fox are greatly developed, they can do no more than partly compensate for the absence of the coracoids, because the position of the clavicle is anterior and external to the central and interior position which the coracoids, if present, would occupy. The clavicles play no part in the formation of cervical ribs, but by holding the scapula off the thorax, they afford the arm the means of executing a wider range of rotary movement.

If vestigial structures possess the ability to come back to functional activity, the coracoid processes of this flying mammal should re-establish the coracoid bones; instead of that, the clavicle, by over-development, throws the pectoral limbs from the ventral to the lateral thoracic position. The coracoid process remains unaffected in spite of the demands that flight makes upon coracoid bones. If atavism were a real thing in relation to ribs and other bones, the flying-fox should have coracoid bones.

Marine Mammals.—The New Zealand dolphin has had the bones of its neck fused into a short, solid mass by impulses engendered by the impact of water on the head, which is driven against the water by the force exerted by the tail. This animal does not emerge from the sea, and consequently it has entirely abandoned quadrupedal gait. The mammalian character of its neck has been destroyed by the fish-like impulses that its acquired habits have set up. The *Susue* has seven flattened neck bones that occupy very little space. On the second, third, fourth, fifth and sixth cervical vertebrae the costal processes are widely separated from the transverse processes; on the seventh there are no costal processes, but the head of the first rib articulates with the body of the seventh vertebra, and its tubercle with the transverse process of the first thoracic vertebra. A similar arrangement to this occurs in the Beluga Whale.

Seals, sea-lions and walruses form an interesting class of sea mammals. Their necks are long, and they are true to mammalian neck type, and this is due to these animals using their fore-limbs to lift themselves out of the water, and also to their habit of travelling over the rocks after the manner of quadrupeds.

At the end of the long neck of the seal are well-developed fore-limbs. At the end of the shortened neck of the New Zealand dolphin is an atrophic pair of fore-limbs. This association of structure suggests that as the limbs descended the neck, during the evolution of limb progression, a gradual increase in the size of the limbs took place; and as the limbs recede up the neck, as quadrupedal progression is abandoned, and the upper part of the pectoral limb is progressively less used, the limbs progressively become smaller as they approach nearer and nearer to the head. Thus not only can the evolution of the neck be studied, but it is also possible to study the involution of the neck.

The seals demonstrate more plainly than any other mammals the effect of quadrupedal progression on structure; for there can be no doubt that the long neck of the seal handicaps its progress through the water, though the neck is retained for the functions it performs on the land.

The order *Sirenia* offers a valuable mass of material bearing on cervical ribs. The following quotations are from Flower's Osteology of Mammalia, 1885, p. 42:—

"In the order Sirenia the Dugong (Halicore) has seven cervical vertebrae."

"The Rhytina, a large animal of this order, which became extinct towards the close of last century, has also seven cervical vertebrae, and the Miocene halitherium had also the same number."

"The Manatees (genus Manatus), of which there are two well-known forms, one inhabiting the West Coast of Africa, and the other the East Coast of Central and South America, never have more than six vertebrae in the cervical region."

"In a specimen of the Manatus senegalensis, in the Museum of the College of Surgeons, the second and third are ankylosed by their bodies. In the skeleton of M. Americanus, in the Museum of Cambridge, the sixth cervical vertebrae carries a distinct moveable rib."

Flower does not explain why only six bones occur in the neck of the manatee, but it is quite clear that the details he describes point most strongly to the fact that the normal seventh cervical vertebrae of mammalia has in the manatee developed a pair of perfect cervical ribs.

The evidence in support of this is open to no other interpretation, especially in face of the fact that the specimen at Cambridge has extended the rib-forming process as far as the sixth bone, and also in face of the added fact that the specimen of the manatee in the Melbourne Museum shows upon the body of the six vertebra demifacets for the head of the rib that rests in an articulation formed by the sixth and seventh bones. It also seems that as the miocene *Halitherium* was true to mammalian type, the manatees have acquired the change to the six neck bones.

The *Dugong* occupies a variable position in regard to cervical ribs; usually this animal is without cervical ribs; the specimen in the Melbourne Museum has a pair of short cervical ribs upon the seventh cervical vertebra; they are about two inches long, and they form movable articulations. All the bones of the neck of the dugong are flattened, and they are not fused by ankylosis.

It is not as easy to ascertain the cause of the development of cervical ribs in manatees and dugongs as it is in man, for in these animals it is necessary to consider two possible causes, and then to determine which is the causative factor. It is therefore necessary to discuss whether the manatee develops its cervical ribs to stiffen its neck area, as fish structure suggests, or whether the cervical ribs of the sirens develop for respiratory purposes. If material could be readily procured for dissection, the matter could easily be cleared up, but even at Port Darwin a specimen of a dugong for investigation is most difficult to procure. If the manatee required a stiffer neck than it has, impulses would probably set up an ankylosis such as that which exists in the porpoise; the ankylosis that is already established between the second and third bones, places it beyond doubt that the manatee can, under suitable impulses, set up ankylosis of its neck bones.

It is unlikely that the manatee uses two means to stiffen its neck, ankylosis and cervical rib formation, when by ankylosis alone the porpoise has produced a much stiffer neck than the manatee. The ankylosing process is all-sufficient for stiffening purposes. The ribs that develop on the seventh vertebra of the manatee are perfect sternal ribs, and they bear every evidence of being respiratory ribs.

The impaction and ankylosis of the neck bones of the porpoise has carried ts head towards its lungs, and the formation of cervical ribs has carried the thorax of the manatee nearer the head. Marine animals derive some advantage by the lungs being near the head, for there, by buoyancy, they assist the nostrils to come to the surface when the oxygen supply has been used up beneath the water.

It appears that cervical ribs develop in manatees and dugongs in association with the lungs, and that the need for the stiffening effect of ribs upon the neck, as an aid to water progression, may be ignored as a causative factor in the development of cervical ribs.

It is difficult to ascertain the rate of speed at which these slow-moving sirens travel, but as the fast-moving porpoises exhibit impacted necks, it may be inferred that the greater the speed, the greater the impaction of the neck. When the neck is ankylosed, as the result of impaction, it is, for all practical purposes, reduced to a condition that functionally corresponds to the neck area of fish. Under the sluggish movements that are executed by the dugong, the force that is set up by the action of the tail muscles, and which is resisted by the water, is mainly transmitted through the bones of the spine, and it is not great enough to impact the cervical vertebrae and its effect on the bones is shown only by their flattened state.

It appears from the study of mammalian neck bones that water pressure, in the absence of quadrupedal progression on land, is a great destroyer of fixed mammalian neck-type, but that even these extremely hostile neck impulses are insufficient to destroy mammalian neck-type when use is made on rock and ice of the fore-limbs for supporting the weight of the body.

Mammalian Quadrupedal Progression.

All mammals that go on four limbs are not equally developed in the fore and hind limbs, and there are many degrees of quadrupedality. The most perfect quadruped is the horse; its limbs are entirely devoted to progression and supporting body weight: therefore its neck type is fixed and cervical ribs are unknown in these animals.

Animals that have the power of standing for long periods have narrow chests; a narrow chest is a good point in a horse, and great transverse measurement is the mark of an underbred or slow animal. The full pectoral region that is so admired in soldiers has its counterpart in the flying-fox. Narrowness of the cephalic end of the thorax serves to keep the lungs within the thorax and to prevent them migrating to the neck.

From the quadrupedal baboon through the semi-erect apes to erect man, a progressive comparative decrease in the relative size of the fore-limb to the hind-limb is to be observed. In other words, man's arms are small compared with his legs; the fore-limbs of the baboon are larger than its hind-limbs. The baboon shows on its thorax the effect of bearing the weight of the body. The neck of the elephant is compressed by the weight of its head, the neck of swine by rooting, the neck of man by his head weight. Compression of the neck destroys the neck curves and curtails neck mobility. In man the neck curves have been obliterated, and the first ribs have become fully curved. From these two causes the lung is permitted to rise in the neck as the erect position has sunk the heart in the thorax and displaced the lung upward. Lung in the neck has set up impulses that cause cervical ribs to develop. Such development has occurred in relation to the disappearance of progressive and other active uses of the shoulders and arms of the upper limbs, and this fact explains why cervical ribs are three times as common in women as they are in men.

As quadrupedal progression has been abandoned by all mammals that have cervical ribs, and no quadrupedal mammal has cervical ribs, it may be assumed that the crawling period of infancy is the great factor that keeps the human neck true to type, or approximately true to type; for since the neck of seals keeps true to type, although its fixed type is challenged every time it swims with its head beneath the surface, a very moderate amount of quadrupedal exercise is evidently sufficient to keep the neck true to type.

The Unstable State which follows the Destruction of the Mammalian Neck-type by Erect Bipedal Progression.

The migration of the lung towards the neck has led to a mass of lung tissue being piled above the heart, and to an atrophy of the lower thorax, hence the diaphragmatic base of the human lung is small in comparison with the phrenic base of the quadrupedal mammalian lung. As the functions of the lower thorax of man have been transferred to the upper thorax, diaphragmatic breathing has become less perfect, and costal breathing has begun to show up. This change has been caused by the erect position. The lightest organs in the thorax rise to the top, which top, in man, is the widened space between the first pair of ribs; the sinking of the heavy heart displaces the lighter lung upward; this sinking is evident from the fact that the pericardium in man has a more extensive attachment to the diaphragm than it has in any other animal, and also by the aorta having a longer arch.

Arthur Keith, in his work on "The Mechanism of Respiration in Man," on page 187 of "Further Advances in Physiology," edited by Leonard Hill, 1909, draws attention to the observation of Colbeck that during inspiration the apices of the lungs recede from the neck. In a rough way this observation can be confirmed by making forced inspiration in the front of a mirror and there watching the dimpling of skin in the neck that takes place with each inspiration. On page 200 of the same book Keith refers to the observation of Wenckebach. "In subjects of extreme visceroptosis, the diaphragm is thrown out of action by its visceral fulcrum being lost, and breathing is carried on by an elevation to the upper part of the thorax." This important observation shows as plainly as does the effect of tight corset lacing, that curtailment of the action of the diaphragm is compensated by costal breathing, and there can be no doubt that the diaphragm is a more efficient muscle of inspiration than the upper intercostal muscles.

As the encroachment of the lungs into the neck is the cause of the development of cervical ribs, it follows that full curvature of the upper ribs and loss of the curves of the neck are changes that prepare the way for the apices of the lungs to pass through the space between the first ribs, and consequently such changes are co-operating factors in the production of cervical ribs.

In man the costal development that is associated with the seventh cervical vertebra ranges through all grades from the quadrupedal type to fully formed cervical ribs. In other words, the seventh cervical vertebra of man may show:—

(1) The absence of costal processes (extinct ribs).
(2) Costal processes (vestigial ribs).
(3) Cervical ribs in various stages of development.

Far reaching as these changes are, they do not include all variations, for unequal development of the two sides of the seventh cervical vertebra is by no means uncommon.

The quadrupedal baboon is, like other quadrupeds, devoid of costal processes, and therefore it is probable that during the stage of quadrupedal progression of the human race the seventh vertebra of man was constantly without costal processes; in other words, these ribs were extinct.

The gorillas in the Melbourne Museum are without costal processes on the seventh vertebra. An orang, in the same museum, is also without them. One chimpanzee is without costal processes, another has them. Of the skeletons of apes in the Melbourne Museum only one has costal processes on the seventh cervical vertebra—a small chimpanzee.

The causes that determine the development of cervical ribs appear to be:—

(1) Disuse of the upper limbs for the purpose for which they were developed, viz., quadrupedal progression. The removal of the weight of the body from the sides of the ribs has allowed the first and upper ribs to become curved, and thus an increased space has been afforded through which the lung has migrated, hernia fashion, into the neck.

(2) Hostile impulses assailing the established mammalian neck type; the chief of these arise from the presence of lung in the neck. Nowhere amongst the mammals are jointed ribs seen except in association with lung and the function of respiration.

The following changes have occurred in the human neck:—

(1) The bodies of the neck bones have been flattened by the weight of the head, and thereby the neck has lost mobility.

(2) The erect position has caused the neck curves to be reduced and the neck and chest to be brought into more direct line.

Lateral Curvature of the Spine (Scoliosis).

This condition is so extremely rare in quadrupedal mammals that it may be said not to occur in such animals. In man lateral curvature is common, and, associated with cervical ribs, lateral curvature may be said to be the rule. The surgical treatment of cervical ribs is inseparable from a careful consideration of the part played by lateral curvature. In the review of the necks of seals and porpoises, it has been seen that disuse of the fore limbs for progression on land is accompanied by a profound atrophy of the pectoral limbs. The term involution of the neck may be applied to this atrophic condition. The arms of Man that are associated with cervical ribs are in a state of atrophy, and they have receded towards the head by the distance occupied by the cervical ribs. It will be remembered that the fore-limbs of the slowly moving lizards are near the head, in other words in the early evolution of the neck the fore-limbs are near the head. Surgeons have repeatedly recorded that cervical ribs shut off by pressure the arterial blood supply of the upper limbs, and Keen shows an artery that is much larger in lumen on the proximal than on the distal side of the cervical rib over which it passes. Anatomy abounds with evidence that during development arteries mould bone to their service. Bones support and protect the more delicate tissues of the body, even the delicate convolutions of the brain leave their indented impressions on the hard inner tables of the clavarium. The reason that cervical ribs appear to strangulate the blood supply of the limbs is that from the involuted limbs no impulses arise to put into the heart and artery enough force to drive blood in greater quantity to the involuted limbs than their atrophic state demands. If the development of cervical ribs occurred with big and vigorous pectoral limbs, there would be force enough in the artery to groove the ribs and to accommodate itself so that the blood supply would be unimpeded.

The treatment of cervical rib is confronted by greater difficulties than a piece of bone: cervical rib is but the index of an undesirable evolutionary condition which Oppenheim calls "stigmata of degeneration." Some of the results of the abandonment of quadrupedal progression are:—

(1) Weak upper limbs.
(2) Atrophy of the neck.
(3) Costal breathing.
(4) Migrated lung.
(5) Depressed heart.
(6) Liability to brain injury through curtailment of neck mobility.

The practical side of the subject of cervical ribs divides itself into two sections:—

(1) The treatment of those suffering from the conditions that are associated with neck ribs. (This is work belonging to experienced surgeons.)
(2) The physical training of the human body so that the existing occasional tendency to develop cervical ribs may be turned into a tendency to remain true to normal neck-type.

The crawling period of infancy is probably the great factor keeping the human neck, arms and thorax true, or approximately true, to mammalian type; therefore games of a quadrupedal nature are beneficial to children. Growing children should be examined periodically for the detection of any tendency to lateral curvature of the spine. Exercises for the development of the great serrated muscles should during the period of growth and development, be taken daily. During childhood, adolescence and adult life, diaphragmatic breathing should be regularly practised. Adults starting to take exercises should remember that there are two types of neck, (1) the normal or mammalian; (2) the aberrant type in which cervical ribs occur.

The exercises that have been advocated are of the nature of a return to natural function which the erect position has thrown out of use. It should be clearly borne in mind that those adults who have cervical ribs are likely to cause themselves pain by doing quadrupedal exercises, as their evolved tissues are ill-fitted for such work.

Summary.

The mammalian neck was evolved to co-ordinate its movements with those of the fore-limbs during elevated quadrupedal progression. Elevated quadrupedal progression caused the mammalian to become the most fixed type amongst necks. The mammalian neck remains fixed to type so long as the functions which compel its evolutions remain constant. The mammalian neck remains true to type after its functions have been abandoned until such times as it becomes assailed by hostile impulses. Cervical ribs in the mammalian neck express the breaking down of fixed mammalian neck-type.

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Proc. Roy. Soc. Victoria 25 (N.S.), Pt. I., 1912.

Art. VII.—*Contributions to the Flora of Australia, No. 19.*[1]

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(With Plates V. and VI.).

[Read 9th May, 1912.]

Abutilon indicum, Sweet. "Indian Lantern Flower." (Malvaceae).

Coode Island, Victoria. J. R. Tovey, March 23rd, 1912.

A native of the tropical regions, also found in South Africa. An exotic not yet sufficiently established to be considered naturalised in this State.

Acaena montana, Hook. f. (Acaena tasmanica, Bitter, in Bibliotheca botanica, Heft 74, (Stuttgart).). (Rosaceae).

(Determined by Dr. Bitter, Bremen, September, 1911).

Alpine regions of Mount Field East, Tasmania. F. Mueller, Jan., 1869.

Acaena sanguisorbae, Vahl. forma. (Rosaceae).

(Determined by Dr. Bitter, Bremen, September, 1911).

Summit of Mt. Dayman, New Guinea, 9000 ft., W. E. Armit, 1894.

Aizoon rigidum, L. var. angustifolium, Sond. "Rigid Aizoon." (Ficoideae).

Coode Island, Victoria, J. R. Tovey, December, 1908, and March 23rd, 1912.

Indigenous to South Africa. An exotic not yet sufficiently established to be considered naturalised in this State.

1 No. 18 in Proc. Roy. Soc. Victoria, vol. xxiv. (n.s.), p. 255, 1911.

Albizzia amoenissima, F. v. M., Fragm. viii., p. 165. (Leguminosae).

This plant was given in the first Census, from New South Wales, Queensland and Victoria, omitted from the second Census (presumably inadvertently), and restored in the manuscript. The only specimens in the Herbarium are the original types from the north-east boundary of New South Wales. There is no Victorian specimen or record of this plant, which must hence be deleted from the Victorian Flora.

Ambrosia artemisifolia, L. "Roman Wormwood." (Compositae).

Wimmera, Victoria, M. Guerin, 1890; Tabilk, Victoria, Mrs. James, 1905; Shepparton, Victoria, J. C Walker, October, 1911; Coode Island, J. R. Tovey, March 23rd, 1912.

This Composite, a native of North America, recorded as a garden escape in the "Weeds, Poison Plants and Naturalised Aliens of Victoria," p. 94 (1909), has now evidently permanently established itself as a naturalised alien in Victoria.

Andropogon gryllus, L. (Gramineae).

North Australia, Dr. Gilruth, 1911.

Andropogon sericeus, R.Br. (Gramineae).

North Australia, Dr. Gilruth, 1911.

Anthistiria avenacea, F. v. M. (Gramineae).

Roper Plains, North Australia, Dr. Gilruth, 1911.

"Locally known as Blue Grass. Generally eaten last by stock."

Anthistiria membranacea, Lindl. (Gramineae).

North Australia, Dr. Gilruth, 1911.

"Stock fairly fond of this grass."

Anthyllis vulneraria, L. "Kidney Vetch." (Leguminosae).

Lilydale district, Victoria, Mr. Kerr, January, 1912.

This herbaceous perennial plant has now established itself in the Lilydale district, and may be considered naturalised. It is a native of Europe, Asia and Africa, and is a useful pasture plant for dry pastures.

Aristida calycina, R.Br. (Gramineae).

North Australia, Dr. Gilruth, 1911.

Astrebla triticoides, F. v. M., var. lappacea, Benth. (Gramineae).

Bull Oak Creek, North Australia, Dr. Gilruth, 1911.

Atriplex stipitatum, Benth. "Kidney Saltbush." (Chenopodiaceae).

Werribee Gorge, Victoria, P. R. H. St. John, January 29th, 1912.

A new locality for this plant, only previously recorded in Victoria from the north-west.

Bartsia Trixago, L. "Trixago Bartsia." (Scrophulariaceae).

Near Newstead, County of Talbot, Victoria, F. M. Reader, Oct., 1909; Boorhaman, North-east Victoria, per J. Callander, October, 1911.

This naturalised alien is now recorded from four widely separated localities, and is evidently spreading. Like "The Common Bartsia" (*Bartsia latifolia*, Sibth. and Sm.), it is probably parasitic on the roots of grasses.

Brassica adpressa, Boiss. "Hoary Brassica." (Cruciferae).

A native of Europe, now naturalised as an alien round about Melbourne and in the Sale district. It has not previously been recorded. It has no pasture or economic value, and is usually a weed of waste places. If neglected it is capable of becoming a troublesome weed in cultivated ground and even in pastures, owing to its free powers of seeding. Sheep appear to eat the young shoots, especially when pasture is scarce.

Calycotome spinosa, Link. "Spiny Broom." (Leguminosae).

Growing along roads at Bolwarrah, near Ballarat, C. French, junr., July 27th, 1909, spreading on the top of the cliffs at Mornington, C. French, junr., March 3rd, 1912.

This plant, a native of Spain, can now be regarded as a permanently established naturalised alien. It was possibly originally planted in a hedge, thence running wild. It has no known economic value beyond its value as a hedge plant, and is quite capable of becoming a troublesome weed if neglected.

Cnicus benedictus, L. (Carbenia benedicta, Adans.) "Blessed Thistle." (Compositae).

North Ovens Shire, Victoria, Feb., 1905; North Wangaratta, C. T. Kidd, Oct., 1911; Springhurst, J. E. Aldridge, Nov., 1911.

This hardy annual, a native of the Mediterranean regions, was recorded in the "Weeds, Poison Plants and Naturalised Aliens of Victoria," p. 94 (1909), as a garden escape, but it has now apparently established itself and may be considered naturalised. According to the 1905/6 Botanical Congress, *Carbenia benedicta*, Adans., becomes *Cnicus benedictus*, L., as the only representative of the genus *Cnicus*, and all other species described under *Cnicus* must be transferred to either *Carduus* or *Cirsium*.

Cryptandra uncinata (F. v. M.), Gruning. (Rhamnaceae).

This plant was originally described by Mueller as *Beyeria viscosa*, var. *uncinata* (Euphorbiaceae), and by Baillon as *Beyeria* (!) *uncinata*. Bentham states "male flowers unknown." Gruning, to whom specimens were sent in connection with the preparation of Engler's Pflanzenreich, finds five stamens to be present, and transfers the species as above. The original label by Mueller is "*Beyera viscosa*, Miq., var. *uncinata*." A second label, apparently by Baillon, reads, "*Beyeria* (!) *uncinata*. In Adansonia VI. (Spec. certe ab. *B. viscosa* distincta)," and it was published by Baillon as *Beyeria* (!) *uncinata*.

Dianthus Armeria, L. "Deptford Pink." (Caryophyllaceae).

Upper Gundowring, Victoria, A. B. Braine, December, 1911.

This European plant has only previously been recorded in Victoria from Darebin Creek (see Benth. Fl. Aust, vol. i., p. 156 (1863)), and was placed in the list of naturalised aliens in the "Weeds and Poison Plants of Victoria," p. 76 (1909), as probably only a garden escape. It appears, however, to be now permanently naturalised.

Eragrostis tenella, Beauv. (Gramineae).

Water-course bottom, Bull Oak Creek, Northern Territory Expedition, Dr. Gilruth, 1911.

Eriochloa punctata, Hamilt. (Gramineae).

Bull Oak Creek, North Australia, Dr. Gilruth, 1911.

"Fairly common, eaten readily by stock."

Grindelia squarrosa, Dunal. "Tar-weed." (Compositae).

Kerang, Victoria, February, 1905; Tatura, W. F. Mahon, Feb., 1909; Shire of Kerang, H. Butson Hooper, April, 1912.

This plant is a native of North-west America. It has no economic value, but appears to be establishing itself slowly as a naturalised alien in this State. Though first recorded in the Kerang shire in 1905, it is still scarce there, and is found mainly on close, retentive or clayey soils.

HERMANNIA VELUTINA, DC. "Velvet Hermannia." (Sterculiaceae).

Coode Island, Victoria, J. R. Tovey, March 23rd, 1912.

Indigenous to South Africa. An exotic not yet sufficiently established to be considered naturalised in this State.

HUXLEYA, Ewart, new genus. Verbenaceae. Tribe 2, Viticeae.
Sub-tribe 3, Oxereae.

Ovary distinctly 2 or 4 lobed. Calyx 5 cleft. Plants erect, leaves undivided.

Flowers rather large, solitary, without bracteoles in the axils of leaves. Calyx deeply cleft into 5 segments. Corolla tube narrow and elongated, about the same width throughout, limb spreading into 5 segments. Stamens 4, protruding beyond the tube of the corolla. Anthers 2-celled, dehiscing longitudinally. Ovary 2-celled, each cell containing one anatropous ovule attached to the side near the base. style long, stigma slightly bifid.

This genus differs from *Faradaya*, the only other Australian genus of this sub-order, in having the calyx 5-lobed (instead of 2), 5-lobed corolla (instead of 4), equal stamens (not didynamous), ovary 2-lobed (not 4), in being an upright herb (not a woody climber), in the flowers solitary (instead of in terminal panicles).

These distinctions are almost sufficient to make an additional sub-tribe.

HUXLEYA LINIFOLIA, Ewart and Rees. (Verbenaceae).

Flowers on long pedicels without bracteoles in the axils of opposite leaves (usually 2) near the apex of the stem. Calyx about 5 lines long, tubular below, spreading above into 5 narrow acuminate segments, sparsely beset with hairs on the outer surface.

Corolla tube about 1 inch in length. Segments about half the length of the tube, with tufts of hair at the base, somewhat obovate, regular or nearly so. Stamens exerted, filaments attached to corolla tube below the rim, protruding about 1½ lines beyond it. Anthers somewhat sagittate with a bluntly pointed tip. Ovary dark, almost black in dried specimen. Style almost 1 inch in length, slightly bifid. Stigma reaching to the opening of the corolla tube. No fruit present on the specimen.

Locality—Port Darwin, North Australia, N. Holtze, 1892.

Herbaceous plant about 1 foot in height. Stem 4-angled, channelled, and devoid of hairs. Leaves 1½-3 inches in length, long, linear, accuminate, opposite or sometimes alternate towards base of stems, under surface sparsely pitted with minute glands.

Lasiospermum radiatum, Trevir. (Compositae).

Highways in Tasmania, R. A. Black, April, 1912.

A native of South Africa which has reached Tasmania either as a garden escape or with imported seed. It is occasionally grown in Botanic Gardens, but is of no economic importance.

Mercurialis annua, L. "Annual Dog's Mercury." (Euphorbiaceae).

Coode Island, Victoria, J. R. Tovey, March 23rd, 1912.

A native of Europe and Africa which may be classed as an exotic not yet sufficiently established to be considered naturalised. The plant contains a substance which turns the leaves, when drying, to the colour of indigo blue, and also gives a bluish tinge to the milk of cows eating it.

Oleandra neriiformis, Cav. (Filices).

Recorded as new to Australia in Proc. Linnean Soc. N.S. Wales, vol. xxxiv., p. 368. Specimens of this plant from the Sydney Botanic Gardens did not agree with those in the National Herbarium, and Dr. Christensen suggests that it may be a subglabrous form of *O. Cumingii*, J. Sm., which is a native of China, India, Assam, Malay, Luzon and Tahiti, and has the same shape of lamina.

Baker says (Synopsis Filicum, p. 303), "Probably this (*O. Cumingii*) occurs in tropical Australia, as there are specimens among Leichhardt's plants."

Panicum Crus Galli, L. "Barnyard Grass." (Gramineae).

North Australia, Dr. Gilruth, 1911.

"Fairly common, though much scarcer than Mitchell Grass. Stock eat it readily."

Paspalum scrobiculatum, L. (Gramineae).

North Australia, Dr. Gilruth, 1911.

Petrophila incurvata, W.V.F., Journal of Botany, vol. 50, 1912, p. 22. (Proteaceae).

Mt. Churchman, West Australia, Young, 1876 (?); Watheroo, West Australia, Max Koch, 1905, No. 1522.

This plant was originally described by Baron Mueller as *P. semifurcata*, var. *planifolia*, in Fragmenta, vol. x., p. 47, 1876, owing to the resemblance of the cones to this species. Owing to the absence of flowers the stigmas were not seen, but the later specimens show them to be distinctly fusiform, so that apparently the new species formed from this variety is based upon valid characters apart from the foliage.

Phebalium apricus (Diels). (Rutaceae).

This species was described by Diels as *Eriostemon apricus*, in Engler Bot. Jahrb., band xxxv., p. 321 (1905). This plant also has glabrous or slightly glandular filaments, and must therefore be placed under *Phebalium* as in the next species.

Phebalium deserti (Pritzel). (Rutaceae).

This plant was described as a new species under *Eriostemon (Phebalium) intermedius*, Ewart, in Proc. of the Roy. Soc. of Vict., vol. xix., p. 40 (1906), but was subsequently found to be the same as the new species described by Pritzel as *Eriostemon deserti*, in Engler's Bot. Jahrb., band. xxxv., p. 321 (1905).

Since, however, the plant has glabrous filaments, and since it appears best, if only for practical convenience, to adopt the generic subdivision of Eriostemon as given in Bentham's Fl. Aust., vol. 1, and also in Engler's Pflanzenfamilien, the plant must be placed in *Phebalium*, as above.

Prasophyllum ciliatum, Ewart and Rees, new species. (Orchidaceae).
Sect. 3. Genoplesium. Labellum ciliate or fringed.

Green Valley, County of Talbot, Victoria, F. M. Reader, June 19th, 1910.

Stem about 5 inches long, bract small and less than half an inch below the inflorescence. Spike about ½ inch long. Lateral sepals united at extreme base, slightly gibbous, narrow lanceolate, acuminate, margins curved inwards, 2½-3 lines long, ovate accumate hooded. Lateral petals slightly shorter than dorsal, narrow, lanceolate, ending in long fine point with dark stripe down the centre. Labellum attached by a claw to the base of the column, about 1½ lines long, long and narrow, in a blunt tip, channelled down centre, margin fringed with short cilia, inner plate has the margins free and curving slightly, extending to the end of labellum. Column about 1¼ lines long, about as long below anther as anther. Lateral appendages about the same length as anther, adnate to base of column, divided into 2 short lobes, inner shortly acuminate outer somewhat falcate, with outer margin fringed with short cilia. Stigma comparatively large, rostellum small and extending but little above the base of the anther. Ovary about 1½ lines long, oval and swollen looking in the fully-opened flowers.

Appears nearest to *P. Woollsii*, from which it differs in having larger flowers, no cilia on lateral petals, and in the form of the labellum.

PRASOPHYLLUM DESPECTANS, Hook, f., var. INTERMEDIA, Ewart and Rees. (Orchidaceae).

Eucalyptus forest, Green Valley, County of Talbot, Victoria, F. M. Reader, May 4th, 1910.

In spite of slight difference in the shape and curvation of the lateral appendages (see Proc. Roy. Soc. Vict., vol. 23, Pt. 1), this specimen seems best referable to the above variety.

In view of the amount of variation which seems to be shown in the lateral appendages of the column, it is questionable whether too much attention is not attached to them in classification.

PRASOPHYLLUM SUTTONI, Rogers and Rees. (Orchidacea).

Buffalo Plateau, Victoria, Dr. Sutton, December, 1902.

Plant about 10 inches, fistula about 3 inches below spike, leaf about 2 inches. Spike consists of about 9 flowers, from which the colours have been discharged in the process of drying, although the faint tints on all the sepals and the dark tints on the column suggest that these have been purple. The petals look as though they had been white, with a coloured dark central streak.

Flowers very shortly stalked and subtended by a small semi-ovate bract about as broad as long. Lateral sepals about 4 lines, quite free, not gibbous, rather narrow lanceolate, dark stripe down middle, convex below, channelled on top (i.e., labellar side). Dorsal sepals about 3 lines, rather narrowly hooded, pointed, not recurved. Lateral petals broader and longer than lateral sepals, 4½ lines, rather broadly linear with triangular tips, membranous, with dark stripe down middle. Lateral index 112. Labellum on short claw, obovate recurved at an angle of about 60 deg. at the middle, proximal part measuring about 2 lines from claw to bend, not gibbous, with entire margins, distal part measuring about 2 lines from bend to tip, latter rather broadly blunt and rounded, margins and surface almost entirely membranous, slightly crenulated; callous portion rather narrow, channelled, increasing in thickness towards the bend and ending slightly beyond the latter in 2 raised lines. Anther not pointed, hidden behind rostellum and much shorter than latter. Appendages of column large, reaching quite to level of rostellum, falcate, with small basal ovate lobe, adnate only to base of column. Rostellum voluminous, purple, much higher than anther, triangular. Stigmatic surface large. Ovary short (about 2½ lines), turgid, obovate, on very short pedicel.

The species appears to be perhaps most closely allied to *P. fuscum*, though also related to other species. The examination and description of the plant was carried out jointly by Dr. Rogers and Miss Rees.

SARGA STIPOIDEA, Ewart and White, Proc. Roy. Soc. Vict., vol. xxiii., 1911, p. 297. ANDROPOGON SARGUS, Ewart.

The genus "*Sarga*," though originally placed in a widely different position, would have been practically a revival of the sub-genus *Chrysopogon*, which it is now generally agreed can best be referred to *Andropogon*. The description of the plant already given stands without modification.

SESBANIA ACULEATA, Pers. (Leguminosae).

Northern Territory Expedition, North Australia, Dr. Gilruth, 1911.

SILENE CONICA, L. "Striated Catchfly." (Caryophyllaceae).

Bridgewater, South-west Victoria, per J. L. Wyatt, Nov., 1911.

This plant is a native of Europe and Asia. It usually grows near the sea, and has apparently been established for some time in this district of Victoria, though not previously recorded. It is not likely to become a serious weed, though of no economic value.

STERA (Ewart, Contrib. to Flora of Aust., No. 18, in Proc. Roy. Soc. of Vict., vol. 24, p. 263, 1911) = CRATYSTYLIS (Spencer le Moore, in Journal of Botany, vol. 43, p. 138). (Compositae).

This genus and its 3 species are made from *Pluchea conocephala*, F. v. M., and its two varieties, *microphylla* and *subspinescens*. I was unaware at the time that Spencer le Moore had already made this change, but the fact that the same decision has been arrived at from two sources quite independently, is a sufficient proof, if any were needed, of the necessity of raising this new genus on the basis of "*Pluchea conocephala*, F. v. M." Spencer le Moore's generic name being the earlier one has, of course, priority.

THRYPTOMENE RACEMULOSA, Turcz. (Myrtaceae).

Coolgardie, West Australia, Mrs. Markes, 1895.

TRICHODESMA LATISEPALUM, F. v. M. (TRICHODESMA ZEYLANICUM, R. Br., var. LATISEPALUM, F. v. M.) (Boraginaceae).

Bull Oak Creek, Northern Territory, Dr. Gilruth, 1911.

UROSPERMUM DALECHAMPII, F. W. Schmidt. (Compositae).

Domain, near Botanic Gardens, Hobart, Tasmania, R. Black, Feb., 1912.

A native of Southern Europe, now introduced into Tasmania, either by the agency of impure seed or as a garden escape, but not yet sufficiently established to be considered naturalised.

EXPLANATION OF PLATES.

Plate V.

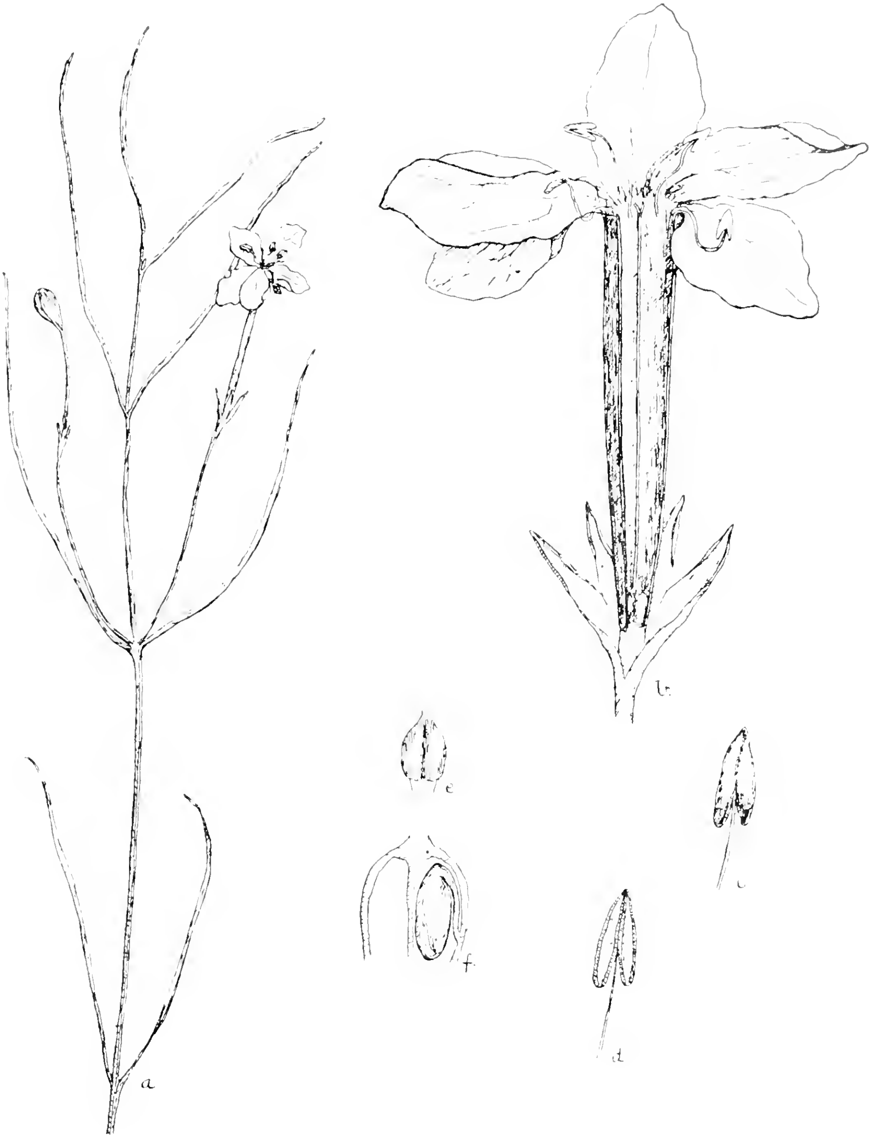
Huxleya linifolia, Ewart and Rees.

Fig. a.—Portion of plant.
b.—Single flower with calyx and corolla tubes split longitudinally and opened back.
c.—Single anther, back view.
d.—Single anther, front view.
e.—Ovary.
f.—Ovary opened, showing ovule in one cell.

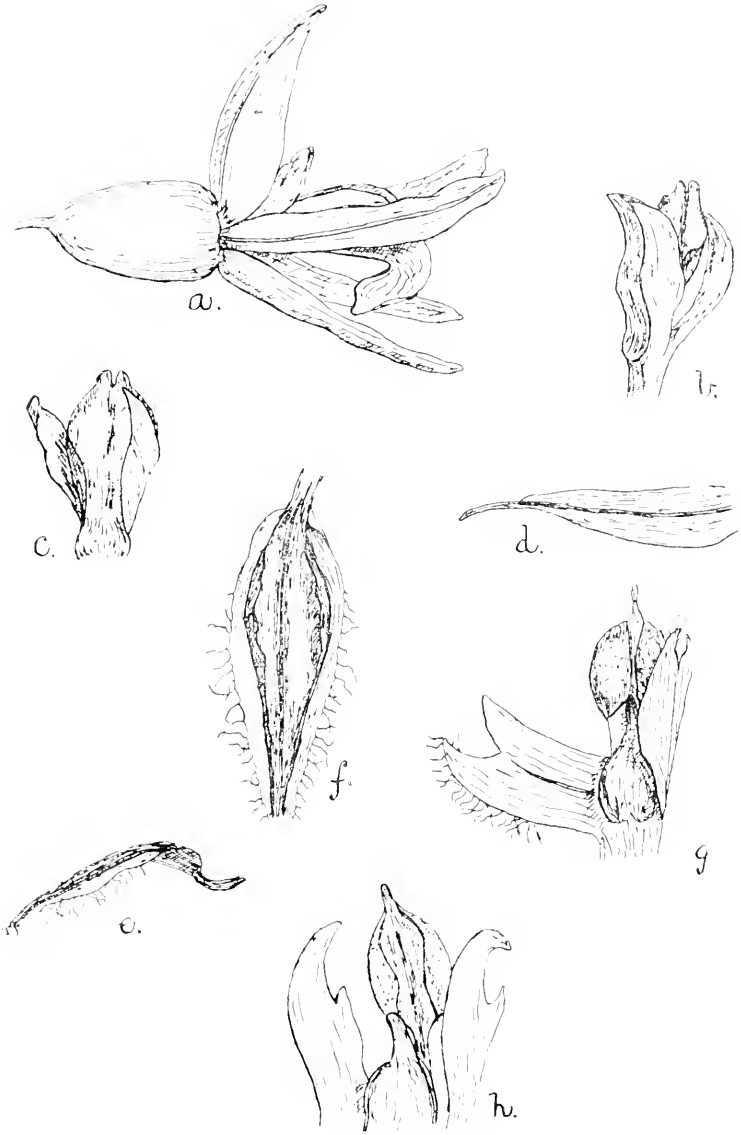
Plate VI.

Prasophyllum, sp.

Fig. a.—Prasophyllum Suttoni.
b.—Column of same, side view.
c.—Column of same, front view.
d.—Lateral petal of P. ciliatum.
e.—Labellum of same, side view.
f.—Labellum of same, flattened out.
g.—Column of same, one appendage turned back.
h.—Column of P. despectans, var. intermedia.



Huxleya linifolia, Ewart and Rees.



Prasophyllum, sp.

Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. I., 1912.

Art. VIII.—*The Ascent and Descent of Water in Trees.*

By ALFRED J. EWART, D.Sc., Ph.D., F.L.S.

(Professor of Botany and Plant Physiology in the Melbourne University).

(With Plate VII.).

Read 9th May, 1912.

The question as to whether the aid of living wood tissue is necessary for the continuous conduction of water up lofty trees is still an unsettled one, being answered by some investigators in the affirmative, and by others in the negative. According to the theory put forward by Dixon and Joly, as well as by Askensay, the ascent is wholly, or almost wholly, due to the suction exercised by the transpiring leaves upon the cohering columns of water suspended from them in the wood vessels; so that the water is drawn up from the roots in much the same way that a rope might be hauled up by hand. In a previous paper[1] it was pointed out that an explanation was required, not merely as to how the water was held suspended in the vessels, but also as to how the kinetic resistance to flow was overcome, and it was shown by calculation and experiment that in actively transpiring trees the total kinetic resistance to flow might be several times greater than the statical resistance due to the height of the tree. In other words, the suspended water columns in the vessels might at their highest points in the tallest trees, be under a tension equivalent not merely to a head of 300 feet of water, but to one of one or two thousand feet, or even more. Water columns are capable of standing such tensions, but only under conditions which are not presented in the wood vessels of trees—namely, the water columns must be entirely free from air or dissolved gases, they must be enclosed in rigid walls impermeable to water and to dissolved gases, and apparently, also, to judge from some of the experiments performed, the water must be as free as possible from suspended solid particles. Further, so far as I am aware, all the physical experiments which have been successful in demonstrating a high tensile strength for columns of water, have been carried out with stationary columns. It is quite an open question as to whether a column of water flowing with fair rapidity through a tube would exhibit the same tensile strength as a stationary one, particularly if its flow were interrupted by roughness and occasional transverse partitions, producing eddy currents or irregular flow instead of steady stream line flow. This question is, of course, one for physicists, but

1 Phil. Trans. Roy. Soc. London, B., vol. 198, 1905, p. 41

until it is answered it is not permissible to assume that the results obtained in glass tubes with stationary columns of water can be directly applied to the flowing columns of water, surrounded by the rough, water impregnated walls of the wood vessels, which are also readily permeable to air under pressure.

In a second paper, experiments were conducted on entire trees to determine whether any of the high tensions postulated in the water tension theory in the ascent of sap, could be detected in the wood of actively transpiring trees. The results obtained were in the negative, but, as pointed out by Dixon, the ordinary manometer experiments are unable to provide against the existence of air cavities in the wood tissue, so that the pressure exhibited by a manometer might be considerably less than that actually existing in the cavities of the wood vessels themselves. In any case this very fact makes it difficult to see how a high tension could be maintained for any length of time in a water column contained in a tube whose walls were saturated with water, and which bordered externally upon air spaces. The appearance of the minutest bubble of air in such a column of water would immediately cause its tension to be reduced to some fraction of an atmosphere. Actual observations, which have been confirmed by more than one observer, have shown that the wood vessels in the functioning wood of actively transpiring plants do actually contain bubbles of air, and hence cannot possibly transmit any tension exceeding an atmosphere.

In the same paper an account was given of an experiment with an entire tree, carried out on the same lines as those by Strasburger — namely, by cutting an entire tree at its base, and allowing first a poisonous and then a coloured solution to be drawn up the trunk of the tree. The experiments showed that there was a distinct tendency on the part of the sap to avoid the parts of the wood which had been killed by poison, and to flow in the older parts of the wood to which less poison had penetrated, but in which the flow is usually least active under normal conditions.

Apparently this pointed to the necessity of the existence of living wood cells to maintain the function of the wood vessels as conducting chambers, even for short lengths of time, and this would tend to show that the water tension theory only afforded a partial explanation of the ascent of water in tall trees. It was, however, obviously advisable to complete such observations by experiments carried out on the tallest trees available of 200 to 300 feet in height. The initial difficulty lay, however, firstly in the comparative inaccessibility of such trees for scientific experiments, and secondly in the difficulty and cost of carrying out the required manipulations, which would include very

1 Phil Trans. Roy. Soc. London, B, vol. 199, p. 341.

strong scaffolding and special apparatus for rapidly cutting the base of the tree and avoiding its exposure to air. Accordingly a simple preliminary experiment was tried upon a small tree of *Acacia mollissima* growing in the Herbarium grounds. The tree was four years old, 25 feet high, and had a circumference, $1\frac{1}{2}$ feet above ground, of 26 inches. The spread of the tree was 14 feet, and the head was nearly cylindrical up to 6 feet from the top, the lowest branch being 5 feet from the ground. The base of the tree was surrounded by a cup made of canvas, and cemented until watertight. The cup had a capacity of 15 litres when filled up to a mark below the brim. In March, after filling the cup with water, a ring of bark and wood was cut away under the water near the base of the cup, by means of a sharp chisel, to a depth of $1\frac{1}{2}$ inches all round the tree. The remaining core of wood was quite strong enough to support the entire tree, but was apparently inactive in the ascent of sap. (See Pl. VII.). Sufficient copper sulphate was then added to make a 5 per cent. solution, and after some 26 litres had been absorbed, which meant the addition of a large amount of water, the copper sulphate remaining was washed out and replaced by a solution of eosin. As can be seen from the data given beneath, the amount of water absorbed was considerable, but rapidly fell off after the first few hours.

Time.	Amount absorbed	Conditions.
Wednesday, 13th		
10 a.m. - 11.30 a.m.	6 litres.	Bright sun
11.30 a.m. - 12.30 p.m.	7 litres.	,,
12.30 p.m. - 1.30 p.m.	$8\frac{1}{2}$ litres.	,,
1.30 p.m. - 2.30 p.m.	5 litres.	,,
	Copper sulphate replaced by eosin.	
2.30 p.m. - 3.30 p.m.	$4\frac{1}{2}$ litres.	,,
3.30 p.m. - 4.30 p.m.	$2\frac{1}{2}$ litres.	,,
4.30 p.m. - 10.30 p.m.	9 litres. ($1\frac{1}{2}$ litres per hour)	
10.30 p.m. - 9.30 a.m.	11 litres. (1 litre per hour)	
Thursday, 14th		
9.30 a.m. - 10.30 a.m.	Fresh surfaces of wood cut	Overcast, clearing slightly to mid-day
10.30 a.m. - 11.30 a.m.	2 litres.	
11.30 a.m. - 12.30 p.m.	$1\frac{1}{2}$ litres.	
12.30 p.m. - 1.30 p.m.	$2\frac{1}{2}$ litres.	Cloudy
1.30 p.m. - 2.30 p.m.	$1\frac{1}{2}$ litres.	Sun and slight clouds
2.30 p.m. - 3.30 p.m.	$1\frac{1}{4}$ litres.	Cloudy
3.30 p.m. - 4.30 p.m.	1 litre.	Slight sun
4.30 p.m. - 10.30 p.m.	5 litres (0.83 per hour)	
10.30 p.m. - 10.30 a.m.	5 litres (0.83 per hour)	
Friday, 15th.		
10.30 a.m. - 11.30 a.m.	$\frac{3}{4}$ litre.	Bright sun
11.30 a.m. - 12.30 p.m.	1 litre.	,,

The following table from the Melbourne Observatory records gives the hygrometric conditions for the first day of the experiment.

March 13th, 1912.

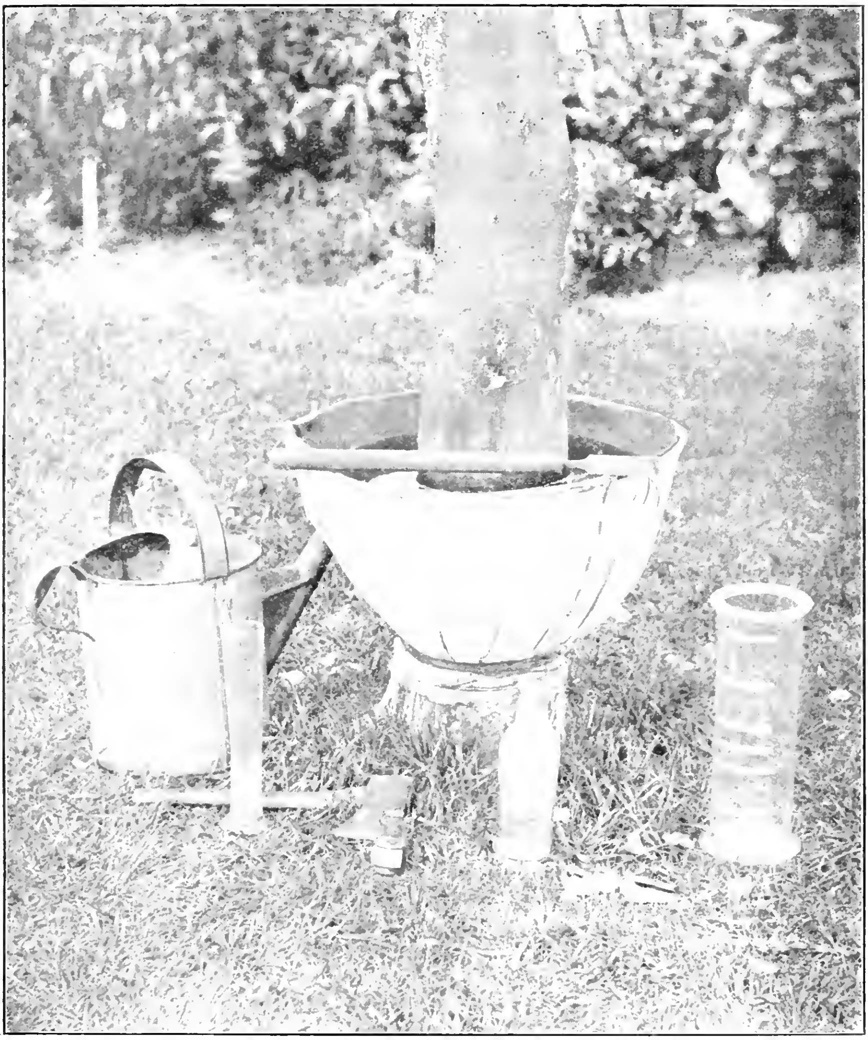
Time	Dry Bulb	Wet Bulb.	Computed relative humidity. 100 = satuaration.	Evaporation at a free surface of water.
9 a.m.	62.5	55.2	63 per cent.	Amount of water evaporated from 9 a.m. to 6 p.m. 0.086 inches.
3 p.m.	65.3	56.0	54 ,, ,,	
6 p.m.	60.8	53.0	58 ,, ,,	

With a spread of 14 feet diameter, the tree covered an area of ground of 142,588 square centimetres. With a rate of evaporation of 2.19 millimetres per 9 hours, this would give a total loss from a free surface of water of 31 litres, or 3.4 litres per hour. The estimated rate for the whole tree from branch observations made at 10 a.m., 1.30 p.m. and 4.30 p.m., represented an average total of 2.2 litres per hour during the same period. This is considerably less than the actual amount absorbed, and less than the amount that would have evaporated from a free surface of water covering the same area as the spread of the tree. Since the leaflets of the cut branches were, however, in all cases partially folded by the close of the experiment, it is possible that the estimated rate of transpiraton was somewhat less than actually occurred in the tree as a whole.

In all experiments in which eosin is used to indicate the ascent of water, the lateral diffusion of the dye makes it not altogether a perfectly safe guide as to the exact path of the water current. For this reason, copper sulphate was used as the poison to precede the eosin.

When copper sulphate is added to a strong solution of eosin, the greater part of the dye is precipitated, and hence it was thought that the ascending eosin would be fixed in the walls of the wood vessels by the copper sulphate impregnating them, and so largely or entirely prevented from lateral diffusion. This was actually the case. An examination of the wood showed the almost exclusive part played by the wood vessels in the ascent of sap. No indication could be seen of any connection of the medullary ray cells with the ascending stream, but as the copper sulphate had killed then before the eosin had entered the stem, this fact affords no evidence one way or another.

In addition, the presence of copper sulphate in the wood caused the eosin to be held back to such an extent as to make it useless as a measure of the movement of the sap. Thus when the tree was cut down at the end of the third day, eosin was only perceptible in the main trunk up to a height of 10 feet, and was entirely restricted to the outer layers of wood 1 to 1½ inches in depth at the base, and tapering to a depth of ¼ inch upwards.



Traces of copper were, however, detected in the outer wood at the top of the tree, after incinerating and treating the residual ash with a drop of nitric acid and an excess of ammonia. At the same time, however, it was found that the eosin solution had also travelled down the stem, and it was traced out for distances up to 7 feet along the lateral roots, up to roots less than ½ inch in diameter. Judging from the depth of colouration, a greater flow had taken place down the stem than up it from the point of section. We are so accustomed to think of the sap as always ascending, that this result seems at first sight somewhat surprising. As a matter of fact, the water would flow more easily downwards, particularly if the central intact wood cylinder exercised a suction upon the roots below the point of injury. The fact that this is possible, however, makes this method of investigation unsuitable for application to the largest trees, unless two conditions can be fulfilled, which are—(a) it must be possible to cut away the whole of the alburnum, leaving only perfectly non-conducting duramen; (b) the lower cut surface must be blocked with wax or some similar substance.

The total amount of liquid absorbed by the upper and under cut surfaces from 10 a.m. to 4.30 p.m. on the first day, was no less than 33½ litres, or 5.1 litres per hour. A large proportion of this, however, may have been absorbed either to bring the wood to full saturation point, or a portion may have actually oozed out from the roots into the soil. That pressure applied to a cut stem will cause water to exude out through the roots, is easily shown, and the pressure of continuous columns of water in the tallest trees, if it were transmitted directly to the absorbing roots would certainly cause an outward flow through them. Whether the forces preventing this are derived solely from the suction of the leaves, or are partly the result of agencies acting in the stem along the path of the transpiration current, is still an open question, to which the foregoing experiment affords no decisive answer.

Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. I., 1912.

Art. IX.—*Description of Two New Ischnochitons from Western Port, Victoria.*

By A. F. BASSET HULL
(Sydney).

Communicated by C. J. Gabriel.

(With Plate VIII.).

Read 11th July, 1912.

The two shells here described were dredged in from 6 to 8 fathoms, between Phillip and French Islands, Western Port, Victoria, by Mr. C. J. Gabriel, of Abbotsford. They were submitted to Professor Joh. Thiele, of the Imperial Zoological Museum, Berlin, who expressed the opinion that they were both new species, and after careful examination I concur, although one of the shells has already been taken by dredging at Frederick Henry Bay, Tasmania, and identified by Tate and May as *Ischnochiton tateanus*. It is, however, undoubtedly quite distinct from that species.

The small shell, which I propose to associate with the finder, is considered by Prof. Thiele to be certainly an *Ischnochiton*, although I am inclined to think that it possesses more of the characteristics of the *Lepidopleuridae*, inasmuch as valves ii. to viii. are unslit, and even the anterior valve has very rudimentary slits.

The types of both species are in the collection of Mr. C. J. Gabriel.

1. Ischnochiton gabrieli, n. sp. (Pl. VIII., Figs. 1, a, b, c, d, e, f).

Shell small, elevated, carinated. Colour yellow, irregularly maculated with brown. Anterior valve finely granulose, the granules tending to a radial arrangement, the rays slightly curved. Median valves, lateral areas slightly raised, covered with irregularly disposed granules; central areas with granules arranged in radiating rows, curving outwardly and diverging upwards over the jugum. Posterior valve irregularly granulose; mucro obtuse, behind the middle. Girdle covered with small, smooth densely imbricating irregular scales. Interior white; sinus broad and shallow; anterior valve interiorly grooved and with 9 slits; median and posterior valves unslit.

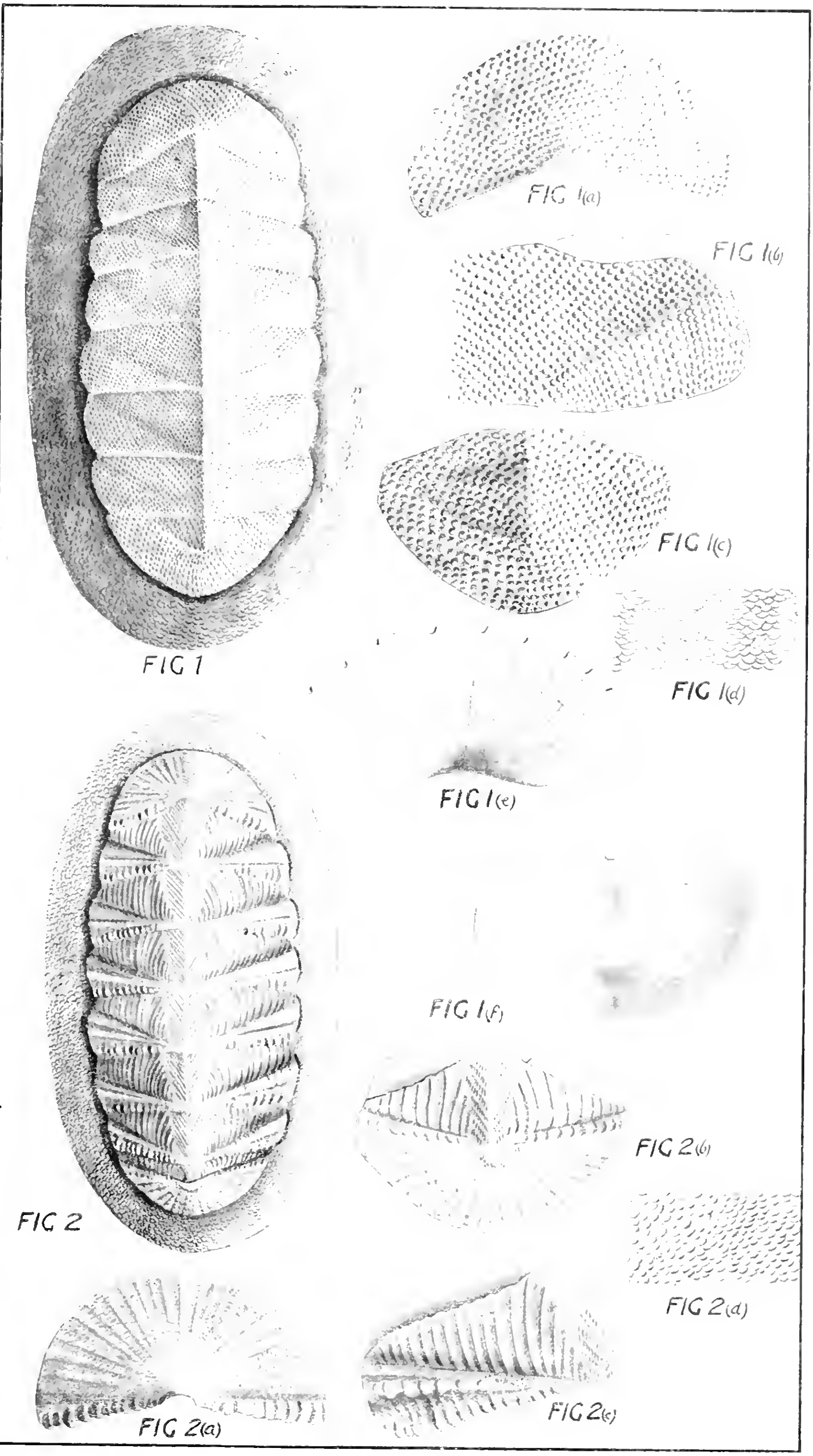


FIG 1
FIG 1(a)
FIG 1(b)
FIG 1(c)
FIG 1(d)
FIG 1(e)
FIG 1(f)
FIG 2
FIG 2(a)
FIG 2(b)
FIG 2(c)
FIG 2(d)

Dimensions. Length, 6 mm.; breadth, 4 mm.

Station. 6 to 8 fathoms (dredged).

Habitat.—Between Phillip and French Islands, Western Port, Victoria.

2. **Ischnochiton falcatus,** n. sp. (Pl. VIII., Figs. 2, a, b, c, d).
Ischnochiton tateanus, Tate and May, non Bednall, Census Marine Moll. Tasmania, Proc. Linn. Soc. N.S.W., 1901, p. 413.

Shell elevated; moderately carinated. Colour ochraceous, irregularly maculated with white, chiefly on the sides and anterior valve. In some specimens nearly the whole jugal tract is white. Anterior valve finely radially ribbed, the posterior margin strongly pustulose, the projecting pustules imparting a serrated appearance to the edges. Median valves, lateral areas strongly raised, with two or three radiating ribs, sometimes bifurcating towards the margin; the posterior rib strongly pustulose, the edge deeply serrated. Central areas deeply sulcate, the sulci curving outwardly, the curves being most marked near the jugum. Jugal tract with V-shaped striae, the apex directed backwards. Posterior valve, mucro median; the posterior half finely radially ribbed like the anterior valve, the anterior half similar to the central areas, the two sections divided by a pustulose rib. Girdle with very irregular, striate scales. Interior bluish, with pink spot in sinus and centre of end valves. Anterior valve having 11, median 1-1, and posterior 13 slits.

Dimensions.—Length, 15 mm.; breadth, 9 mm.

Station.—6 to 8 fathoms (dredged).

Habitat.—Between Phillip and French Islands, Western Port, Victoria. (Frederick Henry Bay, Tasmania, Tate and May.)

Remarks.—This shell differs from *I. tateanus* in the much finer sculpture of the anterior valve, the deep sulci of the central areas, and the much coarser sculpture of the lateral areas. A specimen sent to me by Mr. W. L. May, dredged in 10 fathoms at Frederick Henry Bay, Tasmania, is identical with the Victorian shell now described.

[Proc. Roy. Soc. Victoria, 25, (N.S.), Pt. I., 1912.]

Art. X.—*An Investigation of Fifty-Two Tasmanian Crania by Klaatsch's Craniotrigonometrical Methods.*

By L. W. G. BÜCHNER

(Goverment Research Scholar in the Anthropological Laboratory of the University of Melbourne).

Read 11th July, 1912

When Huxley (1) write that he had arrived at the conclusion "that no comparison of crania is worth much that is not founded upon the establishment of a relatively fixed base line, to which the measurements in all cases could be referred," he considered that it would not be a very difficult matter to decide what that base line should be, and eventually suggested his now well-known basil-cranial axis. Many investigators have, however, employed modifications or adaptations of Huxley's basi-cranial axis, whilst others have devised totally independent base lines. The great objection, however, to the majority of these base lines is that they are non-correlative with any previous work, and when the next new base line appears, the others are, to a large extent, rendered valueless. Such a variety or multiplicity of methods creates unnecessary complications, and makes it impossible to obtain comparative data, and the result is, that notwithstanding the numerous craniological reséarches of the last fifty years, there has been but little appreciable advance in reducing these measurements to one common standard.

Bolk (2) considers that a rational base line of a craniometrical system must be able to serve for, at least, a primary division of the skull. In referring to the base lines which have been drawn through the base of the skull, he raises this objection, that whilst these base lines may be of value as boundary lines between the cerebral and facial skull, they are valueless as the basis of a craniometrical system. He thus criticises the base lines of Topinard, Aeby and Rauber. Sollas (3) writes that it is interesting to observe how closely in the consideration of base lines the latest researches have followed those first laid down by Huxley.

Considerable interest attaches to the methods instituted by Schwalbe (4), of Strassburg, on the calvaria of *Pithecanthropus erectus* particularly, and pre-historic man generally. In this work he employs as a base line the plane between the glabella and inion, that is, the plane previously associated with Rieger's name.

In selecting this plane, Schwalbe was compelled to make use of the glabella as one of the fixed points, owing to the fact that in calvaria of *Pithecanthropus erectus*, the face is missing, a remark which also applies to many of the other calvaria examined by Schwalbe, and which left him no choice in the matter. In deciding on this plan he says:—"so erweist sich als einfachste und natürlichste die vom vorderen Glabellarende bis zu dem am weitesten nach hinten vorragenden Medianpunkte des queren Hinterhauptwulstes, welchen Dubois als "scheinbares Inion" bezeichnet hat. Ich schlecthin als Inion bezeichnen werde."

In their researches on the Tasmanian crania, Berry and Robertson (5) also adopted, in the first place, Schwalbe's methods of "form analysis," based on the glabella inion plane, as they were anxious to institute comparisons of evolution between the Tasmanian and primitive man. Klaatsch (6), in his memoir on the Australian crania, also adopted the glabella inion plane. He says:—"To secure a common standard I take the glabellar point and glabellar inion plane," and again, "for purposes of the more precise comparative investigations with the fossil fragments, the glabella inion plane is clearly preferable." In his later works, however, he departs from the base line. Turner's (7) base line, that is, the nasio-tentorial plane, when available, appears to be one of the most satisfactory and rational planes for craniological purposes. In selecting this plane in opposition to the glabella inion plane, he states that the variation of the glabella, in association with the frontal sinus, "unfits it to be used for taking the point in front from which to estimate the length of the cerebral part of the cranial cavity."

Berry and Robertson (5) agree with Turner that the glabella inion plane is not the best (when others are available), "from which to estimate the cerebral part of the cranial cavity," but consider that "the nasio-inion plane coincides more closely with the cerebral part of the cranial cavity than either the glabella inion or nasio-tentorial planes."

The influence of the frontal sinus on the glabellar region has been carefully considered by many authors, notably Schwalbe (4, 8, 9), Logan Turner (10), Bianchi (11), Zuckerlandl (12) and Cunningham (13).

Cunningham considers that the relationship which exists between the sinus and glabella is a problem which must for the meantime remain unsolved.

As with the glabella, so also the position of the inion has been the subject of considerable investigation. Keith (14), Klaatsch (15), Sollas (3), Anderson (16), Rieger (17), Fraipont and Lohest (18), Kramberger (19), and others, all agree that variations exist in the positions of the external and internal protruberantia.

The choice of a base line is therefore, from every standpoint, a matter of difficulty, and no matter what the ultimate choice may be, it is clear that objections may be raised against it.

Notwithstanding the many base lines which have already been employed, Klaatsch (15 and 20) has recently introduced yet another method in order to secure a suitable standard basis for craniometrical observations. Whilst attempting to reconstruct the facial part of the Neandertal skull, he found that the glabella inion plane was not suitable for this purpose. He also found that when the skull is oriented in the Frankfort plane, the position assumed is not in harmony with the natural position of the head in the living subject, that is, with the eyes directed to the horizon.

On referring to Sollas's work on the Gibraltar skull, he found that that author had made use of median outline tracings of the cranial part of the skull minus the face, cut out in paper in order to establish the centre of gravity of the brain part of the cranium. Klaatsch reproduced this method, but as an experiment included the face as well. The centre of gravity now naturally fell further downward and forward, and to differentiate this new point from that of Sollas, Klaatsch designated the two points S and K respectively (Fig. 1), S being the centre of gravity as determined by Sollas, without the face, and K the centre of Klaatsch with the face.

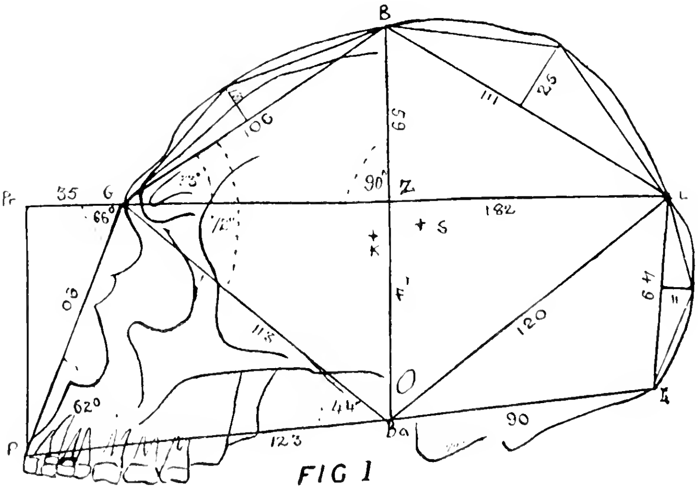


Fig. 1. —Sagittal diagram of an Australian Skull (Klaatsch). Half natural size.

K = Klaatsch's Gravitation Point.

S = Sollas's Gravitation Point.

Pr = Prognathic Point.

Z = Zentrum.
BGL = Upper Glabella Angle.
LGBa = Lower Glabella Angle.
BGBa = Anterior Glabella Angle.

On making further experiments Klaatsch was struck with the constant relationship which the point K bore to the basion bregma line, the point being always in that line, or a few millimetres to one or other side of it. On adding the glabella lambda line, Klaatsch noticed that it almost always intersected the basion bregma line at a right angle. The point of intersection he therefore terms the "Zentrum."

On account, therefore, of, firstly, the centre of gravity falling in, or close to, the basion bregma line; secondly, that line intersecting the glabella lambda line at a right-angled "Zentrum," and, lastly, the natural coincidence of this glabella lambda plane with the natural position of the head in life, Klaatsch proposes that this plane should be made the natural base line for all future craniometrical work. Upon this base line he further proposes that a quadrilateral figure should be devised, the sides of which are drawn from the glabella to the bregma, the bregma to the lambda, the lambda to the basion, and the basion to the glabella, respectively. These four lines, therefore, correspond in part, but not entirely, to the chords of the frontal, parietal and occipital bones, and the "basi-cranial" axis. On the four sides of this quadrilateral figure Klaatsch further proposes the erection of a series of triangles for the study of angles of curvature and other allied points in connection with the several bones of the skull.

The whole of this system he designates as a "craniotrigonometrical" method for studying the skull (Fig. 2). One advantage, amongst others claimed by its author for his method, is that the various angles will now receive their correct nomenclature, as Klaatsch, in common with others, has criticised Schwalbe's method of naming or misnaming these angles. Klaatsch, for example, proposes to obviate any confusion that may arise by designating angles by the position of their apices. He says: "Mein Prinzip ist jeden Winkel nach seinem Scheitelpunkte zu benennen." He thus terms the angle bounded by the bregma glabella and lambda glabella lines the upper glabellar angle. (See Fig. 2.)

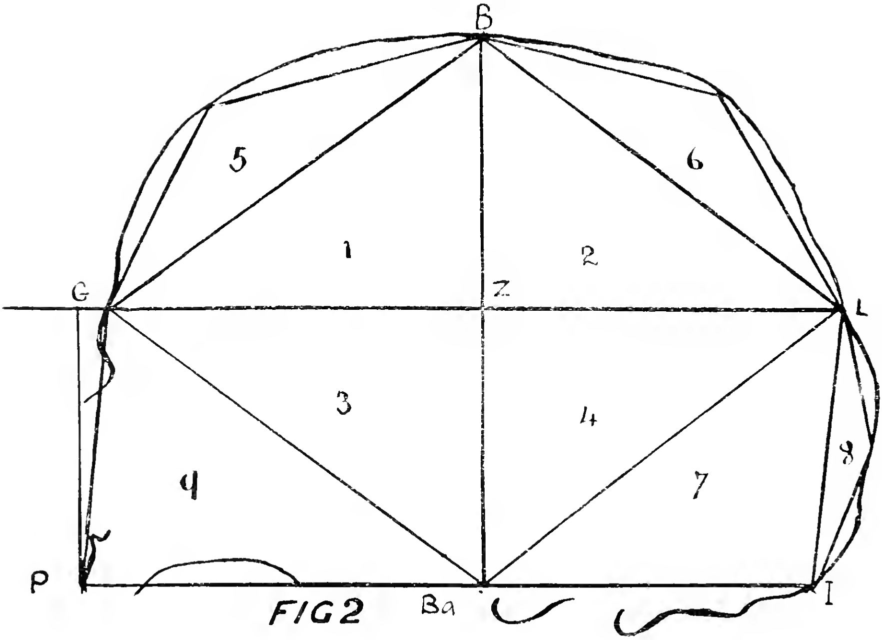


FIG 2

Fig. 2.—Illustrating Klaatsch's Craniotrigonometrical Method.
G = Glabella. B = Bregma. L = Lambda. I = Inion. Ba = Basion. P = Prosthion. S = Zentrum.
1-4 Inner Triangles. 5 Frontal Triangle. 6 Parietal Triangle. 7 Chief Occipital Triangle. 8 Adjacent Occipital Triangle. 9 Upper Facial Triangle.

It was suggested to me by Professor Berry, of Melbourne University, that I should apply this new craniotrigonometrical method of Klaatsch to the fifty-two Tasmanian crania previously examined by Dr. Robertson and himself (5) to ascertain if the methods just referred to as having been recently used by Klaatsch, were better adapted to the evolutionary morphology of the skull, than the older "form analysis" method of Schwalbe; and, in the second place, to ascertain if the several ranges of variation of the measurements to be recorded by this new method led to the same general conclusion as those obtained by the older method.

The material upon which this investigation is based will be found in Berry and Robertson's Dioptrographic Tracings in Four Normae of Fifty-two Tasmanian Crania (21). The present series of observations will be found in Norma A, that is, the medium sagittal tracing.

I have recorded in Table I., twenty-seven selected observations on every skull, where the natural condition of preservation enabled such to be recorded. The observations recorded are as follow:

1. The glabella lambda length.
2. The glabella zentrum length.
3. The zentrum lambda length.
4. The basion bregma height.
5. The bregma zentrum height.
6. The zentrum basion height.
7. The angle at the zentrum.
8. The glabella bregma chord.
9. The bregma lambda chord.
10. The lambda basion chord.
11. The basion glabella chord.
12. The glabella bregma basion angle.
13. The lambda bregma basion angle.
14. The bregma lambda glabella angle.
15. The basion lambda glabella angle.
16. The lambda basion bregma angle.
17. The glabella basion bregma angle.
18. The basion glabella lambda angle.
19. The bregma glabella lambda angle.
20. The glabella bregma lambda angle.
21. The bregma lambda basion angle.
22. The lambda basion glabella angle.
23. The basion glabella bregma angle.
24. The lambda inion chord.
25. The inion basion length.
26. The basion prosthion length.
27. The prosthion glabella length.

As the nature of these twenty-seven can be easily followed from figure 2, in which they are displayed, it is unnecessary to describe them. Should more information be required as to their character and nature, the reader may be referred to Klaatsch's original works (15 and 20) dealing with his methods herein followed.

In Table I., I have followed the lines laid down by Berry and Robertson (5). This serial number, the present location of the skulls, and the original number are recorded in the upper three horizontal lines. In the three left-hand columns are set forth the numbers and the names of the recorded observations. In the vertical columns of serial numbers are set forth the individual numbers of each skull. The male and female skull measurements have been separated, and the results are, therefore, tabulated in separate columns. The four vertical columns on the right, after the male skull measurements, record the number of observations made, the minimum and maximum figures for that particular observation, together with the average results. The results of the female skull measurements are likewise recorded in the columns to the right of the measurements, whilst the total results of the unsexed skulls will be found in the columns on the extreme right. The maximum and minimum figures have been indicated by a + or — sign in each row, and this method has been adopted uniformly throughout.

As was also the case in Berry and Robertson's work on these particular Tasmanian crania, it was not possible to record all of the observations upon every skull. Number 48 being a juvenile subject, the measurements recorded upon it have been uniformly omitted from the final results. In numbers 4 and 8, where the results concern the prosthion, they have also been omitted.

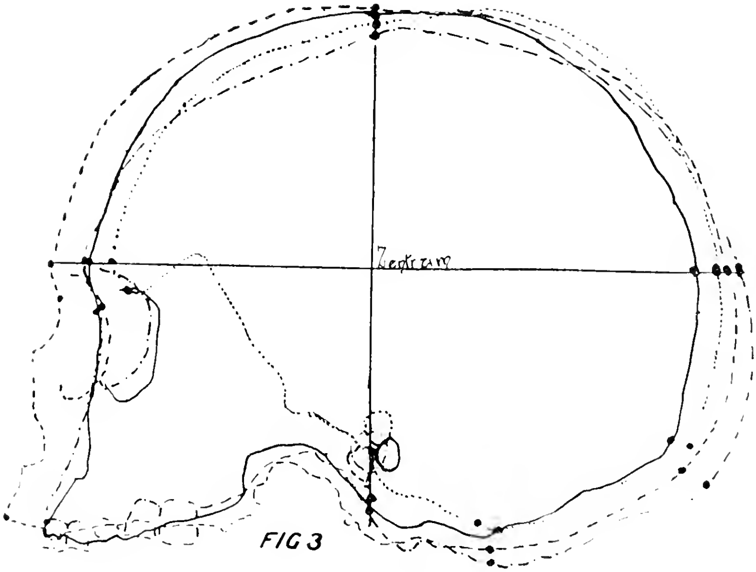


Fig. 3.—Four Tasmanian Crania superposed on Klaatsch's Base.

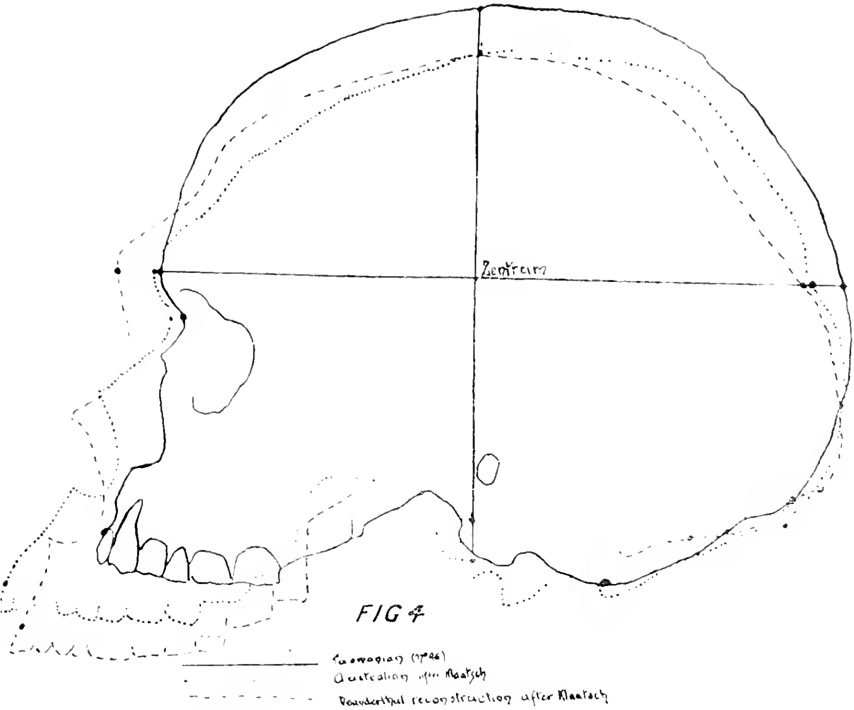


Fig. 4.—The Neanderthal (Klaatsch), Australian, and Tasmanian Skulls superposed on Klaatsch's Base.

Unfortunately no comparative data for this method are yet available, and so I can only record these observations without instituting any morphological or evolutionary comparisons. Klaatsch, however, records the measurements of one Australian (see Fig. 1), when the angle at the Zentrum is given at 90 deg., but Wetzel (22), on the other hand, found that in the Australian in no one of this three specimens was the angle of 90 deg.

In the Tasmanian, my investigations show that this Zentrum angle in over 25 per cent. of the crania examined, is exactly 90 deg., but it is obvious that in view of the insufficiency of numbers of the Australian, and the discrepant results obtained by Klaatsch and Wetzel from those numbers, no comparison can be instituted between my results for the Tasmanian, and those already mentioned for the Australian, and these apart, there are absolutely no other figures available.

The Tasmanian crania as drawn by Berry and Robertson (21), were "oriented in the Frankfort plane and then drawn by means of

Martin's Dioptrograph." The resulting diagrams are therefore strictly accurate and correlative.

Klaatsch, however, in his Australian work did not employ mechanical methods for fixation in the plane determined on, but used a yielding substance like plasticine. He says:—"In order to obtain exact results, the skull has to be carefully placed in proper position, it being essential that the tracing of its contour be made on the level of a definite common horizon." But the question arises, can a skull always be placed in its proper position without fixed mechanical methods? Personally I think not, and for this reason I have not availed myself of the diagrams furnished in Klaatsch's memoir on the Australian aboriginal, as it is open to doubt whether the orientation is absolutely reliable. Consequently, apart from the few comparative data of the "Zentrum" angle referred to, I do not propose to institute any further craniotrigonometrical comparisons between my Tasmanian results and those of other observers on the Australian.

I content myself, therefore, with leaving to those interested the further examination of the various figures now for the first time made available in Table I.

Concerning, therefore, the value of Klaatsch's craniotrigonometrical system, my investigation leads me to the belief that, for reconstructional work, such as that of the face from the calvaria, the method may be of some value, inasmuch as I have satisfied myself that in the Tasmanian, at all events, the angle formed by the basion bregma and glabella lambda lines is, as averred by Klaatsch, for all skulls, remarkably constant at or about 90 deg.

Apart from this the method does not appear to possess any advantage whatsoever, as compared with the existing method of Schwalbe. The latter method has been shown, notwithstanding its imperfections, and the fact as proved by Cross (23) that all its data are not of equal morphological value, to be of very real advantage for estimating the relative evolutionary growth of the brain, and of thus determining the relative positions of pre-historic and recent man of both low and high civilisations, one to another.

My final conclusion is, therefore, that greater progress will be made in the craniology of peoples by extending the observations of Schwalbe, Berry and Robertson, Cross and others to as many nationalities as possible, than by the invention of new methods.

Concerning the range of variations in the 27 observations herein recorded, it is important, in view of the attention now being almost generally devoted to this question, to examine it carefully.

Without going into the modern vexed question of the causes of variations and mutations, it may be stated that there are, at all events two widely divergent schools. The views of the one school may be illustrated by a quotation from Thomson (24), who says, when speaking of the causes of variation: "In regard to the causes of variation it is too soon to speak, except in tentative whispers. What Darwin said must still be said, 'Our ignorance of the laws of variation is profound. Not in one case out of a hundred can we pretend to assign any reason why this or that part has varied.'"

The other line of thought may be illustrated by a quotation from Cossar Ewart (25), than whom there is no greater living authority on this particular subject. He says:—"Domestic animals reproduce themselves with great uniformity if kept apart; but the moment one mixed up the two different races, strains, or breeds, one did something that was difficult to put in words, the result was what has been best described as an 'epidemic' of variations."

The main question in dispute as to the origin of the Australian aboriginal is as to whether he is, or is not, an autochthonous race, that is, a pure-bred race, or the result of a cross, and in the Melbourne School of Anthropology, almost all the several lines of research laid down by Professor Berry have been evolved with the solution of this problem in view.

From what Cossar Ewart has said, it is clear that, if the Tasmanian be a pure-bred and homogeneous race, the range of variation should be small, whilst conversely if the Australian be an impure or mixed race the range of variation should be high. With the Australian I am not at present concerned, but the subject will shortly be dealt with by Professor Berry and Dr. Robertson.

Concerning the mode of studying the range of variation, provided there be some standard object of comparison, it is an easy matter to express the range of the variation of the subject under consideration in terms of percentage with the standard object, as is now actually being done by my fellow investigators in this school.

The results are not, as yet, quite ready for publication, but the work comprises a comparative study of the range of variation of "form analysis," and other cranial and facial measurements of supposed pure races like the Tasmanian and Andamanese, of known impure races like the modern Italian, and of the doubtful race under investigation, the Australian.

In my study of the craniotrigonometrical characters of the Tasmanian skull, it is obvious that as there are no other figures available to me, I cannot employ this particular method of studying the percentage range of variation, but have had to fall back on an ordinary arithmetical figure for displaying the mean range of variation. I am well aware that it is more accurate to employ the modern biometric methods, but in this particular case the final results of the one method are not materially different from those of the other.

I have therefore worked out the ranges of variation for the whole of the twenty-seven observations for the males, the females, and both sexes combined. I have subtracted the minimum range of variation from the mean, and the mean from the maximum, added all these differences together, and divided the quotient by fifty-four, that is, by twice the number of recorded observations, being once for the minima and once for the maxima.

The result is that in the twenty-seven craniotrigonometrical observations herein recorded, in fifty-two Tasmanian crania the range of variation is as follows:—

For males, 7.9.
For females, 7.5.
For both sexes, 9.9.

As, however, thirteen of my twenty-seven observations comprise angles only, in which the range of variation can never be appreciably great, I have again worked out the range of variation for those fourteen of the twenty-seven observations which do not comprise such angles, and with the following results:—

For males, 10.2.
For females, 9.9.
For both sexes, 10.1.

In either case the range of variation is so surprisingly small that it would seem to be reasonable to apply Ewart's dictum that "Animals reproduce themselves with great uniformity if kept apart," and to conclude by stating that the Tasmanian is a pure race. This conclusion is the more warranted, because when the results obtained by my colleagues, Drs. Berry and Robertson, are available, it will be found that they achieve identical results by different methods.

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TABLE I—THE INDIVIDUAL AND GENERALISED RESULTS OF THE EXAMINATION OF FIFTY-TWO TASMANIAN CRANIA

Probable Sex: Males

Nature of Observation		1 (Tasmanian Museum, Hobart, 4288)	2 (4294)	3 (4301)	4 (4301)	5 (4298)	12 (Hobart, 4302)	13 (4297)	16 (4296)	18 (Cook)	19 (Taylor 1)	23 (T M H)
1 Glabella Lambda Length	Frontal Length	*178	180	*189	176	177	181	181	172	180	179	
2 Glabella Zentrum Length		82	80		79		88		84	88	94	
3 Zentrum Lambda Length	Occipital Length	96	97		97		93		88	92	95	
4 Basion Bregma Height		125	128		132		*139		136	127	136	
5 Bregma Zentrum Height	Calvarial Height	64	60		65		65		61	72	71	
6 Zentrum Basion Height	Basal Height	64	50		67		*74		*75	‡55	65	
7 Angle at Zentrum		90	88		88.5		90		*93.5	90	90	
8 Glabella Bregma Chord	Frontal Chord	103	111	*118	101	107	111	112	108	114	111	117
9 Bregma Lambda Chord	Parietal Chord	111.5	121	*127	118	110	117.5	115	103.5	117	118.5	
10 Lambda Basion Chord		115	112		115		*123		111	118	114	
11 Basion Glabella Chord		104	*118		106		116		109	103	110	
12 Glabella Bregma Basion Angle		53	53		51		53		51	51	‡49	
13 Lambda Bregma Basion Angle		58	53		55		58		*58	52	53	
14 Bregma Lambda Glabella Angle		33	35	37	34	31	34	37	36	*38	37	
15 Basion Lambda Glabella Angle		34	32		36		37		*39	31	34	
16 Lambda Basion Bregma Angle		55	60		52		53		‡48	50	56	
17 Glabella Basion Bregma Angle		53	55		48		50		50	*58	53	
18 Basion Glabella Lambda Angle		38	33		40		39		*44	33	37	
19 Bregma Glabella Lambda Angle		37	38	41	40	35	37	39	‡34	39	40	
20 Glabella Bregma Lambda Angle	Bregma Angle	111	106	‡100	106	109	109	106	109	103	102	
21 Bregma Lambda Basion Angle	Lambda Angle	67	67		69		71		*75	69	71	
22 Lambda Basion Glabella Angle	Basion Angle	108	115		100		103		‡98	117	109	
23 Basion Glabella Bregma Angle	Glabella Angle	75	71		*80		76		78	72	77	
24 Lambda Inion Chord	Occipital Chord	62	62	56	55	58	69	63	*73	62	50	
25 Inion Basion Length		90	88		85		80		81	77	90	85
26 Basion Prosthion Length		101	108		94		99			98	94	
27 Prosthion Glabella Length		78	81	‡62	67	70	82	80		‡62	68	

Nature of Observation	24 (Jolly)	25 (Launceston Museum, 1201)	27 (1203)	28 (1204)	29 (1205)	30 (T D M 1)	32 (1)	33 (2)	34 (E O Cotton 3)	35 (4)	36 (5)	37 (6)	38 (7)	39 (1)	40 (3)	42 (W L Crowther 5)	43 (6)	44 (7)	45 (8)	46 (9)	50 (13)
1	175	187	175	181	186	182	181	183	173	175	174	‡167	181	170	176	170	186	182	176	184	
2	88	88		86	92	83	88	87	79	88	84		85	79	81	‡77	*93	84	‡77	85	
3	‡87	*99		95	94	*90	93	96	94	‡87	93		96	91	95	93	93	98	*90	*99	
4	129	136		131	135	124	122	135	129	127	127		130	‡118	130	126	134	136	128	138	
5	66	66		67	65	64	65	63	67	67	62		67	‡54	66	57	68	68	66	*73	
6	63	70		67	70	60	57	72	62	60	65		63	64	64	69	66	68	62	65	
7	90	90		91.5	93	88.5	89.5	90	89	87	88		87.5	88	89.5	89	90	89	‡85	90	
8	110	110	108	110	114	103	110	108	104	108	103	98	107	95	104	‡94	110	109	107	112	103
9	‡99	119	114	114.5	111.5	119	114.5	116	115	113	114	109	110.5	107.5	125	108.5	115.5	120.5	123	123	
10	109	122		117	121	115	110	120	111	‡103	110		112	110	114	114	114	119	111	118	
11	108	113		107	112.5	114	105	114	‡100	108	110		108	102	103.5	106	113	108	104	106	
12	53	53		51	53.5	54	53	54	50	55	*56		53	53	50	54	53	51	53	‡49	
13	54	57		56	57.5	56	54	56	54	‡50	54		53	*58	55	57	54	55	52	55	
14	37	34	36.5	36	34.5	32	35	33	35	36	42	34	34	30	35	‡31	37	35	33	37	
15	36	35		34	‡30.5	32	31	37	34	36	36		34	35	*39	38	35	35	34	33	
16	54	55		54	51	60	59	54	57.5	57	57		58	58	57	54	53	57	*62	57	
17	55	52		52	55	58	57	50	52	54	52		52	51	51	‡47	56	50	48	52	
18	36	39		38.5	38.5	‡31	32	34	38	34	36		35	38	38	41	36	38	36	37	
19	36	36	39	37.5	34.5	*44	37	36	40	38	37	38	39	35	39	37	36	39	42	40	
20	106	110	104	107	111	110	107	110	104	105	110	107	106	*113	105	111	107	106	105	104	
21	73	69		70	65	‡64	66	70	69	72	68		68	65	74	69	72	70	67	70	
22	109	107		106	106	113	110	104	109.5	111	109		110	107	108	101	109	111	110	109	
23	72	75		76	73	75	‡69	70	78	72	73		74	73	77	78	72	77	78	77	
24	54	66	54	60	70	48	47	57	53	50	48	49	53	48	55	53	49	65	54	58	
25		83	90		86	89.5	96	82	92	82	77	90		86	86	90	88	91	84	83	
26	103	110		95	102	106	98	108	‡88	99	101		94		106	96	*111		98	99	
27	72	85	69	76	79	*88	60	74	70	72	71	66	70		72	71	78		78	72	71

Probable Sex: Males (summary) and Females

Nature of Observation	Males No	Males Min	Males Av	Males Max	6 (Tasmanian Museum, Hobart, 4287)	7 (4293)	8 (4280)	9 (4302)	10 (4294)	11 (4292)	14 (4290)	15 (4295)	17 (4303)	20 (Taylor 2)	21 (T M H 1572)	22 (H)
1	30	167	178.7	189	167	169	170.5	174	166	172	181	163	166	176		‡162
2	25	77	84.8	93	74	79	80	80.5	81		87		76	80		
3	25	87	93.3	99	94	90	90.5	92.5	85		94		90	96		
4	25	118	130.1	139	132	117	126	125	124		*136		130	130	129	
5	25	54	65.4	73	68	60	66	63	64		*69		67	65	67	
6	25	55	65	75	61	57	60	62	60		64		61	*66	62	
7	25	85	89.3	93.5	88	89.5	90	94	88.5		90		90.5	‡88		
8	32	94	107.6	118	90	98	103	106	*112	106	111	93	103	102		‡87
9	30	99	115.3	127	118	108.5	113	107	115.5	110.5	116	*99.5	113	*118.5		
10	25	103	114.3	123	111	105	109	104	‡102		*116		110	*116		
11	25	100	108.6	119	98	98	101	98.5	102		108		109	105		
12	25	49	52.4	56	‡48	53	51	50	52		51		49	52		
13	25	50	54.8	58	‡52	57	54	58	53		54		54	55	55	
14	30	31	34	38	35	33	35	34.5	37	37.5	36	42	37	34		‡29
15	25	30.5	34.6	39	37	33	35	32	35		34		35	35		
16	25	48	55.6	62	58	58	57	*77	56		54		55	57	62	
17	25	47	52	58	‡48	53	53	*56	54		54		50	50		
18	25	31	36.8	44	*40	36	38	38.5	36		37		39	38		
19	30	34	38	44	*44	37	39	40.5	40	38.5	38	45	41	40		40
20	30	100	106.8	113	‡100	108	105	108	105	104	105	*113	107	107		110
21	25	64	69	75	70	66	70	67.5	72		70		72	68	73	
22	25	98	107.8	117	116	112	110	113	110		109		105	106		
23	25	69	74.7	80	*84	73	77	75	75		75		80	78		
24	30	47	56.7	73	58	53	54	49	54		56			57	56	60
25	25	77	86	96	79	79	85	80.5	‡75		80			85	82	
26	22	88	99.6	111	91	90	80				97		93		96	
27	27	62	73.5	88	68	78	*80			77.5	68.5		‡59		69	

Probable Sex: Females (continued), with Females summary and Total summary

Nature of Observation	26 (L M 12 2)	31 (D T Md 2)	41 (W 4)	47 (L Crowther 10)	49 (12)	51 (Nat Mus Melb 12022)	52 (12667)	48 (W L Crowther 11)	Females No	Females Min	Females Av	Females Max	No	Min	Av	Max
1	171	*178	177	163	168	164	166	152	18	162	169.5	178	48	162	175.2	189
2	80	88	78	‡71	*88	77	85	78	15	71	80.2	88	40	71	83	93
3	95	90	*99	92	‡75	87	81	84	15	75	95.0	99	40	75	94.8	99
4	124	127	124	‡112	120	129	122	112	16	112	125	136	41	112	128	139
5	60	62	60	63	64	67	‡58	62	16	58	63.9	69	41	54	64.8	73
6	64	62	64	59	‡56	62	64	59	16	56	62	66	41	55	64.8	75
7	91	88.5	90	90	92	90	92	*94.5	15	88	90.4	94.5	40	85	89.6	94.5
8	101	106	98	95	100	101	104	95	18	87	101.5	112	50	87	105.2	118
9	111	111.5	115	113	107	110	100	108	17	99.5	110	118.5	47	99	113.1	127
10	*116	109	*116	105	105	106	105	101	15	102	108.9	116	40	102	112.0	123
11	101	111	100	‡86	94	98	105	92	15	86	101	111	40	86	105.7	119
12	53	*55	52	‡48	50	49	*55	48	15	48	51.2	55	40	48	51.9	56
13	*59	53	58	55	55	‡52	56	57	16	52	54.9	59	41	50	54.8	59
14	33	35	31	35	37	*42	36	40	18	29	36	42	48	29	35.1	42
15	34	34	33	‡28	32	31	*38	29	15	28	35.6	38	40	28	35	39
16	56	56	58	62	56	54	‡50	56	16	50	60	77	41	48	57.7	77
17	51	55	51	55	54	51	54	50	16	48	52.2	56	41	47	52.3	58
18	36	36	38	‡34	37	*40	38	38	15	34	37.6	40	40	31	37	44
19	40	37	38	43	40	40	‡34	40	18	34	38.8	44	48	34	38.2	44
20	112	100	110	103	105	101	111	108	18	100	106.8	113	48	100	106.7	113
21	67	70	64	‡64	69	73	*74	65	16	64	69	74	41	63	69.2	75
22	107	109	109	110	110	105	‡104	112	15	104	110	114	40	98	108.9	[illegible]
23	75	‡72	76	77	76	80	‡72	78	15	72	75	84	40	69	75.3	84
24	*63	46	58	47	‡45	46	53	50	16	45	53.3	63	46	45	55.5	73
25	79	88	*90	84	78	82	78	85	15	75	82.7	90	40	75	84.7	96
26	100	102	80		80	88	96	82	12	80	92.5	102	34	80	97	111
27	71	70	70		68	74	70	64	13	59	70	80	40	59	72.5	88

* read + ‡ read

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Art. XI.—*A Study of the Prognathism of the Tasmanian Aboriginal.*

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Read 11th July, 1912.

According to Topinard (1), prognathism has, since the time of Prichard, been understood to mean "the elongation and prominence or the obliquity of the jaws, common in the black races of Africa and Oceania, accidental in some Europeans." As thus defined, Topinard has divided prognathism into two categories, (1) superior facial, and (2) inferior facial.

The former he still further subdivides into three divisions:—

(a) The entire facial prognathism.
(b) The superior facial prognathism.
(c) The alveolo subnasal prognathism.

The latter he divides into two:—

(a) The inferior dental prognathism.
(b) The inferior maxillary region, the teeth being independent of the jaws.

In reviewing the various methods of determining that form of facial projection already defined as "superior facial," Topinard gives a brief resumé of ten methods, which include such well-known angles as Camper's facial angle, Welcker's nasobasal angle, Vogt's angle (a modification of Welcker's angle), Vogt's palatine and vomerian angle, and Virchow's method, the old German method, that is, the comparison of the glabella-occipital line with the alveolo-occipital line; Busk's facial radii, Broca's auricular radii, the same author's projection method, Lucae's method, and, finally, Topinard describes his own method, by means of which he estimates the "true" prognathism, determined by means of the angle formed by the profile line with the horizontal plane.

Ihering (2) and Lissauer (3) likewise give a resumé of the methods employed by the German school up to 1872.

With the possible exception of Topinard's method, most of the above are now out of date. The more modern means of determining prognathism and dolichocephaly will be discussed later.

Of the factors which produce prognathism, many investigations have been made: for example, Duckworth (4) points out that prognathism is dependent on two factors, firstly, the size of the teeth and the length of the palate, and secondly, the size of the nasopharynx, which may be estimated by the distance from the pharyngeal tubercle and basi-occipital to the palatal spine, and thirdly, the degree to which the base is bent at the sphenoethmoidal junction.

Keith (5) has also devoted some thought to this problem, and in an extract from "Nature," he states:—"The prognathism of the negro is due to several factors; it is chiefly due not so much to a larger, but a healthier dental development, which ensures a due forward revolution of the jaws during the eruption of the permanent teeth, thus providing an ample air-way through the pharynx. In Europeans the revolution forwards of the jaws showed a distinct tendency to become arrested prematurely, thus contracting the pharynx. The negro condition was the more simian, but it also one which modern Europeans would willingly share with him, because of its functional methods."

The correlation between prognathism and other cranial features has also been exhaustively studied. Thus Thomson (6) says that an association between dolichocephaly and prognathism has been widely recognised, and he himself finds that prognathism is generally correlated with an extension backwards of the occipital region, a view Daffner (7) also holds. Brinton (8) considers this correlation between prognathism and dolichocephaly is brought about by increased muscular action. But, whatever the cause of such association of prognathism and dolichocephaly may be, Flower (9), Wohlbold (10) and Duckworth (11) are each clearly of opinion that it is, as exemplified in the case of the Australian aboriginal, a characteristic of race.

Huxley (12) was of opinion that there existed a relationship between prognathism and the slope of the foramen occipitale magnum. The greater the facial skeleton, that is, the more pronounced the degree of prognathism, the more perpendicular was the slope of the foramen occipitale magnum found to be. By superposing median diagrams of the highly prognathic skulls of a negro, Australian and Tartar, he found that the slope of the foramen occipitale magnum in these particular sculls formed a somewhat smaller angle with the basi-canial axis, than was the case in orthognatic skulls. On the other hand, Welcker (13) failed to see any connection between prognathism and the slope of the foramen occipitale magnum, but thought there was some correlation between prognathism and the position of the opening, which, as Bolk (14) says, "comes practically to the same thing, if a connection between position and slope be assumed." Welcker (15) says, "Biegt am Vorderschadel der Oberkiefer des Menschen mehr nach vorn (Prognathismus) so rückt zugleich am Hinterschädel das Foramen medullare mehr nach rückwarts." Aeby's (16) views do not agree with those of Huxley. He says, "Huxley glaubte die Neigung mit dem Prognathismus in Verbindung bringen zu können. Die Steilheit der Stellung sollte in gleichem Masse wie die letztere wachsen. In unseren Tabellen findet sich keine Bestatigung dieser Ansicht." Hopf (17), Darwin (18), (19), Spencer (20), Keith (21), Duckworth (22), Wiedersheim (23), Schaafhausen (24), have each and severally considered the successive stages of growth of the maxillary region, and the reasons therefor, in order to determine, if possible, the causes which produce or accompany an increase or reduction, as the case may be, in the amount of prognathism present.

Without pursuing further the subject of factors responsible for prognathism, and their association with other cranial features, it should be sufficiently clear that much attention has been devoted to both aspects of the question, and that our knowledge of the subject is correspondingly enhanced.

Of the modern methods of determining prognathism by direct linear measurements, mention may first be made of Flower (9), who calculated the prognathism of the skulls in the Museum of the Royal College of Surgeons, London, by what is now known as Flower's Gnathic, or Alveolar Index—an index which expresses the ratio which the basi-nasal line bears to the basi-prosthionic line, the former being taken as 100 (see Fig. I.).

Fig. I.—Illustrating Flower's Gnathic Index, and Fraipont's Methods. G=Glabella: Pr=Prognathic point: N=Nasion: Ba=Basion: L=Lambda.

Fraipont, in order to estimate the forward projection of the premaxillary region, introduced at the 1903 Liège Congress of French Anatomists, a new method, employed by him in his investigations upon the Spy crania. The method consists in producing the glabella lambda line forwards, and then dropping perpendiculars at right angles to it (Fig. 1). The one drawn from the glabella, usually cuts the second premolar, and, more rarely, the first molar, and is occasionally known as "Fraipont's line. The point of intersection of the line drawn parallel to Fraipont's line, and cutting the prosthion, with the glabella-lambda line, continued forwards constitutes Klaatsch's "Prognathic point" (25), (Fig. 1). The distance from the glabella to the "prognathic point" expresses, in millimetres, the amount of prognathism present, that is, the amount of facial projection in front of the glabella. Fraipont, from the results thus obtained, deduced the fact that the amount of facial projection, or prognathism, in the Spy crania, was greater than had been previously suspected (Fig. 1).

Thomson and MacIver (26), consider that the method devised by Flower has several weak points, and they therefore depart from it in their examination of the ancient Egyptian crania. In their proposed method, they take into consideration two factors which present themselves in the upper jaw; firstly, the degree of variation in the vertical face length, that is, the nasi-prosthionic length, and secondly, the variations in the horizontal length of the basi-prosthionic line. By connecting three points—the basion, prosthion and nasion—a triangle is formed.

From a series of measurements of 38 skulls, these authors found that the angle formed by the basi-nasal line and the Frankfort horizontal plane varied between 22 degrees and 34 degrees, with an average of 27 degrees. They availed themselves of the constancy of this angle in order to construct a new horizontal, upon which to estimate the degree of prognathism, their procedure being as follows:—Prolong the basi-nasal line indefinitely downwards and backwards, upon this erect a horizontal, at an angle of 27 degrees, open forwards with the basi-nasal line. This line may be prolonged indefinitely backwards and forwards, and the figure is now converted into a triangle, by dropping from the nasion a perpendicular, which cuts the new horizontal at a right angle. (See Fig. 2). The amount of projection of the prosthion in front of the perpendicular line N-P indicates the degree of prognathism, and is read off by means of their specially-devised trigonometer. Fürst (27) has also studied this method, but he comes to the conclusion that the basal angle possesses so great a degree of variation that he cannot, like Thomson and MacIver, accept a constant size for it. He says, "Aus allem, was ich oben angeführt habe, geht deutlich hervor dass, wenn wir mit einer normalen Grösse des Basalwinkels rechnen wollen, dieser wohl 30 Grad angesetzt werden muss. Aus den Tabellen wird es aber auch deutlich, dass die Grösse des Basalwinkels eine so weite Variationsbreite hat, dass man nicht wie Arthur Thomson und Randall MacIver bei ihm eine konstante Grösse annehmen und danach andere anthropologische Merkmale angeben kann."

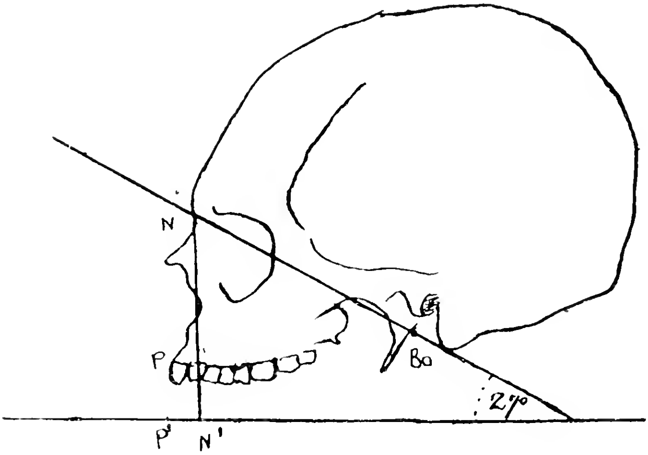


Fig. 11.—Illustrating Thomson and MacIver's Method.
N=Nasion: P=Prosthion: Ba=Basion.

Keith (28), in describing a new craniometer, states that "the most satisfactory index is in the area of the palate, estimated by plotting out the diameters of the palate on millimetre paper." This he does by means of the instrument he describes, but as this was not available in Melbourne, I have been unable to adopt his suggestion. In any case, it is, perhaps, open to question, whether, in view of the fact that the present research is largely comparative, it would have been advisable to adopt methods which so obviously restrict the field of comparison.

From the foregoing brief analysis of such comparatively modern methods of estimating prognathism, as those associated with the names of Flower, Thomson and MacIver, Fürst and Keith, it is apparent that none are entirely satisfactory, or altogether free from objection. It has been shown that Fürst differs from Thomson and MacIver, as to the constancy of the basal angle, whilst Keith's method not only requires a special apparatus, but also special modes of investigation. Turner (29) had apparently this same difficulty in mind when he wrote, in reference to the estimation of prognathism of the Tasmanian crania in the Oxford collection:—" The differ sults procured by these methods on the same skulls illustrate the difficulty of obtaining a precise estimate of the degree of prognathism."

With the exception of Keith's method, all were introduced prior to the invention and general adoption of the dioptrograph and diagraph, and it is questionable whether all that is claimed by the authors quoted for their special methods cannot really be better done now with the diagraph. In any case, the perpetual multiplication of new methods and special instruments for the same purpose, renders it almost impossible to collect sufficient data for the comparative investigation of the several races. For all these reasons, therefore, I have thought it advisable to confine myself to dioptrographic tracings, which, for the Tasmanian, have now been rendered available to all by Berry and Robertson, and to record the degree of prognathism by Flower's method. This procedure has the great advantage over and above all the others herein discussed, that it enables me to institute a series of comparative observations of the Tasmanian with other races. Personally, I am of opinion that in this way only will any real progress be made in the complex science of the craniology of race.

The material upon which the present research is based will be found in Berry and Robertson's "Dioptrographic Tracings in Four Normae of Fifty-Two Tasmanian Crania" (30). All the observations recorded herein are calculated from the median sagittal tracings, shown in Norma A, and are as follow:—

1. The basi-nasal length.
2. The basi-prosthionic length.
3. Gnathic index.
4. The nasi-prosthionic length.
5. The glabella prosthion basion angle.
6. The prosthion glabella basion angle.

Of these observations, the first three comprise the data necessary for the estimation of prognathism by Flower's method, and the last three are supplementary measurements, upon which to estimate the general projection and height of the face.

As stated elsewhere (31), it was not possible to record all of the observations on every skull. Number 48, being a juvenile subject, the measurements recorded on it have been uniformly omitted from the final results. The results of Numbers 4 and 8 have also been omitted where they concern the prosthion.

In Table I. are set forth the individual observations upon the crania referred to.

In the two columns on the left are recorded the original numbers and their serial numbers. In the columns to the right the several observations recorded are displayed, with the crania separated into sexes, and the results tabulated accordingly. At the foot of the male and female observations respectively, the minimum and maximum figures are recorded, together with the average results. The total results, for both males and females are set forth at the end of the table.

TABLE I.—MALES.

Original number.	Serial number.	Basi-nasal length.	Basi-prosthionic length.	Gnathic index.	Nasi-prosthionic length.	Glabella prosthion basion angle.	Prosthion glabella basion angle.
4288	1	95	101	106.3	67	69	66
4298	2	100	106	106	73	69	66
4300	3			...	55	...	...
4301	4	100	91 ?	94 ?	58	80	61
4298	5	...	...	...	67		..
4302	12	+ 106	99	93.4	74	77	58
4297	13	..	...	...	70		...
4296	16	102	..	...	...		...
...	18	– 92	98	106.5	– 53	76	+ 67
1	19	97	94	96.9	59	80	62
...	23	...	...	...	..	...	...
..	24	99	103	104	62	74	66
1201	25	103	110	106.8	73	75	66
1203	27		...	...	59		...
1204	28	98	95	96.9	65	76	60
1205	29	98	102	104.1	70	75	61
1	30	94	106	112.8	+ 76	65	61
1	32	93	99	106.5	56	77	66
2	33	104	98	94.2	65	– 62	– 58
3	34	90	– 88	97.8	60	80	58.5
4	35	100	99	99	60	76	63
5	36	98	101	103.1	60	77	64
6	37		...		56		
7	38	97	94	96.9	62	+ 81	60
1	39	– 92	92	...	...		...
3	40	96	96	100	62	75	62
5	42	96	96	100	59	75	63
6	43	103	+ 111	108.8	67	72	+ 67
7	44	99		...	...		...
8	45	94	98	104.3	67	73	63
9	46	94	99	105.3	61	76	64
13	50	.		...			...
Number	32	25	21	21	27	21	21
Maximum	...	92	88	93.4	53	62	58
Average	...	97.6	99.6	102.3	63.6	74	62.8
Maximum	...	106	111	112.8	76	81	67

FEMALES.

Original number.	Serial number.	Basi-nasal length.	Basi-prosthionic length.	Gnathic index.	Nasi-prosthionic length.	Glabella prosthion basion angle.	Prosthion glabella basion angle.
4287	6	89	91	102.2	60	74	65
4293	7	90	90	100	59	75	63
4289	8	92	80 ?	86.9?		+ 85	– 52
3362	9	85	...	...	.	...	...
4294	10	93	...	...	...	...	..
4292	11	.		...	+ 66	...	...
4290	14	100	97	...	– 97	61	75
4295	15	...		...	...	...	...
4303	17	93	100	...	– 52	77	65.5
2	20	91	...	...	...	...	.
1572	91	86	96	111.6	...	...	...
...	22	...	...	...	...	...	...

Original number.	Serial number.	Basi nasal length	Basi prosthionic length.	Gnathic index.	Nasi-prosthionic length.	Glabella prosthion basion angle.	Prosthion glabella basion angle.
1202	26	93	100	107.5	63	− 70	+ 69
9	31	+ 102	+ 102	100	69	77	64
4	41	89	89	100	60	178	60
10	47	− 78	..	...	...	...	...
12	49	86	89	103.5	60	73	63
12922	51	89	− 88	98.9	60	77	59
12997	52	99	96	− 97	59	77	62
11	J48	76	82	107.8	58	66	68
Number	19	16	11	11	11	10	10
Minimum	...	78	88	97	52	70	52
Average	...	91.1	93.7	101.6	60	75.3	63.3
Maximum	...	102	102	111.6	66	85	69

BOTH SEXES.

Number	51	41	32	32	38	31	31
Minimum	...	78	88	93.4	52	62	52
Average	..	95	97.5	102	61.2	74.6	63
Maximum	...	106	111	112 8	76	85	69

For both sexes combined there are 32 crania, which yield a gnathic index of 102, that is, the Tasmania is shown to be mesognathic. Of the sexes considered separately, there are 21 males, with a gnathic index of 102.3, and 11 females, with an index of 101.6, that is, the sexes, individually or collectively, are shown to be mesognathic in type.

Prior to the present work, the largest number of Tasmanian crania examined, with respect to the degree of prognathism, as determined by Flower's index, was 34, a total made up of a combination of individual examinations, and thus collectively referred to by Turner (29). The minimum index was 96.9, the maximum 113.2, and the mean for the series was 103.6, which thus brings the series into the prognathic group.

It will be noted that the two series of figures produce different results, my series of 32 giving a mesognathic result, and the previous collective group of 34 producing a prognathic figure. The actual numerical difference is, however, but slight, as it only amounts to 1.6, and is almost certainly due to the use of insufficiency of numbers. To overcome this objection in so far as is possible to us, I now propose to combine my own entirely new series, of 32 crania, with those of other observers.

I have, therefore, availed myself of the necessary figures recorded in (a) Flower's Catalogue of osteological specimens in the Museum of the Royal College of Surgeons, in London (9), (b) Turner's Memoir, in which are given the observations of the crania in the Brussels Museum, the University of Oxford, and the University of Edinburgh, (c) Klaatsch's Memoir (32) on the Australian skull, (d) one from the

Middlesex Hospital Museum, and (e) Duckworth's (33) study of the Tasmanian crania in the Cambridge Anatomical Museum.

This makes, combined with the figures of the present work, a total of 74 basi-nasal, 66 basi-prosthionic, and 66 gnathic index observations of Tasmania crania, which, it may be noted, is by far the largest number of Tasmanian crania as yet investigated in connection with the question of the prognathism of this now extinct race.

The detailed results of the combined figures, and also of my original figures, are set forth in Table II.

TABLE II.

	Number	Büchner	Number	Turner	Number	Combined Results
1. The basi-nasal length	41	95	...		74	96.60±.47
2. The basi-prosthionic length	32	97.5	...	...	66	98.70±.50
3. Gnathic index	32	102	34	103.6	66	102.38±.30

This table shows that the gnathic index of the 66 Tasmanian crania utilised for the investigation gives a true mean of 102.38±.30, that is, the Tasmanian is mesognathic, but stands at the extreme end of the scale, and is just on the confines of mesognathism and prognathism.

It is clear that these figures must be accepted as furnishing the correct estimate of the degree of prognathism, for two reasons: firstly, because they comprise the largest number of Tasmanian crania ever previously examined for this purpose, many of which are entirely new to science, and secondly, because the final results are attained by biometric methods, and not by the laws of arithmetical average.

Further, it is clear that the position of the Tasmanian on the meso-prognathic borderland, explains many of the discrepant results attained by previous workers with other methods, and insufficient data; for example, we have here, I think, an entirely adequate explanation of the somewhat conflicting results achieved by such competent observers as Turner (29) and Thomson.

For the purpose of establishing a comparison between the prognathism of the Tasmanian and that of other races, I have utilised, for the former, all the figures available to me, in all 74 observations. From these I can only avail myself of 66 gnathic indices, for the sufficient reason that in the remainder one or other of the necessary measurements was missing. The selected races for comparison are the Australian, the Veddah, the Chinese, and Andamanese, and the modern Italian. The selection so made is not a mere casual one, but is specially chosen as furnishing examples of admittedly pure races, like the Andamanese, impure types like the modern Italian, and races of doubtful purity, like the Australian. The figures in each instance are taken from Flower's Catalogue, and the results are set forth in Tables III.-V.

Table III. deals with the basi-nasal length, and shows the provisional mean, the true mean, and the standard deviation of same, and the co-efficient of variation, together with the numbers of examples of each race. The six races are arranged in the order of the true means of the basi-nasal length.

From this we infer that the basi-nasal length is shortest in the pure races (Andamanese, Veddahs and Tasmanians), longest in impure races, like the Chinese and modern Italians, and longest of all in the doubtfully pure Australian.

TABLE III.

Basi-nasal Lengths.

	Number	Provisional mean	True mean	Standard deviation	Coefficient of variation
1. Andamanese	19	91	91.26± .44	2.84±.31	3.11±.34
2. Veddah	10	96	95.60±1.29	6.08±.92	6 37±.96
3. Tasmanian	74	94	96.60± .47	6 02±.33	6.24±.35
4. Chinese	35	97	97.23± .63	5.53±.44	5.71±.47
5. Italian	50	99	98.62± .62	6.46±.44	6.51±.45
6. Australian	88	99	98.75± .41	5.77±.29	5.85±.30

Table IV. deals with the basi-prosthionic length for the six races in the same way. The Australian, again, has the longest basi-prosthionic axis, and the pure Veddahs and Andamanese have the shortest. The Tasmanians and Italians have changed places, and the Chinese are in the same relative position as before.

TABLE IV.

Basi-prosthionic Lengths.

	Number	Provisional mean	True mean	Standard deviation	Coefficient of variation
1. Veddahs	7	91	91 00±1.34	5.26±.05	5.85±1.06
2. Andamanese	19	93	92.74± .72	4.64±.51	5.00± .55
3. Italians	50	92	94 62± .68	7.11±.48	7.52± .51
4. Chinese	30	96	98.70± .55	4 74±.39	4.95± .43
5. Tasmanians	66	98	98.70± .50	6.00± 35	6.08± .36
6. Australians	90	101	100.91± .47	6.60±.33	6.54± .33

In Table V. are set forth the gnathic indices for the six races, whence we learn that Italians, Veddahs, and Chinese are orthognathous, the last-named being on the ortho-mesognathic borderline. The Andamanese are distinctly mesognathic, as are also the Tasmanians, but, as already indicated, it is, on the whole, fairer to regard the Tasmanian as on the meso-prognathic borderline, a remark which also applies to the Australian, with the reservation that the latter is more prognathic than the Tasmanian.

TABLE V.

GNATHIC INDICES.

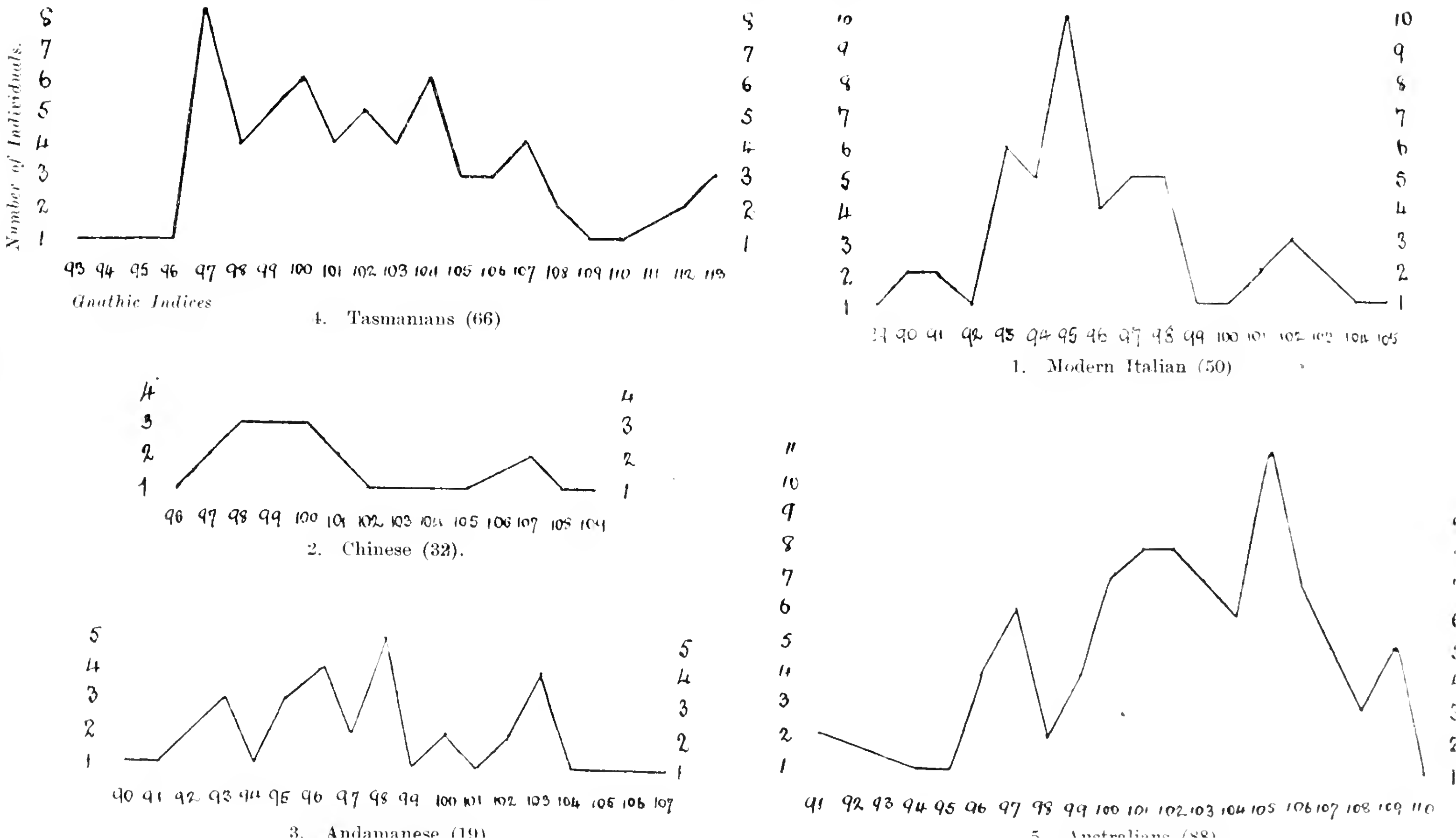
	Number	Provisional mean	True mean	Standard deviation	Coefficient of variation
1. Italians	50	96	95.92±.34	3.54±.24	3.69±.25
2. Veddahs	6	96	96.00±.72	2.80±.52	2.8 ±.55
3. Chinese	32	98	97.94±.48	4.03±.34	4.11±.36
4. Andamanese	19	102	101.32±.55	3.60±.39	3.56±.40
5. Tasmanians	66	102	102.08±.40	4.83±.28	4.73±.28
6. Australians	88	102	102.38±.30	4.13±.22	4.04±.21

In view of the fact that Table V. only includes six Veddahs, it would, I think, be better to exclude them from the comparison. This having been done, there emerges the broad fact that the more primitive races of mankind tend to be less orthognathic than the higher races, a conclusion which the following extract from Wiedersheim (23) supports:—"The prognathous type of skull has been assumed to be a reversion to a pithecoid condition; but this consideration is by no means a simple one. The cousins Sarasin have pointed out that the lowest forms of human skulls, e.g., those of Veddahs, Andaman Islanders and Bushmen, are of orthognathous, or (Andaman Islanders) mesognathic type. The orthognathous type may thus have been attained by human beings at a very early period, and subsequently lost. If this be the case (but it is doubtful), the prognathous condition of Negroes and Melanesians, and the great projection of the jaw in some woolly and straight-haired races, must be a secondary condition, which has been preceded by orthognathy. In this case the orthognathy once more attained by Europeans must be regarded as a third phylogenetic phase of the evolution of the skull (Sarasin)."

A further examination of Table V., from the standpoint of racial impurity or otherwise, reveals little or nothing. The standard deviation, which reflects to a certain extent the influence of the range of variation, is found to be greatest in probably the purest race of all, namely, the Tasmanian, and, excluding the Veddah, for the reason already given, least in the known and admittedly impure race, the modern Italian. Looked at from this standpoint, we find that, as regards the standard deviation, the five races compared (Veddahs excluded) may be arranged in an ascending series as follows:—

Modern Italian	3.54
Andamanese	3.60
Chinese	4.03
Australian	4.13
Tasmanian	4.83

Fig. III.—Frequency Polygons of Gnathic Indices.



Notwithstanding that there are at the two ends of the scale known pure and impure races, it is sufficiently clear that it would be very injudicious to endeavour to draw any conclusions whatsoever as to the purity or impurity of race from the range of variation of a secondary racial character like prognathism. What, however, does emerge very clearly from the present research is that the Tasmanian is, as estimated from Flower's gnathic index, on the meso-prognathic border line, and slightly more orthognathic than the Australian.

In conclusion, there are appended five frequency polygons of the gnathic indices in the selected races, and Table VI., which establishes comparisons of the prognathic index, and measurements between anthropoid apes, prehistoric and recent man. (See Fig. III.).

The anthropoid figures are derived from Oppenheim (34), and from them I have calculated the gnathic index.

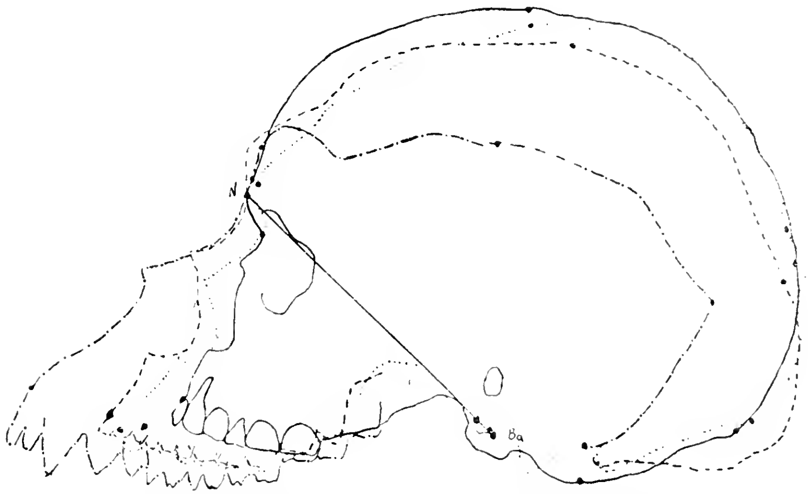


Fig. IV.—Tasmanian ———————
Australian..................................
Neandertal (Klaatsch) - - - - - - - - - - - -
Glorilla — · — · — · — · — · — ·
(Superposed on basi-nasal axis.)

The remaining measurements are mostly from Flower's Catalogue, supplemented in the case of the mesognathic 90 Australians by figures derived from other sources. Concerning the Tasmanians, the 32 there included are the original contribution of this work to the subject.

The entire results are classified according to their degree of pro-meso-, or orthognathism, but it is important to bear in mind that the results set forth for the 90 Australians, 32 Tasmanians, 19 Andamanese and 32 Chinese have been re-calculated by me by biometric methods, and are therefore more accurate than the remainder, which are only arithmetical averages.

The entire table contains an interesting survey of the subject of prognathism from an evolutionary and racial standpoint, and is fairly free from the objection which so commonly attaches itself to such tables of too sweeping deductions from an insufficiency of numbers.

TABLE VI.

Number.		Basi-nasal length.	Basi-prosthionic length.	Gnathic index.	
43	Orang Utan (female)	92	162	176	Prognathic.
	Orang Utan (male)	96	164	170	
40	Chimpanzee (male)	101	133	131	
	Chimpanzee (female)	102	129	125	
55	Gorilla (male)	140	173	123	
	Gorilla (female)	123	148	120	
	Gibraltar (Sollas)	106	112	105.7	
36	African Negroes	98	102	104.4	
58	Melanesians	96	103	103.4	
90	Australians	98.75	100.91	102.38 ± .30	Mesognathic.
32	Tasmanians	96.60	98.70	102.08 ± .40	
19	Andamanese	91.26	92.74	101.32 ± .55	
29	Hindus	101	94	98.7	
32	Chinese	97.23	95.70	97.94 ± .48	Orthognathic.
184	Europeans	98.1	92	96.2	
50	Modern Italians	98.6	94.6	95.92 ± .32	

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Art. XII.—*The Psychrometric Formula.*

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[Read 11th July, 1912.]

In a paper published last year by Dr. Love and myself[1] we discussed a modification proposed by Ekholm to be made in the formula for the wet-and-dry-bulb hygrometer, which would have important consequences if confirmed. The formula so modified would be

$$x = \eta f - AB\ (t - t'),$$

where x and f are respectively the actual vapour-pressure in the atmosphere and the saturation vapour-pressure at the temperature t' of the wet-bulb. A is the ordinary psychrometric constant, and η the co-efficient, less than unity, whose insertion Ekholm advises in order to allow for diminution of vapour-pressure at the surface of the wet-bulb by a hygróscopic action of the material covering it.

It was shown that, if there were an appreciable hygroscopic action affecting the temperature of the wet-bulb, a perceptible difference would be observed between several thermometers covered with different materials. The results recorded showed, however, that three wet-bulb thermometers, covered respectively with silk, linen and cotton, agreed in their readings to within the limits of observation, which were 0.05°C, the thermometers being divided into tenth-degrees. In all, 63 sets of observations were given, each set comprising a comparison of the three wet-bulbs with a Regnault condensation hygrometer. By the application of least squares to the modified formula, the value of η was found to be 0.9974, which is unity to the order of approximation possible in such experiments. The conclusions arrived at were that the proposed change was not justified by the evidence which Ekholm himself produced, and that a direct test showed the supposed basis of it to be incorrect.

These observations, taken in May and June, were all under conditions of fairly high humidity, above 50 per cent. in every case, and consequently low values of the difference $t - t'$. In order to test the formula under a more extended range of circumstances, the observations were resumed, and continued until December. No change was made in the conditions of exposure, nor in the method of procedure, both of which were fully described in the former paper. The cover-

1 Proc. Roy. Soc. Victoria 24 (n.s.), Pt. II., 1911.

ings of the wet-bulbs had been kept clean by periodical washing during the first series of experiments, but on resuming this was neglected until August 10, when 31 more sets had been obtained. It was then found that they were considerably soiled, and an examination of the results indicated that this had seriously affected the readings. After cleaning, some superfluous portions were cut away, leaving the bulbs somewhat freer, and thenceforward the materials were regularly washed. The results herein detailed comprise only the observations since August 10, numbering 103; some figures obtained from the other 31 sets will be presented, as evidence of the necessity for clean coverings to the wet-bulbs. During the last month of the work observations were mostly restricted to hot, dry days in order to gain experience of low humidities. The range of temperature and humidity has thus been largely extended, the humidities now varying between 18.01 per cent. and 95.11 per cent., and the dry temperatures between 7.35° and 31.35°C, while the values of $t-t'$ extend up to 14.6°C.

Observations.

The wet-bulb readings are given in Table I., with the differences between them, the thermometers being numbered 2 (linen), 3 (cotton) and 4 (silk), as before.

TABLE I.

No.	2	3	4	2—3	2—4
1	11.55	11.65	11.70	0.10	—0.15
2	11.05	11.10	11.05	— .05	0
3	11.65	11.65	11.70	0	— .05
4	9.45	9.40	9.40	.05	.05
5	9.45	9.50	9.45	— .05	0
6	9.85	9.85	9.75	0	.10
7	8.45	8.50	8.50	— .05	— .05
8	9.15	9.10	9.10	.05	.05
9	9.15	9.10	9.10	.05	.05
10	10.55	10.60	10.55	— .05	0
11	9.55	9.60	9.50	— .05	.05
12	11.85	11.85	11.85	0	0
13	12.75	12.65	12.70	.10	.05
14	11.45	11.45	11.50	0	— .05
15	12.45	12.40	12.40	.05	.05
16	11.65	11.55	11.65	.10	0
17	11.15	11.00	11.05	.15	.10
18	12.55	12.45	12.50	.10	.05
19	12.65	12.65	12.70	0	— .05
20	10.65	10.60	10.65	.05	0

No.	2	3	4	2—3	2—4
21	10.45	10.45	10.45	0	0
22	11.25	11.15	11.20	.10	.05
23	10.40	10.40	10.45	0	— .05
24	11.40	11.35	11.45	.05	— .05
25	13.90	13.90	14.00	0	— .10
26	12.95	12.95	12.95	0	0
27	10.65	10.70	10.65	— .05	0
28	8.75	8.80	8.80	— .05	— .05
29	7.35	7.40	7.40	— .05	— .05
30	9.35	9.40	9.40	— .05	— .05
31	11.25	11.25	11.25	0	0
32	13.80	13.90	14.00	— .10	— .20
33	13.50	13.60	13.70	— .10	— .20
34	12.45	12.55	12.60	— .10	— .15
35	7.85	7.90	7.90	— .05	— .05
36	9.95	10.00	10.00	— .05	— .05
37	10.70	10.70	10.70	0	0
38	12.35	12.35	12.40	0	— .05
39	13.35	13.30	13.40	.05	— .05
40	14.00	14.00	13.95	0	.05
41	12,70	12.65	12.70	.05	0
42	12.55	12.55	12.60	0	— .05
43	13.15	13.05	13.10	.10	.05
44	11.35	11.25	11.35	.10	0
45	11.85	11.75	11.85	.10	0
46	13.55	13.55	13.60	0	— .05
47	13.40	13.35	13.40	.05	0
48	14.10	14.00	14.10	.10	0
49	16.60	16.60	16.60	0	0
50	16.55	16.50	16.60	.05	— .05
51	13.90	13.80	13.90	.10	0
52	12.25	12.15	12.20	.10	.05
53	14.50	14.40	14.50	.10	0
54	10.55	10.50	10.55	.05	0
55	10.95	10.90	10.95	.05	0
56	9.65	9.60	9.60	.05	.05
57	11.35	11.25	11.35	.10	0
58	14.30	14.20	14.35	.10	— .05
59	14.90	14.80	14.95	.10	— .05
60	13.90	13.80	13.90	.10	0
61	14.00	13.90	14.00	.10	0
62	12.35	12.35	12.40	0	— .05
63	15.00	14.90	15.00	.10	0

No.	2	3	4	2—3	2—4
64	7.75	7.70	7.80	.05	— .05
65	9.75	9.70	9.80	.05	— .05
66	10.85	10.80	10.85	.05	0
67	8.85	8.85	8.90	0	— .05
68	9.65	9.65	9.65	0	0
69	9.45	9.40	9.40	.05	.05
70	9.25	9.20	9.20	.05	.05
71	9.05	9.00	9.10	.05	— .05
72	9.55	9.50	9.60	.05	— .05
73	12.75	12.65	12.70	.10	.05
74	12.60	12.55	12.70	.05	— .10
75	13.60	13.50	13.60	.10	0
76	13.15	13.05	13.15	.10	0
77	13.60	13.55	13.70	.05	— .10
78	13.40	13.40	13.50	0	— .10
79	14.10	14.00	14.10	.10	0
80	10.55	10.60	10.65	— .05	— .10
81	8.95	9.00	9.00	— .05	— .05
82	11.45	11.35	11.45	.10	0
83	11.95	11.90	12.00	.05	— .05
84	13.15	13.05	13.20	.10	— .05
85	11.45	11.35	11.50	.10	— .05
86	17.20	17.10	17.20	.10	0
87	9.15	9.00	9.00	.15	.15
88	15.10	15.00	15.10	.10	0
89	18.00	17.80	17.90	.20	.10
90	16.80	16.70	16.80	.10	0
91	17.50	17.30	17.40	.20	.10
92	13.50	13.40	13.60	.10	— .10
93	12.75	12.60	12.60	.15	.15
94	12.80	12.65	12.70	.15	.10
95	15.10	15.10	15.10	0	0
96	16.10	16.10	16.10	0	0
97	16.50	16.50	16.40	0	.10
98	16.20	16.10	16.15	.10	.05
99	19.25	19.25	19.30	0	— .05
100	15.60	15.50	15.80	.10	— .20
101	12.40	12.40	12.50	0	— .10
102	15.80	15.80	16.00	0	— .20
103	16.10	16.10	16.20	0	— .10

The differences are again very slight, and by no means comparable with those which would correspond to any appreciable hygroscopic action. In the case of linen and cotton, out of 103 pairs, 27 show no difference, and only 6 differ by more than 0.1°; the mean difference is 0.04°, while the observable limit is 0.05°. In the other case of linen and silk, 36 show a zero difference, and only 9 show above 0.1° difference, while the average is 0.015°. Combining these with the observations already published, we find the average differences in the two cases to be respectively 0.030° and 0.01°, while out of the large number of differences only 10 in one case and 11 in the other are greater than a tenth of a degree.

We must conclude from these figures that the value of the coefficient η is not perceptibly dependent on the nature of the covering used for the wet-bulb thermometer, this result holding true throughout a considerable range of temperature above zero, and under practically all conditions of humidity.

The full details of the observations are contained in the next table. Under the heading t' are given the mean values, where necessary, of the wet-bulb readings; the pressure is given corrected for temperature.

TABLE II.

No.	t	t'	Dew-point	B	Wind
1	16.60	11.65	6.80	765.8	Fresh N.
2	17.40	11.05	3.85	764.8	Light N.
3	15.20	11.65	8.20	761.0	Strong N.
4	10.55	9.40	7.80	765.5	Calm.
5	11.80	9.45	6.85	761.5	Light S. E.
6	14.20	9.80	4.40	764.6	Light S. E.
7	11.45	8.50	5.35	766.1	Very light S.E.
8	13.65	9.10	4.15	764.8	Very light S.E.
9	11.60	9.10	5.95	764.8	Calm.
10	14.75	10.55	5.00	760.6	Gentle N.
11	14.75	9.55	5.55	759.5	Light N.
12	16.70	11.85	7.95	762.6	Strong N.
13	18.90	12.70	6.85	761.4	Strong N.
14	17.60	11.45	6.55	761.6	Very strong N.
15	20.35	12.40	5.45	760.1	Strong N.
16	18.60	11.60	5.75	760.7	Very strong N.
17	17.50	11.05	4.75	753.4	N. breeze.
18	19.60	12.50	6.10	750.8	N. breeze.
19	14.60	12.65	10.70	751.7	Calm.
20	12.20	10.65	8.60	762.9	Very light S.
21	12.65	10.45	8.50	761.3	Very light S.
22	12.40	11.20	9.85	763.3	Very light S.
23	11.85	10.40	9.25	763.2	Very light S.
24	12.50	11.40	10.65	762.6	Calm.
25	17.30	13.95	11.15	758.8	N. breeze

No.	*t*	*t*	Dew-point	B	Wind
26	17.90	12.95	9.15	756.3	Light N.
27	12.70	10.65	8.30	758.3	Calm.
28	11.40	8.80	6.55	758.1	N. breeze.
29	11.60	7.40	2.25	765.4	Calm
30	14.55	9.40	3.65	761.8	Very light N.
31	15.85	11.25	7.35	759.2	Light N.
32	18.40	13.90	9.60	757.5	Calm.
33	20.45	13.60	7.35	751.8	Fresh N.
34	20.75	12.55	4.35	750.0	Light N.
35	10.85	7.90	5.55	756.4	S. breeze.
36	12.20	10.00	7.80	765.3	Light S.
37	13.35	10.70	6.15	764.3	Calm.
38	16.15	12.35	9.70	760.7	Very light N.
39	18.30	13.35	8.65	758.5	Very light N.
40	17.90	14.00	10.50	758.5	Calm.
41	18.20	12.70	7.95	756.8	Gentle S.
42	16.05	12.55	9.80	758.7	Calm.
43	17.55	13.10	10.10	757.5	Calm.
44	13.45	11.30	9.50	760.2	Very light S.
45	16.15	11.80	8.15	758.8	Very light S.
46	20.25	13.55	7.45	760.3	Fresh N.
47	19.55	13.40	7.45	759.1	Very light N.
48	20.05	14.05	8.40	757.6	Gentle N.
49	21.05	16.60	13.55	754.0	Light N.
50	21.80	16.55	12.95	751.4	Gentle N.
51	17.00	13.85	11.35	754.2	Gentle S.
52	15.25	12.20	9.60	759.8	Gentle S.
53	20.95	14.45	9.80	756.6	N. breeze.
54	14.55	10.55	6.25	760.3	Light N.
55	14.25	10.95	8.45	764.1	Light S.W.
56	13.45	9.60	5.95	764.7	Gentle S.
57	15.25	11.30	7.85	762.9	Very light S.
58	18.60	14.30	11.35	762.1	Very light S.
59	21.20	14.90	9.40	761.2	Very light N.
60	16.60	13.85	12.05	760.5	Very light S.
61	16.80	13.95	12.15	759.4	Very light S.
62	15.35	12.35	9.75	756.0	Light N.
63	19.25	14.95	11.05	753.5	Gentle, variable.
64	12.70	7.75	2.45	762.7	Fresh S.W.
65	14.75	9.75	3.75	761.0	Gentle W.
66	15.85	10.85	5.60	759.5	Light S.
67	13.15	8.85	4.40	763.2	Light S.
68	14.25	9.65	3.15	762.3	Light, variable.

No	t	t′	Dew point	B	Wind
69	13.15	9.40	5.85	764.8	S. breeze.
70	14.20	9.20	3.65	765.0	S. breeze.
71	13.85	9.05	4.05	766.2	Light S.
72	14.35	9.55	4.85	765.5	Light S.
73	19.00	12.70	6.20	761.9	Strong N.
74	19.80	12.60	5.45	761.0	Strong N.
75	22.45	13.55	5.95	758.6	Strong N.
76	21.95	13.10	5.05	758.1	Light N.
77	23.60	13.60	5.25	756.4	Strong N.
78	25.65	13.45	3.85	754.8	Strong N.
79	24.40	14.05	4.95	754.8	S.W. breeze.
80	15.15	10.60	6.70	755.0	Light S.
81	14.05	9.00	4.15	759.8	Light S.W.
82	15.55	11.40	7.40	765.9	Very light S.
83	15.75	11.95	8.90	765.0	Gentle S
84	17.20	13.15	8.95	765.5	Light S.
85	15.50	11.45	7.45	766.0	Gentle S.
86	29.90	17.15	5.75	755.2	Strong N.
87	13.75	9.05	5.35	768.9	S. breeze.
88	23.80	15.05	8.60	758.7	Light N.
89	31.20	17.90	7.35	755.3	Light N.
90	31.35	16.75	4.15	755.3	Gentle N.
91	30.95	17.40	5.95	755.3	Gentle N.
92	18.20	13.50	9.40	759.5	Gentle S.
93	17.85	12.65	7.90	759.0	Light S.
94	17.10	12.70	8.80	758.6	Light S.W.
95	24.35	15.10	7.85	754.5	Strong N.
96	27.40	16.10	6.95	752.1	Strong N.
97	23.60	16.45	10.40	755.6	Light S.W.
98	21.90	16.15	11.55	754.7	Very light S.W.
99	28.10	19.25	13.90	756.6	Light N.
100	26.10	15.65	7.05	745.2	Strong N.
101	21.90	12.45	2.60	752.5	Very light N.
102	24.55	15.85	9.60	749.8	Gentle N.
103	27.90	16.15	5.65	749.5	Very light S.W.

Method of Reduction.

In dealing with the former series of observations, the individual values of the constant A were determined from the formula

$$x = f - AB(t - t'),$$

taking the vapour-pressures x and f from Broch's tables. The arithmetic mean of these values was taken to be the most probable, or most suitable, value of A to be used in the formula. The same method was followed at first in reducing the present series, and considerable time was spent in grouping and examining the values of A before it was discovered that the method was incorrect in principle, though yielding approximately correct results so long as the number of observations was not too small.

By the application of the method of least squares to the more general formula

$$x = \eta f - \mathrm{AB}(t - t'),$$

in which there are two constants, η and A, to be determined, a single value of each is obtained to represent the whole set of observations. The corresponding formula with these numerical co-efficients has the property that it gives the value of x with the least probable error from observations of the values of the other quantities concerned.. Now this is evidently the result which is required; in practice the psychrometer is used alone, and we are required to determine from its readings the actual value x of the vapour-pressure in the air. We therefore seek a formula of the recognised type with such numerical co-efficients that the value of x will in the long run of similar trials be given with the smallest possible margin of error. If the simple formula

$$x = f - \mathrm{AB}(t - t'),$$

be used, or, in other words, if the co-efficient η be assumed to be unity, this end will be attained by a direct application of least squares to the equation as it stands, and not to the severally determined values of the constant A. Taking the arithmetic mean of the values of A is an application of least squares which makes the errors of A a minimum, instead of those of x. The correct value of A which is appropriate to the whole set of observations is therefore given by the equation

$$\mathrm{A}\Sigma z^2 = \Sigma(f - x)z,$$

where z is put for convenience in place of B $(t - t')$. Since the individual value of A is given for each observation by

$$\mathrm{A} = (f - x) / z,$$

the correct result is the same as would be obtained by weighting the individual values proportionally to z^2, that is practically to $(t - t')^2$. Since $t - t'$ is frequently small, and is in the denominator, this makes it seem probable that the correct value for the present purpose would also be a better value than the simple mean, if the object were to determine A with the least margin of error. (This latter might be the case, for example, if the formula were assumed to be absolute and not merely an approximation of varying accuracy; then the value of A might be considered as an aid to investigation of the properties of air or water-vapour. It need hardly be said that such a procedure would be absurd.)

When this method of reduction was first recognised as more correct, it was not known that any other experimenter had used it. But on investigation, the same method, with a small alteration, the reason for which I could not discover, was found given without remark in Ferrel's paper on "Psychrometrical Tables,"[1] though there are some obvious misprints. The method used by Regnault and most others is not stated in their papers: on the other hand, Angot[2], Pernter[3] and Svensson[4] certainly used arithmetic mean values. For this reason I have thought it well to call attention to the discrepancy between the two methods, though the actual results may not be much different in a good series of observations. For investigating the effects of wind-velocity and other circumstances, the same method is appropriate, and was used in all further study of my own observations.

Results.

The value of A derived from the 103 observations recorded in this paper is 0.0007232 ± 0.0000048. Taking the mean of individual values, the result is higher—viz., 0.0007330; but the probable errors of a single observation of x in the two cases are respectively 0.229 mm. and 0.231 mm., so that the difference in the value of A is of small practical moment. The value given in the previous paper was 0.0007228; using the more correct method of reduction it would become 0.0007167. From the whole set of 166 observations taken together the resulting value is 0.0007227 ± 0.0000043. These various values all agree when only two significant figures are taken, and that is all that can be regarded as really valuable. The final result is then that A = 0.00072, with a probable error of about half a unit in the last place, i.e., $(72 \pm \frac{1}{2}) \times 10^{-5}$. The equation thus becomes

$$x = f - 0.00072B(t - t').$$

Applying the two-constant formula, the values of η and of A are found to be 0.9877 and 0.0006967 respectively. For the 63 observations of the earlier series, η had the value 0.9974. The lower value now obtained might be regarded as due to incomplete saturation of the air leaving the wet-bulb, or some similar failure in the action which is assumed in theory to occur. But it seemed scarcely likely that this would be more noticeable in the present series than in the other one, since the later observations were distinctively superior in other respects. In order to determine whether the lessened value might be due to the observations at low humidity, the series was

1 Ferrel, Report of Secretary of War, U.S., 1886, vol. iv., p. 233
2. Angot, J. de Physique, 1, 1882, p. 119
3. Pernter, Sitzungsber. Wiener Akad. 87, 1883
4. Svensson, Meteor. Zeitschr. 1896, p. 201.

divided into two groups, in which the humidities were all above and all below 50 per cent. respectively. In the earlier series all humidities were above 50 per cent. The application of the formula to each group separately gave $\eta = 0.9589$ below 50 per cent. humidity and 0.9715 above. Both these values are less than that obtained for the two groups combined, instead of being one greater and one less, as we might expect. Such a result seems to indicate very clearly that the value of the second constant η is almost entirely dependent on the nature and distribution of the accidental errors of the first constant A, so that it will vary arbitrarily with the particular group of observations chosen. In other words, there is no physical justification for the insertion of a second constant. It is probable that its value, determined by trial as above, would always be less than unity, but this does not indicate the existence of any phenomenon which is not implicitly allowed for by the simple formula. The following tables will show that the insertion of it is not attended by any increase in accuracy, provided the observations are good. It may possibly be permissible to say that a series of observations which yields a value of η markedly different from unity is unsatisfactory in some respect.

In Table III. the values of x observed are compared with those deduced from the two formulae, according to the equations

$$x_1 = f - 0.0007232B(t - t')$$

$$\text{and} \quad x_2 = 0.9877f - 0.0006967B(t - t'),$$

and the differences, or errors, $\Delta x_1 = x - x_1$ and $\Delta x_2 = x - x_2$, are also given.

TABLE III.

No.	x	x_1	x_2	Δx_1	Δx_2
1	7.36	7.46	7.43	—0.10	—0.07
2	6.01	6.29	6.30	— .28	— .29
3	8.10	8.25	8.19	— .15	— .09
4	7.88	8.14	8.06	— .26	— .18
5	7.39	7.52	7.45	— .13	— .06
6	6.24	6.59	6.57	— .35	— .33
7	6.67	6.64	6.60	.03	.07
8	6.13	6.09	6.08	.04	.05
9	6.95	7.23	7.17	— .28	— .22
10	6.51	7.17	7.13	— .66	— .62
11	6.76	6.01	6.01	.75	.75
12	7.96	7.66	7.62	.30	.34
13	7.39	7.51	7.50	— .12	— .11
14	7.24	6.67	6.68	.57	.56
15	6.71	6.34	6.37	.37	.34
16	6.86	6.31	6.33	.55	.53

No.	x	x_1	x_2	Δx_1	Δx_2
17	6.40	6.29	6.29	.11	.11
18	7.02	6.92	6.94	.10	.08
19	9.58	9.83	9.74	.25	.16
20	8.32	8.68	8.60	— .36	— .28
21	8.27	8.21	8.13	.06	.14
22	9.05	9.24	9.14	— .19	— .09
23	8.69	8.59	8.50	.10	.19
24	9.54	9.42	9.33	.12	.21
25	9.87	10.00	9.92	.13	— .05
26	8.63	8.39	8.35	.24	.28
27	8.16	8.42	8.34	— .26	— .18
28	7.24	7.00	6.96	.24	.28
29	5.37	5.35	5.34	.02	.03
30	5.92	5.94	5.94	— .02	— .02
31	7.65	7.40	7.38	.25	.27
32	8.90	9.34	9.29	— .44	— .39
33	7.65	7.86	7.85	— .21	— .20
34	6.22	6.37	6.41	— .15	— .19
35	6.76	6.33	6.29	.43	.47
36	7.88	7.92	7.86	— .04	.02
37	7.05	8.12	8.05	—1.07	—1.00
38	8.96	8.59	8.54	0.37	0.42
39	8.35	8.67	8.63	— .32	— .28
40	9.45	9.74	9.67	— .29	— .22
41	7.96	7.91	7.89	.05	.07
42	9.02	8.90	8.84	.12	.18
43	9.20	8.77	8.72	.43	48
44	8.84	8.79	8.71	.05	.13
45	8.07	7.91	7.87	.16	.20
46	7.70	7.86	7.85	— .16	— .15
47	7.70	8.05	8.04	— .35	— .34
48	8.21	8.63	8.60	— .42	— .39
49	11.54	11.61	11.53	— .07	.01
50	11.10	11.15	11.08	— .05	.02
51	10.00	10.05	9.97	— .05	.03
52	8.90	8.89	8.83	.01	.07
53	9.02	8.67	8.65	.35	.37
54	7.10	7.28	7.24	— .18	— .14
55	8.24	7.92	7.86	.32	.38
56	6.95	6.77	6.74	.18	.21
57	7.91	7.79	7.75	.12	.16
58	10.00	9.75	9.69	.25	.31
59	8.78	9.12	9.10	— .34	— .32

No.	x	x_1	x_2	Δx_1	Δx_2
60	10.47	10.26	10.17	.21	.30
61	10.54	10.27	10.18	.27	.36
62	8.99	9.04	8.97	— .05	.02
63	9.80	10.29	10.21	— .49	— .41
64	5.44	5.13	5.13	.31	.31
65	5.97	6.24	6.23	— .27	— .26
66	6.78	6.92	6.90	— .14	— .12
67	6.24	6.09	6.07	.15	.17
68	5.72	6.39	6.38	— .67	— .66
69	6.90	6.71	6.67	.19	.23
70	5.92	5.89	5.89	.03	.03
71	6.09	5.92	5.91	.17	.18
72	6.44	6.21	6.20	.23	.24
73	7.07	7.45	7.45	— .38	— .38
74	6.71	6.89	6.90	— .18	— .19
75	6.95	6.66	6.70	.29	.25
76	6.53	6.36	6.40	.17	.13
77	6.62	6.11	6.17	.51	.45
78	6.01	4.81	4.91	1.20	1.10
79	6.49	6.27	6.33	0.22	0.16
80	7.31	7.03	7.00	.28	.31
81	6.13	5.78	5.77	.35	.36
82	7.67	7.73	7.70	— .06	— .03
83	8.49	8.30	8.24	.19	.25
84	8.52	9.01	8.96	— .49	— .44
85	7.70	7.82	7.78	— .12	— .08
86	6.86	7.58	7.65	— .72	— .79
87	6.67	5.97	5.95	.70	.72
88	8.32	7.91	7.92	.41	.40
89	7.65	7.98	8.05	— .33	— .40
90	6.13	6.20	6.32	— .07	— .19
91	6.95	7.36	7.45	.41	— .50
92	8.78	8.93	8.88	— .15	— .10
93	7.94	8.04	8.01	— .10	— .07
94	8.43	8.51	8.46	— .08	— .03
95	7.91	7.71	7.74	.20	.17
96	7.44	7.45	7.51	— .01	— .07
97	9.39	10.00	9.98	— .61	— .59
98	10.13	10.50	10.45	— .37	— .32
99	11.81	11.73	11.70	.08	.11
100	7.50	7.58	7.63	— .08	— .13
101	5.50	5.61	5.67	— .11	— .17
102	8.90	8.66	8.68	.24	.22
103	6.81	7.27	7.33	— .46	— .52

The errors in the two formulae are never far different ; summing them without regard to sign the results are 27.12 and 27.05, for the 103 observations, so that the average errors are indistinguishable from one another. The same is true of the probable errors deduced by least squares, being 0.229 mm. in each case.

The corresponding values of humidity with the errors of each are given in the following table :

TABLE IV.

No	r	r_1	r_2	Δr_1	Δr_2
1	52.42	53.13	52.92	0.71	—0.50
2	40.72	42.61	42.68	—1.89	1.96
3	63.08	64.25	63.79	—1.17	—0.71
4	83.12	85.86	85.02	—2.74	—1.90
5	71.75	73.01	72.33	—1.26	—0.58
6	51.83	54.73	54.57	—2.90	—2.74
7	66.30	66.00	65.61	0.30	0.69
8	52.75	52.41	52.32	0.34	0.43
9	68.41	71.16	70.57	—2.75	—2.16
10	52.20	57.50	57.18	—5.30	—4.98
11	54.21	48.20	48.20	6.01	6.01
12	56.33	54.21	53.93	2.12	2.40
13	45.56	46.30	46.24	—0.74	—0.68
14	48.43	44.62	44.68	3.81	3.75
15	37.80	35.72	35.89	2.08	1.91
16	43.09	39.64	39.76	3.45	3.33
17	43.07	42.33	42.33	0.74	0.74
18	41.44	40.85	40.97	0.59	0.47
19	77.57	79.60	78.87	—2.03	—1.30
20	78.71	82.12	81.36	—3.41	—2.65
21	75.94	75.39	74.66	0.55	1.28
22	84.50	86.27	85.34	—1.77	—0.84
23	84.12	83.16	82.28	0.96	1.84
24	88.50	87.38	86.55	1.12	1.95
25	67.28	68.17	67.62	—0.89	—0.34
26	56.63	55.05	54.79	1.58	1.84
27	74.73	77.11	76.37	—2.38	—1.64
28	72.18	69.79	69.39	2.39	2.79
29	52.85	52.66	52.56	0.19	0.29
30	48.09	48.25	48.25	—0.16	—0.16
31	57.17	55.31	55.16	1.86	2.01
32	56.62	59.41	59.10	—2.79	—2.48
33	42.83	44.01	43.95	—1.18	—1.12
34	34.19	35.02	35.24	—0.83	—1.05

No.	r	r_1	r_2	Δr_1	Δr_2
35	69.91	65.46	65.05	4.45	4.86
36	74.55	74.93	74.36	—0.38	0.19
37	61.90	71.29	70.68	—9.39	—8.78
38	65.69	62.98	62.61	2.71	3.08
39	53.46	55.51	55.25	—2.05	—1.79
40	62.01	63.91	63.45	—1.90	—1.44
41	51.29	50.97	50.84	0.32	0.45
42	66.57	65.68	65.24	0.89	1.33
43	61.74	58.86	58.52	2.88	3.22
44	77.07	76.63	75.94	0.44	1.13
45	59.16	57.99	57.70	1.17	1.46
46	43.65	44.56	44.50	—0.91	—0.85
47	45.59	47.66	47.60	—2.07	—2.01
48	47.13	49.54	49.37	—2.41	—2.24
49	62.28	62.66	62.22	—0.38	0.06
50	57.25	57.50	57.14	—0.25	0.11
51	69.44	69.79	69.24	—0.35	0.20
52	69.10	69.02	68.56	0.08	0.54
53	49.00	47.09	46.99	1.91	2.01
54	57.68	59.14	58.81	—1.46	—1.13
55	68.21	65.56	65.07	2.65	3.14
56	60.59	59.02	58.76	1.57	1.83
57	61.41	60.48	60.17	0.93	1.24
58	62.81	61.24	60.87	1.57	1.94
59	46.98	48.80	48.69	—1.82	—1.71
60	74.57	73.08	72.44	1.49	2.13
61	74.17	72.27	71.64	1.90	2.53
62	69.37	69.75	69.21	—0.38	0.16
63	59.14	62.10	61.62	—2.96	—2.48
64	49.82	46.98	46.98	2.84	2.84
65	47.87	50.04	49.96	—2.17	—2.09
66	50.67	51.72	51.57	—1.05	—0.90
67	55.47	54.13	53.96	1.34	1.51
68	47.35	52.90	52.81	—5.55	—5.46
69	61.33	59.64	59.29	1.69	2.04
70	49.17	48.92	48.92	0.25	0.25
71	51.74	50.30	50.21	1.44	1.53
72	53.00	51.11	51.03	1.89	1.97
73	43.32	45.65	45.65	—2.33	—2.33
74	39.13	40.17	40.23	—1.04	—1.10
75	34.46	33.02	33.22	1.44	1.24
76	33.37	32.50	32.70	0.87	0.67
77	30.61	28.25	28.53	2.36	2.08

No	r	r_1	r_2	Δr_1	Δr_2
78	24.59	19.68	20.09	4.91	4.50
79	28.60	27.63	27.90	0.97	0.70
80	57.11	54.92	54.69	2.19	2.42
81	51.43	48.49	48.41	2.94	3.02
82	58.42	58.87	58.64	—0.45	—0.22
83	63.84	62.41	61.96	1.43	1.88
84	58.44	61.80	61.45	—3.36	—3.01
85	58.82	59.74	59.43	—0.92	—0.61
86	21.90	24.19	24.42	—2.29	—2.52
87	57.06	51.07	50.90	5.99	6.16
88	38.01	36.14	36.18	1.87	1.83
89	22.67	23.64	23.85	—0.97	—1.18
90	18.01	18.21	18.57	—0.20	—0.56
91	20.88	22.12	22.39	—1.24	—1.51
92	56.57	57.54	57.22	—0.97	—0.65
93	52.27	52.93	52.73	—0.66	—0.46
94	58.18	58.73	58.39	—0.55	—0.21
95	34.97	34.08	34.22	0.89	0.75
96	27.45	27.49	27.71	—0.04	—0.26
97	43.41	46.23	46.14	—2.82	—2.73
98	51.92	53.82	53.56	—1.90	—1.64
99	41.83	41.55	41.45	0.28	0.38
100	29.87	30.19	30.39	—0.32	—0.52
101	28.19	28.75	29.06	—0.56	—0.87
102	38.88	37.83	37.92	1.05	0.96
103	24.40	26.05	26.26	—1.65	—1.86

These figures again show no decided gain in accuracy by the use of the modified formula. The sums of the errors taken without regard to sign are 182.34 and 180.98, showing an average error 0.01 less in one case than in the other. The probable errors are respectively 1.57 and 1.54, the difference being too small to be significant.

Wind-effects.

The value 0.00072 for the constant A was derived from observations taken under all conditions of wind-velocity, no artificial method of ventilation having been used. By grouping the observations in accordance with the strength and direction of the wind, however, the value of the constant is found to vary in the manner generally acknowledged. It is a maximum under calm conditions and decreases as the velocity of the wind rises. From only 11 observations in calm air A = 0.0007887, which agrees with the value 0.0007882 from 17 observations of the earlier series (the values given in the former paper were obtained by taking the arithmetic means). With strong winds, say from 15 to 20 miles an hour (about 25 ft. a second) upwards, the result of 25 observations is that A = 0.0006936. Taking together all those observations in which the air was distinctly in motion, the value is 0.0007213. Thus it would seem that the value 0.00072 is satisfactory for all conditions of ventilation, supposed occurring arbitrarily, while absolute calm should be avoided if possible.

The suggestion previously made that a difference might be found according to the direction of the wind is not confirmed by these observations. In 47 cases the wind was from the north (including N.E. and N.W.), and for these A = 0.0007186; in 42 cases the wind was from the south, and the value comes 0.0007199.

Any relations which may exist between the value of A and the temperature or humidity were completely masked by the wind-effect, and the number of observations was not sufficient to allow of a separation.

Effect of Soiled Coverings.

That the nature of the evaporating surface does not affect the temperature attained by the wet-bulb thermometer is a conclusion which does not extend to the state of cleanliness of that surface. The necessity for frequent renewal or cleansing of the materials is well recognised, and the observations which, as already mentioned, were unintentionally made with soiled coverings, show that this regulation is by no means unimportant. The different wet-bulbs agreed together as closely as when clean, all being equally soiled, or at any rate exposed to the same conditions, but the observations were discordant among themselves, i.e., in the individual values of A, several were erroneous to an extreme, and the wet-bulbs read in practically all cases too high. The value of A derived from the 31 observations was 0.0008684, with a probable error of 0.0000232, while with the two-constant formula the result was $\eta = 0.9254 \pm 0.0155$, A = 0.0005892 ± 0.0000631. The hindrance to evaporation was evidently large, and the instrument in such a state is useless.

In closing, I should like to offer my thanks to both Dr. Love and Professor Lyle for the kindly advice and assistance which have always been placed at my disposal.

Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. I., 1912.

Art. XIII.—*On Some New Species of Victorian Marine Mollusca.*

By J. H. GATLIFF and C. J. GABRIEL.

(With Plate IX.)

[Read 11th July, 1912.]

This paper contains the description of three new species of bivalve shells.

Montacuta dromanaensis, sp. nov. (Pl. IX., Figs. 1-4)

Shell minute, sordid white, very inequilateral, finely ornamented with concentric, irregularly undulating striae; the re-set are distinctly capped by what appears to be the early stage of growth. Equivalve.

Dimensions of Type.—Anterior-posterior diameter 1.6, dorso-ventral diameter 1.2 mm.

Locality.—Type from Dromana San Remo (T. Worcester). Dredged between Phillip and French Islands, Western Port.

Obs.—This species can be readily separated from our other forms by its concentric sculpture. Type in Mr. Gatliff's collection.

Condylocardia chapmani, sp. nov. (Pl. IX., Figs. 5-8).

Shell minute, white, shining, transparent, hinge being discernible from the outside through the shell. Very inequilateral. Ovate, inflated. Lunule slightly discernible. There are three growth lines visible. Equivalve.

Dimensions of Type.—Anterior-posterior diameter 1.4, dorso-ventral diameter, 1 mm.

Locality.—Type dredged off Portsea, Port Phillip: Ocean Beach, Point Nepean; Torquay.

Obs.—A very small, smooth, simple form. Type in Mr. Gatliff's collection.

Modiolaria phyllensis, sp nov. (Pl. IX., Figs. 9, 10).

Shell small, equivalve, suboblique, profoundly convex, semi-transparent, horny colour. Valves thin, fragile. Umboes prominent, with the beaks projecting and slightly incurved to the anterior; the umbonal swelling giving rise to a somewhat sharp slope to the anterior, but a more gradual dip, and with a manifest concavity to the posterior. The anterior border is straight and decidedly produced posteriorly.

As regards sculpture, the shell is adorned with closely-set, radiating ribs, whose surfaces are obtuse and slightly raised from their similarly spaced interstices. Two or three intercalating ribs appear. The area occupied by the central third bearing ribs fewer in number, but of greater substance. The shell is further ornamented with about twenty irregularly-parted, fine, concentric lamellae, which are difficult to enumerate, owing to their frequent discontinuity. The unsculptured portion, generically characteristic, appears in the anterior third, resolving itself into a narrow beam about the width of two ribs, and two grooves. This divides an anterior flank of sixteen ribs from a flank of, approximately, ninety-five to the posterior. The umbonal region is marked by an encircling furrow, situated about one-sixth the length of shell; this discriminates two sets of sculpture, the main ornamental ribs terminating at the furrow; the umbonal ornament is much finer, assuming more the character of radial threads crossed by numerous and stronger lines of growth. This latter area is lighter in colour, and above the level of the shell, forming a sort of cap. Hinge normal. Ligament internal, linear. Muscle scars not clearly defined; pallial impression obscure. Inner margin crenulated by the radial sculpture, which, with the concentrics, may be seen from within.

Dimensions of Type.—Length, 2.50; breadth, 1.75; depth, 1.25 mm.

Locality.—Dredged off Rhyll, Western Port, about 6 fathoms. Type taken alive.

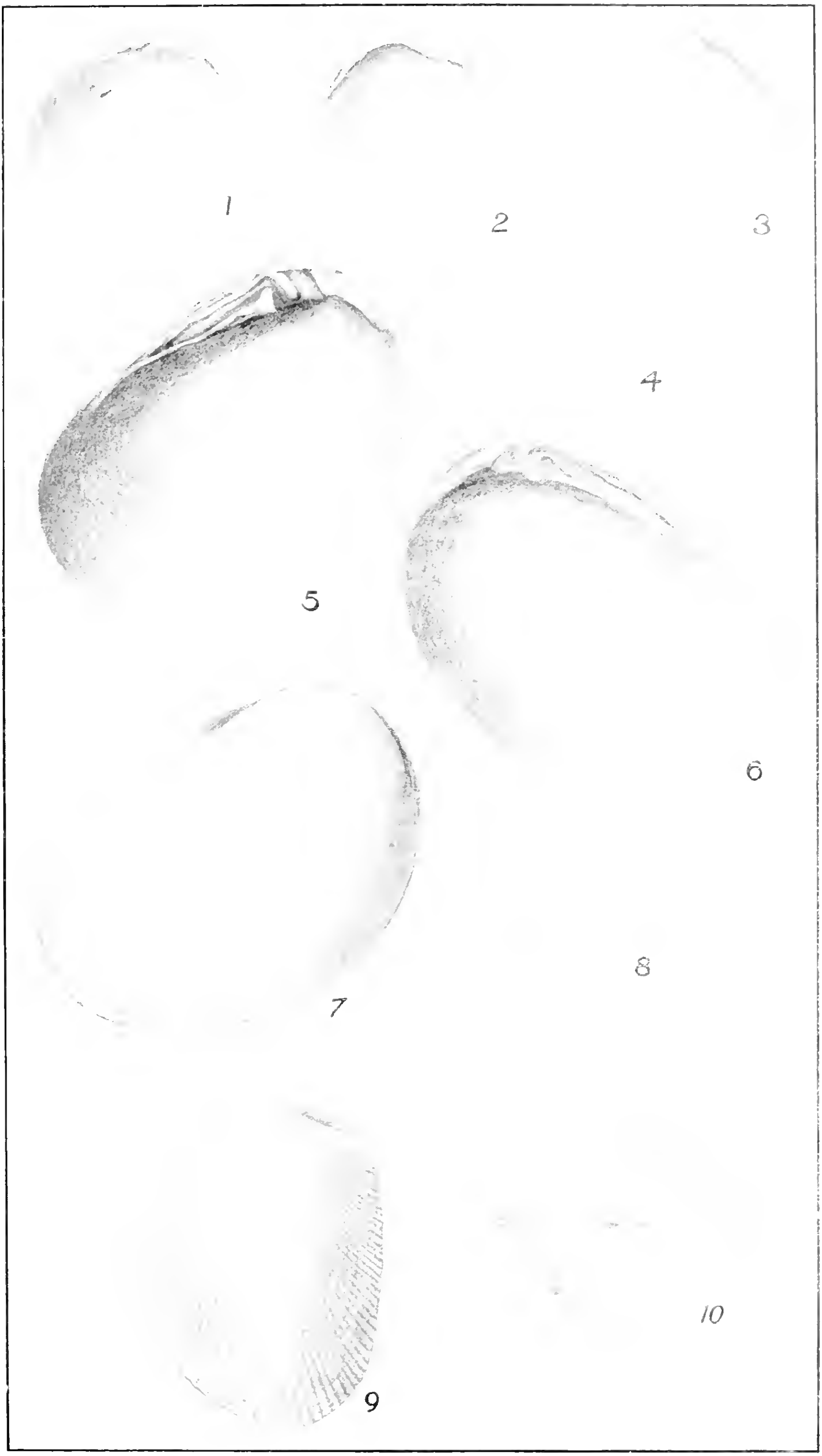
Obs.—This rare and elegant little species has an Australian ally in *M. perstriata*, Hedley (P.L.S., N.S.W., 1906, Vol. XXXI., Part 3, p. 472, pl. 36, f. 9, 10), from which it differs in its broader form, and the peculiar capping of the umbo, this latter feature serving as a useful recognition mark. From its Victorian congeners it is easily distinguished by the narrow beam. Consistency of shape is not apparent, variation existing as regards depth and width of the convexity. The measurements of our few specimens differ considerably, one valve attaining the dimensions of 3.50 × 2.25 mm.

Type in Mr. C. J. Gabriel's collection.

EXPLANATION OF PLATE IX.

Fig. 1.—Montacuta dromanaensis, sp. nov. Interior, left valve.
Fig. 2.—Montacuta dromanaensis, sp. nov. Interior, right valve.
Fig. 3.—Montacuta dromanaensis, sp. nov. Exterior.
Fig. 4.—Montacuta dromanaensis, sp. nov. Exterior, dorsal view.
Fig. 5.—Condylocardia chapmani, sp. nov. Interior, left valve.
Fig. 6.—Condylocardia chapmani, sp. nov. Interior, right valve.
Fig. 7.—Condylocardia chapmani, sp. nov. Exterior.
Fig. 8.—Condylocardia chapmani, sp. nov. Exterior, dorsal view.
Fig. 9.—Modiolaria rhyllensis, sp. nov. Exterior.
Fig. 10.—Modiolaria rhyllensis, sp. nov. Exterior, dorsal view.

The figures are variously magnified.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Proc. Roy. Soc. Victoria, 25 (N.S.), Part I., 1912.

Art. XIV.—*Additions to and Alterations in the Catalogue of Victorian Marine Mollusca.*

By J. H. GATLIFF and C. J. GABRIEL.

[Read 11th July, 1912].

This paper deals with 24 species; 5 are new, 2 are altered names, and 17 are known species. The new species include 2 *Ischnochitons* kindly described for us by Mr. A. F. B. Hull, of Sydney, who has made the *Polyplacophora* his special study. The named Victorian *Polyplacophora* now total 46 species, and the total number of mollusks catalogued is 962.

We have again to thank our former helpers in our work for their kind assistance.

Sepia capensis, d'Orbigny.

1826. Sepia capensis, d'Orbigny. Seichis, pl. 7, f. 1-3.

1835-1848. Sepia capensis. Ferussac and d'Orbigny. Hist. Nat., Ceph., p. 278, pl. 7, f. 1-3, pl. 12, f. 7-11, pl. 17, f. 18, 19.

1879. Sepia capensis, Tryon. Man. Conch., vol. i., p. 198, pl. 94, f. 440-442.

1912. Sepia capensis, Chapman. V.N., vol. xxix., p. 24, pl. 1, three figures.

Hab.—Torquay, Grant Coast (F. Chapman). Shoreham, Western Port.

Obs.—Mr. Chapman gives the following dimensions of a typical specimen:—Length, 120; breadth, 42; greatest thickness 10.5; the mucro from base of attachment to apex, 6.5 mm.

Sepia latimanus, Quoy and Gaimard.

1832. Sepia latimanus, Quoy and Gaimard. Astrolabe Zool., vol. ii., p. 68, pl. 2, f. 2-11.

1879. Sepia latimanus, Tryon. Man. Conch., vol. i., p. 192, pl. 88, f. 400, 401.

1912. Sepia latimanus, Chapman. V.N., vol. xxix., p. 25, pl. 1, three figures.

Hab.—Torquay, Grant Coast (F. Chapman).

Obs.—Mr. Chapman states that a typical specimen from Torquay measures:—Length, 135; greatest breadth, 47; greatest thickness, 13.5 mm.

Turricula bellapicta, Verco.

1909. Mitra bellapicta, Verco, T.R.S., S.A., vol. xxxiii., p. 337, pl. 25, f. 1.

Hab.—Western Port.

Obs.—Size of type: Length, 9.6; breadth, 5.1 mm., Columella quadriplicate. The author remarks: "This may be a variety of *M. vincta*, A. Adams (Volutomitra), close to *M. weldii*, Tenison-Woods."

Marginella nympha, Brazier.

1894. Marginella nympha, Brazier, P.L.S., N.S.W., vol. ix. (2nd series), p. 168, pl. 14, f. 2.

Hab.—Port Albert (T. Worcester).

Obs.—Size of type: Length, 1.75: breadth, 1 mm. "Having much the shape of *M. ovulum*, spire immersed."

Mangilia bilineata, Angas.

1871. Clathurella bilineata, Angas. P.Z.S., Lond., p. 18, pl. 1, f. 23.

Hab.—Port Albert, (T. Worcester).

Obs.—Size of type: Length, 4; breadth, 1.5 mm. Our single specimen is a little larger. We consider this species to be a *Mangilia*, and it somewhat resembles *M. saint-gallae*, T. Woods.

Daphnella mayi, Verco.

1909. Hemipleurotoma mayi, Verco. T.R.S., S.A., vol. xxxiii., p. 295, pl. 25, f. 2.

Hab.—In 300 fathoms, 30 miles south of Cape Nelson, Commonwealth trawler "Endeavour."

Obs. Size of type: Length, 4.6; breadth, 2.4 mm. We do not agree with the author as to the generic position of this species. Our specific identification has been confirmed by him.

Cassis adcocki, Sowerby.

1896. Cassis adcocki, Sowerby. P. Mal. Soc., Lond., vol. ii., p. 14, fig. in text.

Hab. Bass's Strait, Commonwealth trawler "Endeavour."

Obs.—Size of type: Length, 20; breadth, 17 mm. This species was named from a South Australian specimen, and has five encircling rows of brown spots. Our example is a young shell, but the distinguishing characteristics are readily discernible.

Rissoa (Onoba) bassiana, Hedley.

1911. Onoba bassiana, Hedley. Zool., Commonwealth trawler "Endeavour," part 1., p. 108, pl. 19, f. 25.

Hab. Port Albert (T. Worcester). Bass's Strait, Commonwealth trawler, "Endeavour."

Obs.—In vol. xxi., p. 379, of these Proceedings it was stated that we had what we considered to be a large specimen of *Onoba glomerosa*, Hedley. He considers it to be a distinct species, and has named it as above.

Euchelus pumilio, Tate.

1893. Euchelus pumilio, Tate. T.R.S., S.A., vol. xvii., p. 196, pl. 1, f. 3.

Hab.—San Remo (T. Worcester).

Obs.—Size of type: Height, 3; diameter, 3.25 mm.

Lepidopleurus badius, Hedley and Hull.

1909. Lepidopleurus badius, Hedley and Hull. Rec. Aust. Mus., vol. vii., p. 260, pl. 73, f. 1, 2.

Hab.—Torquay, two specimens found under one stone close to shore.

Obs.—Size of type: Length, 6; breadth, 3.5 mm. We determined this species, and submitted it to Mr. Hull, who states: "This shell corresponds very closely with my co-type of *L. badius*; the pustules are rather fewer and more scattered, but I cannot separate it."

Ischnochiton fruticosus, Gould.

1846. Ischnochiton fruticosus, Gould. Proc. Boston Soc., Nat. Hist., vol. ii., p. 142.

1892. Ischnochiton fruticosus, Pilsbry. Man. Conch., vol. xiv., p. 91, pl. 23, f. 78-80.

1894. Ischnochiton fruticosus, Pilsbry. Proc. Acad. Nat. Sci., Philadelphia, p. 72.

1897. Ischnochiton fruticosus, Bednall. P. Mal. Soc. Lond., vol. ii., p. 145.

Hab.—Torquay, one specimen only.

Obs.—Size of type: Length, 33; breadth, 15 mm.

Ischnochiton thomasi, Bednall.

1897. Ischnochiton thomasi, Bednall. P. Mal. Soc. Lond., vol. ii., p. 149, pl. 12, f. 4, 5.

Hab.—Torquay, one specimen only, under small stone at low tide.

Obs.—Size of type: Length, 10.5 to 14; breadth, 5 to 7.5 mm.

Ischnochiton gabrieli, Hull.

1912. Ischnochiton gabrieli, Hull. Antea page 120.

Hab.—Dredged between Phillip and French Islands, Western Port.

Ischnochiton falcatus, Hull.

1912. Ischnochiton gabrieli, Hull. Antea page 120.

Hab.—Same as preceding species; also under stones at low tide, Sunderland's Bight, Phillip Island.

Acanthochites tatei, Torr and Ashby.

1898. Acanthochites tatei, Torr and Ashby. T.R.S., S.A., vol. xxii., p. 219, pl. 7, f. 7a-7f.

Hab. Torquay, one specimen only, under a stone, at low tide.

Obs.—Size of type: Length, 6; breadth, 2.5 mm. Our specimen is larger, being length 8; breadth 3.3 mm. It may be separated readily from our other species by its girdle being "covered with short yellowish-white spicules"; these are in addition to the sutural tufts. Dr. Torr also only found the type specimen in South Australia: the description and figures of it are so excellent that there is no difficulty in recognising the species.

Chiton verconis, Torr and Ashby.

1898. Chiton verconis, Torr and Ashby. T.R.S., S.A., vol. xxii., p. 215, pl. 6, f. 1.

Hab.—Port Fairy.

Obs.—Dr. Torr, of South Australia, writes us that he has a specimen from the collection of the late Mr. Adcock, from the above locality.

Diplodonta globulosa, A. Adams.

1855. Diplodonta globulosa, A. Adams. P.Z.S., Lond., p. 226.

1878. Diplodonta striata, Hutton. Jour. de Conch., p. 51.

1909. Diplodonta striata, Gatliff and Gabriel. P.R.S., Vic., vol. xxii., p. 46.

Hab.—Western Port, Point Cook, Port Phillip, 8 fathoms.

Obs.—Specimens from New South Wales and Victoria were submitted by us to Mr. E. A. Smith, of the British Museum, for comparison with the type, said to be in the Cuming collection; he replied that it was not to be found there.

After again carefully perusing the original description, which is somewhat meagre, and consulting with Mr. C. Hedley, of the Australian Museum, Sydney, we have arrived at the above decision.

Dr. J. C. Verco, of Adelaide, sent us a specimen of *Gastrochaena tasmanica*, T. Woods, upon opening the tube of which we found it to contain two complete specimens of the above species.

DIPLODONTA JACKSONIENSIS, Angas.

1867. Mysia (Felania) jacksoniensis, Angas. P.Z.S., Lond., p. 910, pl. 44, f. 10.

Hab.—Western Port.

Obs.—Size of type: Length, 8; height, 8.5; breadth, 5 mm. We have examples which exceed this size by one-third. It differs from *D. Adamsi*, Angas, in having a broader hinge shelf, being oblique in form, and of a pale, rosy flesh-colour.

MONTACUTA DROMANAENSIS, Gatliff and Gabriel.

1912. Montacuta dromanaensis, Gatliff and Gabriel. Antea page 167.

Hab.—Dromana; San Remo (T. Worcester). Dredged between Phillip and French Islands, Western Port.

CONDYLOCARDIA AUSTRALIS, Bernard.

1896. Condylocardia australis, Bernard. Jour de Conch., p. 176, pl. 6, f. 4.

1908. Condylocardia australis, Verco. T.R.S., S.A., vol. xxxii., p. 360.

Hab.—Ocean Beach, Flinders.

Obs.—Size of type: Anterior-posterior diameter, 1.2; dorso-ventral, 1.14 mm.

CONDYLOCARDIA CHAPMANI, Gatliff and Gabriel.

1912. Condylocardia chapmani, Gatliff and Gabriel. Antea page 167.

Hab.—Type dredged off Portsea, Port Phillip: ocean beach, Point Nepean: Torquay.

CARDITA CALVA, Tate.

1887. Cardita calva, Tate. T.R.S., S.A., vol. ix., p. 189, pl. xx., f. 14.

1908. Venericardia dilecta, Verco (non. Smith). T.R.S., S.A., vol. xxxii., p. 347, pl. xiv., f. 8.

1908. Venericardia dilecta, Verco (non. Smith). Var. excelsior, Verco. T.R.S., S.A., vol. xxxii., p. 348, pl. xiv., f. 9.

1911. Venericardia dilecta, Smith. Var. excelsior, Verco, Hedley. Zool. Commonwealth Trawler "Endeavour," part I., p. 92.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour," one left valve.

Obs.—Our single valve agrees in all particulars with specimens of *V. dilecta* var. *excelsior*, Verco, of which we possess a fine series, kindly sent to us by the author. The description and figure of the tertiary *C. calva*, Tate, suggested to us a striking similarity, and on critical examination, we were forced to the belief that this was another instance of a survivor. With types of both shells existent, we deemed it expedient to have a comparative examination, and submitted to Dr. Verco specimens of *C. calva*, from Forsyth's, Grange Burn, Victoria (of kalimnan age), with our living representative, of *V. excelsior*, from Wilson's Promontory. Our contention is evident, as will be seen in the following reply, received 25.4.12:—"I have examined the type and co-types of *C. calva*, Tate: on his own tablet are 15 shells, two showing the inner view, and 13 the outer. The type specimen is the largest, and is quite indistinguishable from what we have called here *Cardita dilecta*, Smith: its eccentric and radial sculpture are exactly the same, and the part near the umbo has the radial sculpture visible, except immediately round its apex. The other examples on his tablet are smaller, and these have the eccentric (concentric) grooves, well marked, in some instances to the ventral margin; but these are smaller shells—in larger ones this may occupy half the surface of the shell, or more. This part is smooth, and may show scarcely any radial markings; in fact, in one valve, where at least 20 of the concentric markings can be counted, and where they reach the ventral border, only 2 or 3 radial incisions are visible in the anterior, and in the posterior part of the valve. Is not this smooth part simply due to rubbing, and the wearing off of the sculpture? This area is so variable in size, and so limited to the prominent part of the shell, that this explanation suggests itself. I am satisfied that Tate's *C. calva* is my *C. excelsior*, and unless there is an omission in Smith's description and figure, is not *C. dilecta*, Smith. Tate's name is unfortunate, for the 'baldness' (calva) is probably accidental, and his type is barely bald at the extreme apex." *C. calva* somewhat recalls *C. dilecta*, Smith, but is easily distinguished, as Dr. Verco states, by its excentric concentric grooves, which are not in the slightest degree indicated in the figure and description of *C. dilecta* ("Chall. Zool."). The distribution of *C. calva* is interesting, as, with a specimen from the trawler "Endeavour," we are able to extend its range to Oyster Bay, Tasmania.

CARDITELLA EXULATA, E. A. Smith.

1885. Carditella exulata, E. A. Smith. Chall. Zool., vol. xiii., p. 215, pl. 15, f. 6, 6a.

1908. Carditella exulata, Verco. T.R.S., S.A., vol. xxxii., p. 352.

Hab.—Ocean Beach, Phillip Island.

Obs.—Size: Length, 4; height, 2.75; width, 2 mm.

MODIOLARIA RHYLLENSIS, Gatliff and Gabriel.

1912. Modiolaria rhyllensis, Gatliff and Gabriel. Antea page 167.

Hab.—Dredged between Phillip and French Islands, Western Port.

[Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. I., 1912].

Art. XV.—*Notes on some "Stringybark" Eucalypts.*

By ROYSTON DREW, HEBER GREEN and P. R. H. St. JOHN.

(With Plates X and XI).

[Read 11th July, 1912].

I.—The Occurrence of Eucalyptus Consideniana (*Yertchuk*) in the Lower Yarra District.

For some years past one of us has had under observation near Eltham a single "stringybark" tree which was evidently not *E. macrorhyncha*, nor any of the other common species known to be present in that district.

About eighteen months ago another specimen was found near Lilydale, presenting considerable differences both in the size and shape of its carpels and even, as we have since found, in the oil distilled from its foliage.

We have since proved that they are both forms of *E. Consideniana*, the "Yertchuk" discovered by A. W. Howitt[1] in Gippsland, and described by J. H. Maiden,[2] but this is the first record of its appearance so near Melbourne, and our verdict as to its identity has been confirmed by Mr. Maiden. The tree itself grows on the poor soil overlying the silurian shales and resembles the stringybarks of the district (*E. macrorhyncha*) in general appearance and height. The bark, however, is softer and less furrowed, and the leaves are narrower; in these respects it resembles the messmate (*E. obliqua*), but this does not occur near Eltham. The carpels also usually differ from those of *E. macrorhyncha* and other allied species in possessing a red rim and in not being domed.

The usual difficulty of discriminating between the various "stringybarks" was accentuated by the considerable variations shown, especially by the carpels. (See Plate X.)

These variations, which will be referred to later, are much greater than are indicated by Maiden, and it seems advisable to amplify his description.

In our endeavour to identify the tree and to decide whether the various forms observed were of one species only, we sought further information in three directions.

1. Trans. Roy. Soc. Vic., ii., p. 82.
2. Crit. Rev., vol. i., p. 312, and Proc. Linn. Soc. N.S.W., 1904, p. 475.

We examined (1) the seedlings, (2) the flowers, and (3) the chemical composition of the oil.

(1) *The seedlings.* Many seeds of both the Eltham and Lilydale forms and, for comparison, seeds of about half-a-dozen more or less similar species, were planted in small pots.

The resulting seedlings conclusively eliminated *E. pilularis* and *E. eugenioides.*[1]

Seedlings of *E. macrorhyncha, E. Muelleriana* and *E. obliqua* appear indistinguishable in a photograph, although a closer examination show minor but definite differences in each case. Carefully selected typical specimens of the seedlings examined are illustrated in Plate XI.

(2) *The flowers.*—Although buds had been visible for several years, no flowers were observed until the beginning of this year, when both trees came into bloom, and the inflorescence was seen to be identical.

The trees were covered with an abundance of prominent panicles of bloom, white in colour and honey-scented.

The buds in the early stages are narrow and pointed like those of *E. macrorhyncha,* but before flowering they become more swollen and then more nearly resemble the Eastern form of *E. Considenian*a described by Maiden.

Considerable searching in the district of the lower Yarra, especially between Greensborough and Lilydale, has resulted in the discovery of about a score of trees, several of which have been most prolific in bloom.

It is certain that the species was much more common in past years throughout this district, and that the present scarcity is due to its selection by timber splitters, who look upon it as a superior kind of messmate. Indeed, several of the trees that we have had under observation have been cut down during the last few months and utilised in this way. The wood is a clean splitting and durable fencing timber, and resembles that of the yellow stringybark (*E. Muelleriana*), in appearance.

(3) *Chemical composition of the oil.*—This species may possibly be the "peppermint" from which the first eucalyptus oil was distilled by Surgeon Considen (one of the founders of Australia), after whom the tree has been named by Maiden. In any case it is closely related to *E. piperita,* the species generally supposed to have that honour. In view of this possibility, it is fitting that a chemical examination of its oil should be carried out and placed on record.

The oil obtained from the leaves by steam distillation is perhaps not an infallible criterion, but the work of Baker and Smith and,

1 With regard to the latter we would point out that there appear to be two distinct varieties which may possibly both be worthy of specific rank. The form compared here is the ordinary variety occurring so plentifully in Gippsland.

incidentally, our own experiments on these stringybarks have shown that each species yields its own characteristic oil, which varies less than any of the other features usually relied on by morphologists for the identification of botanical species.

We shall therefore describe in some detail our experiments on the oil.

Foliage was collected from four different trees, and in each case one or more sacks of the leaves were distilled with steam in an experimental still at the University Agricultural Chemistry Laboratory. The 400-gallon tanks usually employed in the commercial extraction of eucalyptus oils hold about half a ton of leaves. Our still had a capacity of some twenty pounds only, but the processes were the same in principle in both cases, except that we were able to carry out our operations quantitatively.

The distillation was generally considered to be complete after three and a-half hours. In one experiment the following measurements were noted:—

Time of distillation (hours)	1	2	3	4
Oil distilled	49 cc. ...	18 cc. ...	9 cc. ...	1 cc.

Eucalyptus oils, in general, are mixtures of pinene, phellandrene and eucalyptol, liquids boiling at 156 deg., 172 deg. and 176 deg. respectively. They may contain also small percentages of less volatile complex aldehydes and a sesquiterpene (aromadendrene), with traces of more volatile alcohols, aldehydes and esters.

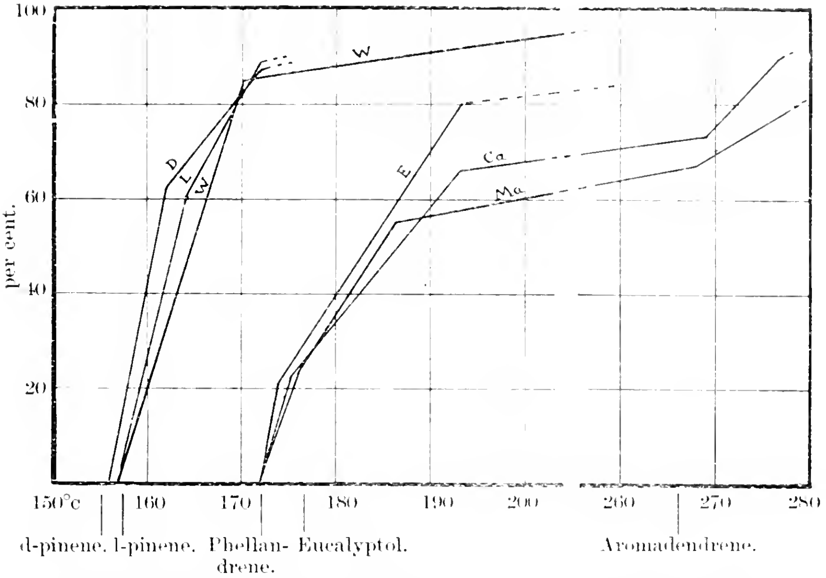
The physical properties of an oil will naturally depend on the variety and proportions of the ingredients present, and are often, though not always, a useful guide to its composition.

A careful fractional distillation enables us, partially, at least, to separate the different constituents and form an approximate estimate of the amount of each present. It should also be a preliminary to the quantitative determination of eucalyptol, aldehydes, etc.

We have for this purpose used a glass still of definite dimensions sealed on to a rod and disc fractionating column so that a definite degree of fractionation will always be obtained. If the quantity of distillate passing over between definite temperature limits be plotted in the form of a temperature-percentage curve, we have a very convenient method of graphically comparing different oils.

In dealing with an unknown oil, refractionation is resorted to, and derivatives of each component prepared, and identified by their physical constants.

Fig. 1.



D. = *E. dextropinea* (d = ·877, α = + 38°). E. = *E. eugenioides* (d = ·913, α = + 4°)
L. = *E. laevopinea* (d = ·875, α = − 47°). Ca. = *E. capitellata* (d = ·917, α = + 4°)
W. = *E. Wilkinsoniana* (d = ·894, α = − 24°). Ma. = *E. macrorhyncha* (d = ·929, α = − 1°)

In Fig. 1, the curves are given for several of the typical stringybark oils, and, although the data recorded by Baker and Smith are somewhat scanty for this purpose, the difference between each curve is clearly to be seen, and corresponds to the characteristic composition of each oil.

These curves distinguish two classes of stringybarks, the one including such species as *E. laevo-pinea*, etc., which yield oils commencing to distil at about 156 deg. C, and containing either dextro - or laevo - pinene, and the second, which like *E. macrorhyncha* yields oils containing phellandrene, but not pinene, and only beginning to distil at above 170 deg. C.

Whereas some of the constituents can be directly determined by chemical methods, others such as pinene can only be approximately estimated by a more or less reliable calculation from the physical constants of the oil and its fractions.

The method we adopted is as follows:—

Fifty cubic centimetres of the oil are fractionally distilled in duplicate, and the density, optical rotation and refractive index of each fraction is observed. The lightest fraction is analysed for volatile aldehydes by absorption with a sodium bisulphite solution; eucalyptol is determined by the resorcin method in the middle fractions boiling from 170 deg. to 190 deg., and the highest fractions are utilised for the estimation by hydroxylamine of aromadendral and associated aldehydes. The optical rotation of the middle fractions gives a measure of the phellandrene content of the oil, when a qualitative test has shown it to be present.

Baker and Smith[1] discovered that if the leaves of *E. macrorhyncha* be extracted with boiling water, a considerable amount of a yellow dye, which they isolated and named myrticolorin, was obtained. This is an important character in the comparison of the stringybarks. and we have readily confirmed their observation, but find little or none of the dye to be present in the leaves of either *E. Consideniana* or of *E. Muelleriana.*

Five different distillations of oil, from four trees of widely varying ages, were examined, and the results are given in Tables I. and II. Nos. I., II. and III. are from trees growing within a quarter of a mile of one another between Eltham and Greensborough. No. IV. was taken from a tree on similar country between Lilydale and Evelyn.

The differences in percentage yield are very marked, but are in accord with the variations in this respect observed in several species.

The optical rotation, however, also shows considerable fluctuations from tree to tree: the chemical significance of this variable rotation is not quite clear, owing to the impossibility of accurately determining the amount of phellandrene present. It has been suggested that the optical rotatory power of *l*-phellandrene is not a constant.

Chemical tests showed that the oil consisted mainly of phellandrene and aromadendrene with about ten per cent. of eucalyptol and small amounts of aromadendral.

TABLE I.

PHYSICAL CONSTANTS OF OILS FROM THE LEAVES OF *Eucalyptus Consideniana.*

	Approx. Age of tree.	Date of distillation.	Percentage yield.	Volumes 80 per cent. alcohol dissolving one volume oil.	Specific gravity.	Optical rotation.	Refractive index.
Ia.	20-30 years	July, 1911	0.55	insoluble	.876	− 44.0°	1.4795
Ib.	,, ,,	Oct., ,,	0.50	insoluble	.871	− 49.4°	1.4790
II.	70-100 years	Sept., ,,	0.65	1 vol.	.885	− 36.5°	1.4790
III.	100-150 years	Oct., ,,	1 05	2 vols.	.896	− 23.5°	1.4837
IV.	50-70 years	July, ,,	0.20	1¼ vols.	.905	− 17.3°	1.4804

TABLE II.

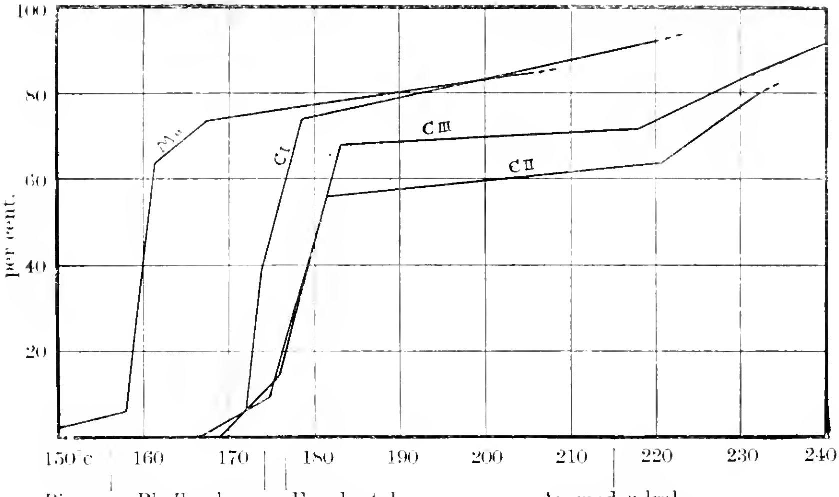
CHEMICAL PROPERTIES OF OILS FROM THE LEAVES OF *Eucalyytus Censideniana.*

	Eucalyptol.	Alcohol.	Volatile aldehydes.	Higher aldehydes.	Esters.
Ia.	8.7 / 9.6	.88 / .83	1.7	1.4	2.7
Ib.				—	1.2
II.	2.51 / 2.50	2.6 / 2.1	2.3		4.5
III.	7.5	—	0.5	—	1.6

We were unable to detect pinene or endesmol in any sample.

1. Smith, Journ. Chem. Soc. (1898), 73, 697.

Fig. II.



Mu = *E. Muelleriana*: C I., C II., C III. = *E. Consideniana*.

The distillation curves obtained for three of the oils examined are given in Fig. II., and will be seen to fall between those of the two classes of stringybark oils shown in Fig. I. There is undoubtedly a wide variation here, as well as in the optical rotation, partially, though not quite, bridging the gap between this species and others closely related.

It will be of interest to compare this variation of chemical characteristics with that shown by the carpels so largely used by morphologists as a basis for the classification of the eucalypts.

Of the carpels figured in Plate X., No. I. was forwarded to one of us by Mr. J. H. Maiden, as a type of the species occurring near Metung, Gippsland; it can be almost exactly matched by a carpel of *E. Sieberiana*: Nos. 2 – 9 were all collected from one single tree, that growing at Eltham, and from which oils Ia. and Ib. were distilled, and they also have been matched by carpels from eight different species as indicated. No. 10 grew on a Lilydale tree and the divergence exhibited in the chemical composition of the oil is seen to be more pronounced in the shape and size of the carpel, which closely resembles that of E. *macrorhyncha*.

Such a wide variation as we have found is not indicated in J. H. Maiden's description of the species, nor in the accurate and detailed field notes of Dr. Howitt, where he pictures the Yertchuk as he saw it in Gippsland. It may be noted that the latter describes the timber as being worthless for splitting; possibly the value put on the tree by woodmen around Eltham may be due to the dryness of the soil in that district.

Conclusion.

The composition of the oils and their physical constants, as tabulated, are not matched by the oil of any of those species examined by Baker and Smith that could possibly be regarded as similar to the Yertchuk. Hence from morphological characters of the buds, carpels, leaves, seedlings and bark, as well as from the characteristic oil distilled from the foliage, it is evident that these trees in the valley of the lower Yarra can only be included in the species *E. Consideniana;* for although they show considerable variations among themselves, they diverge still further from any other known species.

Mr. J. H. Maiden has included a very careful review of this species in his Critical Revision of the Eucalypts (Vol. I., p. 312), with accurate figures of the forms found in New South Wales, but for the reasons given we would venture to amend and amplify his description of the species, indicating our own alterations and additions by means of italics.

Description.

A tree of medium height, *varying from 20 to 60 feet.*

Bark.—Fibrous, resembling *Eucalyptus obliqua*, but softer, grey in colour on the outside, and *reddish inside (inner bark yellowish, like E. Muelleriana.).* Persisting up the trunk and main branches. *Small branches smooth; branchlets angular.*

Juvenile Leaves.—*Seedlings: Leaves opposite*, narrow-lanceolate, *soon becoming ovate and ovate-lanceolate to broad ovate-lanceolate, and acuminate; smooth or rough*, sessile and petiolate, varying from one inch to three inches in length, and one half-inch and more in breadth, *grey-green or sap-green in colour. Margins entire or undulate with small tufts of stellate hairs, stems reddish, warty glandular, ultimately smooth.*

Epicormic Shoots. *Leaves opposite, shortly petiolate, obtuse, ovate to broad ovate-acuminate, slightly oblique and falcate, and lanceolar-acuminate, often nearly straight, becoming alternate with longer petioles.*

Branchlets smooth, terete and angular. Intramarginal vein distinct, not far removed from the margin, with a second faint vein between the inner and outer margins.

Primary and sub-primary veins spreading and distinct.

Mature Leaves.—Alternate, petiolate, narrow to broad *lanceolate, straight or falcate, oblique and acuminate, firm in texture, with a hardened recurved point.*

Varying in length from 2 to 9 inches, and from ½ to 2½ inches in width: *erect, horizontal or drooping.* Colour equally green on both sides, dull or shiny, blue-green or a bright sap-green.

Veins strongly marked, and spreading; intramarginal vein, often looped, and *not far removed from the edge.*

Oil-dots numerous.

Buds.—*Numerous or few,* clavate, with *or without* pointed opercula. (*Some Southern forms are more "macrorhyncha"-like in the young state than the Eastern would appear to be*).

The pointed opercula less conspicuous when matured; young buds are provided with calyptra-like bracts.

Flowers.—*Inflorescence paniculated or axillary; panicles sometimes leafless. Stamens: White, uniform in length. Anthers reniform.*

Flowers honey scented.

Fruits.—*Very variable in size and shape: (three forms sometimes occurring in one umbel); pedunculate, pedicellate, or sessile, pedicels varying from 1 line to half-inch in length.* Pyriform, *pillular,* conical or *hemispherical.*

Rim usually reddish, smooth, broad, flat or slightly domed.

Valves, *one to five* sunken; the small deltoid points sometimes slightly exserted. *Umbels, solitary or paniculated, containing from 1 to 8 fruits, ¼ to ½ inch in diameter.*

Peduncles, slightly angular or flattened. Calyx tube tapering or suddenly contracted into the pedicel.

Timber.—Wood, pale-coloured, with kino rings, remarkably like that of the common Sydney Peppermint (*E. piperita*) or of the "Yellow Stringybark" (*E. Muelleriana*). *A durable timber, in demand for fencing, when growing in dry country.*

Oil from leaves.—*Specific gravity, 0.87 to 0.91; optical rotation —15° to—50°; refractive index, 1.479 to 1.480. It is usually,* *though not always, soluble in one or more volumes of 80 per cent. alcohol. It consists essentially of phellandrene with some aromadendrene and from 2.5 to 10 per cent. of eucalyptol.*

The leaves contain little or no myrticolorin.

II.—The Oil of Yellow "Stringybark" *(Eucalyptus Muelleriana).*

As it had been suggested that the Yertchuk trees described in the preceding section were forms of the yellow stringybark, it seemed desirable to make a direct comparison of their oils.

The oil of *E. Muelleriana* has not been described by Baker and Smith, nor does this species grow nearer to Melbourne than Southern Gippsland; but, by the courtesy of Mr. H. Mackay, Conservator of Forests, who has had a supply of the foliage collected for us at Yarram, we have been enabled to distil and examine the oil from the leaves of two trees, one mature and the other a sapling.

The oils from these two trees were almost identical except for an insignificant difference in colour (a brilliant greenish blue), although the yield from the mature foliage was twice as great as from the sapling.

This identity is a striking confirmation of the reliability of the composition of the oil as a specific characteristic.

The table of physical properties of these two samples and of other oils obtained from the ordinary or red stringybark (*E. macrorhyncha*),[1] still further illustrates this consistency.

TABLE III.

PHYSICAL CONSTANTS OF STRINGYBARK OILS.

	Locality.	Date.	Percentage yield.	Solubility in alcohol.	Specific gravity.	Optical rotation.	Refractive index.
E. Muelleriana—							
Sapling	Yarram	Nov., 1911	0.40	insoluble in 80 p.c.	0.887	+20	1.4735
Mature	,,	,,	0.80		0.884	+22°	1.4738
E. macrorhyncha—							
Mature	Eltham	Oct., 1911	0.11		0.923	6.5°	
,,	,,	Feb., 1912	0.11		0.914	±0	1.4923
,,	N.S.W.	*	0.27	soluble in 1¾ vols. 70%	0.929	±0°	1.4802

* Average results given by Baker and Smith.

1. In the case of *E. macrorhyncha* oils, the small yields obtained have rendered impossible their systematic chemical examination and fractional distillation, but their physical constants may be compared with the results given by Baker and Smith (Research on the Eucalypts, p. 115) for trees grown in New South Wales.

Photograph shewing variation of fruits of Eucalyptus Consideniana, and comparison with other species

E. pilularis ; E. Consideniana ; E. eugenioides.

E. Consideniana ; E. obliqua ; E. Muelleriana ; E. macrorhyncha.

Eucalyptus seedlings (about six months old).

Fractional Distillation of Oil of *E. Muelleriana.*

Fraction.	Percentage.	Refractive Index.	Optical Rotation.
155°—160°	30	1.4640	+ 21°.2
160°—161°	20	1.4640	+ 21°.6
161°—165°	20	1.4645	+ 19°.5
165°—190°	16	1.4675	+ 16°.3
190°—205°	8	1.4720	± 0°

The yellow stringybark oils consists mainly of dextropinene although phellandrene is also present, as may be seen from the graph of its fractional distillation (Fig. II.); this fact at once absolutely distinguishes it from *E. Consideniana*, which is chiefly composed of the laevo-rotatory phellandrene, and from *E. macrorhyncha*, which contains considerable amounts of eucalyptol and but little pinene.

Hence the chemical composition of the oils (also shown graphically by their distillation curves in Figs. I. and II.) places *E. Muelleriana* in one division of the "stringybarks" with *E. dextropinea*, *E. laevopinea* and *E. Wilkinsoniana*; whilst *E. macrorhyncha* is placed in the other main division with such species as *E. capitellata*, *E. eugenioides*, *E. piperita*, *E. obliqua* and *E. Delegatensis*.

E. Consideniana appears to be the only known representative of a division occupying an intermediate position.

[Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. I., 1912.]

Art. XVI.—*New or Little-known Victorian Fossils in the National Museum.*

Part XV.—Some Tertiary Gasteropoda.

By FREDERICK CHAPMAN, A.L.S., etc.
(National Museum, Melbourne).

(With Plates XII and XIII.).

[Read 11th July, 1912].

Introductory Remarks.

Seven species of gasteropoda are herein discussed, four of which are new, viz., *Astralium (Imperator), undosum, Homalaxis praemeridionalis, Cypraea gabrieli* and *Pleurotoma sayceana.* The species of *Astralium* is distinctly Australian in character, showing affinities both with the New Zealand living *A. heliotropium* and the Table Cape fossil *A. hudsonianum*, and is older than the last-named fossil species. One of the chief points of interest in regard to the occurrence of *Homalaxis* is that the genus should be discovered in strata in the Southern Hemisphere, nearly as old (i.e., oligocene) as that of its first known fossil horizon (middle eocene) of Europe. It is an extremely rare and beautiful form, and the present species shows close affinity with that lately dredged up from the coast of New South Wales. To the group of giant cowries, centreing around *Cypraea gigas,* belongs the species now described as *C. gabrieli.* The contused surface is highly interesting, and suggests affinities with *C. contusa,* which ranges from balcombian to janjukian (oligocene to miocene). *Pleurotoma sayceana* is allied in some respects to several members of the genus now found living, generally in warmer seas adjacent to Australia.

Of the three previously described species, one, *Acmaea octoradiata* is described as a fossil for the first time, whilst the two remaining species, *Turbo etheridgei* and *T. atkinsoni* are recorded from localities other than Table Cape, to which they seemed restricted, but from the same janjukian horizon.

Fam. Patellidae.

Genus Acmaea, Eschscholtz.

Acmaea octoradiata, Hutton sp. (Plate XII., Figs. 1, 2.)

Patella octoradiata, Hutton, 1873, Cat. Mar., Moll., N. Zealand, p. 44, No. 201. *Acmaea saccharina*, var. *perplexa*, Pilsbry, 1891, Man., Conch., vol. XIII., p. 50, pl. XXXVI., figs. 69-71. *Patella perplexa*, Pilsbry, Pritchard and Gatliff, 1903, Proc. Roy. Soc., Vict., vol. XV. (N.S.), pt. I., p. 194. *Acmaea octoradiata*, Hutton sp., Hedley, 1904, Proc. Linn. Soc., N.S. Wales, vol. XXIX., pt. I., No. 113, p. 188. Pritchard and Gatliff, 1905, Proc. Roy. Soc., Vict., vol. XVIII. (N.S.), p. 65. Verco, 1906, Trans. Roy. Soc., S. Austr., vol. XXX., p. 209.

Observations.—The present record is the first occurrence of this species in the fossil state. It is of great interest to find it so low down as the janjukian, to which stage I refer the fossiliferous ironstone of the Flemington Railway cutting. Although the fossils are in the form of casts, the moulds retain very faithful impressions of the external surface of the shell, which can be examined positively by means of a wax squeeze. The internal cast in ironstone also exhibits concentric markings and internal marginal band, characteristic of *Acmaea*.

In Hall and Pritchard's list of Flemington fossils "*Acmaea* sp. aff. *A. costata*" [Sow.], is cited, but that form has a larger number of radial ribs than the present one.[1]

Acmaea octoradiata as a living species has the following distribution:—West Coast of the South Island, New Zealand; Port Phillip, Victoria; Port Jackson (Maroubra Bay), New South Wales.

Occurrence.—Tertiary; janjukian series. Ironstone beds at the Flemington Railway cutting, Melbourne. Specimens collected and presented by Mr. J. Sidney Green.

Fam. Turbinidae.

Genus Astralium, Link.

Sub-genus Imperator, Montfort.

Astralium (Imperator) undosum, sp. nov. (Plate XII., Fig. 3.)

Description.—Shell moderately large, trochoid, somewhat depressed, with an apical angle of 120°; earliest stage of shell nearly smooth, followed by three moderately inflated whorls. Periphery, when perfect, bearing 10 flattened, spinose processes. Surface of shell-whorls ornamented with fine, transverse, undulating wrinkles, which tend to become tubercles at the junction with the sutural lines. Surface of spines relieved by fine, curved striae pointing anteriorly. Inner area of whorl gently inflated, flat at the sutures, and depressed to form a keel around the external margin. The tracery on the spines of the inner whorls barely covered up by the successive turns of the shell, and seen on the external border of the inner whorls. Base of shell concealed by matrix.

1 Proc. Roy. Soc. Vict., vol. ix. (n.s.), 1897, p. 209.

Dimensions. Height from base of the spines, 9 mm.; greatest breadth, to extremities of spines, 34.5 mm.; breadth of last whorl, 10.25 mm.

Observations.—This handsome shell is closely allied both to *Astralium (Imperator) heliotropium*, Martyn (= *imperiale*, Chemnitz)[1] found living round New Zealand; and the janjukian species from Table Cape, Tasmania, *A.* (*I.*) *hudsonianum*, Johnston sp.[2] From the living species the present form differs in having fewer spines, and in the absence of the centrifugally striate surface, excepting to a partial extent on the spines alone. The other. fossil form, from Table Cape, is a heavier and stouter shell with a large number of spines and strongly centrifugal ornament as in *A.* (*Imp.*) *heliotropium*.

Occurrence.—Teritiary; balcombian series. In the blue clays of the Altona Bay Coal-shaft. Coll. by Mr. J. S. Green.

Genus Turbo, Linnaeus.

Turbo etheridgei, Tenison Woods.

Turbo etheridgei, Tenison Woods, 1877, Proc. Roy. Soc., Tasmania, for 1876, p. 98 .

Observations.—This hitherto restricted Table Cape fossil has now occurred in the Flemington tertiary ironstone beds. This record forms an additional and valuable piece of evidence as to the age of these beds, which have hitherto been regarded by some authorities as balcombian, but which, from the prevalence of restricted species of the janjukian fauna, the writer would relegate to the latter horizon.

Occurrence.—Tertiary; janjukian series. Ironstone beds at Flemington Railway cutting, Melbourne. A mould of the shell. Presented by Mr. H. Ford, Station Master, Flemington Bridge Railway Station.

Turbo atkinsoni, Pritchard.

Turbo atkinsoni, Pritchard, 1896, Proc. Roy. Soc., Vict., vol. VIII. (N.S.), p. 118, pl. III., fig. 12.

Observations.—Both the above and the present species are found at Table Cape. A comparatively long series in the Dennant collection shows all gradations, from a shell with stepped whorls to that with straight sides. The chief distinctions of *T. atkinsoni* are the even contour and the broad, sub-carinate base. In the National Museum collection there is a specimen of this subspecific form in

1 Martyn, Con. Icon., 1784, fig. 30. Tryon, Man. Conch., vol. x., 1888, p. 228, pl. lvi., fig. 87.

2 Geol. of Tasmania, 1888, pl. xxix., figs. 12, 12*a* (figures only). Described by G. B. Pritchard, Proc. Roy. Soc. Vict., vol. viii. (n.s.), 1896, p. 116, under the name of *Astralium (Imperator) johnstoni*.

its typical aspect, as described by Dr. Pritchard, from Torquay, Victoria. That locality, although in the same geological stage as the Table Cape beds, is a new one for the above form, since it has hitherto been restricted to the latter place.

Occurrence.—Tertiary; janjukian. Bird Rock Cliffs, Torquay. Coll. by the late Mr. J. F. Bailey.

Fam. SOLARIIDAE.

Genus **Homalaxis**, Deshayes.

Homalaxis praemeridionalis, sp. nov. (Plate XII., Figs. 1-6.)

Description.—Shell small, compressed, subcircular; flat above, rather deeply concave below, side hollow. Protoconch smooth, inflated, consisting of about one turn; remainder of shell consisting of three whorls. Shell, as seen from above, nearly flat, only very slightly concave in the last whorl; bordered externally with a beaded or nodulose margin, whilst from each nodule there proceeds a thin raised thread normal to the margin. Median surface of whorl relieved by a strong but narrow, nodulose raised band, which appears submarginal by the involution of the earlier whorls; general surface finely spirally striate and crossed at right angles by the excessively fine growth-lines, producing a micro-cancellate ornament. Peripheral area stepped below the inner half of the whorl. As seen from below, whorls angulately convex, with a median, raised nodulose band, and several fine, spiral striae parallel to the margin; these are crossed by fine lines of growth; the median band on the inner whorls submarginal in relation to the successive turns of the shell. Mouth subcircular, slightly elongated in the direction of the long axis of shell; the peripheral border and the outer median band standing out in the oral aspect as two strong, salient beaded carinae.

Dimensions.—Major axis, 6.25 mm.; minor axis, 5.5 mm.; height, 1.75 mm.

Observations.—This handsome species represents the first recorded occurrence of the genus as an Australian tertiary fossil. Mr. Chas. Hedley has described and figured a recent species under the name of *Omalaxis meridionalis*,[1] from Port Stephens and off Cape Three Points, New South Wales, 49-50 fathoms ("Thetis"). Several species of this genus were described and figured by Deshayes (under the generic name of *Bifrontia*) from the middle eocene of the Paris Basin,[2] but none has the same type of ornament as the Australian shells, either recent or fossil.

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1 Mem. Austr. Mus., vol. iv., pt. 6, 1903, p. 350, fig. 74.

2 Deshayes, Descr. Coq. Foss. Env. Paris, vol. ii., 1824, pp. 222-7, pl. xxvi., figs. 15-25.

Occurrence.—Tertiary; balcombian series. From the blue clays of the deeper part of the Altona Bay Coal-shaft. Collected and presented by Mr. J. S. Green.

Fam. CYPRAEIDAE.

Genus Cypraea, Linnaeus.

Cypraea gabrieli, sp. nov. (Plate XIII.)

Description.—Shell very large. Seen from above, sub-oval; anterior wide and blunt, posterior acuminate. Seen from the side, back very gibbous, with a steep face on the apical end, and sloping more gradually to the posterior. Spire partly concealed, situated in a depression. Base flatttened, oval; inner lip rounded (somewhat crushed in specimen), smooth within, flattened towards the anterior canal, and terminating in a projecting flange; outer lip rather narrow, fairly smooth, but showing about 6 transverse undulations in the median and posterior area, representing the bases of undeveloped or obtuse teeth. Surface covered with a thin brown enamel which is conspicuously contused all over the shell, appearing as a polygonal system of depressions, fairly regular in size and averaging about 5 mm. across. The underlying shell also bears contused markings, but not so prominently.

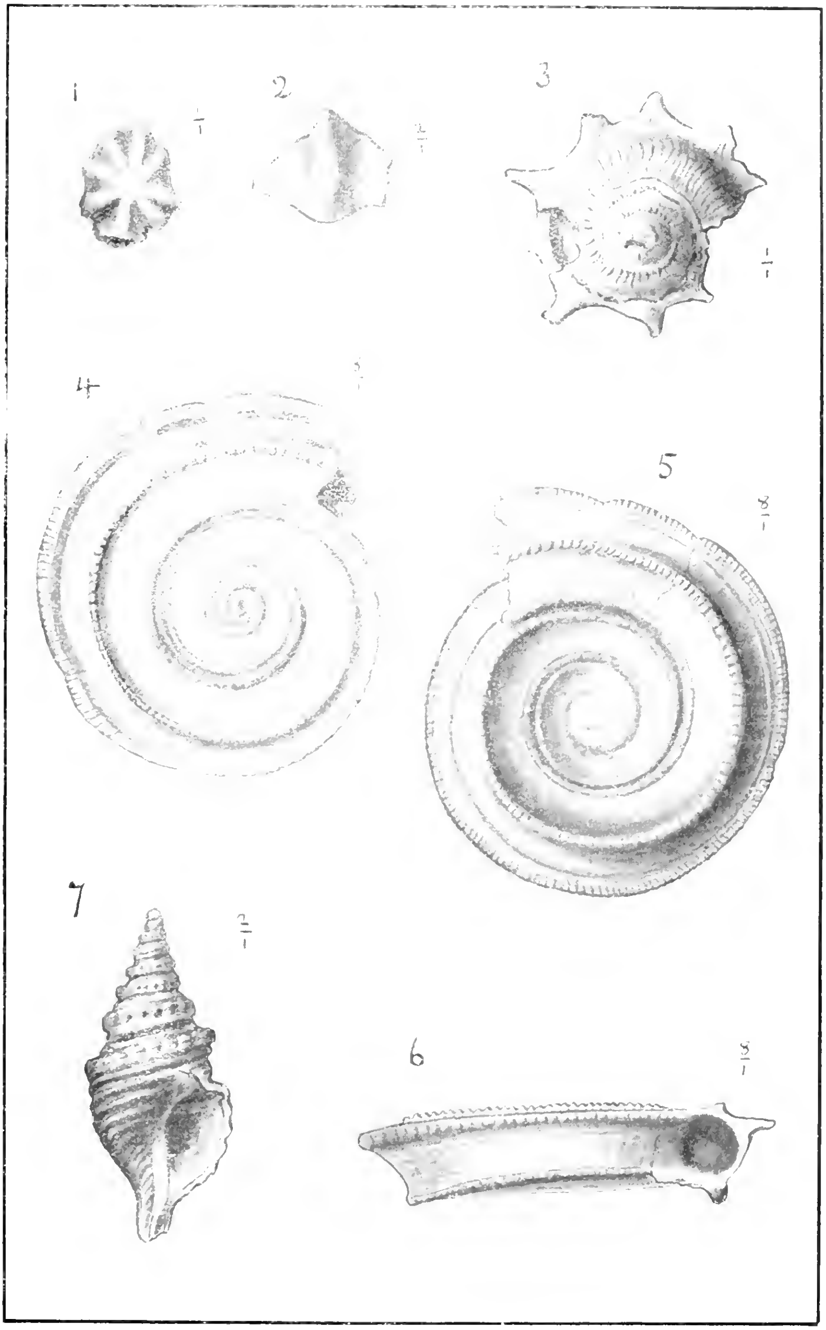
Dimensions.—Length, 136.5 mm.; width, 101.5 mm.; height (base to vertex), 75 mm.; greatest diameter of depressed apical area, 23 mm.; width of middle of mouth, 9.25 mm.; width near posterior end, 11.25 mm.

Observations.—This large and handsome cowry is nearest to *Cypraea contusa*, McCoy,[1] both in general form and in the contused ornament. It is, however, of much larger dimensions, being more than four times as long, and differs in having a broad, flattened anterior with sunken spire, and a flatter base or oral surface.

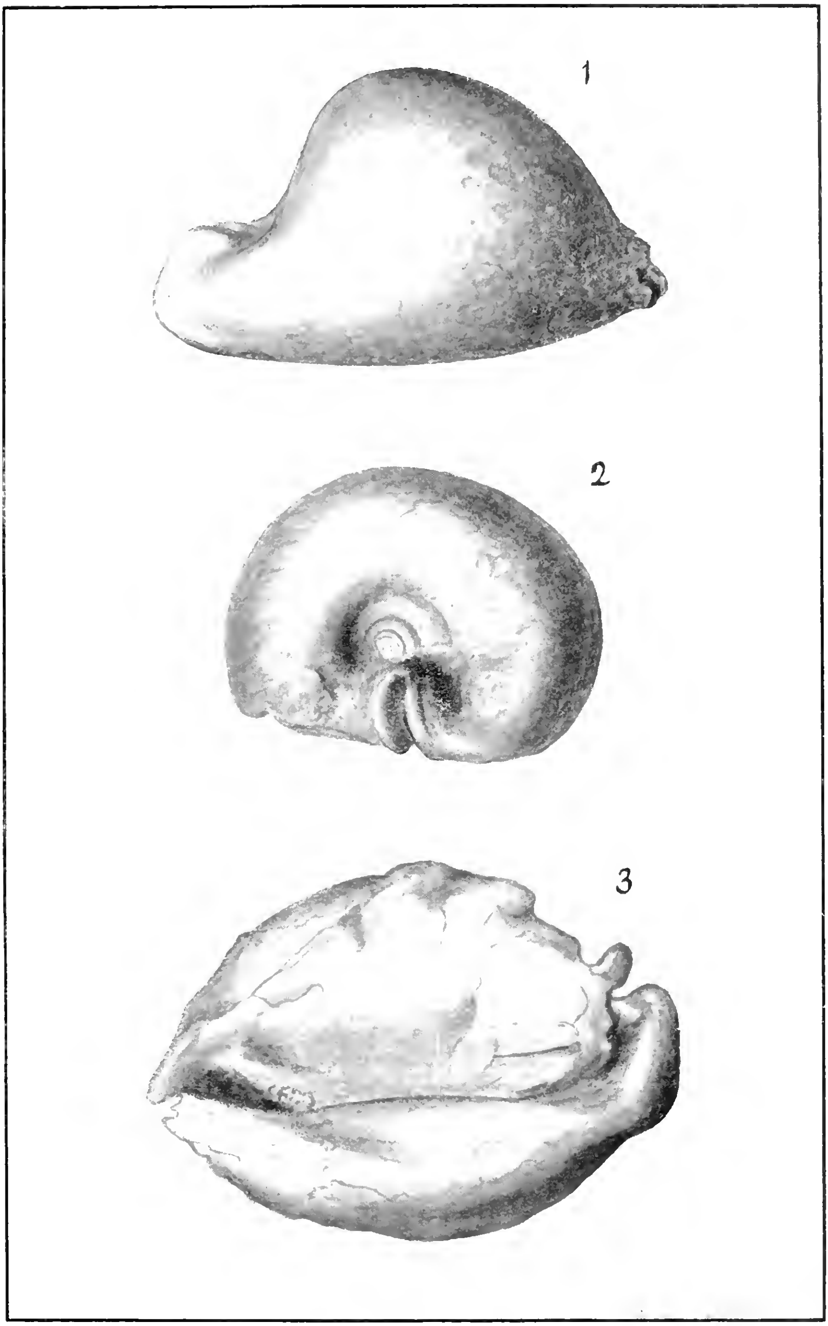
Amongst the giant cowries it is shaped more like *C. dorsata*, Tate,[2] than *C. gigas*, McCoy,[3] being shorter and more tumid than the latter. It is very distinct, however, even from *C. dorsata* in the steepness of the apical face, in which the spire is deeply immersed.

Occurrence.—Janjukian series; Bird Rock Cliffs, Torquay, Vict. Collected and presented by Mr. C. J. Gabriel, after whom the species is named.[4]

1. Prod. Pal. Vict., dec. v, 1877, p. 38, pl. xlix., figs. 3, 4.
2. Trans. Roy. Soc. S. Austr., vol. xiii., 1890, pt. ii., p. 212; pl. x., fig. 4; pl. xi., fig. 6.
3. Prod. Pal. Vict., dec. ii, 1875, p. 19, pl. xv.; pl. xvi., fig. 2; pls. xvii. and xviii., fig. 1 Ibid., dec. iii, 1876, p. 35, pls. xxviii. and xxix., fig. 1.
4. Mr. Gabriel is to be congratulated on the complete success of his endeavour to secure this large specimen, as he was armed only with a pocket-knife. The shell was very badly impregnated with salt from the sea-spray, but by slowly drying and sizing the specimen it has been saved from the rapid disintegration that was going on when obtained.



F.C. ad nat. del. Victorian Tertiary Gasteropoda.



F.C. ad nat. del. Reduced to one-half.

Cypraea Gabrieli, sp. nov. Tertiary: Victoria.

Fam. PLEUROTOMIDAE.

Genus **Pleurotoma**, Lamarck.

Pleurotoma sayceana (Tate M.S.[1]), sp. nov. (Plate XII., Fig. 7.)

Description.—Shell of moderate dimensions, pyramidally ovate; body whorl approximately equal in length to the spire. Protoconch large, consisting of two and a half smooth, inflated whorls, followed by six angulate whorls, with well marked sutures; also a median nodulose keel medially grooved, below which are one or two strong, spiral threads. Last whorl with five rounded, spiral ridges interlineated with fine, secondary lirae. The whole shell surface finely, longitudinally costated with growth-lines. Aperture of medium size, rather broad, pyriform; outer margin arcuate; sinus shallow, situated just below the suture; columellar margin smooth, slightly twisted in front; anterior canal short.

Dimensions.—Length, 22 mm.; greatest width, 9.25 mm.; width of aperture, 4 mm.

Observations.—The nearest species to the above in fossiliferous deposits seems to be the pliocene species *Pleurotoma tuberculata*, Kirk,[2] from Petane, N. Zealand. That shell, however, is more fusiform, the carinal tubercles not grooved, and the aperture proportionally broader. A living Australian species, also nearly allied to the present one, but differing in some important particulars, is *Pleurotoma armillata*, Reeve.[3] This form has a large and deep sinus, the keel more numerously beaded, and it is altogether a smaller and lighter shell.

EXPLANATION OF PLATES.

PLATE XII.

Fig. 1.—*Acmaea octoradiata*, Hutton. Cast of inside of shell in ironstone. Tertiary; janjukian, Nat. size.

Fig. 2.—*A. octoradiata*, Hutton. A cast in wax of the internal mould of the ironstone fossil, showing external ornament. × 2.

Fig. 3.—*Astralium (Imperator) undosum*, sp. nov. Superior aspect of shell. Tertiary; Balcombian. Altona Bay Coal-shaft. Holotype. Nat. size.

1. This species was appropriately designated in M.S. by Prof. R. Tate (see this journal, vol. iii., 1891, p. 57—*Surcula Sayceana*) in honour of the late Mr. O. A. Sayce, A.L.S., who collected amongst the fossils shells in company with Prof. Tate and others in the Gippsland Lakes district.

2. Trans. N. Zealand Inst., vol. xiv., p. 409. Hutton, Macleay Mem. Vol., Linn. Soc. N. S. Wales, 1893, p. 50, pl. vi., fig. 29.

3. Reeve, Iconographia, 1843, vol. i., fig. 176.

Fig. 4.—*Homalaxis praemeridionalis*, sp. nov. Superior aspect of shell. Tertiary; Balcombian. Altona Bay Coal-shaft. Holotype. × 8.

Fig. 5.—*H. praemeridionalis*, sp. nov. Inferior aspect of same shell. × 8.

Fig. 6.—*H. praemeridionalis*, sp. nov. Oral aspect of same shell × 8.

Fig. 7.—*Drillia sayceana*, sp. nov. Tertiary; Kalimnan. Lakes Entrance. Holotype (Dennant coll.). Ventral aspect of shell. × 2.

Plate XIII.

Fig. 1.—*Cypraea gabrieli*, sp. nov. Lateral aspect. Tertiary; janjukian. Bird Rock Cliffs, Torquay. Holotype. Reduced to one-half the diameter.

Fig. 2.—*C. gabrieli*, sp. nov. Anterior aspect. Reduced one-half.

Fig 3.—*C gabrieli*, sp. nov. Oral aspect. Reduced one-half.

Corrigendum.

In Part XIV. of this series, vol. XXIV., pt. II., 1912, p. 300, line 7 from the bottom of page, for "Plesiotype" read "Paratype."

END OF VOLUME XXV., PART I.

[Published August, 1912].

Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. II., 1912.

Art. XVII.—*On the Cross Inoculation of the Root Tubercle Bacteria upon the Native and the Cultivated Leguminosae.*

Preliminary Communication

By

A. J. EWART, D.Sc., Ph.D., F.L.S.
(Professor of Botany and Plant Physiology in the University of Melbourne),

and

NORMAN THOMSON, B.Ag.Sc.
(Government Research Bursar, Melbourne University).

(With Plate XIV.).

Read 8th August, 1912.

Introduction.

If the roots of any leguminous plant are examined, there will always be found certain little round growths attached to them; these are known as nodules or tubercles, and contain countless numbers of bacteria. It is calculated that one such tubercle of an average size (that of a match-head) would contain from 100 to 1000 million bacteria.

It has been found that the growth of any leguminous crop sown in certain new sandy or heathy ground, will receive a decided impetus if soil from a field in which this same crop has been recently grown is scattered over it, either before or after sowing. This is due to the introduction of this bacterium *Bacillus radicicola* (Beyerinck) present in the soil, which causes the formation of the nodules upon the roots, entry into which is gained through the root hairs. In these nodules the bacteria exercise their power of fixing free nitrogen from the air, and passing it on to host plants in forms it can utilise as nitrogenous food supplies.

The Problem.

There is a difference of opinion as to whether inoculation can be carried out on any one plant by the bacteria from the tubercles of that plant only, or from any other plant of the same genus, or indeed, from any cultivated legume at all. The point of special local interest was to determine whether the bacteria from the root nodules of native leguminosae were able to directly infect the leguminosae (lucerne, peas, clover, beans etc.), not native to Victoria, but commonly cultivated.

In the many papers published upon this subject, there has been mention of little work in connection with legumes other than those cultivated, and none which could be regarded as affording a complete and final answer to this question. Nobbe and Hiltner[1] had at different times been able to inoculate the bean plant with bacteria present in the nodules from peas, and Dr. Moore[2] had also successfully carried out cross inoculation on some cultivated legumes.

Its Bearing on Economic Agriculture.—However, since nothing of a definite nature had been done with the native legumes of any country, it seemed worth while carrying out experiments with the better known and more widely spread legumes of this State, and to settle, if possible, the question whether the bacteria from various wild and cultivated plants were all alike as regards their power of cross infection, or whether biological races of the root nodule bacteria existed, each capable of infecting either one plant only or a few plants of similar physiological character. In particular, the question whether the same common and widely spread bacteria, which live upon and enrich such native plants, as for instance *Acacia*, were capable of living in symbiosis with the commoner cultivated members of this order, had an important bearing on agriculture, particularly in regard to the practice to be adopted in opening new ground to cultivation. For instance, if all the root nodule bacteria are capable of direct cross infection, then virgin country, whose flora comprise such plants as *Acacia*, *Swainsona*, *Platylobium*, etc., will, on being cleared, and given over to the cultivation of peas, lucerne, clover, or any other such crops, possess in the soil their necessary adjuncts, the nodule bacteria, which on entering into symbiotic union would cause a more luxurious growth than could otherwise be possible, and without the use of heavy dressings of nitrogenous manures. On the other hand, if the bacteria from native legumes were unable to infect cultivated ones, they must be introduced into the soil in some way, preferably by the means already mentioned.

1 Nobbe. Versuchsst. 1894. Bd. xlv., p. 155.
Nobbe and Hiltner. Centbl. Bakt. u. Par. 2, Abt. 6 (1900), No. 14, pp. 449-457, pl. 1.

2 Dr. G. T. Moore. Inoculation of Soil for Leguminosae. United States Bur. Pl. Ind., 17, 1905.

Method of Attacking the Problem.—Eight of the more important members of the Leguminosae were taken, viz. :—

1. Broad Bean ... ... Vicia Faba.
2. Kidney Bean ... ... Phaseolus vulgaris.
3. Field Pea ... ... Pisum sativum.
4. Soy Bean ... ... Glycine hispida.
5. Lucerne ... ... Medicago sativa.
6. Black Medick ... ... Medicago lupulina.
7. Red Clover ... ... Trifolium pratense.
8. Hairy Vetch ... Vicia villosa.

For cross inoculation purposes, the following plants were chosen :—

1.	Acacia mollissima	Mimosae.
2.	Platylobium obtusangulum ...	Papilionaceae.
3.	Swainsona galegifolia	
4.	Aotus villosa	
5.	Bossiaea cinerea	

Arrangement of Series of Pots.—According to Hiltner and Stormer[1], if pot experiments were to be carried out, inoculation by nodule contents was the best way; but for field work, inoculation by pure cultures of the bacteria yielded the best results. Since it was only possible to keep everything sterile in pot experiments, the eight different kinds of seeds were planted in pots, and each series was inoculated by the bacteria from a different native legume, thus giving five series, a sixth being planted uninoculated, and comprising a control, a total of 48 pot plants being used for each experiment.

As the risk of contamination and outside infection must be completely overcome, everything before use was thoroughly sterilised.

Method of Sterilisation and Precautions.—The pots before sowing were placed in the steamer and kept at boiling point for 2 hours, 2 days later being resubjected to the same treatment; this would effectively get rid of any foreign root tubercle bacteria that might be present. The seeds were well washed for a few minutes in a 2 per cent. solution of formaldehyde, and then several times in boiled water. This treatment seemed effective enough, yet Harrison and Barlow[2] (Canadian investigators) say that the various methods of sterilisation are of no avail in removing the living bacteria from the living seeds; and, in fact, in two cases with clover plants nodules appeared whose origin was difficult to explain except on the

1 L. Hiltner and K. Störmer. Berlin, Arb. biol. Abth. Gesundhtsamt, 3, 1903 (151-307, 445-545).

2 F. C. Harrison and B. Barlow. The nodule organism of the Leguminosae, its isolation and cultivation, identification and commercial application. (Pseudomonas radicicola). Canada, 1907.

assumption that they might have been caused by bacteria remaining on the seed after ineffective sterilisation. Boiled water was used in all cases, and all jars and beakers were placed in boiling water before use to ensure perfect sterilisation and pure inoculation for each series.

Manner of Infection and Sowing.—To infect the seeds, an infusion in water was made of the contents of the nodules from each of the chosen legumes. The nodules were washed thoroughly in sterilised water many times, no disinfecting agent being used for fear of killing the bacteria; they were then crushed up in water, and the seeds before sowing were soaked in this bacterial infusion, each series, of course, in its own inoculating material. After

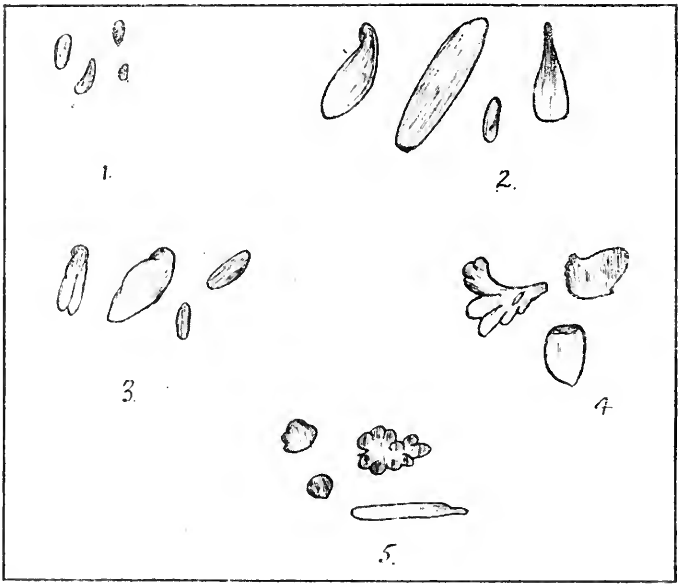


FIG I.—LIFE-SIZE DRAWINGS OF NODULES

1. Platylobium nodules .. 2-4 mm. x 1-2 mm. Colour dark brown, white towards one end. Oval shape.
2. Aotus .. .. 6-20 mm. x 2-5 mm. Light brown colour. Very elongated, though regular shape.
3. Bossiaea .. .. 5-12 mm. x 2-4 mm. Creamy brown, and regular oval shape.
4. Acacia .. .. 6-10 mm. x 4-5 mm. Light brown one end, white the other. Irregular rounded and oval.
5. Swainsona ,, ... 3-20 mm. x 2-3 mm. Brown and white, and very irregular shape, somewhat elongate. Many grouped in bunches.

sowing, each infusion was diluted with the boiled water, and portion of it used to water the pots, the remainder being further diluted and used for three subsequent waterings spread over four or five days, so that in this way, the bacteria were brought into intimate contact with the seeds and young roots.

Possible results of Cross-Inoculation.—The nodules from the various plants showed great differences in size, form and colour, each kind being easy of recognition. If nodule growth on the plants followed inoculation, then it seemed feasible that the size and shape of the mother nodule should be reproduced in the nodules formed upon the roots of the inoculated host plant.

By microscopic examination it was noticed that there were distinct differences in shape and size between the bacteria from the different native legumes, and that the root nodule bacteria from native plants, were much larger than those examined from the nodules of clover and lucerne.

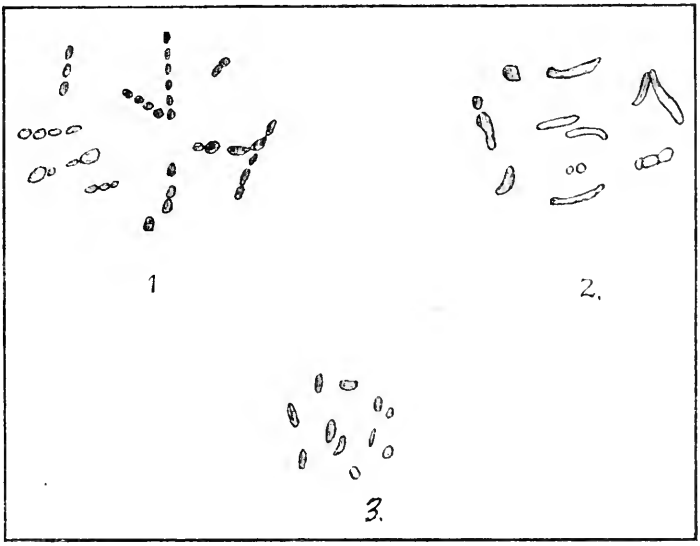


FIG. II.—DRAWINGS OF BACTERIA FROM NODULES OF THREE DIFFERENT NATIVE LEGUMINOSAE (× 690).

1. *Platylobium* nodule bacteria. Congregate in chains, and are small round bacteria.
2. *Acacia* nodule bacteria. Curved rods of varying length, rounded ends. Longer than *Platylobium*
3. *Swainsona* nodule bacteria. Bacteria found singly: short and stumpy, but of regular size.

If the cross-inoculation were successful, it would be interesting to see whether the nodules produced upon the infected plant were not only the same externally, i.e., in size and colour, as those on the infecting plant, but also internally; whether the histology and anatomy were the same, the cells, the cork tissue, the vascular bundles, the bacteria containing cells, etc., were identical in each. If this were so, one would expect the bacteria in the nodules produced upon the roots of clover inoculated with acacia nodule bacteria, the clover bacteria being smaller than the latter, to be of a similar size and shape to the acacia bacteria and of similar physiological and biological characters.

Actual results in tabular form.—The experiments were tried twice, extending over a period of seven months, November, 1911, to June, 1912. After sowing, the plants were allowed varying periods of growth before examination, from seven weeks in the case of most to four months in that of clover and lucerne in the first experiment.

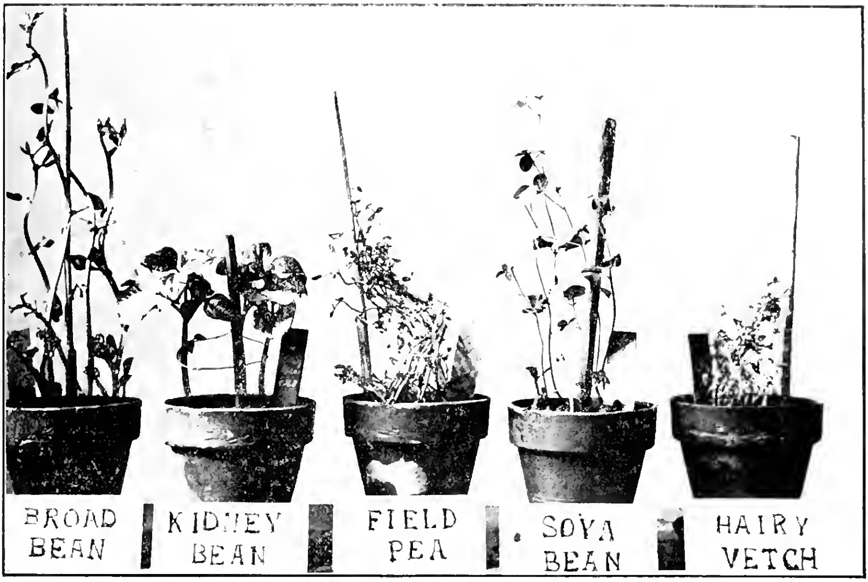
Photographs were taken of the five most forward plants in two series, that uninoculated and the one inoculated with root nodule bacteria from *Platylobium* six weeks after sowing. Although the results show that no nodules were present on the roots of the inoculated series of plants, yet they showed a more decided growth, and were larger and stronger. Whether this was due to the root nodule bacteria continuing to live in the soil and fix nitrogen outside the plants they were unable to infect, is an open question (See Plate XIV.)

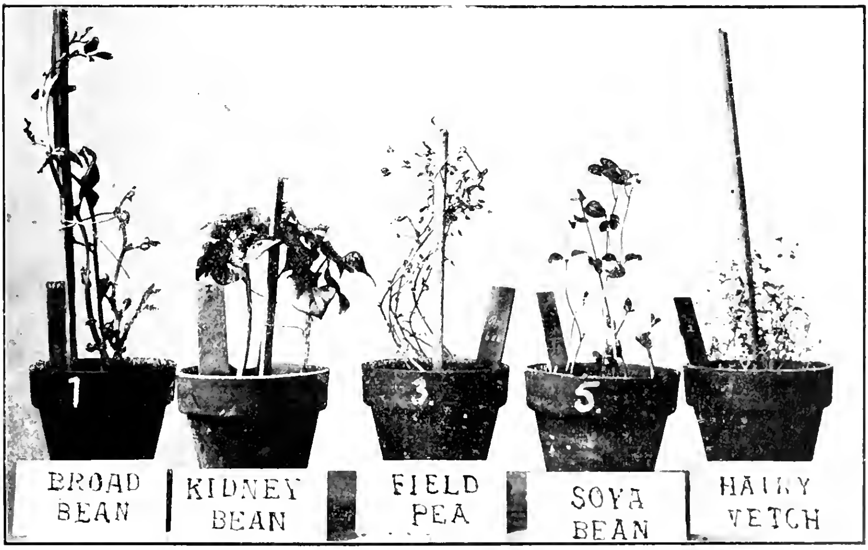
The results may be shown in the following table:—

ROOT TUBERCLES DEVELOPED AFTER INOCULATION WITH BACTERIA TAKEN FROM NATIVE LEGUMES, AS UNDER.

Cultivated Legumes.	Acacia. 1st.	Acacia. 2nd.	Platylobium. 1st.	Platylobium. 2nd.	Swainsona. 1st.	Swainsona. 2nd.	Aotus. 2nd.	Bossiaea. 2nd.	Uninoculated. 1st.	Uninoculated. 2nd.
1. Broad Bean	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
2. Kidney Bean	nil	nil	nil	nil	nil	nil	nil	nil	nit	nil
3. Pea	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
4. Soy Bean	nil	nil	nil	died	nil	died	died	died	nil	died
5. Lucerne	nil	nil	died	nil	died	nil	nil	nil	nil	nil
6. Black Medick	nil	nil	nil	nil	nil	died	nil	nil	died	nil
7. Clover	2	nil	nil	nil	nil	nil	nil	nil	several	nil
8. Vetch	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil

The above table shows that of 80 different lots of plants that were sown, on only two of these, clovers, were nodules found. The uninoculated clover possessed many nodules, and microscopic examination showed these to be packed with bacteria of the usual kind. It is possible that in this case and in the clover infected by


BROAD BEAN
KIDNEY BEAN
FIELD PEA
SOYA BEAN
HAIRY VETCH


1
3
5
BROAD BEAN
KIDNEY BEAN
FIELD PEA
SOYA BEAN
HAIRY VETCH

the root nodule bacteria from acacia, the nodules were derived from clover bacteria adhering to the surface of the small clover seeds and not removed in the process of sterilisation. With this exception all the other results showed that no direct cross inoculation is possible between native and introduced leguminous plants.

Discussion.

The reason for this might be that the bacteria, when taken directly from a particular root nodule, were biologically adapted to the special nutritive conditions peculiar to the given plant, and thus might be unable to directly adapt themselves to a new host plant. If, however, the bacteria were transferred to sterilised soil and allowed to live there, or grown on artificial non-living media as a saprophyte for some months, the special nutritive adaptation in the course of repeated generations might gradually merge into a more generalised condition, so that it could inoculate a plant further and further away either systematically or in physiological condition, the longer it remained in the soil. Ultimately, the soil might contain bacteria capable of infecting any or all leguminous plants, from whatever host they might have been derived.

In the above case, the bacterial contents were used to inoculate the cultivated legumes, and so their specialised nature prevented inoculation with plants presenting dissimilar biological and nutritive conditions. According to Buhlert[1], all nodule organisms are forms of *Bacillus radicicola*, but the bacteria best adapted for inoculating are those from the same host plant, and consequently, unless the nodule bacteria have become generalised in the soil, they are too specialised to infect other plants when used directly from the nodule.

That this is the correct explanation is indicated by the fact that in some cases difficulty was experienced in inoculating red clover and lucerne seedlings with bacteria taken directly from root tubercles of the same plants, namely, red clover and lucerne respectively. Apparently root tubercle bacteria taken directly from the living tubercle are apt to die out in sterilised soil or in water cultures, and will usually do so before they have become sufficiently generalised to be capable of infecting a foreign host plant.

On the other hand, when the bacteria from one plant are grown on nutrient gelatine media, they appear to rapidly develop more

1 H. Buhlert. Centralbl. Bakt., Jena Abt. 2, 9, 1202 (pp. 148-153, 226-240, 273-285, 892-895).

generalised infective powers. Thus, it was found possible to readily infect peas and to a less extent broad beans, grown both in water cultures and in sterilised soil, with bacteria from acacia tubercles, isolated and cultivated on nutrient gelatine. Peas and beans grown in water cultures inoculated with bacteria taken directly from acacia tubercles, failed to develop any root-tubercles except in one case where a pea developed a few tubercles after four months' growth, but after so great a length of time this might have been due to a secondary infection.

When a root-tubercle is dying, any still living nodule bacteria it contains will grow for a time as saprophytes, just as on an artificial medium, and hence may develop generalised nutritive properties, so that they are able to survive when set free in the soil by the decay of the tubercle, and ultimately to become capable of infecting other plants. In this way it is possible to understand how such plants as Alsike clover and peas may develop tubercles in abundance when grown in uninoculated soils, in which neither plant had grown for ten or more years[1]. How long the process of generalisation takes, what conditions favour or retard it, and how far it extends, are problems for future determination.

1 A. J. Ewart. Journ. of Agric. Vict., vol. viii., pp. 98-105, 1910.

Proc. Roy. Soc. Victoria, 25 (N.S.) Part II., 1912

Art. XVIII.—*Paralysis in Horses and in Cows due to the Ingestion of Fodder.*

By J. A. GILRUTH, D.V.Sc., M.R.C.V.S., F.R.S.E.

[Read 12th September, 1912].

For many years a form of progressive paralysis in cattle, evinced primarily by an inability to ingest food, associated with absence of rumination, more or less rapid emaciation and early death, has been recorded as prevalent in Victoria, South Australia, and even in certain districts of Tasmania.

Many articles have appeared in the lay and agricultural press dealing chiefly with the symptoms, the seasonable occurrence, the nature of the food supply, and, to some extent, the *post-mortem* appearances, but little systematic enquiry into the etiology seems to have been attempted.

So far as I am aware, the first accurate and scientific description of the disease was published in the "Australasian Farm and Home," in April, 1896, by my colleague, Dr. W. T. Kendall, and his account of the symptoms is so careful and concise, that no one having perused it could fail to recognise a typical case. Under the head of "*post-mortem* appearances," it is worthy of note that Dr. Kendall states regarding those cases he examined :—"The supposed impaction of the omasum or third stomach to which the mortality has been entirely attributed, did not exist."

Dr. S. S. Cameron, in Victoria, who gives in various articles a definite account of the symptoms, concludes that the condition is a paralysis of the 9th and 10th cranial nerve due either to some form of mould (fungus) poisoning or solely to the non-succulent and innutritious nature of the food supply, either of which he considers a useful hypothesis for future work. At a later date I understand he suggested the term "Impaction Paralysis," on account of the impaction of the rumen, which, in his experience, was almost invariably present. He appears to consider that the diseases known popularly as "Stomach Staggers," "Winton Disease," "Cripples," etc., are one and the same.

In South Australia Mr. J. Desmond has given much attention to the condition. (See report to the Hon. Minister for Agriculture, and Veterinary Journal, Vol. 66, No. 417, page 161.) In his first reports he also considered the disease due to impaction of the omasum and termed it "Dry Bible," but in his last report he claimed to have found the specific bacterium. A description of this organism, and details of his experiments, however, have never been published, hence they cannot be dealt with here.

Dr. Wilmot, in Tasmania, recently in a special report claimed that the disease is really the same as "Louping Ill" of sheep in Great Britain, but his evidence is, to say the least, very unsatisfactory.

Prior to joining the Melbourne University in 1909, I had naturally been aware of the existence of this disease, and hoped to have an early opportunity of observing definite cases, if not of making a thorough investigation of the whole condition. It was only, however, in the late summer months of 1911 that I was able to examine for myself definite cases in cattle, cases that everyone was agreed were typical, and this through the courtesy of Mr. Humm, G.M.V.C., Warrnambool.

During April, 1909, three cows were sent to me by the Department of Agriculture's officials, but none were typical. Indeed, some of those who had had considerable experience of this form of paralysis in cows considered they were not cases at all. One certainly suffered from acute broncho-pneumonia, and died within 36 hours after admission to the hospital, but the other two I now consider were affected with a mild form of the disease.

That the symptoms are frequently very indefinite is proved by the fact that many cases have been reported to me, by laymen chiefly, which proved on examination to be of quite a different nature to the disease under review. For example, one outbreak of pleuro-pneumonia was originally reported both to the Department of Agriculture and to myself, as a severe outbreak of this disease.

The paralysis of the horse, although due to the same cause as that of the cow, is of an entirely different character so far as the muscles affected are concerned.

The disease has been little observed in Victoria, judging by available literature, but in South Australia it appears to be fairly common, and often assumes the character of a severe endemic. It has been carefully studied by Mr. J. F. McEachran, M.R.C.V.S., who, both in correspondence and in consultation, has afforded me valuable information regarding the disease.

Until recently, and indeed until the experiments recorded later were being conducted, the connection between the disease in the cow and that in the horse was not suspected. This is not surprising when the symptoms are compared, especially in view of the fact that while occasionally on farms in South Australia the disease may occur in both cattle and horses, it more frequently happens that the one or the other class of animal is alone affected. Why this is so will, of course, be a matter for further investigation.

Though much has been written regarding the symptoms observed, especially in the cow, and to some extent in the horse, in this article I propose to confine myself to recording what I have personally observed and ascertained from owners of the affected stock.

Symptoms in Cow.

Usually the first symptom of illness observed by the dairyman is either a severe diminution, or almost complete cessation, of the milk supply in a cow which at the previous milking has yielded her normal quantity.

It is more than probable, however, that a careful observer might detect some symptom prior to this, especially if close attention were paid to the animal when feeding or at rest; but in any case, such abnormality is liable to be overlooked until the milk yield is affected. Even then other symptoms are by no means very definite. Rumination is often suspended, but this is not unusual in many cattle diseases. Often it is intermittent. The most definite and probably most characteristic symptom at this stage is a peculiar, slow and very persistent movement of the jaw, not the ordinary movement which occurs during either chewing food or cud, but a slow up and down movement, with little, and often no, lateral movement of the lower jaw. This movement seems to be almost involuntary; it will cease when the animal's attention is distracted, and is resumed again later on. The head is held somewhat straighter than normal, and this becomes more pronounced during the progress of the disease. The expression is peculiar, it may almost be termed wistful and enquiring. Inattentiveness to surroundings is observed, and the animal is generally seen apart from the herd. No attempt to eat or drink is made, but whether at this stage because the animal knows she can only chew and swallow, if at all, with difficulty, or through experience of ineffectual attempts, or through intuition, I have not been able to determine. There is, however, from the first, I think, but little appetite, though it may not have entirely disappeared. In the very mild cases, or cases which progress slowly, a little water may be swallowed, but with great difficulty. In one instance I observed a cow hold her mouth in a bucketful of water for ten minutes, and only succeed in drinking half the contents. On another occasion I observed a cow which we had driven into a waterhole, hold her mouth in the water for almost fifteen minutes. In both these cases some time elapsed before any liquid was swallowed, as observed by carefully watching the movements of the oesophagus, while but a small quantity was swallowed at a time, and at infrequent intervals.

From the beginning, prehension of food, even cut green fodder, is difficult, and soon becomes impossible, even though the animal may be obviously anxious to partake of the material. When it is possible to seize the food, mastication cannot be performed. An attempt is made to chew a blade of cabbage, a stalk of sow thistle, some green clover, or such material introduced into the mouth, but the process resembles more the action of a human being sucking a sweet than the normal mastication of a cow. The buccal muscles do not seem to come properly into action, and there appears to be inability to properly direct the tongue. During this attempt to masticate there is considerable salivation. Often such partially or very slightly chewed material which has been introduced into the mouth will be dropped, and if it is not, it rarely gets beyond the base of the tongue just in front of the velum. Indeed, in nearly all cases it has been observed by most writers that a quantity of partially chewed food is almost invariably found situated there on *post-mortem* examination. In two cattle dead of the disease, or what was probably the same disease in Tasmania, which I had an opportunity of examining *post-mortem* (although unfortunately dead nearly 48 hours), this plugging of the base of the tongue by food was very definite.

But the difficulty in swallowing does not cease here; it is evident that even the oesophagus is in a semi-paralysed condition, for in one case where with considerable patience and persistence the patient had slowly and with some distress succeeded in swallowing a little fresh grass, I found on *post-mortem* examination a few hours later, the ingesta lying along the lumen of the intra-thoracic portion of the oesophagus like a loosely twisted green rope.

As the disease progresses, the champing of the jaws becomes more noticeable, the tongue is frequently protruded as if to make an attempt to lick the dry muzzle, but without success, and may remain so protruded for several seconds or even longer. Salivation becomes more profuse, there being a constant dribbling from the mouth of saliva, which is often ropy in consistence. There is frequently an intermittent mucoid discharge from the nostrils, which is probably saliva which has been only partially swallowed and returned *per* nasal chamber. The expression becomes more wistful and the head more straightly held A slight swaying of the body, accompanied by twitching of muscles, appears, but not invariably, and seems to indicate that the animal is afraid of falling, and even of lying down, in case she cannot rise again. Cases may be found recumbent, but generally in the early stages; when symptoms are very definite the rule is for the patient to stand quietly, even if placed in a loose box. In a box the head may be often found pressed into the corner, as if a partial support were given thereby. If forcibly moved, the gait is more or less staggering, and the desire is to move only in a straight line. Respirations are normal, except when disturbed. The temperature remains normal, though occasionally reaching 103 deg. F., particularly when exposed to the sun. The faeces are scanty but not abnormal. Micturition is generally infrequent, but may be the reverse, and may be accompanied by evidences of pain. At times injection of the visible mucosae may be present. Occasionally some evidence of internal colicy pains is observed, but this is not present in all cases. More or less rapidly, the animal becomes weaker and weaker, chiefly from lack of food, and, especially in animals unhoused, from lack of water. Sooner or later the patient lies or falls down, and can be got to rise with difficulty, or not at all. Gradually a condition of semi-coma ensues, with complete coma and death resulting. Usually the course of the disease lasts from two to four days, but may linger for a week after symptoms are observed. Occasionally, it is said, cases recover, but I believe no immunity is attained against a recurrent attack the next year. I feel certain that were sick animals housed and so kept away from the sun's rays, and especially were they coaxed to drink from the beginning, they would survive much longer. Consequently chances of recovery would be much greater.

The most characteristic symptoms I consider to be the champing of lower jaw, the inability to chew and swallow, the salivation, the expression, the attitude of head; in other words, partial or complete paralysis of the powers of prehension, mastication, and deglutition. The disease is rarely, if ever, seen in animals below two years of age, and apparently never in calves. In Victoria it does not often attack steers, or at all events is rarely observed in that class of stock, although bullocks are not infrequently attacked in Tasmania.

The season of the year when the disease prevails is the dry summer months, especially January and February, though cases may occur earlier or later. For this reason, the dry, often innutritious, nature of the food supply is considered by some as being the primary cause of the impaction and paralysis of the rumen.

Post-mortem Appearances.

There are no pathological macroscopic changes which are constant or in any way characteristic.

The so-called impaction of the omasum, with dry ingesta, which led to the ridiculous term "Dry Bible," observed by some and considered the *causa causans* of the disease, is not constant, and is not greater than may be seen often in long travelled bullocks killed at abattoirs, and is not surprising considering the want of food and water, which may have been for a longer period than generally estimated. The brain and spinal cord are quite normal. The meninges may show slight injections, and while in some cases there has been an abnormal quantity of clear meningeal fluid present, though not sufficient to cause the symptoms noted, in others there was no such excess. The buccal cavity and pharynx are generally quite normal, and in only one instance have I observed congestion of the pharyngeal mucosa. Contrary to some observers, I have never found any food in the pharynx proper, but almost invariably there is to be found a pledget of partially-chewed material situated between the base of the tongue and the soft palate. In addition to this, one may find partially chewed or even unchewed food within the oesophagus, especially the intrathoracic portion. The rumen generally contains matted masses of food, though in one case which had been frequently placed by me in a pond, and had with difficulty by very persistent effort drunk a quantity of water, it was found, when the animal was slaughtered soon afterwards, that this water was almost entirely within the rumen. The abomasum is invariably empty: the small intestines are in a catarrhal condition, and contain more or less milky mucoid material, particularly the duodenum. The large intestines contain normal contents, though small in quantity. All other organs are normal, including the bladder, which is generally empty.

Bacteriological Investigation.

Microscopical examinations of blood and other body fluids have always given negative results. Injection subcutaneous, intraperitoneal, and intravenous of other cows with blood, spinal fluid, and even with emulsion of brain and spinal cord (brought to the laboratry preserved in glycerine and normal saline) have invariably given negative results. A cow drenched with a quantity of the catarrhal material found in the small intestines remained normal. The conclusions to be drawn from these experiments are that the disease is not due to any living organism visible or ultra-visible. Naturally, however, such were the first experiments to be undertaken, especially in view of the discovery of an ultra-visible virus being the cause of human polio-myelitis by Levaditi and Flexner.

Symptoms in Horse.

Instead of localised paralysis as in the cow, the symptoms in the horse are those of a general paralysis. Premonitory symptoms consist, at most, of inappetance. Frequently the animal is not observed ill till seen lying on the side, unable to get up even with assistance, and there may be evidence of intermittent colicy pain. In some cases the first symptoms are those of hyper-acute and sudden attack of colic, from which apparent recovery may occur, to be succeeded, however, by complete motor paralysis of the limbs. Often a peculiar paddling of one or more limbs is observed while the animal lies recumbent. In some cases the patient lies apparently quite quiet for prolonged periods, in others colicy griping pains of the intestines appear to be frequent, judging by the attitude, particularly the turning of the head to the flank. Sensation in the early stage is not lost, as can be demonstrated by pricking the skin, when the muscles of the flank or shoulder will twitch, but the limb cannot be moved voluntarily. The paddling movement appears to be entirely involuntary.

In the early stage the animal retains consciousness, though in the acute cases this soon gives way to semi-coma. The pupils are dilated, and the expression is startled-looking. The temperature remains normal, or it may be slightly above normal. The pulse is weak and rapid. The visible mucosae are slightly injected. Perspiration is often profuse, and may be patchy.

Depending upon the acuteness of the case, semi-coma, succeeded by coma, occurs, the paddling movements cease, and death may take place within 12 to 24 hours from the onset of the symptoms, or in subacute and chronic cases, the animal may linger for several days. Death is usually preceded by a violent paroxysm.

These are the symptoms as observed here in a number of both accidentally and deliberately produced cases.

Post-mortem Appearances.

Skin and subcutaneous bruises are common, but are only bed sores.

In two cases patches of semi-gelatinous, straw-coloured oedema were present in the peri-pharyngeal connective tissue, but were absent in others. The brain and spinal cord show no lesions beyond at times a slight injection of the ventricles. The meninges are generally normal, but in one naturally acquired case, and in one deliberately conferred case, there was an abnormal quantity of clear cerebro-spinal fluid present, especially around the medulla.

The lungs in very acute cases show passive congestion; the pericardium contains a varying, though small, quantity of clear serosity; the heart shows sub-epi- and sub-endo-cardial petechiae; the blood coagulates readily with a firm clot and clear serum. The stomach is generally normal, in only one case a few ecchymoses being seen near the pylorus. The small intestines are invariably in a muco-catarrhal condition with much serous effusion, coagulable on exposure, and mixed with flocculi of shed epithelium. This is found especially in the anterior part of the canal. In one case small necrotic patches of the duodenal mucosa were observed. The large intestines are generally tympanitic, but contain normal ingesta. One case showed a large area of congestion and many petechiae of the colon. The liver and kidneys are slightly congested, and show cloudy swelling. Otherwise the organs are normal.

Bacteriological Examination.

Microscopical examination of the blood and other fluids, such as cerebro-spinal fluid and pericardial serosity, as well as tissues, gave always negative results. Blood secured from the heart and large vessels in sterile pipettes and tubes immediately after death coagulated readily, and remained sterile even at blood heat. Intravenous inoculation with such material gave negative results, so that a living virus as the exciting cause was excluded, so far as such experiments could determine. Fortunately the fodder which had been fed to horses that had succumbed in an outbreak detailed below had been secured by me, and tests with this gave interesting and surprising results.

Observations on outbreak of Horse Paralysis in a Melbourne stable.

In the beginning of November, 1911, I was advised by Mr. W. A Kendall, G.M.V.C., of a serious outbreak of disease affecting three horses belonging to a dealer in one of the suburbs. The three horses, of a very good draught type, became affected almost simultaneously, and succumbed within 24 hours, in spite of treatment. Mr. Kendall's account of the symptoms, and the observations I was able to make through his courtesy, tallied generally with the symptoms recorded above, as did the *post-mortem* examinations, at only one of which I was able to be present and personally secure specimens. The cases did not seem to be those of ordinary poison, and chemical examination of the stomach contents and of the fodder gave negative results. Fortunately, however, I had a quantity of the fodder, consisting of ordinary mixed chaff, with bran and oats, all apparently of good quality, sent to the laboratory for experimental purposes. The material collected was kept separate, and labelled according to the place of collection. These samples were :—

A. From the mangers of the horses that had died.

B. From the nosebags of those horses.

C. From the loft near the chute.

D. From the bulk fodder in the loft.

(N.B.—C and D were similar, with the exception that D was mixed later by a few days than C.)

No unmixed feed remained on the premises.

With the above feed, certain experiments were conducted, but before detailing these it is necessary to record what may well be termed an unpremeditated experiment.

When the first horse died, the knacker was instructed to come for the carcase, and his man arrived with the cart sometime before Mr. Kendall had finished his *post-mortem* examination. While waiting, he espied a nose bag half-full of feed hanging on a peg, and fixed it on his horse's head. The knacker's horse, although fed as usual only a few hours previously, partook of the chaff in the nose bag readily enough, and in due course left. Five days later Mr. Kendall was called in to see this animal, and found him suffering from symptoms exactly similar to those manifested by the original cases. Death occurred within 12 hours of the first symptoms being observed. The carcase was brought to my laboratory, and *post-mortem* examination showed conditions similar to the others. This horse had received no more than a few pounds of fodder, and no symptoms were declared for at least five days Meanwhile our experiments were in progress.

Horse E. 11, an aged animal, in fair condition, was fed about 5 p.m. with 5 lbs. of chaff from the mangers. This he ate readily enough. For the next five days he received a daily ration of 15 lbs. of chaff from D, the bulk feed. On the morning of the 6th day he ate his food as usual. In the evening at 5 p.m. he was again fed.

and at 6.30 p.m. it was observed he had not eaten all the food, though otherwise he appeared normal. At 9.15 p.m. (or a little over five days after the first feed had been given) the animal was found lying down in the box, evidently suffering from abdominal pain. Temperature 102 deg. F. Pulse full, but weak and somewhat irregular. Respiration normal, eyes bright with pupils dilated. When disturbed, he rose and soon afterwards ate a little food. At 10.45 p.m. he was again found lying down, groaning with colicy spasms, and struggling. He tried to get up, but was unsuccessful. He continued to struggle violently for some minutes, but later settled down. Pulse much accelerated, but gradually slowed.

At 11.45 p.m. there was another paroxysm similar to last, but struggling was practically confined to continual banging of the head on the floor, and paddling motion of hind limbs. Gradually he quietened down, and half-an-hour later manifested little tendency to struggle when touched, but remained sensitive to all sounds and skin irritation. Temperature 100.2 deg.

At 12.45 a.m. another paroxysm of struggling occurred, so the animal was given morphine subcutaneously, and left for the night, having been well bedded down.

Next morning the animal was found to have knocked himself about a good deal during the night. Throughout the day he lay quiet for the most part, but off and on there were periods of struggling. Temperature did not rise, but respirations became more laboured, though hypersensitiveness was still marked, until semi-coma ensued shortly before death. The animal died at 5 p.m., 20 hours after having been first noticed lying down, having struggled a good deal during the last hour.

Post-mortem Appearances.—Similar to cases at stable from which fodder was obtained, but less injection of the vessels, little catarrh of small intestine, no oedema around pharnyx, and but slight excess of subdural fluid.

The feed left in the manger of this horse (about 6 lbs.) was divided between two sheep. They ate it readily enough, and remained normal during the several weeks they were under observation.

Pony E. 12 and Cow E. 1.—The remainder of the feed from the manger A was fed to pony E. 12, which received 3 lbs., and to a cow 4 years old, in good condition, which received 9 lbs. For the next week ordinary fodder, as given to other animals at the laboratory stables, was supplied to these animals. Then of the fodder found in the nose bag (B), 2 lbs. was given to the pony, and 5 lbs. to the cow. This was an error, for it was intended by me they should be fed thereafter with material C, from near the chute in the loft. This material was used subsequently, the pony receiving 3 lbs. and the cow 12 lbs. per day.

It may be here observed that the division of the feed was purely arbitrary, for we had no reason to believe either from the owner's statements or from observation that there was any material difference. The lots were kept separate, so that if necessary any definite poison might be tested for in each. The feeding with the bulk material was adopted because the pony had not evidenced any illness, and there appeared no reason for keeping the material for too great a length of time, besides which, it saved our own feed bill.

The result of the experiment was very interesting and extremely instructive.

The pony ate well and appeared normal till the thirteenth day after the first feed, when inappetance appeared, the morning feed being refused. In a few hours a fit of colic occurred, which soon passed off. These attacks recurred at intervals, till later in the day, when they ceased, though the animal still remained dull, listless, and refusing food and water.

Next morning the pony was found lying on his side, the limbs straight out, without making any effort to get up. Consciousness was definite, the head being partially raised from time to time. No evidence of pain. No desire for food or water. Skin of limbs sensitive, as shown by twitching of body muscles on pricking, but otherwise no reflex action or voluntary action was observed. Temperature 100.4 deg. to 101.2 deg. Pulse and respirations normal. No faeces or urine passed. The following or second day condition was much the same. Consciousness remained complete, the pony neighing on hearing another horse pass by the box. When the head was held up, he drank fairly readily, but refused food; he showed paddling of limbs at intervals, respirations were increased, and towards night, the breath was offensive, mouth was clammy, no faeces or urine had been passed, catheter showing comparatively little of latter in bladder, and that of normal character; the pulse was slow and full. During the next two days, little or no change was observed. Bed sores became extensive in spite of frequent turning. A little dung, dry in character, was passed occasionally. Pulse increased to 80 per minute. Temperature remained normal, and breathing was slightly accelerated. Consciousness was still retained, the chief symptom being inability to move the limbs except by the involuntary paddling referred to. At the end of the fourth day no improvement and no aggravation in general symptoms having taken place, except increasing weakness, because of the bedsores and the absence of feeding, the pony was killed.

Post-mortem examination was much the same in results as in previous cases, with the exception of some areas of broncho-pneumonia.

The experimental cow gradually became affected with tongue, buccal, and pharyngeal paralysis. This cow made an admirable subject for experiment. For six months she had been kept (in consequence of another experiment) in a loose box along with a yearling calf, and in the next box another cow had been kept for the same period also with a yearling calf. During that period the four animals had all been fed on the same kind of fodder, i.e., dry chaff, hay, etc., with no green feed, or exercise. Although, as will be seen, the cow fed with the suspected chaff became affected with the paralysis, the other cow and calf remained normal, and continued to do so while fed on ordinary chaff, till killed two months later. Her own companion had been destroyed prior to commencing the feeding experiment. No symptoms of any abnormality whatever were detected till the thirteenth day after receiving the first feed, or the sixth day of continuous feeding on suspected fodder. Then the cow was noticed to be less keen for food, and next day seemed to chew each mouthful for a much longer period than usual, without making any attempt meanwhile to swallow. Although the day was warm, little or no water was drunk. It is safe to say that had a careful watch not been kept for some such evidence of disturbance, it would have been overlooked by the attendant. On the third day of sickness the condition was much the same, but a thin trickle of saliva ran from the mouth, and some mucoid looking discharge was present in the nostrils. The fourth day brought improvement, and the cow seemed practically normal, but on the fifth day the aimless chewing and slight salivation had returned, while the expression was somewhat strained. On the sixth day, the symptoms were for the first time very suggestive of the cattle paralysis. Feed was refused; the head was held straighter than normal, the eyes appeared staring, champing of the jaws with dribbling of saliva was constant, occasionally the tongue protruded in an ineffective way, but seldom was an attempt made to lick the muzzle. On the seventh and eighth days the symptoms were aggravated. Drinking was done slowly and with much difficulty. On the ninth day the condition was much the same, the animal continuously standing, staring unseeingly in front of her, the salivation and movement of the jaw in the characteristic way being almost incessant. A blade of cabbage was picked up and sucked laboriously, being finally rejected in an unchewed condition. It was obviously impossible for her to get the food between the teeth or backward into the fauces. After this she refused cabbage, but attempted a little grass with the same result, and the next time grass was offered, she refused that. Evidently therefore, the appetite was still present, but she remembered her inability to chew or swallow certain materials. Rumination had ceased to be observed for several days. On this ninth day, also, the rumen was slighly tympanitic, and occasionally eructations of gas and fluid occurred, the latter passing down the nostrils.

For the next three days there was little change except that the animal became gradually weaker and poorer in condition; as always, a little faeces and urine were passed, but no food or water was taken. The temperature ranged between 100 and 102 deg.

During this time several veterinarians and others who have had much experience of the cattle paralysis as it naturally occurs, saw the case, and unanimously confirmed my diagnosis that it was a typical, though not acute, case of that disease.

During the night of the twelfth day after the first symptoms were manifested, she gave birth to a fully-developed, healthy calf, but was herself found prostrate and unable to rise in the morning. As she had eaten practically nothing for five days, and very little for a week before that, this weakness was perhaps not surprising. Nothing apparently was to be gained by attempting treatment, so she was killed.

Post-mortem examination showed no abnormality that could be considered in any way pathological or associated with the symptoms, and no excess of cerebro-spinal fluid.

Horse E. 13, aged, and in comparatively poor condition. It was fed for twelve days with 10 lbs. per day of bulk chaff from the loft, and was run in a small bare paddock. The supply of chaff being finished, he was then placed on the ordinary fodder of the laboratory. No evidence of any illness was manifested until sixteen days after the experiment commenced, when he refused his feed, but otherwise did not appear ill. The following day he was found lying on his side, presenting all the symptoms of paralysis observed in the pony, and in the other experimental horse. The next day (Christmas Eve) no change having occurred, and it being evident he might live for several days without any material benefit being derived from studying the case, the animal was slaughtered.

Post-mortem examination was as in other cases.

Summarised, the results of these feeding experiments are as follow :—

(1) *Knacker's Horse.*—Fed with quantity of chaff (B) left in a nose bag, probably not more than 6 to 8 lbs. altogether. *Result* :—In five days symptoms developed, characteristic in every way of the disease as it affected the merchant's three horses, and death occurred under 24 hours later. Other horses belonging to the same owner remained normal.

(2) *Experimental Horse E. 11.*— Fed daily with chaff A removed from the mangers of the horses that died, this being the last feed supplied to those horses, and undoubtedly of the same character as that in the nose bags. *Result* :—Colicy symptoms were exhibited almost precisely five days after first feed was eaten, and three hours later the characteristic symptoms were fully developed, and death occurred seventeen hours later.

The total quantity of feed consumed by this horse was 74 lbs.

(3) *Experimental Horse E. 12*, a pony, fed with 3 lbs. of feed from manger. A week later, no symptoms having developed, it was fed with 2 lbs. from nose bags (B), then fed with 3 lbs. per day of material in loft near chute (C), 33 lbs. of this being eaten altogether up to the time he was observed off his feed. In all, this pony ate 5 lbs. of what had been proved to be poisonous fodder, and 33 lbs. of suspected material, or 38 lbs. altogether. *Result* was that refusal of any food was observed twenty days after first feed, and thirteen days after continuous feeding commenced. This was followed by colicy pains, and later by definite paralysis. In this case, however, the disease was not early fatal, the animal being killed four days after illness commenced, on account of refusal to feed, bed sores, etc.

(4) *Experimental Horse E. 13.*—Fed with chaff (D) from bulk in loft, said to have been mixed a week after that in the manger and nose bags, receiving at the rate of 10 lbs. per day for twelve days, during which time no evidence of illness was manifested, being then placed on the ordinary chaff of the Institute. *Result* :—Fourteen days after feeding commenced, and four days after last feeding of chaff from the merchant's loft he refused food, and next day was found down, and paralysed. The animal was killed 24 hours later, it being evidently a sub-acute case, and the Christmas holidays being in course.

(5) *Experimental Cow.*—Fed simultaneously with pony. Received first 9 lbs. of chaff from manger. A week later received 5 lbs. chaff from nose bags, and thereafter fed daily with 12 lbs. chaff from loft

near chute: *Result:*—On the thirteenth day after first feed, some inappetance was observed, but not marked. Gradually symptoms of buccal, pharyngeal, and to some extent lingual paralysis became manifested; she was killed when almost *in extremis* after having given birth to a healthy calf, and after having eaten and drunk practically nothing for the previous five days, thirteen days after the first symptoms of illness appeared, and twenty-six days after the feeding experiment commenced. In all 88 lbs. of the contaminated or poisonous fodder was eaten by this animal.

It becomes obvious from a consideration of the results of these feeding experiments that the fodder, consisting apparently of ordinary chaffed oaten hay, with the addition of a slight percentage of oats, and of bran, contained some element which was the cause of the fatal results. What this element was, whether some native or other weed, or a fungus (or other) disease of some of the constituent plants, there was no indication, and examination of the cut fodder was unsatisfactory on these points. That the horse paralysis in South Australia, where it has been most observed, is frequently found associated with feeding on musty fodder, would seem to indicate the latter hypothesis; but the fact that this is not invariably the case is against the idea of ordinary moulds being a cause. Again, it must be remembered that if the cause be of a fungoid nature, it is one that does not deleteriously affect the fodder to such an extent as to render it unpalatable or even suspicious to the horse or cow, not to mention ourselves, by any standard we can at present adopt. Further, while I have not heard of any cases of horse paralysis where the animals were not, at least partially, fed on dry fodder such as hay, chaff, etc., cattle paralysis frequently occurs where animals are feeding solely on natural pasturage. The most reasonable hypothesis under the circumstances, is, therefore, that there is some plant which horses are able to avoid while it is growing naturally, but which even then many cattle cannot or do not avoid; a plant also that even the horse does not detect when mixed with other ripe or dried plants, especially if chaffed and mixed.

But again, whether fungoid or herbal in origin, it cannot be gainsaid that the essential cause of the paralysis is some powerful poison of certain cells in the central nervous system. The chemical nature of that poison cannot as yet be even assumed, for we know of no poison alkaloidal or glucosidal in nature, which would have such a latent period before symptoms were produced. In fact, such poisons would be eliminated almost entirely from the system within 24 to 48 hours, provided no physiological effects were produced. In the case of the two first experimental horses and of the cow, a cumulative effect of the poison might be inferred, but the experience with the knacker's horse, which received only one feed, and with experimental horse E. 13 (the former of which showed symptoms only five days after ingestion of a small quantity of the abnormal fodder, the latter four days after feeding on this was discontinued) negative such an assumption being regarded as a complete explanation. The best analogue of this poison, whatever may be its nature and source, is the toxin of tetanus, which has a so-called period of incubaton of four to five days, due to the time taken in reaching the cells of the central nervous system *via* the nerves, instead of by the blood stream. The Rabies virus offers to some extent another analogy, but there it is the living entity that travels along the nerves, and probably liberates the toxin *in situ*.

At all events the whole circumstances seem to indicate the study of the native flora in the affected districts as a field of research offering the most fruitful possibilities. Had the fodder with which I experimented been uncut, I should have had the component plants of a large quantity segregated after the first two experiments, and conducted feeding experiments with each lot. As this was not possible, I requested the Hon. G. Graham, the Minister of Agriculture, to have a botanical survey made by the Government Botanist of the farm in the Western district whereon I had seen the most typical cases of cattle paralysis, to which he kindly consented. This was done, and I append a copy of the report which I received.

The native plants should be secured in some quantity; if necessary they should be artificially cultivated, especially the senecios, pimpernels, isotomas and lobelias, and thorough tests made with each on both horses and cattle.

Mr. McEachran, at my suggestion, is proposing to carry out, at the first opportunity, certain experiments with dry unchaffed fodder, where there has been an epidemic, the endeavour being to segregate the different plants, and carry out feeding experiments with each.

So far as treatment is concerned, I am sure efficacy will only be attained by a study of the poison after it has been isolated, or at least after its origin has been discovered, and meanwhile all endeavours should be directed towards that end.

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APPENDIX.

Report by Professor A. J. Ewart, Government Botanist, on plants found growing on the property referred to in text.

The following is the detailed list of the plants collected :—

GRAMINEAE (Grasses).

Holcus lanatus, L. "Yorkshire Fog Grass." Alien.
Hordeum murinum, L. "Barley Grass." Alien.
Deyeuxia Forsteri Kunth. "Tooth Bent Grass." Native.
Poa caespitosa, G. Forst. "Tufted Meadow Grass." Native.
Lolium perenne, L. "Perennial Rye Grass." Alien.
Briza minor, L. "Lesser Quaking Grass." Alien.
Aira caryophyllea, L. "Silvery Hair Grass." Alien.
Agropyrum scabrum, Pal. "Common Wheat Grass." Native.
Pentapogon Billardieri, R. Br. "Five-awned Spear Grass. Native.
Anthistiria ciliata, L. "Kangaroo Grass." Native.

CYPERACEAE, JUNCACEAE (Sedges and Rushes).

Carex Gunniana, Boot. "Green Sedge." Native.
Carex paniculata, L. "Panicle Sedge." Native.
Heleocharis acuta, R. Br. "Common Spike Rush." Native.
Juncus bufonius, L. "Toad Rush." Native.
Juncus pallidus, R. Br. "Pale Rush." Native.
Juncus planifolius, R. Br. "Broad-leaved Rush." Native.
Juncus communis, E. Mey. "Common Rush." Native.
Juncus prismatocarpus, R. Br. "Branching Rush." Native.

Leguminosae.

Trifolium resupinatum, L. "Annual Strawberry Clover." Alien.

Trifolium fragiferum, L. "Perennial Strawberry Clover." Alien.

Trifolium minus, Rel. "Slender Clover." Alien.

Trifolium repens, L. "White or Dutch Clover." Alien.

Acacia mollissima, Willd. "Late Black Wattle." Native.

Acacia melanoxylon, R. Br. "Blackwood." Native.

Psoralea parva, F.v.M. "Small Scurfy Pea." Native.

Compositae.

Carduus lanceolatus, Scop. "Spear Thistle." Alien. Proclaimed.

Carduus pycnocephalus, Jacq. "Shore Thistle." Alien. Proclaimed.

Carduus Marianus, L. "Spotted Thistle." Alien. Proclaimed.

Cryptostemma calendulacea, R. Br. "Cape Weed." Alien. Proclaimed.

Hypochaeris radicata, L. "Flat Weed." Alien.

Anthemis nobilis, L. "Common chamomile." Alien.

Senecio lautus, Soland. Native.

Centipeda Cunninghami, F.v.M. "Sneeze Weed." Native.

Gnaphalium japonicum, Thunb. "Japanese Cud-weed." Native.

Cotula coronopifolia, L. "Water Buttons." Native.

Helichrysum scorpioides, Lab. Native.

Leptorrhynchus squamatus, Lessing. Native.

Calocephalus lacteus, Lessing. Native.

Various Orders.

Ranunculus muricatus, L. "Sharp-pointed Crowfoot." (Ranunculaceae.) Alien.

Plantago lanceolata, L. "Ribwort Plantain." (Plantaginaceae.) Alien.

Bartsia latifolia, Sibth. & Sm. "Common Bartsia." (Scrophulariaceae.) Alien.

Acaena sanguisorbae, Vahl. "Bidgee Widgee." (Rosaceae.) Native.

Lythrum Hyssopifolia, L. "Small Loosestrife." (Lythrariaceae.) Native.

Epilobium junceum. Forst. "Hairy Willowherb." (Onagraceae.) Native.

Myriophyllum elatinoides. Gaud. "Coarse Water Milfoil." (Haloragaceae.) Native.

Erythraea australia. R. Br. "Austral Centaury." (Gentaineae.) Native.

Villarsia reniformis. R. Br. (Gentaineae.) Native.

Alternanthera nodiflora. R. Br. "Joyweed." (Amarantaceae.) Native.

Polygonum prostratum. R. Br. "Trailing Knotweed. (Polygonaceae.) Native.

Rumex Brownii. Camp. "Swamp Dock." (Polygonaceae.) Native.

Prunella vulgaris. DC. "Selfheal." (Labiatae.) Native.

Mentha Pulegium. L. "Pennyroyal." (Latiatae.) Alien.

Asperula oligantha. F.v.M. "Common Woodruff." (Rubiaceae.) Native.

Gratiola peruviana. L. "Peruvian Booklime." (Scrophulariceae.) Native.

Triglochin procera. R. Br. "Giant Arrow Grass." (Naiadaceae.) Native.

Anagallis arvensis. L. "Pimpernel." (Primulaceae.) Alien.

Myoporum insulare. R. Br. "Boobialla." (Myoporineae.) Native.

Lobelia pratioides. Benth. (Campanulaceae: Lobeliaceae.) Native.

Isotoma fluviatilis. F.v.M. "Swamp Isotoma." Campanulaceae. (Lobeliaceae.) Native.

Among the plants collected were the following poisonous, suspected poisonous, or injurious plants:—

1. Anagallis arvensis, L. "Pimpernel." Alien.
2. Calocephalus lacteus, Less. Native.
3. Centipeda Cunninghami. F.v.M. "Sneeze Weed." Native.
4. Isotoma fluviatilis. F.v.M. "Swamp Isotoma." Native.
5. Lobelia pratioides. Benth. Native.
6. Myoporum insulare. R. Br. "Boobialla." Native.
7. Ranunculus muricatus. L. "Sharp-pointed Crowfoot." Alien.
8. Senecio, lautus. Soland. Native.

Of these, *Calocephalus lacteus*, *Centipeda Cunninghami*, *Myoporum insulare* and *Senecio lautus* are merely suspected poisonous plants. The *Ranunculus* is generally stated to be feebly poisonous when fresh. If the *Senecio* were poisonous, it would probably act like the ordinary ragwort; that is, it would slowly bring on hepatic cirrhosis as described by Professor Gilruth. The *Isotoma* and the *Lobelia* are undoubtedly poisonous, but seem to affect sheep more readily than larger stock, possibly because they are apt to eat relatively more. *Anagallis arvensis*, "The Pimpernel," was recently responsible for the death of a large number of sheep at Lilydale, the round pods of the plant being found in their stomachs in large quantities. This plant is a naturalised alien, which has rapidly spread over Victoria, and is one of those plants which it is almost impossible to suppress. It appears to act as a narcotic poison. It frequently remains green for a time when the grass is dying off, and this may attract the stock to eat it in large quantities if it is abundant. I suggest as the next stage in the inquiry, that the stomachs of the stock affected by the "disease," be examined for the presence of the plants marked 1 to 8, and particularly for numbers 1, 4 and 5.

[Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. II., 1913].

Art. XIX.—*The Anatomy of Two Australian Land Snails, Paryphanta atramentaria, Shuttleworth, and P. compacta, Cox and Hedley.*

By OLIVE B. DAVIES, M.Sc.
(Government Research Bursar, Melbourne University).

(With Plates XV.-XVII.).

[Read 10th October, 1912].

Among some snails (kindly sent to me by Mr. F. J. Thomas, to whom my thanks are due) from Beech Forest, Victoria, were some specimens of *Paryphanta compacta*. Figures, and a description, of the shell of this new species of *Paryphanta* have been given by Dr. Cox and Mr. C. Hedley in their "Index to the Land Shells of Victoria,"[1] but no account has hitherto been given of the animal itself.

The specimens of *P. atramentaria*, which were used in this work, were collected by myself about three years ago, at Blacks' Spur, near Healesville, Victoria. I did not use the animals at the time, and had only this preserved material for working this species. Several descriptions of the shell have been given, but so far as I know, the anatomy has been scarcely touched. I have been unable to see Shuttleworth's original description in Mittheil. Naturf. Gesell., Bern, 1852.

External Features and General Description.

P. compacta.

Dr. Cox and Mr. Hedley describe the colour of the shell as "brown, deepening on the last whorl to black, and on the second whorl passing into straw yellow." The animal itself is dark grey, with a lighter grey round the mouth and the side of the foot, becoming almost white down the mid line of the sole of the foot.

I took measurements of preserved specimens to compare with *P. atramentaria*. An average specimen measured :—

Shell, maj. diam. 20 mm., min. diam. 16 mm., height 15 mm.; sole of foot 20 mm. long, 10 mm. broad; height of part outside shell, 8 mm.

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1 Mem. Nat. Mus. Melbourne, No. 4, 1912, p. 8, pl. i., figs. 3, 4, 5.

There is only one feature in the external description of this animal which I deem worthy of special comment. On examining the live animal, at first sight the smaller tentacle of each side appears bifurcated or double, but on closer examination, the lower of the two parts is seen to be depressed inwards at the tip, instead of ending in a little swollen knob, as the upper does. This depression, I think, is really the opening of a little gland, and I am told that when the animal is crawling, mucus can be seen exuding from this opening, but I have not observed this myself. Mr. Suter, in his communications from New Zealand, in the Journal of Malacology, 1899, Vol. VIII., Pl. III., has drawn a figure of *Rhytida greenwoodi*, in which the "buccal papillae," as he names them, resemble the structures in *P. compacta* more than any other I have seen.

P. atramentaria.

The animal is much larger than *P. compacta*. The shell is flatter and of about the same colour, or, perhaps, a little lighter. The animal itself is the same dark grey colour except at the edge of the mantle and the foot, where it is coloured a brilliant orange-red.

I took the following measurements from an average specimen:—

Shell, maj. diam. 31 mm., min. diam. 26 mm.; height, 18 mm.; sole of foot, 35 mm. long, 17 mm. broad; height of part outside shell, 12 mm.

I have not observed the tentacle in the living animal, but I have one preserved specimen (Plate XV., Fig. II.), in which the two pairs of tentacles are withdrawn, but on each side is a little papilla on the under surface of which is a groove. The left inferior tentacle and papilla of this specimen, was cut out and used for sections.

In other carnivorous land Pulmonates, e.g., *Rhytida*, structures spoken of as labial palps are developed; but these in *Paryphanta*, more especially in *P. compacta*, seem to me to be more nearly connected with the tentacles than with the mouth.

In their internal structure, the two species resemble one another very closely, so that the one description may serve for either, except when otherwise stated.

Organs of the Mantle Cavity.

The kidney is a large, roughly triangular, granular body, pinkish grey in colour, lying on the dorsal side of the last whorl, at the back of the roof of the mantle cavity.

The pericardium forms a pear-shaped sac, lying to the left of the kidney. Through it the auricle and ventricle can be seen.

The renopericardial canal, the ureter, and the rectum, occupy their usual positions, and present no points of special interest.

The Reproductive System.

The reproductive systems of the two species are very similar. In *P. atramentaria*, the hermaphrodite gland is, comparatively speaking, less compact, the hermaphrodite duct is shorter, the albumen gland is larger and coarser, and the receptaculum seminis is slightly smaller than in *P. compacta;* also the vas deferens, in *P. atramentaria*, runs a little further behind the anterior end of the penis, before turning to run to its posterior end. With these differences the following description applies to either species. The hermaphrodite gland has the form of a loose rosette, the lobes of the rosette being somewhat pear-shaped. It is embedded in the liver near the inner edge of the second last whorl of the visceral hump, the first whorl being that nearest the centre. From the hermaphrodite gland the hermaphrodite duct runs in a sinuous course to the albumen gland.

The albumen gland is large and compact; it is indefinitely marked off by slight constrictions into three large and one smaller lobe. It lies near the beginning of the rectum, between this and the first part of the intestine. The common duct is broad and about half as long again as the albumen gland. One side of it is transversely grooved, the other smooth. These two parts eventually separate to form the viaduct and vas deferens respectively.

Shortly after the division of the common duct into vas deferens and oviduct, a long diverticulum is given off from the dorsal surface of the oviduct; this ends in a little swollen knob, the receptaculum seminis. This diverticulum runs right back so that the receptaculum seminis is situated under the auricle.

The penis is a very muscular body, lying beneath the right superior tentacle and across the pharynx.

The retractor penis muscle is attached to its posterior end.

The vas deferens at first sight appears to open into the penis near its anterior end, but further dissection shows that it runs a little behind the anterior end of the penis, then turns and runs back to open into it near its posterior end, just near to where the retractor muscle is attached, at the swollen portion. Its course may be understood by reference to Plates XVI. and XVII., Figs. VI. and X. The oviduct opens to the exterior, just to the right of the penis, through the genital aperture.

The Alimentary System.

The mouth, situated on the under surface of the head, opens into a relatively huge buccal mass or pharynx, running almost the length of the foot. The walls of this pharynx are extremely muscular, more especially so at the posterior end, where they form a rounded muscular pad. Two stout muscle bands are attached to the dorsal surface of the posterior end of the pharynx, and their other ends to the columellar muscle; these assist in the contraction of the pharynx. A number of protractor muscles are attached to the anterior end of the pharynx, and at their other ends to the walls of the anterior end of the body and head.

If the pharynx is opened from the side, the radula can be seen lying on a muscular band, which anteriorly becomes developed into a pad. Attached to this pad are special muscles, connected with the roof of the pharynx, which assist in the forward and backward movement of the radula. There is no jaw. The radula is large, as is usual in the carnivorous land mollusca. It consists of about 98 rows of approximately 118 strong, sickle-shaped teeth, each with a very sharp pointed end and a broadened base, the base being produced in a little knob on the inner side of the sickle, and in the outer teeth being almost quadrate in shape. There is no rachidian. The uncini are larger than the laterals, and of the uncini themselves, those towards the centre are not so large as those near the outside, but the two or three most external become smaller again; this last feature is more marked in *P. atramentaria* than in *P. compacta*. Where one would expect the rachidian, there is a clear space, and on either side of this are teeth much smaller than the laterals, and arranged irregularly; beyond these are the laterals, at first placed almost straight and later becoming more and more triangular till we come to the marginals. I measured the radulas of the two species. That of *P. compacta* was 18 x 4 mm., and *P. atramentaria* was 20 x 5 mm. The teeth are of the same general type in both species, the differences may be seen in Plate XVII., Figs. IX. A. and B. Mr. Suter has given the dental formula for *P. atramentaria* as 50.1.50. I could not find any rachidian, but down the centre of the radula is the clear space I have mentioned above, and to either side of this the irregularly arranged teeth, about one-third the size of the adjacent laterals. I also, in my specimen, counted at least 56 teeth on each side of the central space, but could not be sure of the exact number, as the radula was slightly torn at the margin.

The oesophagus leaves the pharynx from its dorsal surface, about one-third of its length from its anterior end. It runs as a straight, narrow tube for some distance, and then widens slightly to form the stomach. The canal then twists round, as the intestine, under the stomach, and continues running through the liver and finally twists back to run along the right edge of the pulmonary chamber, and opens to the exterior at the pulmonary opening.

The salivary glands are two pear-shaped bodies, lying one on either side of the alimentary canal, just at the beginning of the stomach; they unite in the midline dorsally; from each a duct runs forwards to open into the pharynx, just beside the oesophagus.

The liver forms most of the visceral mass. One of its ducts is seen in Plate XVII., Fig. VII.

The Nervous System.

The cerebrial ganglia are two oval bodies, lying on the dorsal surface of the anterior part of the oesophagus; they are connected in the centre so as to form a band across the alimentary canal. From them two connectives run round each side of the oesophagus to the sub-oesophageal ganglia. Large nerves are given off to the tentacles, both superior and inferior, and one large nerve to the little glandular structure near the inferior tentacle.

The sub-oesophageal ganglia consist of the pedal ganglia, from which nerves pass to the foot, and the visceropleural ganglia from which nerves pass to the viscera and the body-wall.

The eyes do not differ from the ordinary pulmonate type. They are situated a little to the back of the top of the tentacle. In Plate XV., Fig. I., this is not clearly shown, owing to the position of the head, but it may be better seen in Fig. III.

The inferior tentacle, as has been mentioned above, has a little glandular structure with an opening at its base. This structure seems different in the two species. In *P. compacta* it seems to form a little pit on the top of a papilla, while in *P. atramentaria* it has the form of a little papilla with a groove on its under surface; but I have not examined the structure in the living *P. atramentaria*. In sections the glands are composed of the same forms of cells, and in each species there is a large amount of dark staining material, probably mucus, present. In *P. compacta*, however, the gland is not nearly so definite, and seems to lie more in the cephalic wall than in *P. atramentaria*. This may be clearly seen on comparing Figs. IV. and V. in Plate XV. Woodward has noted the very prominent "labial tentacles" of *Nanina caffra*. He says they are extremely sensitive, and "probably tactile in function, but not used for prehesion as suggested for *Glandina*."

I can make no definite assertion as to the function of these structures; they are certainly glandular, and as they are present on carnivorous snails, I think they must have some use in either the capture or killing of their prey.

The pedal gland resembles those described by Mr. Collinge for *P. hochstetteri* and *P. edwardi*. It is greatly developed and folded on itself, lying on the floor of the body cavity. In *P. compacta* it turns to the right, and then to the left; in *P. atramentaria* it only bends slightly to the left before dipping into the cavity bounded by the pedal muscles.

Dr. Cox and Mr. Hedley have placed the genus as follows:—

Group, Sigmurethra; sub-group, Agnathomorpha; family, Rhytididae; genus, Paryphanta.

P. compacta is a new species of Cox and Hedley, but *P. atramentaria* was formed by Shuttleworth in 1852. One or two species have been suggested, at different times, as being most nearly related to *P. atramentaria*. Godwin-Austen has suggested placing *P. atramentaria* and *P. splendidula* in another genus. Suter considers *P. edwardi* stands nearest *P. atramentaria*. Cox and Hedley consider *P. compacta* nearest *P. atramentaria*, and there is a very close resemblance; the differences have been noted in the above for the animal itself, and the following are the differences in the two shells as noticed by Dr. Cox and Mr. Hedley:—"The novelty is nearest in the genus to *P. atramentaria*, but with as many whorls in about half the diameter, the whorls increase more slowly, the last whorl is proportionately smaller, the perforation narrower, and the whole shell more globose. In size it resembles the Tasmanian *P. fumosa*, but the whorls of *compacta* are wound more nearly in the same plane and increase less rapidly. It seems confined to the southern part of the State, while *atramentaria* inhabits the centre."

Unfortunately, I have been unable to consult Beutler's paper, "Die Anatomie von P. hochstetteri, Pfr.," Zool. Jahrb. (Anat. und Ontog.) XIV., 1901, as the work was not procurable in either Melbourne or Sydney.

I wish to thank Dr. Hall, under whom this work was carried on, for all his advice and help; also Miss Raff, M.Sc., for her assistance in procuring specimens.

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EXPLANATION OF PLATES.

In all figures:—

A.	Anus.
A.G.	Albumen gland.
Aur.	Auricle.
B.C.	Buccal cavity.
B.M.	Buccal mass or pharynx.
B.V.	Blood vessel.
C.D.	Common duct.
C.G.	Cerebral ganglia.
E.	Eye.
F.	Foot.
Gl.	Glandular tissue.
G.P.	Glandular papilla.
H.D.	Hermaphrodite duct.
H.G.	Hermaphrodite gland.
I.	Intestine.
I.R.	Small irregular central tooth.
K.	Kidney.
L.	Liver.
L.D.	Liver duct.
L.T.	Lateral tooth.
M.	Mouth.
Mg.	Marginal tooth.
N.	Nerve.
O.	Oesophagus.
OD.	Oviduct.
P.	Penis.
P.O.	Pulmonary opening.

R.	Rectum.
Rad.	Radula.
R.M.	Retractor muscle.
R.O.	Reproductive opening.
R.S.	Receptaculum seminis.
S.	Stomach.
S.D.	Salivary duct.
S.G.	Salivary gland.
T.I.	Inferior tentacle.
T.S.	Superior tentacle.
V.	Ventricle.
V.D.	Vas deferens.
V.H.	Visceral hump.

Plate XV.

Fig. I.—*P. compacta:* the living animal; showing the glandular papilla below the inferior tentacle.

Fig. II.—*P. atramentaria:* head of preserved specimen; showing the retracted superior and inferior tentacles, and the little papilla with the groove on its under surface.

Fig. III.—*P. compacta:* head of living animal; showing position of eye, and the glandular papilla; to compare with Fig. II.

Fig. IV.—*P. compacta:* section of body wall and right inferior tentacle; showing glandular structure beneath the inferior tentacle.

Fig. V.—*P. atramentaria:* section of glandular papilla: showing structure; to compare with Fig. IV.

Plate XVI.

Fig. VI.—*P. compacta:* dissection to show the general arrangement of organs.

Plate XVII.

Fig. VII.—*P. compacta:* alimentary canal.

Fig. VIII.—*P. compacta:* pharynx cut open from the right side to show the radula *in situ*.

Fig. IX. A.—Types of teeth; *P. compacta*.
B.—Types of teeth; *P. atramentaria*.

Fig. X.—*P. compacta:* dissection to show the vas deferens and penis.

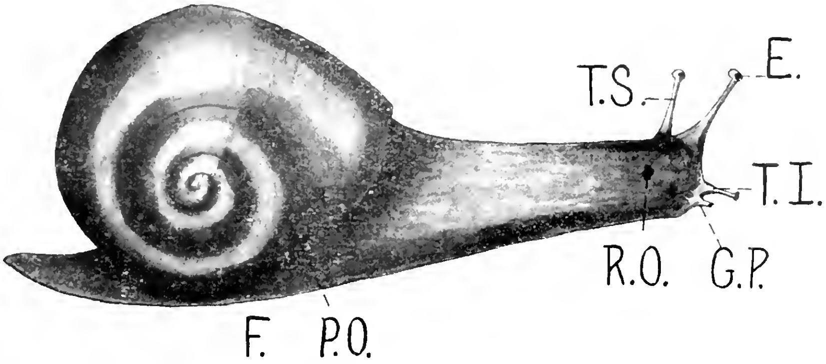


FIG. I.

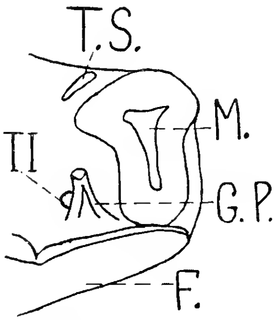


FIG II.

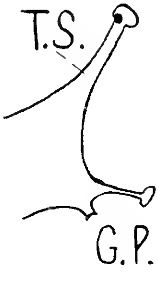


FIG. III.

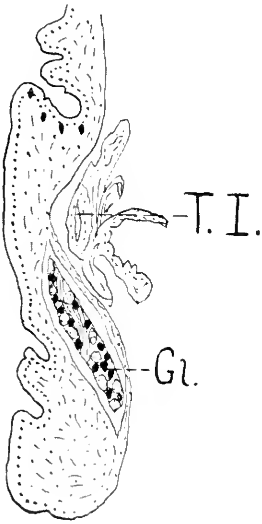


FIG. IV.

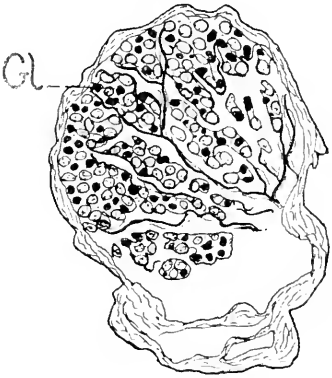


FIG. V.

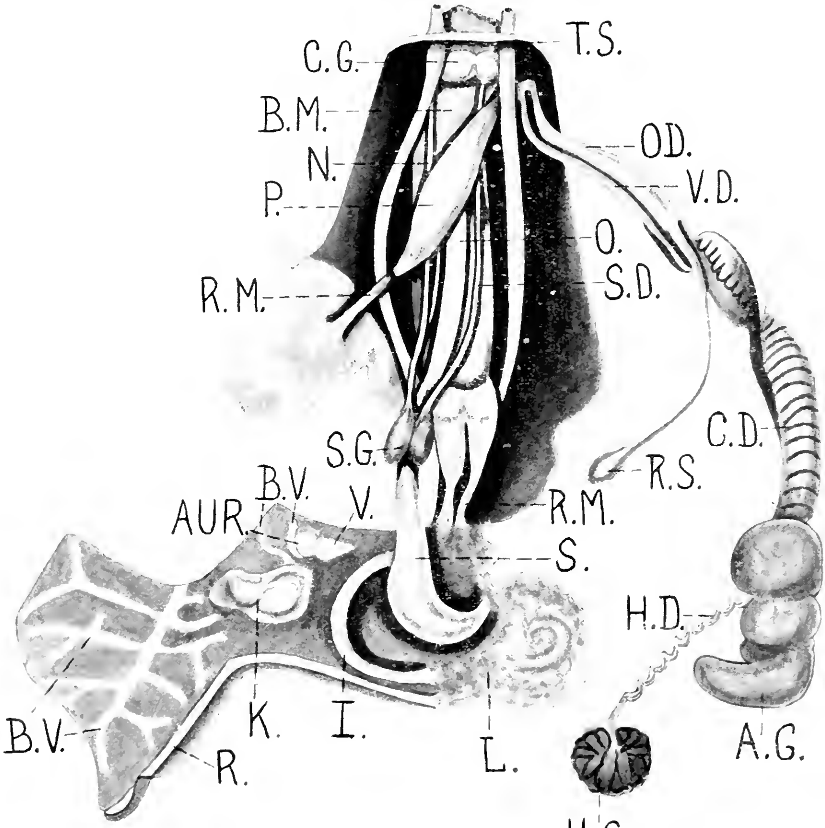


FIG. VI.

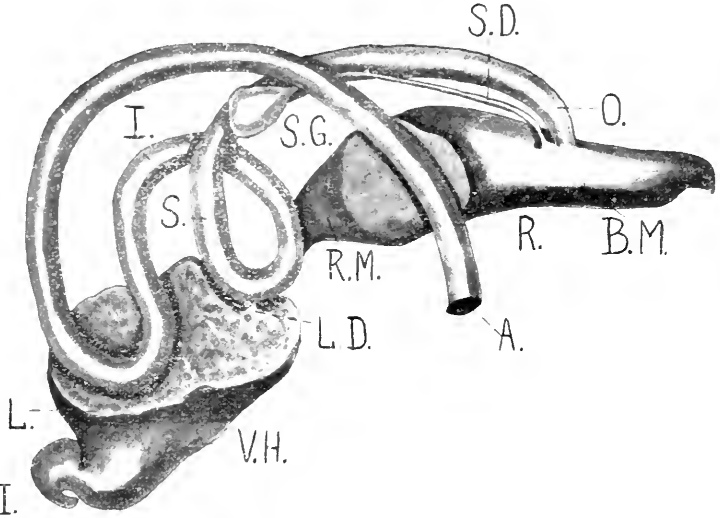


Fig. VII.

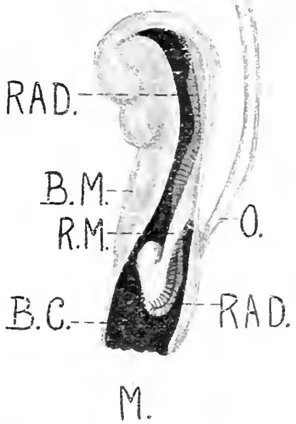
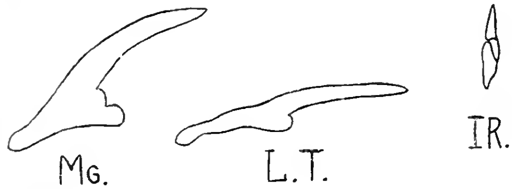
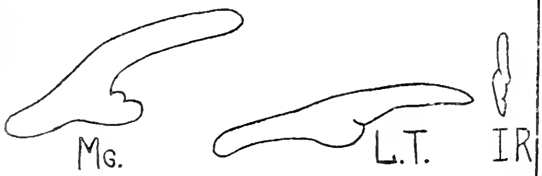


Fig. VIII.



IX A.



IX B.

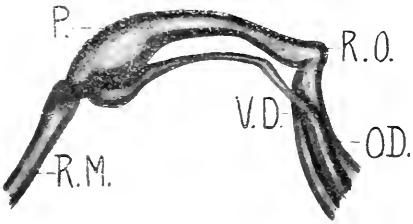


Fig. X.

[Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. II., 1913.]

Art. XX.—*The Correlation of Size of Head and Intelligence as Estimated from the Cubic Capacity of Brain of 355 Melbourne Criminals.*

By RICHARD J. A. BERRY, M.D., F.R.S.E.
(Professor of Anatomy in the University of Melbourne)

AND

L. W. G. BÜCHNER
(Government Research Scholar in the Anatomy Department of the University of Melbourne).

[Read 10th October, 1912.]

The present investigation deals with head measurements of 355 male adult criminals incarcerated in Pentridge and Melbourne Gaols, for various offences against the law. For permission to carry out the research we have to tender our thanks to Mr. Callaway, the Acting Inspector of Penal Establishments, and to Messrs. Paterson and Edgar, the respective Governors of Melbourne and Pentridge Gaols. The objects of the research are threefold. First, to determine the amount of brain in cubic centimetres possessed by a class of the community which is presumably of an inferior position in the human scale of society. Second, by comparing the results obtained with those of admittedly superior education and social status to ascertain what, if any, correlation exists between size of head and mentality. Third and last, to discover, if possible, what light such an investigation throws on our present social and political methods of dealing with habitual offenders against the State.

In view of the marked importance of the second of these objects and the divergent opinion which has been expressed thereon, it will be advisable, at the outset, to ascertain what are the matured opinions of other competent investigators on the hotly-debated question as to the correlation between size of head and intelligence. The problem has been attacked from both a biological and a biometrical standpoint, and with somewhat conflicting results.

Dr. R. J. Gladstone (1), writing in 1903, states there is a "distinct correlation between large size of head and a high degree of mental ability, this correlation being both absolute and relative to the general size and weight of the body."

In 1907 the same observer (2) adds: "If we take the average measurements, however, of a large number of individuals belonging to a particular class, it will be found that there is a small though definite correlation between large size of head and intelligence, and that the large size of head is not only actual, but is proportional to the stature and weight of the individuals. . . . We may say, therefore, that these figures indicate that the more intellectual are not only finer specimens of humanity, but that they have both actually and proportionally to the size of their bodies larger heads than the less intellectual."

Bayerthal (3), working on the circumferential head measurements of school children, finds that large heads are often associated with inferior talents, and surprising discrepancies can often be noted; moderate talent may be associated almost equally with large and small head size.

Pearson (4), in 1906, commenced an investigation "On the relationship of intelligence to size and shape of the head, and to other physical and mental characters," with the following conclusions, derived from former papers:—

a. There is a slight correlation between size of head and general intelligence.

b. This correlation is not sensibly increased by allowing for the size of the body relative to the size of head.

c. The correlation is so small that it would be absolutely idle to endeavour to predict the intellectual ability of an individual from his or her head measurement. On the other hand, if a population were divided into those with large and those with small heads, we should expect to find a very slight balance of average intelligence in the former group."

In the paper from which the foregoing extracts are taken, Pearson also adds that as the measurements therein contained are based on a far larger number than any hitherto published, they are, he thinks, convincing as to the small part played by head size in determining the grade of intelligence.

He also states that it is idle "to assert that head measurements can be of any service in the prediction," and that he wants "to convince the anatomist and the old school anthropologist that head measurements are not of real service as intelligence tests."

Eyerich and Loewenfeld (5) have recently made a very thorough investigation of the relationships of intelligence to size of head, employing as material 935 soldiers, 300 one year enlistments (einjährige), who in Germany are usually derived from the better classes, and 312 boys between 9 and 15 years of age. They reached the following conclusions:—

From the measurements of heads and brains no very extensive conclusions as to mental activity can be drawn.

High intelligence is most frequently found in cases with average head measurements.

Exceptionally large head measurements, as also exceptionally high brain weights, occasionally point to great intelligence, and in the same way exceptionally small head measurements may indicate an especially inferior intellect.

The greatest head measurements and the heaviest brain weights are found fairly uniformly in both highly intelligent and less intelligent persons.

The very smallest head measurements, apart from family or other peculiarities, occur in the mentally less functionally capable.

Pearl (6), in a paper not available to us in Melbourne, applies to the above statistical series of Eyerich and Löwenfeld, Pearson's correlation methods, and deduces therefrom that a perceptible but very slight positive correlation between head size (circumference) and intelligence exists, but warns us from drawing further conclusions or generalisations therefrom.

Buschan (7) supports the view that there is some correlation between great skull capacity or great brain weight and marked mental ability. In support of this he points out, amongst other things, that of the highest professional classes 57 per cent. will have a brain weight of over 1400 gr., and of the lowest classes only some 26 per cent. will possess a corresponding brain weight.

In children, Lee, Lewenz and Pearson (8) conclude "that there is no marked correlation between intelligence and the size and shape of the head."

Lee (9) in the course of an important paper, states "that there is no marked correlation between skull capacity and intellectual power in the case of either sex alone." And, again, "it would not appear from the above results that skull capacity at any rate is a character closely correlated with intellectual ability in the individual, and therefore it is quite conceivably not correlated with racial ability."

In this same paper Miss Lee commits herself to the following statement:—"Personally I am inclined to hold with Professor Pearson that the complexity of the convolutions of the brain, and variety of its commissures, rather than its actual size, are the characters we might expect to differentiate race from race, and sex from sex, and to have developed with man's civilisation."

In 1902 Pearson (10), dealing with "upwards of a thousand Cambridge undergraduates," states that "so far as the Cambridge results go, there is no marked correlation between ability and the shape or size of the head," and concludes finally that "very brilliant men may possibly have a very slightly larger head than their fellows, but taking the general population there is really a very insignificant association between size of head and ability. For practical purposes it seems impossible, either in the case of exceptionally able men or in the bulk of the population, to pass any judgment from size of head to ability or *vice versa.*"

In this same paper Pearson also states "we have found . . . a very definite statement made that able men have large heads. We cannot find, however, that there are really reliable statistics, adequately treated, which in any way prove this general statement. It is perfectly true that the professional classes in this country have a rather larger head than the hand-working classes, and the former are rather more intellectual. . . . Dr. W. R. Macdonell has recently shown that the head of the Cambridge undergraduate is larger than the head of the criminal population, but any deduction from a mixture of these two classes (that ability is correlated with size of head) would be wholly misleading."

Without multiplying instances further, it is clear from the foregoing extracts that there is much divergence of opinion on the interesting point as to whether there is any relationship between size of head and intelligence; and, speaking broadly, the disputants to the problem divide themselves into two camps, the biometricians with no medical training, and the biologists with a corresponding lack of mathematical skill. The former see little or no correlation between the two things, size of head and intelligence, whilst the latter seek to establish some slight connection between the two.

For ourselves we approach the problem from the standpoint of the trained medical man, with a knowledge of the human neurological factor, and just sufficient mathematics to appreciate Pearson's dogma that "statistical enquiry is not a field for guess-work and elementary arithmetic; there is a mathematical science of statistics which must be learnt, and papers dealing numerically with anthropometric and craniometric data, which do not now apply this theory, are simply outside the field of science."

The 355 criminals with which this investigation deals were, as already stated, confined in Pentridge and Melbourne Gaols. They are all Caucasians and adult males. The observations which we have recorded upon them fall into two categories, which may be best described as personal and craniometrical.

Of the personal observations we have recorded the age and the nature of the crime. We were, for obvious scientific reasons, most anxious to obtain also the height and bodily weight, but this was, as it turned out, quite impossible.

As regards the age, we rejected all juveniles, and thus deleted some 40 measurements. Those which we have retained are, therefore, all adults, and the ages run from 20 to 72, with a true mean of 37.90.

Concerning the nature of the crimes, our observational data comprise such crimes as murder, manslaughter, wounding and assault, sexual offences, larceny, embezzlement, forgery, house and shop breaking, cattle stealing, inebriety, wife desertion, obscene language, debt, receiving, false pretences, gambling, vagrancy, maintenance, suspected person, bigamy, impersonation and arson.

As the numbers herein dealt with are very unequally distributed amongst the foregoing crimes, we have thought it desirable to classify them into groups for convenience of working, and we thus reduce the above many crimes to ten divisions, which, with the number of criminals in each, are as follow :—

1.	Murder and manslaughter	11
2.	Wounding and assault	15
3.	Sexual offences	56
4.	Larceny	144
5.	Embezzlement	5
6.	Forgery	14
7.	House and shopbreaking	26
8.	Cattle stealing	6
9.	Inebriety	26
10.	Miscellaneous	52
	Total	355

Of the craniometric data we have recorded the maximum length of the head, the maximum breadth, the auriculo-bregmatic height, the maximum circumference, and the transverse arc. As all these measurements were taken in accordance with the instructions issued by the British Association Committee of Anthropometric Investigation in the British Isles, they require no further comment here.

From the information furnished by the first three measurements we have worked out the estimated cubic capacity of brain of these 355 criminals, as also the cephalic index, but we have made no use whatsoever of the circumferential measurements. They are simply recorded and published for the information and use of any other investigators who may care to avail themselves of the data.

The details for the whole series under both the personal and craniometric heads are set forth in the table which accompanies this work.

Concerning the method by means of which the cubic capacity of brain has been estimated from the three diametral measurements, we have employed Lee's formula No. 14 (9), which for males is as follows:—

$$C = \cdot 000337(L - 11)(B - 11)(H - 11) + 406 \cdot 01.$$

We have selected this particular formula for the estimation of the cubic capacity for three reasons—first, because Miss Lee herself would appear to regard this as the most uniformly accurate of the many methods adopted, and thinks that it gives a result to within 4 per cent. Second, because Miss Lee's opinion is supported by practical experience in this school, one of our fellow-workers, Dr. J. H. Anderson (11), having proved that the Lee formula No. 14 is all the author has claimed for it; and, third, because the data with which we shall compare our results have been compiled with the use of this formula.

The material employed by us for comparison with the criminals has been selected with the special object of establishing the correlation, if any, between the brains of the lower grades of society, and of those who by education and nature of occupation may presumably be regarded as occupying a higher place in the social scale. If between two such opposed classes there should prove to be no difference, or but little, in the true mean of the cubic capacity of brain, then we think we should have to look entirely to environment or heredity, for the solution of the problem of the distinction of the two classes.

Our comparative data belong to two groups—first, those where the methods adopted are in all respects precisely similar to those of the present work, and which, therefore, permits of a direct comparison between the several results; and second, those where the methods of working have been different, and which, consequently restricts us to an indirect comparison.

In the former group, where the methods of working are in all respects precisely the same as our own, and where Lee's formula No. 14 has been uniformly employed for the necessary calculations, we have included:—

1. Thirty-five anatomists.
2. Twenty-five members of the teaching staff of University College, London.
3. Two hundred and fifteen medical students of the Middlesex Hospital and King's College, London.
4. Four Melbourne students.
5. An unknown number of members of the British Association for the Advancement of Science.

The necessary figures for the anatomists, members and teaching staff of the University College, and for the British Association are all taken from "A first Study of the Correlation of the Human

Skull," by Alice Lee, with some assistance from Karl Pearson (9). It is important to note that all are males and that, as stated, the methods of working are precisely similar to those adopted by us for the criminals.

Of the 215 Middlesex and King's College students, the necessary data of length, breadth and height have been taken by us from Gladstone's 1906 work (2), and the cubic capacities worked out by ourselves with the same formula as before. For the results of the former we are not, therefore, responsible, but for the latter any errors are our own.

In our second group of comparative data, where, the methods of working having been different, only indirect comparisons can be instituted, we shall avail ourselves of the published work of Matiegka (12) and Costa Ferreira (20). To these reference will be made later.

The true mean of the cubic capacity of brain of the 355 criminals of the present work is 1437.76 cc. The range of variation extends from 1164 cc., which occurred in a male aged 65, to 1771 cc., which also occurred once in a male aged 33. Both the minimum and maximum figures recorded by us occurred in persons convicted for larceny; this, however, may be merely a coincidence due to the fact that the cases of larceny in the present series comprise a larger number than any of the other groups. Expressed differently, if the true mean of the cubic capacity of these criminals be regarded as being equal to 100, then the minimum and maximum ranges of variation would be indicated by the figures 80.9 and 123.

For the 35 anatomists, the figures as furnished by Lee and Pearson are for the true mean of the cubic capacity 1537. If the amount of brain cubic capacity of the 355 criminals be regarded as being equal to 100, then the relative proportion of brains possessed by the 35 anatomists is 106.8. The range of variation in the 35 anatomists extends from 1372, which occurs once in a German anatomist who was attending the Congress at which the heads were measured, to 1813, which occurs once in a Welshman. If the anatomical true mean be regarded as being 100, then the range of variation extends from 89.2 to 117.9.

In the case of the 25 members of the teaching staff of University College, London, the true mean of the cubic capacity, as given by Lee and Pearson, is 1511, with a range of variation from 1352 to 1633, or in relative numbers, as before, from 89 to 108.

For the males attending the British Association for the Advancement of Science the true mean of the cubic capacity is 1495. As the minimum and maximum figures are not furnished by Lee and Pearson, we are unable to quote the range of variation.

In the case of the four Melbourne students the true mean is 1469 cc., with a range of variation from 1259 to 1590, or in numbers relative to the true mean (100), from 85.7 to 108.2.

The 215 Middlesex and King's College students are given by Gladstone in three groups according as to whether they were medallists and prizemen, students of average intelligence or only students below average intelligence. The individual figures are not available, so we can only deal with Gladstone's material as a whole. We find the true mean, as estimated from his table of average measurement for his three classes, to be 1507.34, with a range of variation from 1451.18 in Class C, the students below average intelligence, to 1565.09 in the medallists of Class A. The range of relative variation is, therefore, from 96.2 to 103.8. The much more restricted range of variation in the Middlesex Hospital and King's College group is due to the fact that it is based upon averages of groups and not upon individuals, as in the cases of all our other groups where we have recorded the range of variation, and consequently we do not specially emphasise the figures.

We do not intend to institute any comparisons in the present work between the cubic capacity of males and females, but it will be of interest to study this relative range of variation in the case of the 30 women students of Bedford College, the original figures for which are again taken from Lee and Pearson. The true mean of the cubic capacity of brain is in these students 1390, with a range of variation from 1200 to 1647, or in numbers relative to the true mean (100), from 86.3 to 118.4.

If the several groups be now arranged in the order determined by the estimated amount of cubic capacity of brain with the minimum and maximum ranges of variation of each group stated in terms of the true mean (100) of that particular group, we obtain the following :—

	Minimum.	True Mean	Maximum.
1. 35 Anatomists	89.2	1537 cc.	117.9
2. 25 University College	89	1511 cc.	108
3. 215 London Medical Students	96.2	1507 cc.	103.8
4. British Association males	—	1495 cc.	—
5. 4 Melbourne Students	85.7	1469 cc.	108.2
6. 355 Melbourne Criminals	80.9	1438 cc.	123

If the amount of cubic capacity of brain of the foregoing groups be worked out in relative numbers from the lowest class, the criminal, whose cubic capacity of brain shall be regarded as 100, we achieve the following results :—

1. 355 criminals	100.
2. 4 Melbourne Students	102.1
3. British Association males	103.9
4. 215 London Medical Students	104.7
5. 25 University College Teachers	105.0
6. 35 Anatomists	106.8

The general order of these groups is fully supported by the work of Matiegka and Costa Ferreira, to which incidental reference has already been made, and whose work constitutes the line of indirect comparison now to be made. Their results have not been incorporated in the above direct comparisons, because we do not know how they achieved their results, and it necessarily follows that if these investigators employed another formula than that herein adopted, their results, in cubic centimetres, cannot obviously be compared directly with ours.

Matiegka (12) examined the brain weights of a considerable number of individuals drawn from different classes of life, and concludes therefrom that it is clear that high intelligence is causally associated with an increase in the brain weight. The undoubtedly many discrepancies he explains on the different degree of muscular development of different individuals. His figures, arranged in grammes as given by himself, and in relative numbers worked out by ourselves, are as follows:—

	Grammes.		Rel. No.
1. 14 Day Labourers of the Navvy Class	1410.0	-	100
2. 34 Workmen - - - -	1433.5	-	101.6
3. 14 Minor Officials, Overseers and Watchmen in whom a certain amount of intelligence was necessary - - - -	1435.7	-	101.8
4. 123 Tradespeople and Artisans -	1449.6	-	102.8
5. 28 Minor Officers, Teachers, Business People, Musicians, etc. - -	1468.5	-	104.1
6. Students, Officers, Doctors, etc. -	1500	-	106.3

Costa Ferreira (13) measured the cubic capacity of 557 skulls from two churchyards in Lisbon. They were the skulls of persons whose position in life was known exactly, and which thus permitted of their subdivision into social groups. The average cranial capacity was 1572.72. This capacity must not, however, be compared directly with ours, as it was almost certainly obtained by a different method, and as the work was done on the skull itself, the measurement is probably direct and not estimated. The order attained by Ferreira's groups may, however, be compared with our own results, and is as follows:—

	Cubic cm.		Rel. No.
1. 95 unknown occupation - -	1538.98	-	100.0
2. 12 House Proprietors - -	1563.02	-	101.5
3. 164 Daily Labourers - -	1570.04	-	102.0
4. 150 Workmen - - -	1573.69	-	102.2
5. 52 Public Servants on the Pension List - - - - -	1584.91	-	102.9
6. 11 Public Servants - - -	1590.18	-	103.3
7. 49 Business Men - - -	1598.58	-	103.8
8. 93 Members Learned Professions -	1629.9	-	105.9

From the foregoing comparisons, both direct and indirect, it is clear that as regards classes the greater the intelligence demanded by the profession the greater the amount of the cubic capacity of brain possssed by that class; in other words, as regards classes in general, the evidence herein adduced distinctly points to a correlation between intelligence and size of head.

We have already stated that the 355 criminals of the present investigation have been divided by us into ten groups according to the nature of their crimes, and in view of the general conclusion contained in the last paragraph, we have thought it advisable to examine these ten classes, to see if that conclusion would be supported or not, by the various criminal groups themselves.

Of these ten groups the true means, probable errors, and standard deviations of the cubic capacities of brains, with the minimum and maximum figures in each group, are as follow:—

355 Criminals divided into 10 Groups according to the nature of the crime.

No.	Nature of Crime.	Minimum.	True Mean.	Standard Deviation.	Maximum.
6.	Cattle Stealing	1280	1377±24.31	88.28±17.20	1516
26.	Inebriety	1191	1423±17.20	129.80±12.14	1657
15.	Assault and Wounding	1268	1425±15.48	88.86±10.95	1595
144.	Larceny	1164	1432± 5.52	98.21± 3.90	1771
26.	House and Shopbreaking	1317	1435±10.82	81.66± 7.63	1610
56.	Sexual Offences	1213	1440± 9.09	100.89± 6.43	1668
11.	Murder and Manslaughter	1261	1456±22.98	113.02±16.25	1675
52.	Miscellaneous	1269	1458± 8.73	93.33± 6.17	1678
14.	Forgery	1267	1459±21.15	117.31±14.95	1701
5.	Embezzlement	1384	1475±31.43	103.94±22.18	1645

If now we express the relative amounts of brain capacity possessed by these several classes of criminals, and those other learned classes selected by us for comparison in terms of the lowest class of all, namely, the cattle stealers, whose cubic capacity of brain shall be assumed to be equal to 100, we obtain the following results, where are also shown the minimum and maximum ranges of variation in the class:—

		Minimum.	Capacity.	Maximum.
1.	6 Cattle Stealing	92.9	100.	110.
2.	26 Inebriety	83.6	103.3	116.4
3.	15 Assault and Wounding	88.0	103.4	111.9
4.	144 Larceny	81.2	103.9	123.6
5.	26 House and Shopbreaking	91.7	104.2	112.1
6.	56 Sexual Offences	84.2	104.5	115.8
7.	11 Murder and Manslaughter	86.6	105.7	115.0
8.	52 Miscellaneous crimes	87.0	105.8	115.8

		Minimum.		Capacity.		Maximum.
9.	14 Forgery - - - -	86.8	-	105.9	-	117.0
10.	4 Melbourne Students -	85.7	-	106.6	-	108.2
11.	5 Embezzlement - - -	93.7	-	107.1	-	111.5
12.	British Association males -		-	108.5	-	—
13.	25 University College Teachers	89.0	-	109.7	-	108.0
14.	35 Anatomists - - -	89.2	-	111.6	-	117.9

The foregoing table seems to us to confirm the general results already attained. Of the criminal classes it is extremely significant that those convicted of skilled crimes like forgery and embezzlement head the list, separated from each other by four students. As the forgers and embezzlers are drawn from the business classes, where intelligence is required, it seems to us that the position occupied in the table by these two groups of criminals is exactly that which might have been expected. The forgers are followed, in our table, by the miscellaneous crimes, which in this instance also include certain crimes where some degree of intelligence would be demanded. Cattle stealing can hardly be termed an intelligent occupation, and it occupies the lowest place on the list. We thus see that the criminal classes occupy positions which seem to us to confirm the results we have already attained from our examination of the learned classes, and which all goes to prove that, as regards the classes, there is an appreciable correlation between size of head and intelligence.

Concerning the ages of the 355 criminals herein dealt with, we find the true mean to be 37.90 years of age. The true means, probable errors and standard deviation of the ages of the several groups into which we have divided them are as under :—

		True Mean of Age.		Standard Deviation.
1.	Cattle Stealing - -	30.83±1.41	-	4.68± .99
2.	Assault and Wounding -	31.8 ±1.52	-	8.77±1.08
3.	Miscellaneous Crimes -	34.1 ±1.14	-	12.20± .80
4.	House and Shopbreaking -	35.53±1.58	-	12.01±1.12
5.	Larceny - - -	37.30± .67	-	11.95± ·47
6.	Sexual Offences - -	39.06±1.27	-	14.17± .90
7.	Forgery - - -	39.00±2.64	-	14.69±1.87
8.	Murder and Manslaughter -	43.19±2.76	-	13.56±1.95
9.	Embezzlement - -	46.40±4.60	-	15.03±3.20
10.	Inebriety - - -	49.43±1.73	-	13.11±1.22

Individually the youngest of these criminals is aged 20 years, and the oldest 72. This notwithstanding, the comparatively high true mean of the criminals as a whole, and in individual groups is somewhat surprising, and may possibly be accounted for by the fact that some of them are serving long sentences. It would, therefore, be unwise to make any sweeping deductions from these ages.

It is, however, somewhat significant that cattle stealing seems to be a crime committed by young persons of exceptionally poor mental ability; still more striking is the fact that embezzlement would appear to be a crime of middle life, when possibly various social causes have tempted the individual of good previous position in society to maintain that position at all hazards; and, lastly, chronic alcoholism would seem to be a disease of middle and old age. A comparison of the table of ages with that of cubic capacity of brain does not appear to show any correlation whatsoever between age and crime.

From the lengths and breadths of the heads of these criminals we have also worked out the breadth or cephalic index. It must be noted that the resulting indices are those for the heads including the soft parts, as we have not thought it worth while to perform the necessary calculations for obtaining from the surface anatomy figures those for the skull itself. We find the true man of the cephalic index of the 355 criminals to be 78.96 ± 0.36, and the standard deviation 3.63 ± 0.25. The group, as a group, is thus mesaticephalic, as were also the 3000 criminals examined by Macdonell (14) with an index of 78.538. Of the individual groups, all, with the exception of the forgers, are also mesaticephalic, and the forgers just come into the brachycephalic class with an index of 80.36 ± 1.64. The results are as follow :—

Table of the Cephalic Indices of 355 Criminals.

	True Mean.	Standard Deviation.
6 Cattle Stealing - - -	$77.34 \pm .91$ -	$3.30 \pm .64$
15 Assault and Wounding -	$78.07 \pm .61$ -	$3.50 \pm .43$
52 Miscellaneous Crimes - -	$78.25 \pm .33$ -	$3.61 \pm .23$
144 Larceny - - -	$78.90 \pm .18$	$3.28 \pm .13$
11 Murder and Manslaughter -	$79.00 \pm .77$ -	$3.78 \pm .54$
26 House and Shop-breaking -	$79.30 \pm .40$ -	$3.09 \pm .28$
56 Sexual Offences - -	$79.37 \pm .34$ -	$3.83 \pm .24$
5 Embezzlement - - -	79.10 ± 1.10 -	$3.92 \pm .73$
26 Inebriety - - -	$79.57 \pm .78$ -	$5.93 \pm .55$
14 Forgery - - -	80.36 ± 1.64 -	$3.57 \pm .45$

The standard deviations in the above table make it evident that, whilst the whole group is, as stated, and broadly speaking, mesaticephalic, yet many of the classes range from dolichocephaly to brachycephaly.

As with the age so with the cephalic index, there does not appear to be any correlation between the cephalic index and crime.

Having thus disposed of the questions of age and cephalic index, we may now revert to the major question, namely, the correlation between size of head and intelligence.

We have already shown, as fairly as we can, that on this point there is a marked divergence of opinion, and we now propose to examine the facts from both the medical and the biometric side with a view to determining how far the present research tends to harmonise the undoubtedly conflicting opinions on the subject. With this object in view we shall first submit the results of the present work and the selected objects of comparison in a table wherein are shown the true means of the estimated cubic capacities with their probable errors, the standard deviation of the same with their probable errors, as also the extreme minimum and maximum figures in every class where they are known to us.

Concerning this last, Udny Yule (15) has written, "The simplest possible measure of the dispersion of a series of values of a variable is the actual range, i.e., the difference between the greatest and least values observed. While this is frequently quoted, it is as a rule the worst of all possible measures for any serious purpose. There are seldom real upper and lower limits to the possible values of the variable, very large or very small values being only more or less infrequent; the range is, therefore, subject to meaningless fluctuations of considerable magnitude according as values of greater or less infrequency happen to have been actually observed."

In the table which follows, Yule's objection, the very proper one of the mathematician, is met by the inclusion of the standard deviation, and the individual range of variation is retained for reasons which appeal strongly to the medical man on medical grounds alone.

Table of true means, standard deviations, probable errors and individual range of variation of 355 criminals and other classes of comparison.

No.	Class.	Minimum.	True Mean.	Standard Deviation.	Maximum.
35	Anatomists	1372	1537 ± 9.86	86.40 ± 6.97	1813
34	Anatomists	1372	1529 ± 8.53	73.81 ± 6.04	1656
25	Teachers	1352	1511 ± 11.04	81.90 ± 7.81	1633
215	London Students	—	1507		—
·	B. A. A. Sc.	—	1495	—	
5	Embezzlement	1384	1475 ± 31.43	103.94 ± 22.18	1645
4	Melbourne Students	1259	1469 ± 42.69	126.59 ± 30.27	1590
14	Forgery	1267	1459 ± 21.15	117.31 ± 14.95	1701
52	Miscellaneous	1269	1458 ± 8.73	93.33 ± 6.17	1678
11	Murder and Manslaughter	1261	1456 ± 22.98	113.02 ± 16.25	1675
56	Sexual Offences	1213	1440 ± 9.09	100.89 ± 6.43	1668
26	House and Shop-breaking	1317	1435 ± 10.82	81.66 ± 7.63	1610

No.	Class.	Minimum.	True Mean.	Standard Deviation.	Maximum.
144	Larceny	1164	1432 ± 5.52	98.21 ± 3.90	1771
15	Assault and Wounding	1268	1425 ± 15.48	88.86 ± 10.95	1595
26	Inebriety	1291	1423 ± 17.20	129.80 ± 12.14	1657
6	Cattle-stealing	1280	1377 ± 24.31	88.28 ± 17.20	1516
355	Melbourne Criminals	1191	1437.76 ± 10.47	99.74 ± 7.10	1771

We do not think that any unprejudiced person can study this table and deny that as regards classes there is an undoubted correlation between size of head and intelligence, or, put more accurately, between cubic capacity of brain, as estimated from three diametral head measurements, and intelligence. This statement is the more probable inasmuch as it is strongly supported by the work of Gladstone, Matiegka, and Costa Ferreira, to which reference has already been made, and whose work supports in every detail the general conclusion here drawn. In view of the fact that Venn and Galton, quoted by Haddon (16), have shown for 1000 Cambridge students that education prolonged into years of adolescence, as amongst students at a University, increases the size of the brain, we fail to see how the thesis can be contested. We are, of course, aware that many of the opponents of the view talk somewhat vaguely of quality of brain rather than quantity. It has, however, been proved by Flechsig that the short association fibres of the human cerebral cortex do not myelinate until such time after birth as education and the exercise of the intellect have stimulated different parts of the cerebal cortex to act in harmony. If there be no education at all, these fibres do not myelinate, and, consequently, such a brain could not, other things being equal, ever attain the same size as the brain in which such nerve fibres had myelinated.

Similarly with the statement previously quoted from Miss Lee that "personally I am inclined to hold with Professor Pearson that the complexity of the convolutions of the brain, and the variety of its commissures, rather than its actual size, are the characters we might expect to differentiate race from race and sex from sex, and to have developed with man's civilisation"; to us it would rather appear as though increased complexity of cerebral convolutions means an increased number of brain cells and of axones of cells, and consequently an increase in size of brain, and that the commissures cannot be more varied without a corresponding increase in the commissural exones, and a consequent corresponding increase in the size of the brain. This line of argument is supported by the well-known anthropological fact that man's civilisation has resulted from a steady increase in cubic capacity of brain from *Pithecanthropus erectus* with his 1000 cc. of brain through the men of the palaeolithic ages with 1100-1200 cc., the modern day Australian aboriginal with 1200-1300 cc., to the learned classes of the 20th century with their 1500 cc. This is still further supported by Buschan's recent work (7), which investigated the question as to whether the skulls of to-day permit us to recognise an increase of intelligence as compared with those of past ages; with which object he examined a number of French and Rhenish skulls from neolithic to modern times, and found that in the neolithic skulls of France the largest percentage (30 per cent.) had a cubic capacity of from 1300 to 1400 cc. Of Parisian skulls of the 12th century 37 per cent. had a cubic capacity of from 1400 to 1500 cc., whilst modern Parisian crania had, on an average, a cubic capacity of from 1500 to 1600 cc. Buschan attains like results with his Rhenish skulls, as also for the ancient Egyptians, and in the later he actually finds a diminution of the cubic capacity coincident with the mental decline of that ancient and highly civilised people. It seems to us, therefore, on neurological and anthropological grounds that Miss Lee's opinion is in reality an argument in favour of correlation of size of head and intelligence, and not against it, as she seems to imagine.

It consequently follows that if the expression "quality of brain" means anything at all, it denotes an activity of nerve cells due to some subtle and as yet unmeasured and unmeasurable chemical or physical reaction. As thus defined we do not deny the possibility of "brain quality" entering into the problem, but there is as yet no proof of it. All the facts, as we know them, point to an association between size of brain and mentality, and *per contra* we know of no evidence capable of scientific investigation which points to quality of brain rather than quantity as forming the dominant factor in the mentality of the several classes of mankind.

From the evidence of the present work, supported by the facts of others, and confirmed by the great principles of neurology and anthropology, we are of opinion that there is an appreciable correlation between size of head and intelligence in the several social human classes.

What holds good for the class should also be true for the individual. But here the problem is so obscured by environment, heredity, disease, disposition, habits of laziness or industry, and many other more or less disturbing factors that we entirely concur in the opinion of the biometric school of thought as expressed by Miss Lee, when she says: "there is no marked correlation between skull capacity and intellectual power in the case of either sex alone." To argue, however, as she does, that because there is no marked correlation in the individual, there is "quite conceivably no correlation with racial ability" seems to us to be erroneous reasoning.

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From our observation of the problem we reason from the class to the individual and not *vice versa* as does Miss Lee.

We do not think, however, that any medically trained man or physical anthropologist, knowing the possibility of error in the of the individual, would base any opinion on the intellectuality of that individual from the mere study of his head measurements; in all cases excessively large or small figures of estimated cubic capacity of brain should, on medical grounds alone, be regarded with suspicion. Extremely small ones begin to border on the confines of microcephalic idiocy, and the large ones quickly verge into, or are suggestive of, hydrocephalus. Thus, a hydrocephalic individual who lived to the age of 34 (a male), and whose head was measured by one of us (Berry), had an estimated capacity of 3860 cc. Conversely, a boy aged 14, who was measured by Professor Berry on behalf of a Melbourne oculist, had an estimated cubic capacity of but 1169 cc. This examination, combined with the opthalmological report, played an important part in the future of the patient, whose father was dissuaded by the oculist from entering his son for any of the learned professions.

Then, again, an examination of the figures quoted by us on page 241, shows that the range of variation is so great amongst the different members of the several classes as to more than warrant extreme caution in passing an opinion on the individual. Individually some of the criminals have a much greater cubic capacity of brain than have the true means of the learned classes. It is, however, extremely interesting to note that in one case we are, from our own knowledge, enabled to state that the criminal who heads the list amongst the inebriate group, is a graduate of Oxford, and a man of great and undoubted intellectuality who has attained his present unfortunate position as the result of alcohol and neglected opportunity. The same table shows, on the other hand, that there are some individuals amongst the criminal classes who possess so few brains it is a mere mockery to go on punishing them for crimes, the heinousness of which they have not the brains to realise.

Concerning, then, the three objects with which the present investigation has been primarily concerned, we conclude:—

1. That the inferior, that is the less well educated, classes of the community, have an appreciably less amount of cubic capacity of brain than have the more highly educated.

2. That amongst classes there is a distinctly measurable correlation between size of head and intelligence, but that, as Pearson expresses it, "it would be absolutely idle to endeavour to predict the intellectual ability of an individual from his or her head measurements."

3. That amongst the criminal classes there is an undoubted percentage sufficiently devoid of brains as to render their repeated punishments for acts of which they are hardly responsible as undesirable as it would appear to be inhumane.

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Measurements of 355 Criminals.

Serial Number.	Nature of Crime.	Age.	Length.	Breadth.	Height.	Circumference.	Transverse Arc.	Cephalic Index.	Capacity.
1	Embezzlement	63	189	154	126	545	345	81.5	1392
2	,,	50	194	142	135	560	382	73.2	1407
3	Misappropriation	36	185	150	131	540	352	81.1	1384
4	Embezzlement	23	190	159	139	573	369	83.7	1548
5	Misappropriation	60	205	158	140	579	369	77.1	1645
6	Forgery	21	186	142	134	550	372	76.3	1356
7	,,	26	192	158	130	560	358	82.3	1473
8	,,	45	194	150	138	565	360	77.3	1494
9	,,	45	193	157	135	563	370	81.3	1516
10	,,	63	179	146	135	570	356	81.6	1353
11	,,	25	189	144	130	540	343	76.2	1355
12	,,	41	185	141	124	533	350	76.2	1267
13	,,	49	195	149	127	545	340	76.4	1398
14	,,	40	186	150	140	560	362	80.6	1463
15	,,	46	199	164	143	571	369	82.4	1685
16	,,	69	189	165	126	541	324	87.3	1468
17	,,	21	187	160	135	552	376	85.6	1501
18	,,	31	197	163	147	606	380	82.7	1701
19	,,	24	185	148	135	530	340	80.0	1402
20	Wife Desertion	28	198	149	142	565	370	75.3	1545
21	Obscene Language	28	180	152	125	545	355	84.4	1321
22	Debt	33	188	145	126	550	350	77.1	1325
23	Obscene Language	24	189	154	130	557	365	81.5	1426
24	Receiving	30	190	144	125	547	347	75.8	1320
25	False Pretences	23	190	146	134	553	350	76.8	1407
26	Wife Desertion	26	200	145	137	558	360	72.5	1481
27	Gambling	44	198	155	134	565	363	78.3	1522
28	Debt	33	188	148	138	550	360	78.7	1443

Serial Number.	Nature of Crime.	Age.	Length.	Breadth.	Height.	Circumference.	Transverse Arc.	Cephalic Index.	Capacity.
29	False Pretences	25	199	155	138	576	372	77.9	1564
30	..	42	197	146	140	565	365	74.1	1497
31	Debt	36	206	151	132	575	365	73.3	1528
32	Vagrancy	51	190	152	140	557	377	80.0	1503
33	False Pretences	20	189	131	131	520	342	69.3	1269
34	Debt	32	200	149	140	573	389	74.5	1539
35	Obscene Language	25	186	150	128	510	370	80.6	1365
36	Maintenance	46	189	148	128	550	360	78.3	1367
37	Obscene Language	23	198	156	137	570	380	78.8	1557
38	Maintenance	29	194	151	130	550	360	79.4	1455
39	Vagrancy	28	195	148	136	560	382	75.9	1467
40	Suspected Person	31	192	148	124	525	360	77.1	1358
41	Vagrancy	24	185	150	127	543	358	81.1	1351
42	Bigamy	31	202	153	134	563	372	75.7	1530
43	Vagrancy	35	195	162	134	572	362	83.1	1557
44	Train Wrecking	27	204	158	134	577	368	77.5	1582
45	Smuggling	57	200	147	140	575	365	73.5	1523
46	Vagrancy	23	197	148	134	549	375	75.1	1462
47	..	47	185	148	129	545	352	80.0	1353
48	False Pretences	24	192	141	134	548	360	73.4	1381
49	Vagrancy	20	185	149	142	530	360	80.5	1466
50	Bigamy	29	195	150	129	545	345	76.9	1423
51	Impersonation	52	195	156	139	565	375	80.0	1556
52	Vagrancy	23	182	149	127	535	340	81.9	1328
53	Gold-buying	29	182	154	134	555	350	84.6	1419
54	..	38	188	156	129	560	362	83.0	1426
55	..	24	190	160	133	562	373	84.2	1502
56	Bigamy	68	200	149	134	570	360	74.5	1487
57	Receiving	26	195	148	132	538	348	75.9	1433
58	Loitering	35	195	154	144	560	380	79.0	1585
59	Trespassing	47	194	149	130	550	340	76.8	1418
60	False Pretences	41	192	160	134	560	366	83.3	1523
61	Receiving	23	195	160	136	572	375	82.1	1560
62	Bigamy	31	191	156	133	551	354	81.7	1479
63	Receiving	66	187	156	130	555	354	83.4	1429
64	Illegally on Premises	23	200	150	130	565	359	75.0	1459
65	Suspected Person	57	200	154	136	578	360	77.0	1544
66	Vagrancy	43	195	148	126	565	335	75.9	1382
67	Receiving	27	188	134	130	568	357	71.3	1279
68	..	27	199	162	144	561	374	81.4	1678
69	Vagrancy	29	195	161	136	574	360	82.6	1568
70	Arson	63	184	150	130	533	352	81.5	1370
71	..	27	195	148	141	562	348	75.9	1510
72	Manslaughter	27	182	143	130	547	350	78.6	1311
73	Murder	50	197	157	131	570	370	79.7	1504
74	..	30	192	151	134	568	362	78.6	1456
75	..	32	190	152	132	555	330	80.0	1435
76	..	30	193	146	136	550	340	75.6	1441

Serial Number.	Nature of Crime.	Age.	Length.	Breadth.	Height.	Circumference.	Transverse Arc.	Cephalic Index.	Capacity.
77	Murder	46	187	142	133	570	331	75.9	1353
78	,,	47	185	139	125	528	345	75.1	1261
79	,,	61	194	152	136	545	360	78.4	1492
80	,,	33	195	156	142	572	372	80.0	1583
81	Manslaughter	52	193	161	149	569	370	83.4	1675
82	Murder	69	195	164	127	560	360	84.1	1506
83	Assault	27	205	151	136	570	370	73.6	1558
84	Murderous Assault	22	195	144	134	550	350	73.8	1420
85	Wounding	33	198	146	127	550	340	73.7	1392
86	Assault	30	190	156	147	555	355	82.1	1595
87	,,	26	187	152	132	550	375	81.3	1417
88	,,	28	188	152	131	544	344	80.9	1415
89	,,	47	178	149	122	520	320	83.7	1268
90	,,	29	194	155	131	558	358	79.9	1471
91	Wounding	25	184	145	131	535	335	78.8	1343
92	,,	25	190	139	130	535	342	73.2	1324
93	,,	39	189	149	135	560	362	78.8	1432
94	Attempted Murder	53	200	150	135	561	352	75.0	1503
95	Assault	30	180	149	130	533	334	82.8	1318
96	Criminal Assault	40	190	150	130	530	340	78.9	1403
97	,, ,,	23	198	148	140	563	354	74.7	1519
98	S xual Offence	22	197	141	125	550	340	71.6	1334
99	,, ,,	22	187	143	131	545	356	76.5	1345
100	,, ,,	52	198	155	127	554	354	78.3	1458
101	,, ,,	29	182	139	131	520	345	76.4	1291
102	,, ,,	21	184	142	133	557	355	77.2	1337
103	,, ,,	48	185	151	135	538	372	81.6	1423
104	,, ,,	57	193	152	137	565	365	78.8	1495
105	,, ,,	21	192	159	132	560	355	82.8	1498
106	,, ,,	39	193	150	120	540	340	77.7	1335
107	,, ,,	60	201	157	132	568	362	78.1	1537
108	,, ,,	23	200	158	140	580	389	79.0	1613
109	,, ,,	34	191	152	133	550	350	79.6	1449
110	,, ,,	21	189	142	131	530	342	75.1	1348
111	,, ,,	42	190	149	133	542	370	78.4	1421
112	,, ,,	26	180	148	127	548	340	82.2	1311
113	,, ,,	33	190	136	134	534	352	71.6	1333
114	,, ,,	38	194	151	127	551	326	77.8	1407
115	,, ,,	58	190	148	140	550	360	77.9	1472
116	,, ,,	32	199	156	129	550	356	78.4	1490
117	,, ,,	35	197	154	137	558	358	78.2	1535
118	,, ,,	29	201	150	134	567	360	74.6	1500
119	,, ,,	54	185	138	129	530	330	74.6	1284
120	,, ,,	56	195	150	140	545	350	76.9	1517
121	,, ,,	45	185	154	132	545	340	83.2	1420
122	,, ,,	52	200	160	144	570	372	80.0	1668
123	,, ,,	61	194	148	130	567	360	76.3	1411
124	,, ,,	32	205	154	135	578	370	75.1	1565

Serial Number.	Nature of Crime.	Age.	Length.	Breadth.	Height.	Circumference.	Transverse Arc.	Cephalic Index.	Capacity.
125	Sexual Offence	38	190	160	142	549	381	84.2	1583
126	,, ,,	37	189	152	141	571	346	80.4	1505
127	,, ,,	70	195	160	129	562	361	82.1	1496
128	,, ,,	66	179	162	135	542	364	90.5	1466
129	,, ,,	32	196	154	127	539	356	78.6	1440
130	,, ,,	31	185	162	131	578	360	87.6	1468
131	,, ,,	28	186	156	127	543	340	83.9	1397
132	,, ,,	38	182	149	127	530	335	81.9	1328
133	,, ,,	32	188	149	142	548	345	79.3	1484
134	,, ,,	53	191	150	130	553	370	78.5	1409
135	,, ,,	34	197	154	140	570	364	78.2	1562
136	,, ,,	44	185	144	130	530	348	77.8	1334
137	,, ,,	46	202	165	136	587	345	81.7	1645
138	,, ,,	25	194	154	150	557	375	79.4	1631
139	,, ,,	26	184	146	130	528	350	79.3	1342
140	,, ,,	34	192	148	127	550	330	77.1	1375
141	,, ,,	55	192	148	130	540	350	77.1	1408
142	,, ,,	33	179	152	135	523	356	84.9	1395
143	,, ,,	21	196	154	134	551	361	78.6	1501
144	,, ,,	21	192	160	130	560	361	83.3	1487
145	,, ,,	35	192	150	128	549	352	78.1	1397
146	,, ,,	39	189	151	131	545	360	79.9	1407
147	,, ,,	30	174	150	120	520	330	86.2	1238
148	,, ,,	30	192	160	136	568	365	83.3	1540
149	,, ,,	58	190	138	126	530	359	72.6	1302
150	,, ,,	68	196	160	130	553	350	81.6	1511
151	,, ,,	70	189	165	127	540	323	87.3	1484
152	,, ,,	23	200	147	134	573	363	73.5	1471
153	,, ,,	28	179	134	127	528	320	74.9	1213
154	Shopbreaking	40	188	150	122	545	334	79.8	1326
155	Housebreaking	25	182	153	134	553	370	84.1	1412
156	,,	27	192	140	131	557	340	72.9	1350
157	,,	59	196	149	130	569	349	76.0	1551
158	Shopbreaking	63	178	150	136	542	362	84.3	1383
159	Housebreaking	23	178	154	132	542	360	86.5	1379
160	,,	56	196	157	134	553	530	80.1	1525
161	,,	24	197	149	131	564	350	75.6	1444
162	,,	33	190	148	126	540	338	77.9	1356
163	Shopbreaking	22	191	146	132	550	355	76.4	1396
164	Housebreaking	36	195	154	136	558	362	79.0	1514
165	,,	50	196	153	140	568	372	78.1	1548
166	,,	24	187	150	125	553	350	80.2	1345
167	,,	29	198	160	130	562	360	80.8	1523
168	,,	36	187	148	130	560	362	79.1	1372
169	Shopbreaking	25	198	152	134	535	345	76.8	1498
170	Housebreaking	22	193	146	133	557	365	75.6	1416
171	,,	26	197	161	130	567	355	81.7	1524
172	Shopbreaking	32	197	160	140	578	372	81.2	1610

Serial Number.	Nature of Crime.	Age.	Length.	Breadth.	Height.	Circumference.	Transverse Arc.	Cephalic Index.	Capacity.
173	Housebreaking	30	190	160	130	564	364	84.2	1475
174	Shopbreaking	39	185	146	126	533	342	78.9	1317
175	Housebreaking	38	184	146	128	533	350	79.3	1326
176	Shopbreaking	45	199	153	132	560	357	76.9	1407
177	Housebreaking	32	198	160	128	550	356	80.8	1504
178	Shopbreaking	56	188	148	130	530	325	78.7	1373
179	Housebreaking	32	197	145	132	568	370	73.6	1430
180	Horse-stealing	25	182	143	126	540	350	78.6	1280
181	,,	32	197	145	132	568	370	73.6	1430
182	,,	32	183	168	133	565	380	91.8	1516
183	Sheep-stealing	30	186	144	125	529	325	77.4	1300
184	Horse-stealing	26	195	146	134	562	348	74.9	1435
185	Sheep-stealing	40	186	144	125	540	362	77.4	1300
186	Inebriety	44	200	147	119	574	372	73.5	1341
187	,,	51	178	144	116	520	330	80.9	1191
188	,,	72	190	147	125	550	359	77.4	1341
189	,,	30	190	149	125	550	345	78.4	1335
190	,,	43	187	146	122	556	361	78.1	1207
191	,,	45	190	140	126	534	340	73.7	1300
192	,,	27	195	145	131	556	365	74.4	1403
193	,,	43	190	150	130	545	361	78.9	1403
194	,,	65	190	143	128	545	345	75.3	1337
195	,,	63	185	150	131	549	363	81.1	1384
196	,,	49	187	159	132	572	370	85.0	1468
197	,,	64	180	146	126	526	340	81.1	1290
198	,,	72	206	149	131	564	350	72.3	1494
199	,,	46	190	150	133	543	355	78.9	1428
200	,,	34	200	157	136	584	370	78.5	1568
201	,,	40	170	155	124	540	348	91.2	1277
202	,,	63	189	153	133	550	360	81.0	1445
203	,,	66	185	156	128	540	-53	84.3	1400
204	,,	60	195	159	141	565	380	81.5	1599
205	,,	52	203	156	140	574	382	76.8	1616
206	,,	28	203	160	140	578	370	78.8	1649
207	,,	49	190	146	126	545	350	76.8	1342
208	,,	29	190	152	130	545	355	80.0	1418
209	,,	51	197	162	140	600	365	82.2	1626
210	,,	48	188	152	132	544	340	80.9	1463
211	,,	51	198	165	137	600	370	83.3	1657
212	Larceny	42	188	142	124	530	325	75.5	1288
213	,,	24	195	148	135	570	368	75.9	1459
214	,,	64	190	140	130	550	350	73.7	1322
215	,,	38	187	143	121	549	345	76.5	1267
216	,,	26	187	146	125	552	360	78.1	1318
217	,,	51	180	146	130	543	370	81.1	1320
218	,,	40	184	152	133	545	367	82.6	1408
219	,,	33	188	149	133	535	357	79 3	1410
220	,,	39	202	155	126	590	365	76.7	1471

Serial Number.	Nature of Crime.	Age.	Length.	Breadth.	Height.	Circumference.	Transverse Arc.	Cephalic Index.	Capacity.
221	Larceny	29	189	150	122	552	358	79.4	1331
222	,,	23	192	149	134	547	365	77.6	1441
223	,,	27	198	157	129	570	359	79.3	1491
224	,,	38	188	152	120	545	340	80.9	1322
225	,,	36	190	144	125	544	340	75.8	1320
226	,,	54	198	142	130	558	362	71.7	1388
227	,,	22	196	145	135	564	362	74.0	1441
228	,,	22	194	149	140	550	390	76.8	1503
229	,,	37	192	142	130	565	360	74.0	1356
230	,,	36	184	150	125	538	343	81.5	1329
231	,,	42	192	147	129	550	345	76.6	1384
232	,,	24	190	142	139	547	345	74.7	1417
233	,,	66	190	138	134	535	330	72.6	1355
234	,,	33	179	149	134	523	350	83.2	1374
235	,,	25	190	148	132	545	325	77.9	1405
236	,,	38	188	145	128	545	360	77.1	1341
237	,,	23	191	156	136	557	360	81.7	1514
238	,,	23	188	141	125	545	345	75.0	1305
239	,,	45	191	151	126	565	355	79.1	1372
240	,,	47	200	154	134	565	370	77.0	1526
241	,,	31	186	154	129	553	360	82.8	1401
242	,,	33	198	153	135	568	380	77.3	1515
243	,,	50	198	159	132	550	360	80.3	1534
244	,,	28	196	146	136	554	370	74.5	1458
245	,,	30	195	158	143	560	352	81.0	1609
246	,,	28	203	145	130	555	376	71.4	1437
247	,,	23	189	154	141	550	360	81.5	1521
248	,,	30	194	144	132	550	350	74.2	1398
249	,,	24	195	157	128	543	350	80.5	1465
250	,,	28	192	146	134	554	360	76.0	1418
251	,,	21	187	151	140	540	350	80.7	1477
252	,,	24	177	156	132	542	360	88.1	1397
253	,,	29	194	149	143	568	378	76.8	1529
254	,,	25	192	150	134	560	380	78.1	1448
255	,,	41	192	159	126	552	360	82.8	1444
256	,,	53	192	146	132	555	350	76.0	1402
257	Robbery	35	186	147	137	525	345	79.0	1417
258	Larceny	57	196	152	130	570	370	77.6	1452
259	,,	24	195	147	143	570	390	75.4	1519
260	,,	30	195	150	135	562	350	76.9	1474
261	Robbery	27	192	152	127	557	355	79.2	1403
262	Larceny	23	192	163	132	570	370	84.9	1527
263	,,	22	189	148	130	542	342	78.3	1383
264	Robbery	21	180	135	132	524	353	75.0	1260
265	Larceny	50	183	159	136	575	365	86.9	1478
266	,,	61	175	148	125	581	366	84.6	1269
267	,,	25	189	160	130	555	368	84.7	1469
268	,,	28	194	144	136	538	362	74.2	1431

Serial Number.	Nature of Crime.	Age.	Length.	Breadth.	Height.	Circumference.	Transverse Arc.	Cephalic Index.	Capacity.
269	Larceny	68	195	160	124	550	330	82.1	1450
270	,,	39	196	153	137	570	370	78.1	1521
271	,,	32	200	149	134	562	345	74.5	1487
272	,,	51	190	149	133	555	352	78.4	1421
273	,,	33	202	156	136	573	363	77.2	1572
274	,,	40	184	140	131	525	344	76.1	1308
275	,,	26	184	139	137	535	342	75.5	1346
276	,,	53	186	146	120	530	325	78.5	1273
277	,,	37	193	156	140	550	360	80.8	1553
278	,,	26	188	146	130	548	330	77.7	1364
279	,,	39	198	146	136	560	350	73.7	1469
280	,,	27	188	144	130	518	330	76.6	1350
281	,,	50	194	156	134	562	362	80.4	1505
282	Stealing	26	192	158	142	576	380	82.3	1580
283	Larceny	31	189	152	130	542	350	80.4	1412
284	,,	37	185	148	128	539	344	80.0	1345
285	,,	36	185	150	126	540	350	81.1	1343
286	,,	32	184	140	121	550	345	77.2	1246
287	,,	55	190	154	125	550	348	81.1	1389
288	,,	48	192	160	130	550	354	83.3	1487
289	,,	38	192	150	130	563	372	78.1	1414
290	,,	40	195	152	134	551	360	77.9	1481
291	,,	26	197	153	134	552	355	77.7	1500
292	,,	29	196	158	136	556	364	80.6	1551
293	,,	41	183	154	140	581	362	84.2	1475
294	,,	48	191	153	131	567	370	80.1	1439
295	Theft	63	196	158	130	570	349	80.6	1496
296	Larceny	65	199	154	138	545	350	77.4	1556
297	,,	50	194	150	127	547	342	77.3	1400
298	,,	38	186	152	129	520	345	81.7	1387
299	Robbery	42	200	161	140	584	340	80.5	1638
300	Larceny	35	188	146	133	535	350	77.7	1388
301	,,	28	182	150	130	552	342	82.4	1359
302	Theft	29	189	154	130	540	350	81.5	1426
303	,,	42	200	149	130	563	340	74.5	1451
304	Larceny	49	188	142	132	540	360	75.5	1351
305	Stealing	40	188	160	133	560	355	85.1	1490
306	Larceny	28	200	157	130	570	358	78.5	1512
307	Stealing	35	182	144	123	523	324	79.1	1295
308	Larceny	40	192	152	138	560	362	79.2	1498
309	,,	31	187	152	137	510	355	81.3	1459
310	,,	50	206	162	142	580	370	78.6	1705
311	Robbery	23	189	150	142	540	365	79.4	1498
312	Larceny	35	191	151	141	547	346	77.8	1528
313	,,	38	192	157	131	561	262	81.8	1474
314	,,	32	200	156	138	574	364	78.0	1578
315	,,	26	185	146	130	545	360	78.9	1348
316	,,	27	191	142	132	531	340	74.3	1367

Serial Number.	Nature of Crime	Age.	Length.	Breadth.	Height	Circumference.	Transverse Arc.	Cephalic Index.	Capacity.
317	Larceny	60	192	152	125	558	335	79.2	1386
318	,,	58	200	149	137	578	362	74.5	1513
319	,,	33	184	149	128	537	345	81.0	1347
320	Robbery	34	184	150	134	561	371	81.5	1405
321	,,	48	186	160	132	545	352	86.0	1469
322	,,	35	186	152	136	525	345	81.7	1445
323	Larceny	27	197	148	140	555	345	75.1	1513
324	,,	36	194	156	140	560	360	80.4	1559
325	,,	29	190	136	130	570	367	71.6	1303
326	,,	30	176	138	126	548	346	78.4	1203
327	Theft	41	183	139	128	561	350	76.0	1274
328	Larceny	66	189	145	134	560	360	76.7	1394
329	,,	28	180	155	128	549	352	86.1	1355
330	,,	33	197	170	148	574	368	86.2	1771
331	Robbery	26	186	152	128	544	344	81.7	1378
332	Larceny	52	193	153	126	540	335	79.3	1407
333	,,	27	190	150	140	545	354	78.9	1487
334	Robbery	45	194	160	134	570	360	82.5	1536
335	Larceny	46	195	154	140	562	362	79.0	1549
336	Robbery	26	196	160	136	566	365	81.6	1567
337	Larceny	29	189	143	130	550	349	75.7	1348
338	,,	57	195	149	137	562	360	76.4	1484
339	,,	45	189	157	130	548	345	83.1	1448
340	,,	39	205	160	150	574	380	78.0	1750
341	,,	65	170	132	128	512	345	77.6	1164
342	,,	49	195	150	133	545	342	76.9	1474
343	,,	46	194	161	135	562	362	83.0	1553
344	,,	55	190	154	122	550	348	81.1	1350
345	,,	26	197	150	128	548	349	76.1	1425
346	Theft	29	185	154	143	548	330	83.2	1511
347	Larceny	48	195	146	140	538	360	74.9	1485
348	Robbery	27	181	138	126	536	334	76.2	1242
349	Larceny	51	196	149	136	569	362	76.0	1481
350	,,	21	184	146	124	532	350	79.3	1295
351	,,	29	190	144	130	548	330	75.8	1360
352	,,	25	182	153	134	553	370	84.1	1412
353	Robbery	26	189	150	130	548	361	79.4	1398
354	,,	38	195	153	132	570	362	78.5	1471
355	,,	26	190	154	135	555	368	81.1	1475

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Art. XXI.—*The Correlation of Size of Head and Intelligence as Estimated from the Cubic Capacity of Brain of 33 Melbourne Criminals Hanged for Murder.*

BY

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[Read 14th November, 1912.]

In a communication (1) presented to the Royal Society of Victoria on the 10th October, 1912, we dealt with the debatable question of the correlation of the size of head and intelligence as estimated from the cubic capacity of brain of 355 Melbourne criminals. That communication was based on observations recorded on the living subject, whereas the present paper differs fundamentally inasmuch as it is based on measurements recorded upon casts of the heads made after the judicial death. It consequently follows that in the present communication there is ample scope for error, the extent of which will be pointed out later, whereas our former communication was free from any such objections.

For permission to examine the casts of the heads of these 33 criminals hanged for murder we have to thank Mr. Paterson, the Governor of the Melbourne Gaol, in whose possession all the casts are safely housed. He informs us that as regards the technique of the casting the procedure is as follows:—The execution takes place at 8 a.m., and the body remains upon the gallows for not less than an hour. An inquest is held, and about 3 p.m. the head is shaved and a cast made. It would appear that such casts have been consistently made until about 1904, whereafter the procedure has apparently been discontinued, inasmuch as there is no cast subsequent to that of James Williams, who was hanged upon the 8th September, 1904.

Upon these casts we had originally intended to record the length, breadth, height, and the several standard circumferential measurements. These last, however, we subsequently discarded, as it was quickly borne in upon us that the possibility of error was sufficiently great as to render them, in our opinion, practically valueless. We therefore concentrated our attention entirely upon the three diametral measurements necessary for the subsequent calculation of the cubic capacity of brain, and even with these, there are three very disturbing factors to be taken into consideration. These are:—1. The fact that the cast, unlike the living subject, does not "give" before the callipers. It is, therefore, quite impossible to obtain that maximum pressure which is so necessary in recording measurements upon the living. To obviate this source of error as far as possible, we invariably recorded the least possible figure which we could obtain for the maximum length, breadth or height. That we were fairly successful in this, is, we think, shown by our measurements of the casts of the head of the notorious criminal Albert Williams, *alias* "Deeming." Of this man's head the Melbourne Gaol possesses three casts, all taken under the conditions already pointed out. We measured each of these three casts, and obtained readings which only differed by 1 millimetre for breadth and height, and by 3 millimetres for the length. The three several readings so obtained are shown in Table 1. The possible amount of error under this cause cannot amount, for the estimated cubic capacity of brain, to more than 1.1 per cent. of the maximum reading obtained, and is, therefore, inappreciable.

2. The second source of error consists in the fact that notwithstanding that the customary procedure in obtaining the cast is to shave the hair of the head, this has not been consistently done throughout. Thus in the casts of the heads of Edward Feeney, William Colston and George Syme, the cast was undoubtedly taken without the head having been shaved. The head measurements and the estimated cubic capacity of brain are, therefore, for these three, undoubtedly slightly too high. We are also of opinion that this same source of error is present in some other instances, though from the evidence of the cast we cannot exactly specify which. In the cases specifically mentioned, the hair is so distinctly visible as to afford no doubt whatsoever upon the subject. In the case of the females the head is not shaved, but prior to death the hair is neatly coiled upon the vertex, and the cast taken in the same way. In the cases of all the females, but particularly so with the woman Frances Knorr, there is no question that the presence of the hair has resulted in too high readings for the three diametral measurements.

3. The third and last source of error is the undoubted presence in many of the casts, in how many it is impossible to say, of *post mortem* oedema. This source of error is the most interesting of the three, as it raises the whole question of the physiological causes of death in judicial death by hanging. To this interesting phase of the subject we shall recur later.

In view of these three undoubted sources of error, which were patently obvious to us before even more than two or three of the casts were measured, it became a real problem as to whether it was worth while continuing the research. In view, however, of the interesting possibilities opened up by the source of error due to the oedema, we decided to continue the work, and we shall presently relate the methods adopted by us to reduce the threefold source of error to a minimum for the purposes of estimating the cubic capacity of brain. Before dealing with this point, it will be well to say something of the sex and nationality of the material, and of the technique employed by us in the research.

As already stated, our material comprises the casts of the heads of 33 criminals hanged for murder and other crimes in Melbourne between the years 1853 and 1904. Amongst these are some of world-wide notoriety, such as Albert Williams, *alias* "Deeming," Edward or "Ned" Kelly, the celebrated Australian bushranger, as also "Captain" George Melville, and many other equally infamous but less well known murderers. Of the 33 all are males except 3, the three females being Martha Needle, hanged upon the 22nd October, 1894; Frances Knorr, on the 15th January, 1894; and Emma Williams, upon the 4th November, 1895.

As regards nationality, all but three are Caucasian, the three exceptions being Fatta Chand, a Hindu, Ah Gaa a Chinese, and Frederick Jordan, an American negro. The oedema already referred to was particularly well marked in the case of the Chinese.

Of the remaining 27 male Caucasians, all are of Anglo-Saxon stock except three—namely, Filipi Castillo, an Italian, August Tisler, a Russian Finn, and Basilio Bondietto, a Swiss Italian.

The ages are, in the majority of cases, unknown to us, and this notwithstanding a careful search through the legal records; the reason, of course, being that in many instances the antecedents of these criminals were altogether unknown even to the properly-constituted legal authorities. We cannot, therefore, deal with the question of age.

Such being the material, we may now pass to the technique. The measurements were the maximum length, maximum breadth and auricular height, and the mode of recording them was in accordance with the instructions of the Anthropometric Committee of the British Association for the Advancement of Science.

The formula for the calculation of the estimated cubic capacity of brain was that employed by us in our previous paper, (1), and for the reasons therein adduced—namely, Lee's formula, No. 14, which for each sex is as follows:—

$$♂ \quad C = 0.000337\,(L-11)\,(B-11)\,(H-11) + 406.01$$

$$♀ \quad C = 0.000400\,(L-11)\,(B-11)\,(H-11) + 206.60$$

We have already stated that the nationality of these 33 criminals was not always the same, and the question immediately arises as to whether Miss Lee's formula is equally applicable to all races. Miss Lee has herself, in a very able paper (2), investigated this very point, and states that "the general rule for deducing the best results would clearly be to work with the formula for the most closely associated race. But if no association can be predicted, then we shall hardly have an error as large as 2 per cent. if we use the mean formula. As this error is less than that frequently obtained by different observers for the same series, I conclude that a fairly satisfactory formula has been reached for the reconstruction of skull capacity from external measurements." As Miss Lee also adds that "on consideration, accordingly, we may conclude that formula 14 or its linear form 17 gives the best results," we have very naturally employed it throughout the present investigation for all races of the same sex, the figures for the three females being calculated, of course, from the formula specially recommended by Miss Lee for females.

Notwithstanding that we knew, before commencing the necessary calculations, all of which were effected on the "Millionaire" calculating machine, that there was a triple source of error, we first estimated the cubic capacity possessed by these murderers from the diametral figures recorded on the casts themselves. The individual results so obtained are set forth in Table I., and the true means for males and females, with their probable errors and standard deviations, are set forth in Table III. An examination of either of these tables will, we think, prove convincingly that the cubic capacity of brain, as estimated from the measurements recorded on the casts without correction, is far too high. Thus the true mean for the 27 male criminals attains the very high figure of 1611 c.c. of brain with a standard deviation of 87.66 ± 8.95, and an individual range from 1456 to 1804. The same table also shows that the probable errors of both the true means and also the standard deviations are higher for these uncorrected cast figures than for any other groups in the table. These facts, supported by our personal examination of the casts, together with the information courteously supplied us by Dr. C. H. Mollison. Lecturer on Forensic Medicine in this University, that in his opinion, and from personal observation, the amount of error due to *post mortem* oedema after death by hanging and the other incidental causes referred to might amount to as much as 10-15 mm., should, we think, convince the most sceptical that the cubic capacity of brain cannot be estimated from the uncorrected figures of the casts.

This being the case, the problem arose in what way was the necessary correction to be made. Our first intention was to make the cubic capacity calculations four times, first from the uncorrected figures of the casts themselves, and for the remaining three calculations to deduct 4, 7 and 11 millimetres respectively from the lengths, breadths, and heights. By working out the true means, standard deviations and probable errors of these several series of calculations, it was hoped that we should, by the application of general principles to the results so attained, be enabled to form a pretty accurate opinion as to which series of deductions gave the most probable result.

On further reflection it seemed to us that any such procedure would be at best highly empirical, and on medical grounds was open to the serious objection that under no possibility could the oedema affect all three diametral measurements equally, certainly not the height in which one of the fixed points is the meatus acusticus externus. We, therefore, decided to abandon any such irrational method of establishing the correction, and to seek for some more scientific method of effecting our purpose.

While examining the literature of the subject for our previous communication (1), we had read a short paper by Dr. G. B. Griffiths, Deputy Medical Officer in H.M. Prison Service in England, on the "Measurements of one hundred and thirty criminals" (3), and had noticed that in this he records the head lengths, breadths and heights of 36 male English murderers incarcerated in Parkhurst Prison, England.

As Griffiths's paper is strictly technical, and deals with nothing more than the mere record of his measurements, we do not know whether these English criminals were under sentence of death, or whether they were reprieved murderers serving a life sentence in commutation of hanging, but in view of the comparatively large number, it is only reasonable to assume that they were reprieved murderers. What, however, is for our purpose much more important, is that Griffiths's measurements were recorded upon the living subject, and upon men of the same nationality as the vast majority of those herein dealt with. We very naturally felt, therefore, that in establishing a direct comparison between the lengths, breadths and heights as given by Griffiths for living murderers with the same measurements as recorded by ourselves upon the casts, we should be in an infinitely stronger position to make the corrections which the evidence at our disposal showed were necessary for the Melbourne criminals. As a control experiment we also incorporated in the comparison the lengths, breadths, and heights of 11 criminals previously recorded by us (1). These last measurements were all made upon the living subject, and comprise 11 males convicted for the crime of murder, with the sentence of death subsequently commuted to penal servitude.

The comparisons of the lengths, breadths and heights for these three groups is set forth in Table II. In every instance the true means for lengths, breadths and heights is greater for the Melbourne cases than for either the 36 Parkhurst living criminals or the 11 living Melbourne murderers, another proof, if indeed further proof be required, of the necessity of making some correction for our 33 condemned Melbourne murderers. Omitting decimal points, the true means of the lengths of heads as measured upon the casts exceed the Parkhurst figures by 7 mm., and the small group of 11 reprieved Melbourne murderers by 10 mm. The corresponding excess for the breadth is 10 and 9 mm., and for height 2 and 4 mm. respectively.

On examining the data afforded by this table it is at once clear that of the standard groups of comparison, the small Melbourne group is open to the objection of insufficiency of numbers, and also affords the greater possible errors throughout. Further, had we corrected the Melbourne casts from the figures attained by the 11 living and reprieved Melbourne murderers, the cubic capacity of brain for the 33 murderers hanged would have been considerably less than we shall subsequently show it to be.

On the other hand if we establish direct comparisons between the true means of length, breadth and height for the 36 Parkhurst criminals, and the 33 Melbourne casts, we have a close approximation of numbers, and an excess of the former over the latter of, for length, 7 mm., breadth 10 mm., and height 2 mm. If, therefore, we were to correct the Melbourne figures as recorded upon the casts by deducting therefrom the figures just mentioned, we should establish a correction which would conform, on medical grounds, in the most singularly exact way, with what we should expect to find as the results of oedema. It is clear that any oedema would effect the vertical height measurements least, inasmuch as in this measurement a fixed point is employed which could not under any cicumstances be effected by oedema, whilst the other point, being the vertex of the head upon the scalp, would be but little swollen no matter how great the oedema. The breadth would most clearly reflect the influence of oedema, inasmuch as the callipers touch upon both sides the temporal regions where the layers of the scalp are more numerous, and are in the direct channel of the v. jugularis externa. For somewhat similar reasons the length would occupy an intermediate position in any form of oedema, as here the callipers touch two parts liable to be swollen, but those two parts are not so nearly in the direct path of venous channels as are those for breadth, and hence we should expect an oedema of the head to affect breadth measurements most, height measurements least, with length measurement in the intermediate position.

For all of these reasons we finally determined to correct the readings obtained upon the Melbourne casts by the deduction of 7 mm. from the length, 10 mm. from the breadth, and 2 mm. from the height, and we are of opinion that in making such deductions we have been guided by thoroughly rational, scientific and medical reasoning.

Having thus determined what seemed to us to be an accurate mode of correcting our readings upon the casts, we recalculated the cubic capacity of the brain of these 33 criminals, and the results so attained are set forth in the extreme right hand column of Table I. alongside those obtained from the uncorrected readings. As it will be remembered that in Lee's formula, No. 14, eleven millimetres is uniformly deducted from length, breadth and height, it follows that in order to obtain the corrected cubic capacity we have, in addition to this deduction, also had to deduct 7 mm. for the length, 10 mm. for breadth, and 2 mm. for height. In other words, the calculations obtained in the "cubic capacity corrected" column are achieved by the use of Lee's formula, No. 14, with 18 substracted from the lengths, 21 from the breadths and 13 from the heights. In this same Table I., are also shown the names of the murderers hanged, the dates of their execution, the lengths, breadths and heights as recorded by us upon the casts, the cubic capacity of brain as calculated from the uncorrected figures of the casts, as well as the final and more nearly correct readings obtained after the necessary corrections. We have arranged them, not in chronological order, but in the order of their cubic capacity of brain from the lowest to the highest. It will be noted that the notorious "Deeming" occupies the second lowest place upon the table, with "Ned" Kelly in the sixth position. Of the female murderesses one, Martha Needle, is credited by the corrected reading with a surprisingly small amount of brain—namely, 1124.5 c.c.

In Table III. is established a direct comparison between the English Parkhurst murderer and the Australian murderer. Here are also shown the uncorrected and corrected figures for both the male and female Australian criminals. Concentrating our attention solely upon the corrected readings, the table establishes the fact that the English murderer is a slightly more intelligent person than is his Australian confrère, for the true mean of the former is 1491 ± 10.25, as against the latter's 1471.9 ± 10.57.

What, however, is more important than the slight difference of the true mean in favour of the English criminal, is the fact that a study of the standard deviations, as well as of the individual range of variation shows clearly that murder, as a crime, is not nearly so restricted to one section of the community in England as in Australia. Why this should be we have no means of knowing, but we think the table clearly reveals that such is the case.

In Table IV. we have instituted a comparison of the cubic capacity of brain of these English and Australian murderers with those several learned classes utilised by us in our previous communication on this subject (1). The general result attained by this table confirms the conclusions previously drawn—namely, that for classes there is an appreciable correlation between size of head and intelligence. It will be seen that the three groups of criminals are at the bottom of the list altogether behind the true means of the learned classes. The same general conclusion also holds good for the females where we have been enabled to institute a direct comparison between three Melbourne murderesses and 30 Bedford College women students. For the latter figures we are indebted to the work of Miss Lee (2), from whose statistics we have ourselves calculated the standard deviations and probable errors. The table shows clearly that for the classes of both sexes the correlation between size of head and intelligence would appear to hold good.

In Table V., the last of the series, we have instituted a comparison between the corrected cubic capacity of each individual Melbourne murderer and the true means of the several learned and criminal classes of our previous work (1). The list is headed by six criminals, then follow two of the learned classes, two more criminals, another of the learned classes, two more criminals, and finally the last of the educated groups. Of the 27 individual Melbourne murderers herein dealt with, no less than

63 per cent. fall altogether behind the lowest of the several learned groups. In view of the severity of the comparison established by this table, the result is a surprising one, and seems to furnish one more additional proof of the truth of the statement that in the case of classes there is an undoubted correlation between size of head and intelligence.

In view of the fact that the table is headed by six criminals, we thought it advisable to search the criminal records in order to ascertain, if possible, if these six had been guilty of crimes displaying in their committal an unusual degree of intelligence. For this permission we have to thank Mr. Anderson, Secretary of the Crown Law Department of Victoria. We cannot, however, add that our investigation of the criminal records throws much light upon the degree of intelligence or otherwise of the few criminals who head the list.

Of Freeland Morrell, who actually appears at the top of the list with a corrected cubic capacity of 1649.7 cc., we can obtain but meagre information. He was an American seaman who was hanged for the murder by stabbing of the second mate of the boat upon which he was employed. He died " with a sneer on his lips," and the words, " I'll show you how an American can die."

Charles John Hall owed his downfall to alcohol, and to sexual excesses, and was hanged for the murder of his wife at the early age of 22.

David Young is a relic of the days of the transportation of convicts from England to Australasia. He was an English criminal who arrived in Tasmania in 1850, under sentence of ten years' transportation for burglary. His record is a black one, and his treatment of women, children and dumb animals was particularly diabolical. Like Hall, he was hanged for the murder of his wife, and like Hall he was an alcoholic and a sexual maniac.

Charles Bushbee, *alias* " Baker," closely resembles Young. There can be no doubt from his record that he was an alcoholic and a sexual maniac. The most surprising thing about Bushbee is that, at the time of his trial, any medical man could be found, as actually occurred, who could enter a witness box and testify to the man's sanity, for here is his record prior to the crime for which he was hanged. On the 7th October, 1877, he attempted suicide by drowning at Sandhurst, having been " disappointed in love." For this he was arrested and committed to Kew Lunatic Asylum. On his discharge from the asylum he was lost sight of for some time, but subsequently reappears in the records of Pentridge Gaol. Here are recorded against him many convictions for passing worthless cheques, and for forgery, as also for drunkenness and associating with prostitutes. Yet in the face of this particularly black record, medical witnesses went into the witness box some years later to testify to the convict's sanity and responsibility.

Of Feeney and Syme it is unnecessary to speak, because we have already pointed out that in our opinion even the corrected cubic capacity reading is too high, due to the fact that the casts were, in these instances, taken with the hair unshaved.

In almost every one of these criminals the cause of the downfall is almost invariably the same, drink and sexuality, with or without an associated insanity, or at all events, lack of will power. What some of those criminals, who are shown in our tables to possess a sufficient amount of brain, might have become with suitable opportunity and a more happily devised system of education, it is impossible to say, but there seems no scientific reason to doubt that given educational opportunities, and with the avoidance of alcohol they might have developed into useful members of the community.

The last point to which we wish to refer is the question of *post mortem* oedema after judicial death by hanging. There is no question that such oedema is present in many, though not in all, of the cases herein dealt with. It was perfectly obvious to us when measuring the casts, and that observation has since been confirmed by our colleague, Dr. C. H. Mollison, from personal observation on the cadavera of persons who have died from death by hanging. Now there is no question that in some of the judicial hangings death is instantaneous. In the records of the Melbourne Gaol there is a photograph of the atlas or first cervical vertebra taken from a criminal who had been hanged. This vertebra is fractured clean across, and must, therefore, by pressure of the dens of the epistropheus upon the medulla, have produced instantaneous death. The blood pressure would fall almost to zero, and there could not possibly be any *post mortem* oedema.

On the other hand, should the vertebra not be fractured, death may not be instantaneous, but of a more lingering character, in which case oedema would naturally be present. It is perfectly true that in judicial hanging, the rope and knot are adjusted with the express object of producing, with the "drop," fracture of the vertebra referred to and instantaneous death. Yet our records show that this may only occasionally be the case, and that in other instances death may be of a more lingering character.

It seems to us, on the evidence at our disposal, that the physiology of judicial death by hanging is but imperfectly known, and it might well be, that given more accurate information as to the precise cause of death in such cases, some more perfect method of administering capital punishment might be devised.

In this connection there is very opportunely to hand the accounts of the 1912 Dundee meeting of the British Association for the Advancement of Science. In the Anthropology Section, Dr. F. Wood-Jones presented a communication on the lesions caused by judicial hanging (4). He stated that during the first season's field work of the Egyptian Government Survey of Nubia there was unearthed in the neighbourhood of Chellal, a series of bodies buried roughly in trenches, showing the effects of various forms of violent death. There was every indication that they had been executed in Roman times. One man actually had the hangman's rope around his neck, and a very large number showed a curious lesion of the base of the skull. Dr. Wood-Jones was apparently inclined, at the field examinations, to attribute this lesion to the hanging, but a more detailed laboratory search caused him to abandon the opinion, and he concludes by stating that "hanging" might imply—(1) the hanging of a corpse, (2) the hanging (strangulation) of a living being, or (3) the dropping and hanging used to-day as the form of judicial death in England. Each had its historical aspect, and its anthropological and pathological interest.

Our own contribution to the subject of judicial death by hanging is, therefore, that from the evidence at our disposal, we are inclined to believe that even the "dropping and hanging" may sometimes imply slower death by suffocation, that is, Wood-Jones's "hanging or strangulation" of a living being.

Concerning the subject of the correlation of head size and intelligence, we are clearly of opinion that the present paper confirms in every detail our previous results, and amounts to this, that the correlation undoubtedly holds good for the classes, but is, in the cases of individuals, so obscured by other pathological and physiological causes as to make it idle to endeavour to predict intellectuality from head measurements alone.

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TABLE I. Details of 33 Melbourne Criminals hanged for Murder.

Order	Name	Date	L	B	H	Cubic Capacity uncorrected	Cubic Capacity corrected
1.	Alfred Archer	21/11/1898	193	148	136	1450.3	1327.2
2.	A. Williams "Deeming"	23/5/1892	192	161	129	1485.6	1358.2
	A. Williams "Deeming"		189	160	130	1469.6	1343.1
	A. Williams "Deeming"		190	160	130	1475.5	1348.6
3.	John Weechurch	6/12/1875	200	154	132	1508.0	1376.7
4.	Albert Edward Macnamara	14/4/1902	197	149	139	1513.2	1378.9
5.	John Wilson	23/3/1891	190	160	135	1520.5	1388.9
6.	Edward ("Ned") Kelly	11/11/1880	199	161	130	1536.9	1405.1
7.	William Hastings	14/3/1877	198	155	137	1549.2	1413.9
8.	Filipi C. Castillo	16/9/1889	203	154	135	1553.3	1417.6
9.	William Barnes	15/5/1885	195	156	139	1556.8	1420.6
10.	John Kelly	5/10/1866	198	155	139	1567.5	1430.2
11.	Ernest Knox	19/3/1894	197	153	143	1580.9	1441.1
12.	Robert Landells	16/10/1889	205	156	136	1590.9	1452.4
13.	James Williams	8/9/1904	205	150	142	1596.4	1454.7
14.	August Tisler	20/10/1902	195	168	133	1593.7	1458.2
15.	——— Cooley		199	165	134	1606.0	1468.8
16.	George Melville (Captain)	3/11/1853	198	159	140	1609.1	1469.1
17.	John Thomas Phelan	16/3/1891	200	167	133	1618.2	1480.5
18.	John Conder	28/8/1893	204	158	140	1639.3	1496.6
19.	Basilio Bondietto	11/12/1876	195	167	139	1644.1	1503.3
20.	William Robert Jones	26/3/1900	203	163	138	1655.0	1512.6
21.	William Colston	24/8/1891	203	162	139	1656.6	1513.6
22.	George Syme	11/8/1888	203	162	144	1705.4	1557.5
23.	Edward Feeney	15/7/1872	204	168	140	1723.2	1576.2
24.	Charles Bushbee "Baker"	3/9/1885	211	165	138	1724.2	1576.7
25.	David Young	21/8/1865	209	167	138	1727.9	1580.7
26.	Charles John Hall	13/9/1887	200	170	147	1783.3	1630.6
27.	Freeland Morrell	7/1/1886	203	171	146	1803.6	1649.7
	3 Females (Caucasian).						
1.	Martha Needle	22/10/1894	183	143	127	1260.0	1124.5
2.	Frances Knorr	15/1/1894	190	163	133	1534.3	1378.9
3.	Emma Williams	4/11/1895	195	159	147	1688.0	1515.8
	3 Males not of Caucasian Race.						
1.	Fatta Chand [Hindu]	27/4/1891	205	148	138	1543.5	1406.4
2.	Ah Gaa [Chinese]	30/8/1875	189	173	137	1630.4	1492.1
3.	Frederick Jordan [Negro]	20/8/1894	204	165	140	1698.1	1552.3

TABLE II. Comparison of the Lengths, Breadths, and Heights to show the amount of correction made on the casts of the Melbourne Murderers.

Length.

				Min.	True Mean.	Standard Deviation.	Max.	Correction.
33 -	Melbourne Murderers.	Hanged.	Casts.	189 -	201.3 ±.79 -	6.68±.56 -	211 -	
36 -	Parkhurst Murderers.	Reprieved.	Living	185 -	194.10±.57 -	5.09±.40 -	206 -	7
11 -	Melbourne Murderers.	Reprieved.	Living.	182 -	191.0 ±.89 -	4.38±.63 -	197 -	10

Breadth.

				Min.	True Mean.	Standard Deviation.	Max.	Correction.
33 -	Melbourne Murderers.	Hanged.	Casts.	148 -	160.0±.80 -	6.78± .57-	173 -	
36 -	Parkhurst Murderers.	Reprieved.	Living.	138 -	150.0±.45 -	4.07± .32-	160 -	10
11 -	Melbourne Murderers.	Reprieved.	Living.	139 -	151.2±1.56 -	7.66±1.10-	161 -	9

Height.

				Min.	True Mean.	Standard Deviation.	Max.	Correction.
33 -	Melbourne Murderers.	Hanged.	Casts.	129 -	138.5±.56 -	4.73±.39 -	147 -	
36 -	Parkhurst Murderers.	Reprieved.	Living.	119 -	137.1±.89 -	7.94±.63 -	157 -	2
11 -	Melbourne Murderers.	Reprieved.	Living.	125 -	134.11±1.31-	6.44±.92 -	149 -	1

TABLE III. Comparison of the Cubic Capacity of Brain of various English and Australian Criminals condemned for Murder.

Description.	Min.	True Mean.	Standard Deviation.	Max.
3 - Females. Melbourne. Hanged—				
Uncorrected from Casts -	1260 -	1494 ±69.01	177.02±48.93 -	1688
Corrected from Casts -	1125 -	1340 ±63.15 -	161.98±44.77 -	1516
11 - Males. Melbourne. Reprieved.	1261 -	1456 ±22.98 -	113.02±16.25 -	1675
27 - Males. Melbourne. Hanged—				
Uncorrected from Casts -	1456 -	1611 ±11.39 -	87.66 ± 8.05 -	1804
Corrected from Casts -	1327 -	1471.9±10.57 -	81.37 ± 7.47 -	1650
36 - Males. Parkhurst. Reprieved.	1286 -	1491.5±10.25 -	91.18 ± 7.25 -	1712

TABLE IV. Comparison of the Cubic Capacity of Brain of Murderers, Criminals and Learned Classes.

Males.

No.	Class.	Min.	True Mean.	Standard Deviation.	Max.
35 -	Anatomists - -	1372	- 1537.0 ± 9.86 -	86.40±6.97 -	1813
25 -	University College Staff	1352	- 1511.0 ±11.04 -	81.90±7.81 -	1633
215 -	London Students -	—	- 1507.0 -	— -	—
	British Association A. Sc.	—	- 1495.0 -	— -	—
36 -	Parkhurst Murderers -	1286	- 1491.5 ±10.25 -	91.18±7.25 -	1712
27 -	Melbourne Murderers -	1327	- 1471.9 ±10.57 -	81.37±7.47 -	1650
355 -	Melbourne Criminals -	1191	- 1437.76±10.47 -	99.74±7.10 -	1771

Females.

No.	Class.	Min.	True Mean.	Standard Deviation.	Max.
30 -	Bedford College -	1200 -	1390 ±13.75 -	111.55± 9.72 -	1647
3 -	Melbourne Murderesses	1125 -	1340.0±63.15 -	161.98±44.77 -	1516

Table V. Comparison of the Individual Melbourne Murderers with the true means of the Learned and Criminal Classes.

	Individual or Class.	Min.	Individual Capacity or True Mean.	Standard Deviation.	Max.
	Freeland Morrell	—	1649.7	—	—
	Charles John Hall	—	1630.6	—	
	David Young	—	1580.7	—	
	Charles Bushbee ("Baker")	—	1576.7	—	
	Edward Feeney	—	1576.2	—	
	George Syme	—	1557.5	—	
35	Anatomists	1372	1537.0±9.86	86.10±6.97	1813
25	University College Staff	1352	1511.0±11.04	81.90±7.81	1633
	William Colston	—	1513.6	—	—
	William Robert Jones		1512.6	—	—
215	London Students		1507.0		—
	Basilio Bondietto	—	1503.3		—
	John Conder	—	1496.6		—
	British Association Adv. Sc.	—	1495.0		—
	John Thomas Phelan	—	1480.5		
5	Embezzlement	1384	1475.0±31.43	103.94±22.18	1645
	George Melville (Captain)	—	1469.1	—	—
	— Cooley	—	1468.8		
14	Forgery	1267	1459.0±21.15	117.31±14.95	1701
52	Miscellaneous Crimes	1269	1458.0±8.73	93.33±6.17	1678
	August Tisler	—	1458.2	—	—
11	Murder and Manslaughter	1261	1456.0±22.98	113.02±16.25	1675
	James Williams	—	1454.7		
	Robert Landells	—	1452.4		
	Ernest Knox	—	1441.1	—	—
56	Sexual Offences	1213	1440.0±9.09	100.89±6.43	1668
26	House and Shop-breaking	1317	1435.6±10.82	81.66±7.63	1610
144	Larceny	1164	1432.0±5.52	98.21±3.90	1771
	John Kelly	—	1430.2		
15	Assault and Wounding	1268	1425.0±15.48	88.86±10.95	1595
26	Inebriety	1191	1423.0±17.20	129.80±12.14	1657
	William Barnes	—	1420.6	—	—
	Filipi C. Castillo	—	1417.6		
	William Hastings	—	1413.9		
	Edward ("Ned") Kelly	—	1405.1	—	—
	John Wilson		1388.9		
	Albert Edward Macnamara	—	1378.9	—	—
6	Cattle-stealing	1280	1377.0±24.31	88.28±17.20	1516
	John Weechurch	—	1376.7	—	
	Albert Williams ("Deeming")	—	1358.2	—	
	Alfred Archer	—	1327.2	—	—

[Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. II., 1913.]

Art. XXII.—*On the Country between Melbourne and the Dandenong Creek.*

By T. S. HART, M.A., B.C.E., F.G.S.

[Read 14th November, 1912].

The area whose features are now dealt with extends from the Yarra, near Toorak and Hawthorn, south-easterly to the Dandenong Creek. A part of it is included in quarter sheets Nos. I. S.E. and I. N.E. of the Geological Survey of Victoria. The Lands Department contour maps of Melbourne and suburbs extend to beyond Box Hill and Oakleigh, and further contour maps of the same department cover the parish of Moorabbin, and the country south of the Gippsland railway as far as Dandenong. Mr. Saxton kindly directed my attention to the latter map, and also furnished me with levels of several other points.

In 1910, Mr. J. T. Jutson[1] in "A Contribution to the Physiography of the Yarra and Dandenong Creek Basins," dealt with a part of this district, but not so much with the southern part. His conclusions, so far as relevant to the present subject, may be summarised as follows:—

The general slope of the country from about Surrey Hills and Mitcham is south-westerly. The name of the Mitcham Axis is given to a line of high land through these two places turning north-east from Mitcham.

Main Creek, and another further west, follow down the general slope to Gardiner's Creek. Gardiner's Creek flows from lower country about Murrumbeena through higher country north of Malvern.

He considers that Main Creek may have originally continued south-west, and that Gardiner's Creek has cut rapidly back and captured the upper part of the original Main Creek.

He admits difficulties in the north-westerly courses of Scotchman's Creek and the Elsternwick Creek. Alternatively he suggests that Gardiner's Creek and its tributaries may be antecedent streams.

1 Proc. Roy. Soc. Victoria, vol. xxiii. (New Series), pp. 469-511.

He suggests also that the "Croydon Senkungsfeld" includes the Carrum Swamp, and possibly part of Port Phillip, and that the west boundary fault of this sunk area is replaced by a gentle tilting about Scoresby and Springvale.

I propose to show that a north-westerly course of the valleys and ridges is the rule south of Gardiner's Creek, and that a north-west and south-east trend of the surface features extends as far as Dandenong, with great regularity in Brighton and Moorabbin, but affected by the southward fall to the Carrum Swamp in the more easterly parts. An important axis extends from Mitcham to the vicinity of Cheltenham and Blackrock, on the line of the continuation of the north-east end of Jutson's Mitcham axis. Another important divide extends from South Yarra to Dandenong, and no outlet can have existed for Main Creek to the south-west. At Murrumbeena, on the contrary, there is a recent diversion of waters north into Gardiner's Creek. The numerous closed and ill-drained hollows and some other points will also be referred to.

General Description of the Area.

A part of this district drains to the Yarra, either direct or by way of Gardiner's Creek. South of this the outlet is direct to Port Phillip by the Elsternwick Creek, and a series of parallel valleys through Brighton and Sandringham. Between Cheltenham and Dandenong the waters run naturally to the Carrum Swamp. With the assistance of shallow drains, waters from near Oakleigh are discharged through this area. The Springvale valley runs south-east, and turns south near Dandenong. It receives tributaries from the north from a little beyond the Fern Tree Gully-road. A small area about Glen Waverley discharges into Scotchman's Creek, ahead of Gardiner's Creek. From Wheeler's Hill to Mitcham a triangular area falls direct to the Dandenong Creek.

The chief dividing line extends from Mitcham south-westerly through Notting Hill to Cheltenham. Parallel to this is the highland from north of Surrey Hills to Malvern, broken by the outlet of Gardiner's Creek. Transverse to these is the divide from South Yarra to near Dandenong, on the south-west side of the valleys of Gardiner's Creek, and the Springvale Creek. The south-west limit of the Elsternwick Creek is a parallel line, as are also the divides between the Brighton valleys. The high land from Wheeler's Hill north-westerly is parallel to these, and in the same line is the Reservoir Hill at Surrey Hills, and the south limit of the Koonung Creek further to the north-west. South-east from

Wheeler's Hill are the Police Paddock Hills, and the Dandenong Creek contracts its valley to pass between these and Wheeler's Hill, as well as changing to a south-easterly direction. The simplicity of such a rectangular plan is broken by the way in which the Gardiner's Creek catchment is enlarged at the expense of its neighbours.

Gardiner's Creek.

North-west of the Malvern Camberwell highland, the fall is direct to the Yarra. The valley from near Malvern railway station has a very direct north-west course. The outlet of Gardiner's Creek has also a north-west direction, and a valley no doubt continues under the basalt to join the buried valley of the Yarra. The fall would be steeper than is now seen in Gardiner's Creek. From the junction of Gardiner's Creek and Main Creek the fall is from 85 to 25 above sea level in three miles. A mile and a-half lower, Gardiner's Creek joins the Yarra at 2 feet above sea level; the probable junction of the buried valleys is a mile or a mile and a half further on, and about 60 feet below sea level. Even allowing the buried valley to extend some distance up Gardiner's Creek, the fall will still be greater than the 20 feet to the mile higher up the valley.

The natural continuation of the Gardiner's Creek valley is by Scotchman's Creek through Oakleigh; a little valley can be followed south-east to Notting Hill. But by far the greater part of the area drained by Gardiner's Creek and Scotchman's Creek is to the north of the main line of Gardiner's Creek. The contributions from the south are insignificant in amount, and the most important of these, the little creek at Murrumbeena, will be shown later to be new.

The mouth of Gardiner's Creek must be a quite early feature. Probably the whole system developed soon enough to secure the waters of the area about Blackburn, which might have gone to Koonung Creek, and to capture Black Flat (Glen Waverley) from the eastern valleys. Throughout the Gardiner's Creek area the streams have cut down to the bedrock. A much larger proportion of the rainfall must be immediately discharged than by a system in the absorptive tertiary rocks. The excavating power of the streams is thereby increased, and the higher levels allow deeper dissection than in the country to the south. No undrained areas of the kind common further south occur. Detail of the course of the creeks is influenced by bedrock structures, which no doubt contribute to the numerous small irregularities.

Area draining to Balaclava and Elsternwick.

A short distance south of the Malvern railway station is a swampy area formerly known as Paddy's Swamp. The 140 ft. contour runs round an area about 40 chains by 10, leaving an outlet at the west end, which, however, cannot drain away all the surface water. Thence the valley falls south-west and west to the flat at Balaclava, reaching the sea to the south of the St. Kilda Hill. South-east from Paddy's Swamp is the flat in the Caulfield Racecourse, and again south-east, another area of difficult drainage, to be referred to later.

The trend of the lowest ground of the Elwood Swamp is from south-east to north-west. Up stream the valley can be followed almost straight to its head north of Cheltenham. The south-west limit of the Elsternwick Creek waters is a ridge from near the power house of the Brighton electric tram south-east in an almost straight line. It is close to the Point Nepean-road from North Brighton to Moorabbin station; thence a little east of the road, which has turned a little more southerly. This may conveniently be called the Moorabbin Ridge. The Elsternwick Creek lies close north-east of this ridge, a small parallel valley intervening at North Brighton. The creek then receives practically nothing from the left bank, but on the right or north side it receives two important tributaries; one of these runs south from near the Caulfield Town Hall, and turns west to join the creek near Gardenvale station. The other flows south, near the Mordialloc railway, receiving much water from its east side, including that from the swamp south of Carnegie station. Here the 140 ft. contour almost surrounds a long narrow area stretching for a mile and a quarter south-east to north-west. The outlet is south-west to the Elsternwick Creek tributary, but at a point a long way back from the north-west end of the elongated hollow. At its south-east end it merges in an ordinary valley from the south-east.

A remarkable broken valley line lies north-east of the Elsternwick Creek. One portion of it runs through the entrance to the Brighton Cemetery, and extends south-east for some distance lower. This part and another north-west of it fall into one of the Elsternwick Creek tributaries. On the same line further south-east, a pair of similar valleys falls into the next tributary, and a fifth section, reaching the Elsternwick Creek by another route, occurs further on, east of the Bentleigh station. It is either a valley broken up by three captures, or indicates a marked tendency to produce valleys along one line.

The head of the Elsternwick Creek is in a broad open valley north of Cheltenham. On each side of the valley the 120 ft. contour runs in two nearly parallel lines from south-east to north-west, 20 to 30 chains apart. The 110 ft. contours come in at the two ends of this flat, a mile and a half apart. Most of the flat drains to the Elsternwick Creek, but the south-east end falls to the south-east and the outlet is steeper than the other end.

The Elsternwick Creek and its tributaries nowhere cut down to the bed rock; probably much of the main valley at least is in less permeable beds low in the tertiary series. The average fall over $4\frac{1}{2}$ miles from 110 to 10 ft. above sea level is about 22 ft. to the mile.

A north-westerly trend of the valleys is the rule throughout this area, but the two tributaries from the north bring nearly all the waters down to the south-west side of the system. The more important of these tributaries receives nearly all its water by north-westerly valleys. The levels along the divides on the north-east and south-east of this system range from 190 to 150. The Moorabbin ridge, however, only reaches 150 at its highest point, and the actual head of the Elsternwick Creek is below 120.

The Brighton and Sandringham Valleys.

These are six parallel valleys with a north-westerly direction. The first is very straight and regular, starting east of the Point Nepean-road, not far north of Cheltenham, running close to the Moorabbin Ridge, and entering the sea at the foot of North-road, North Brighton. The second heads close to the railway between Highett and Cheltenham, but after running north-west for a mile and three-quarters, turns south-west into the third valley. Another valley starts within half a mile of the angle, and continues to the sea on the second valley line. The third extends practically straight from the swamps in Cheltenham Park to Middle Brighton. The fourth heads a mile west of Cheltenham, but after running north-west to a point north of Hampton station, turns south-west into the fifth. On the line of the fourth lower down two other little valleys occur. This series is well seen on the Brighton railway, the first just south of (North) Brighton station; the second and third on each side of Middle Brighton. The fourth is here only represented by a very slight hollow. The railway follows the fifth from Brighton Beach to Hampton, and the sixth is seen inside the Beach-road below Sandringham.

Above the apparent head of the fifth valley east of Sandringham station, there is on the same line a long valley with no outlet, terminating in a lagoon east of the golf club house. A flattening of the grade of all these valleys occurs about the line of the Bluff-road, and on the same line occurs the flattest part of the Elsternwick Creek (except its head and swamps at the mouth). The grades of the valleys are shown in the accompanying table in which the letter D indicates that the valley is here diverted south-west, and the letter B that it is blocked with no free outlet.

On the sixth or Sandringham valley the 40 ft. contour is the last above the cliffs.

Elsternwick Creek and Brighton Valleys. Distances in Chains between Successive Contours.

Levels	E. Ck.	Brighton Valleys. 1	2 upper	2 lower	3	4	5 upper	5 lower	6
130 to 120	—	21	1½		29	11	—	—	—
120 to 110	—	38	27	—	60	11	18	—	—
110 to 100	39	44	50	—	26	47	16	—	—
100 to 90	28	19	41	4	18	74	B	12	—
90 to 80	44	48½	85D	14	65	4		11	
80 to 70	52	50	—	41	25	18	—	37	—
70 to 60	23	23	—	37	29	32	—	12½	15
60 to 50	25	23½	—	43	40	23	—	12	14
50 to 40	25	35		34	19½	27D	—	12½	16
40 to 30	35	32	—	47	29		—	16	—
30 to 20	52	26		12	29		—	13	—
20 to 10	54	38½		14	20	—	—	—	—
10 to sea	90	3	—	3	3	—	—	—	—
Average 100 to 20 10 ft. fall in	35	32	—	29	32	24	—	16	—
Fall in feet per mile	23	25	—	27½	25	33½		50	—

The ridges between the valleys show a gradual descent with few irregularities. On a section at right angles to the valley the south-west side is nearly always lower than the north-east. Taking the general level of the ridges the fall is on the whole west, not north-west. All the departures from regularity in these valleys are the few diversions to the south-west and the loss of grade, producing swamps. Numerous ill-drained or undrained areas occur about the heads of the valleys near Cheltenham, and as far west as close to the Red Bluff, Sandringham. These are usually very closely related to, or actually part of, the valleys. The high land at the head of the series reaches 170 at one point at Cheltenham. The heads of the first valley, and less distinctly the second and fourth, are continuous with valleys on the opposite fall. The tertiary rocks are never cut through, but less permeable beds are probably often reached, and the waters of the permanent lagoons may be taken as representing the level of permanent saturation about 120 ft. above sea level near Cheltenham.

Parish of Mordialloc and adjacent parts of Moorabbin and Dandenong.

At Mordialloc and Mentone, and east of Cheltenham, and thence north-east to near Clayton, the valleys fall to the south-east off the highland at the heads of the Brighton valleys and the Elsternwick Creek. They commonly show a very regular south-easterly direction, but ultimately their waters reach a channel which runs south from near Clayton to the main drain east of Mordialloc. This is, however, for the most part the natural course of the waters. A valley starts on the South-road, a mile and a half east of Moorabbin station, and runs south-east through the Benevolent Asylum grounds. Another parallel to this starts near the Centre-road, east of Bentleigh, and runs south-east into Reedy Swamp. Another valley starts about a mile west of Clayton station near the Centre-road, and after running south-east for a little distance turns south through Heatherton, becoming the main channel. The fall from 160 to 60 feet above sea level extends over two and a half miles, about 40 feet to the mile, and thus considerably steeper than the Brighton valleys.

A south-easterly valley starts between Oakleigh and Clayton, and its waters are also turned south by an artificial channel into this main channel, but a definite south-easterly trend of the valleys is seen to the east of this made drain.

Ill-drained and swampy places are common within this area. From Heatherton the old Dandenong-road continues south-easterly close to the 70 ft. contour, touching 60 in some of the valleys, but never again reaching 80. Three shallow valleys with a southerly trend cross the road, but in the country between this road and the Gippsland railway a south-easterly trend is often seen and just south of the railway a definite south-easterly ridge marks the south-west limit of the Springvale valley.

Near the main channel south of Heatherton, the contours begin to show the effect of recent alluviation as high as the 40 ft. level, but in the neighbourhood of Mordialloc the well-defined south-easterly ridges and valleys can be seen as low as the 10 ft. contour.

Springvale.—A valley runs in a south-easterly direction near the Gippsland railway from a little beyond Clayton to about a mile before Dandenong. It receives very little from the south; on the south side of the railway is the ridge just referred to gradually descending in three miles from 170 to 100 above sea level. This Springvale valley receives tributaries from the north; the most westerly of the tributaries receives valleys falling south-east off the high land about Notting Hill. A fall of 20 feet to the mile in the Springvale valley seems to be sufficient to allow recent scouring out of the channel, necessitating the protection of bridges. This is in agreement with Gardiner's Creek. The Brighton valleys, though slightly steeper on the whole, show little tendency to scour, a difference which is no doubt due to the slow delivery of rain from the highly absorptive tertiary sands. The valleys of Springvale and its tributaries are often comparatively broad and open.

East of Notting Hill one of the heads of this system runs south-south-west across the Fern Tree Gully-road. It starts about three-quarters of a mile to the north-east where a low ridge separates it from Glen Waverley.

Glen Waverley.—This is an open valley with gentle slopes near the crossing of Springvale-road and the Waverley-road. Its west end is highest, being formed of the hills north-west of Wheeler's Hill. Beyond these there is a rapid fall to the Dandenong Creek. The outlet from Glen Waverley is now by a steep narrow valley to Scotchman's Creek. The open valleys could have been formed if this outlet were maintained for some time at a higher level. The present outlet crosses the high land north of Notting Hill, and it is probable that the original outlet was south-easterly across the low ridge which now separates Glen Waverley from the valley falling to Springvale.

Northward from Glen Waverley the Springvale-road crosses a number of gullies which fall east to the Dandenong Creek. A line drawn north-west from Wheeler's Hill and another south-west from Mitcham would mark the approximate limits of this area. Further north, at the corner of Canterbury-road, there is a valley which forms one of the heads of Main Creek. The above description is sufficient to show clearly that the north-west and south-east valleys are the rule throughout the country south of Gardiner's Creek and the Springvale valley. There is no reason to exclude these two creeks from this regular system. North of Gardiner's Creek the south-westerly fall of its principal tributaries is the prominent feature, but this it to some extent anticipated in the tributaries of the Elsternwick Creek. Main Creek receives most of its waters from the east. That the north-west valleys have not ceased is also shown in the course of the north-east head of Main Creek and of the Koonung Creek.

North of the Springvale Valley the southerly fall is conspicuous, but a north-westerly ridge again appears through Wheeler's Hill.

The Notting Hill Cheltenham Axis.—The importance of this divide is shown in the description. It is not a narrow ridge, but a broad elevation or flat arch in shape, with a gradually decreasing elevation to the south-west. Hence the actual heads of valleys are not, and need not ever have been, on a straight line. The heads are sometimes nearer to one side and sometimes to the other. The general form of the axis is well shown by the 200, 150 and 100 ft. contours. They run in a southerly direction on the west side, cross the axis and run away to the north-east. The fall in levels on the crown of the axis is not, however, uniform. At Mitcham the elevation is about 500; at Notting Hill 320. Thence the fall is somewhat rapid to the Centre-road, where the 200 ft. level is passed, but at Cheltenham the highest point is still 170. This is certainly an isolated summit, but the part of the axis north of Cheltenham has probably suffered more severely, as the valleys are near together, and in some places nearly or quite cross the axis.

The open valley at the head of Elsternwick Creek suggests that perhaps this divide was not original, but that valleys once headed clear of it and ran across its position. But though the eastern fall may have been steepened a little, there is no indication of any general alteration of direction of flow even in those valleys which nearly cross the high land. The head of the Elsternwick Creek alone might have been thought to have once started further east, and to have lost its upper part by a subsidence in this direction, but the valley of Reedy Swamp has certainly always been an easterly valley, and generally the whole series of valleys gives no support to any other view than that this axis is original. The flat at the head of Elsternwick Creek is no doubt due to the great power of widening that a valley in these permeable beds acquires as soon as it reaches an impermeable bottom. The permanent water in brick holes east of Moorabbin station indicates that here at least the permanent water level is practically at the surface (110 ft. above sea level), and the mere existence of the brick pits shows that the bed of the valley is not in the purer and more permeable sands.

The northward part of the axis beyond Notting Hill is indeed broken by the outlet from Glen Waverley, but this is obviously new, not an original feature.

The Coast Line.—Ormond Point (Red Bluff, St. Kilda), lies on the extension of the ridge south-west of the Elsternwick Creek. The coast soon curves and runs nearly south, crossing the Brighton valleys at a small angle. The projecting points are due to the greater resistance of the lower beds of the tertiaries, and do not correspond in position to the ridges. The Elsternwick Creek enters the sea through the Elwood Swamp; there is a flattening of its gradient, but in all the Brighton valleys the reverse occurs. There is, to put it otherwise, never room for the fall to continue to the sea at the same rate as the fall from 30 to 20 above sea level. All of them must be regarded as slightly encroached upon by the sea. From Brighton Beach the coast runs in general nearly south-east, curving out to the west at points due to the greater resistance of the brown rocks. The attack of the sea is evidently more powerful here than at Brighton, as is seen also in the nature of the beach sand. At Brighton also, where the coast crosses a ridge, there is a steep rise, usually back in the tea tree scrub. At Sandringham the cliffs rise higher and direct from the beach. Towards Rickett's Point there again seems to be a less rapid advance, but here the outcrop of the resistant rocks is much more continuous. From Elwood to this point most of the best dip observations give a north-westerly strike in the brown rocks with low dips 10 degrees or less. Joints are often prominent, and in these north-westerly strike is most common, though others are also frequent.

Near Beaumaris the coast turns north-east for a mile with continuous cliffs to 70 feet high forming one side of Beaumaris Bay. At the head of the bay is seen a comparatively steep dip in the tertiaries 25 degrees south-easterly. By this the resistant rocks are carried well below water level, and a vertical cliff in the soft upper beds follows, the coast having resumed a south-easterly direction. The fold is not seen all along the north-west side of the bay. At the end, where the water appears deep and the beds do not seem to be curving, it is possibly replaced by a fault or has been crossed by the marine encroachment.

The upper beds of the tertiaries are not seen on the north-west side of the bay. The highest hill near reaches 100 feet, but its top is wind-blown sand. As the removal of the upper beds does not seem to be connected with the subaerial denudation, it was probably achieved by marine action during emergence. As usual, in a very short distance from the coast, the valley system is quite independent of the coast line.

The fold at Beaumaris Bay is no doubt a part of the structure giving rise to the Cheltenham axis, its strike passing along the east flank of the higher ground not far from several places where the east fall is steeper than usual.

Beaumaris Bay is no doubt due to marine attack favoured by the structural character. Further to the south-east the sea has had to give place to the material brought down from the east side of the Cheltenham axis, and by the Dandenong Creek. Recent marine fossils occur at the mouth of the main drain at the head of the creek at Mordialloc just above sea level.

The relation of the rocks to the valleys.

The tertiary rocks may be divided for the present purpose into two parts—the upper, very weak sandstones, usually pale coloured, but occasionally more ferruginous and then stronger; the lower usually brown and often more clayey, with ironstone bands and some strong coarse ferruginous beds. The upper parts are highly permeable, they readily lose their iron cement in weathering; probably even the more ferruginous and stronger beds yield fairly easily to soil waters. These form the bulk of the higher cliffs, and are exposed in every railway cutting of any depth in the tertiary areas. The lower less permeable beds are seldom touched in the artificial cuttings, but probably form the floor of many of the valleys. They are seen at many points on the coast, and some of the springs can be seen to occur at their upper edge.

On a catchment consisting of the upper parts of the tertiaries, a very large proportion of the rainfall must be absorbed, and if the valleys have not reached less permeable beds, may never reappear on the land surface in the vicinity. The erosive power of the stream would be correspondingly reduced, and when, in addition, there are small catchments, low grades, and only a moderate rainfall, the streams must be very weak. When the stream reaches the less permeable lower beds it will receive additions from springs. These springs must produce a local weakening, and hence greatly increase the power to widen the valley or to cut out a channel of a branch gully on the line of a spring. A steeper slope can be seen sometimes behind a spring at the foot of a hill. This power of widening has already been referred to, and is no doubt of general application. It will evidently give increased power to the stream which first reaches the less permeable beds, that is, other things being equal, to the stream on or near the anticline. A somewhat similar effect could be produced by any stream reaching the permanent water level, but in this district the two causes are probably practically coincident.

The valleys about Cheltenham have very little power to re-open their channels if blocked by any cause. For example the swamp east of the Golf Club House at Sandringham lies at the north-west end of a hollow below the 100 ft. contour, about 50 chains long and of an area of 50 acres. The whole catchment up stream from the swamp is only about 300 acres. If a barrier below the swamp were only to reach 102 ft. above sea level, it would require, neglecting the depth below the 100 ft. contour, two feet of water over more than 50 acres to surmount the barrier, or over 4 inches of rain delivered into the hollow so rapidly that absorption could be neglected. A very low barrier is evidently insurmountable in such a case. The valley would be re-opened by the stream cutting back from the lower side of the barrier, and as the direct catchment here is very small, the chief agent wouid be the oozing of water along the old bed. If the old bed had reached impermeable material this would be much more powerful. A stream which has reached less permeable beds is therefore much more able to keep its channel open. Wind action or the wash from adjacent slopes might make a barrier, especially after a portion of the heath had been swept by fire and the sand left unprotected. It may be noticed that while two and a half feet to the chain can be regarded as moderately steep in the tertiaries, some hillsides reach as much as 10 feet to the chain, and might rapidly supply much material from these relatively unstable slopes.

As has been noticed, strikes of beds and of joints are often north-westerly in the tertiaries. Any actual inequalities of surface produced by slight folding before emergence of these beds would be liable to be largly or wholly levelled by marine action during the elevation. Relatively weak parts might even be excavated, and these weaker parts would probably be nearer anticlines. Hence there is no probability of the production of anticlinal ridges, but there is a strong probability of lines of easy excavation parallel to the strike of the folds. The north-west and south-east valleys therefore, besides being near the direction of steepest slope from the axis, are probably structurally in a strong position. The relation of the unusual fold at Beaumaris to the Cheltenham axis is already noticed.

Explanation of Surface Features.

The Brighton valleys from their simplicity and regularity are no doubt the only system which has ever existed on this area. They do not exactly follow the present general slope, but this may have been altered, either by a general depression to the south or, less likely, by the process of denudation. But to form such a series of parallel valleys, so close together, merely as consequent streams, seems to require a very regular original surface. Small irregularities can scarcely be negligible with valleys so close to one another. Therefore it is probable that the valleys have been from the first guided by lines of easy erosion. Actual inequalities of surface to guide them need not here be required.

Further north, however, we begin to have evidence of a more important south-west fall of the country. The Notting Hill-Cheltenham axis itself falls to the south-west; so does the high land from East Camberwell to Malvern. The tributaries from the north are necessarily more important. Yet they have not been able to continue south-west. Either Elsternwick Creek and Gardiner's Creek are on lines of weakness which gave them an immediate advantage, or there was originally an irregularity in the south-west fall. There is actually no reason why the original elevated surface should not possess regularly arranged inequalities. Ordinarily streams have been able to do so much work that minor features have been lost, but here we are dealing with the weakest of streams. It must be remembered, however, that all these creeks had to start as weak streams in the upper beds of the tertiaries. It may have needed no more to determine the courses of Gardiner's Creek and the Elsternwick Creek than those of the Brighton valleys. It may be noticed, however, that Malvern Hill is a little higher than we would expect if the ridge is falling uniformly to the south-west, and that the correspondence between Gardiner's Creek and the Springvale valley on the opposite fall, favours the idea of an original structural character or inequality. The Elsternwick Creek system is a further development of a system like the Brighton valleys with the addition of the influence of the south-west fall as soon as the main axis is left. In Gardiner's Creek and its tributaries these characters are further developed. If the tertiaries north of Gardiner's Creek are mostly terrestrial, and those to the south mostly marine, this would involve an original slope of deposition in the terrestrial part and original streams before the emergence of the southern area, but these streams would all be in shallow valleys.

Area south of Carnegie and Murrumbeena.—If Main Creek ever continued to the south-west it must have been across this locality. The comparatively low levels of the ridges, somewhat lower than the hills near Caulfield station, and also than the high land to the south-east, at first suggest a broad valley. But the detail of the surface is not easily explained on this supposition. By examining the course of the 150 and 140 ft. contours, it will be seen that the little creek at Murrumbeena takes the water from a long hollow with a distinct north-westerly trend. This is the lower end of valleys which head some distance to the south-east. The present outlet is a mile back from the north-west end, and is evidently well able to cut deeper. It seems to be clearly a new diversion of the waters of a valley flowing north-west. Immediately to the south of this hollow is another, also elongated in a north-westerly direction, and making the down stream end of a valley from the south-east. The present outlet is to the south-west, and again is a mile back from the north-west end. The outlet is more developed than in the other hollow, but is still narrow compared with the size of the hollow, and actually did not naturally drain it completely. Again it seems clearly a new diversion. The ridge south-west of this hollow, which is breached by the present outlet, is a well-defined ridge from the south end of Caulfield Racecourse to the higher land east of Bentleigh. Nor does the country to the south-west further on show any sufficient evidence of an old valley of Main Creek. There is indeed the southward tributary to the Elsternwick Creek, but eventually a south-westerly stream would reach places where the north-west valleys and ridges run right across its line. The idea of a south-west continuation of Main Creek would necessarily involve the supposition that some character of the rocks so strongly favoured easy excavation on the usual north-westerly lines as to make an earlier south-west fall a matter of little consequence, so that later valleys sometimes entered the old valley at an acute angle, heading up stream. Nor does the general run of the surface levels in Caulfield and Brighton favour the idea of an old valley, even if a broad one, crossing this area.

This argument evidently does not exclude the possibility of a stream somewhere near Main Creek before the emergence of the land south of Gardiner's Creek, but this would be antecedent to the development of the present topography. Such a stream may possibly have had its mouth about this locality, but it might almost equally have been anywhere else.

It remains to find an explanation of the absence of any outlet to these valleys to the north-west. They are not alone in this respect; on the same line are the flat in Caulfield Racecourse, with a poor outlet, and Paddy's Swamp. The most probable explanation seems to be a continued or renewed warping of the surface subsequent to the establishment of the present valley system.

There is no doubt that the elevation was accompanied by deformation of the surface.

The deformations and elevations would not be likely to cease suddenly. The flattening of the grades of all the Brighton valleys near Bluff-road has been referred to. This admits of two explanations: either that there is something which the valleys found it hard to cut through, or that there has been an elevation against the grade of the valleys which they have not yet been able to smooth out. The former explanation receives slight support from the occurrence of the flattest part of the Elsternwick Creek near the ferruginous rock of the "gravel" pits west of Bentleigh. On this view the complete obstruction of the valley east of the Golf Club House at Sandringham would be due to the flat grade allowing this stream, one of the weakest, to be completely obstructed by other causes. On the view that there has been a late deformation of the surface, the flattening of all these valleys, and the complete loss of level in the case just mentioned are the direct result of the deformation. But the diversion of the second valley of the Brighton system into the third is probably due to an earlier slight irregularity on the same line. Following the same line north such a warping would increase the power of the southward valley near McKinnon as compared with the north-west valleys, and would at the same time account for the blocking of the two hollows south of Carnegie, and facilitate the formation of a south outlet from the southern one.

The same explanation may be further extended to the course of Gardiner's Creek through the high land north of Malvern. Gardiner's Creek probably preceded the present elevation of the land. This receives some support from the levels of the base of the tertiaries, which is lower up stream than it is at this high land, and apparently falls much lower on the Yarra side of the high land. If we suppose that deformations, and not mere elevations and depressions took place, there is no reason to suppose that Malvern and Hawthorn were equally affected with the Yarra valley, in the depression which is known to have taken place there.

A similar explanation might extend to the steep fall south of the Dandenong-road at Armadale, and to the steep fall on the Notting Hill-Cheltenham axis near the Gippsland railway. It would then also explain why the southern divide of the Gardiner's Creek area is lower at Murrumbeena. It also introduces a cause with a general power of forming lagoons and closed hollows such as are numerous at and about Cheltenham and many other places.

Wheeler's Hill.—The north-west line of hills through Wheeler's Hill may be either a more uplifted area or a relic of earlier features. Jutson remarks (p. 492) that a fault scarp is suggested at

Wheeler's Hill, that is, to the east of the hill; but also that the hill seems to rise above the general height of the plateau in this locality. Possibly there may be a fault on the north-east of this group of hills, but the deflection produced in the Dandenong Creek may be sufficient cause for the steep slope along the north-east fall. My suggestion that there has once been a continuous ridge to beyond Surrey Hills may raise the objection that it would seem that the country about Blackburn should have had its easiest outlet to Koonung Creek, which, with a direct course, now joins the Yarra at 24 ft. above sea level. But if we imagine the low valley of Koonung Creek filled in, and the ridge from East Camberwell continuous to Doncaster, the outlet of this area is difficult by any route, and Main Creek might at some stages in the development be the easier in spite of the necessity to cut through the ridge.

Jutson (p. 479) mentions a decreasing throw of the Brushy Creek fault from north to south till it is no longer traceable as a fault, and appears to be represented by a gentle tilting on a line continuing south-westerly toward Springvale (with a possible fault for a short distance at Wheeler's Hill). Following this idea it seems better to consider this fault line as replaced by a wider easterly tilt from the Notting Hill axis. Then the course of the Dandenong Creek at Wheeler's Hill is in accordance with the direction of tilt till it finds its way through the hills. The Springvale valley also lies within the tilted area and further south the tilt extends from Beaumaris across the Carrum Swamp.

The slope on which the formation of swampy land appears at the lower parts of the creeks is in close agreement in the three examples in this district. The Dandenong Creek begins to be swampy below the 50 ft. contour, falling from 50 to 40 in 50 chains, or a grade of 1 in 330. The channel from Dingley southward falls from 50 to 30 in 65 chains, and from 30 to 10 in about 105 chains; this brings it into the once swampy land north of the main drain from the Dandenong Creek to Mordialloc. The Elsternwick Creek falls from 50 to 30 in 60 chains, and from 30 to 10 in 106 chains; thence to the outlet is much flatter.

In considering the lagoons, the question suggested itself as to whether there was any cause acting to keep them from silting up or even to increase their size. In spite of statements about running sands in some wells, there does not seem much likelihood of underground channels by which sand could move; and actually the closed hollows usually hold water. There seems a slight possibility that under peculiar circumstances some of the upper sand might slip in mass on an inclined clayey bed either down a valley or sidewise. As the slopes which stand are sometimes about 10 degrees on the surface, it would probably want a steeper slope than this. It might possibly occur at a time of ground movements or warping or elevation, but would be exceptional. Wind action would tend rather to fill than to excavate, as the moist bottom of the hollow must be less acted on even if the wind blew up the valley. The existing closed hollows may then be regarded as mostly newly closed.

General Summary.

The detail of the drainage system is not to be regarded as developed on a simple sloping surface. A south-westerly fall is noticeable across the Gardiner's Creek, and, to a less marked degree, the Elsternwick Creek area. Slight indications of it are seen even in the Brighton district. A south-westerly and southerly fall is also seen in the Springvale area; and the parish of Mordialloc (i.e., from near Clayton to the main drain of the Dandenong Creek) is under the influence of the southerly fall to the Carrum Swamp. But the drainage system is largely controlled by the Notting Hill-Cheltenham axis, parallel to which is a subordinate axis through East Camberwell. An easterly tilt from the latter and other late warping movements are probable. But primarily the Notting Hill-Cheltenham axis divided the north-western from the south-eastern streams. The south-westerly tributaries, though important, in many cases seem to be definitely blocked at certain lines, especially that on the south-west sides of Gardiner's Creek and the Springvale Valley. This feature, combined with the extreme regularity of the Brighton system, and the structures of the rocks so far as seen, favours the idea that the streams are guided or strengthened on their south-east or north-west courses by lines of weakness or by structural features, and that there may even have been original reversals of slope against the south-west fall in some cases.

All the valleys in their earlier stages were in the weak and absorptive tertiary sandy beds. On reaching impermeable beds such a valley would receive additions from springs, and weak places would be produced on the lines of springs which might result in a great power of widening the valley or cutting a tributary valley.

Closed hollows are of frequent occurrence, and are easily produced owing to the extreme weakness of the upper parts of the streams. Small local causes may have possibly produced some, but some of the larger ones more remote from the valley heads are probably due to warping after the development of the valleys.

There is no necessity to regard the late depression, known to have occurred in the Yarra valley, as uniformly affecting a large area, but rather as part of a movement which acted unequally in different places even a short distance apart.

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Art. XXIII.—*The Syrinx of the Common Fowl, its Structure and Development.*

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(With Plates XVIII.-XXIV.).

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Introduction.

The material for this investigation consisted of a large number of syringes of the adult common fowl, and of sets of longitudinal and transverse serial sections of chick embryos, in all stages, from nine days' incubation until the time of hatching, examined in regard to the structure and development of the syrinx; and lastly, embryos at several stages were dissected, especially in regard to the relation of the respiratory air sacs to the syrinx.

The work was carried on in the Biological Laboratory of the Melbourne University, at the suggestion, and under the direction, of Professor Baldwin Spencer, to whom I owe many thanks. Thanks are also due to Dr. T. S. Hall and Dr. Sweet, for assistance and advice, and to Mr. J. Brake, and all others who have helped in various ways.

Adult Structure.

As far as the adult structure is concerned, the description which follows corroborates the work of, and gives details additional to those given by Wunderlich (1884, p. 79), who has figured the adult syrinx, and Garrod (1879, p. 377), who, in discussing the conformation of the thoracic extremity of the trachea in birds, deals briefly with the condition in *Gallus bankiva*.

I.—*External Aspect.*

The syrinx or vocal organ of the bird (known previously to Huxley as the lower larynx), is constituted by the modified tracheo-bronchial junction, and in the common fowl both trachea and bronchi are involved in its formation. Each side of the lower tracheal extremity presents a membraneous appearance. The ventral surface is mainly occupied by a triangular-shaped plate, more or less cartilaginous in structure; and a similar but smaller plate is present on the dorsal surface. The chamber of the syrinx or "tympanum," is seen to be compressed from side to side, but there is a corresponding increase of depth dorso-ventrally. The outer walls of the bronchi are strengthened by semi-rings of cartilage, while the inner walls are membraneous, and bands of fibrous tissue termed the bronchidesmus, pass from one bronchus to the other, so as to enclose beneath the bronchial junction a large air space. The body of the ventral triangular plate is seen to be continuous with that of the dorsal surface, through the medium of a semi-cartilaginous or calcareous rod, termed the pessulus. The basal angles of the plates articulate with the extremities of the first bronchial semi-rings, and in close relation to each side of the plates are the lower tracheal rings, which are much modified, lying embedded in the thin membraneous walls of the trachea. As to the syringeal muscles, they do not appear to be directly and intimately associated with the syringeal membranes, as they are in many other birds. Lastly, the whole of this syringeal chamber, or "tympanum," is in close relation to respiratory air sacs, which extend, not only up between the two bronchi, but also around each surface of the syrinx, so that the whole organ is completely enveloped.

II.—*Detailed structure of the syrinx.*

The syrinx consists of the following structures :—

1. Supporting framework,
2. Syringeal membranes,
3. Syringeal muscles,
4. Syringeal air sacs.

1. Supporting framework.

In place of the simple cartilaginous tracheal rings and bronchial semi-rings, there has been much modification at the tracheo-bronchial junction, in the formation of the supporting framework of the syrinx, so that we may distinguish the following elements:—

(a) The rod-like portion of the pessulus.
(b) Dorsal triangular plate of the pessulus.
(c) Ventral triangular plate of the pessulus,
(d) Last six tracheal rings,
(e) First two bronchial semi-rings.

(a) Pessulus.—The pessulus is situated just below the junction of the bronchi, and it passes from the ventral to the dorsal surface of the tracheal extremity. It is rod-like in shape, and in the adult partly osseous in structure. Ventrally, it expands into the body of a large median triangular plate, with a cranially-directed apex. Dorsally, it is continued into a similar but smaller plate, the whole structure (rod and two plates) resembling somewhat a double-headed bolt. Along the cranial margin of the pessulus there is a thin fold of mucous membrane, termed the membrana semilunaris.

(b) Ventral Triangular Plate.—As already stated, this is situated on the ventral surface of the tracheal extremity. Its apex extends as far cranially as to lie just behind the fourth last tracheal ring. Its basal angles articulate with the extremities of the first bronchial semi-rings. Its lateral edges are in close relation to the last three tracheal rings, fusion taking place usually only with the last ring. Its body is partly calcareous, and may be even osseous in structure.

(c) Dorsal triangular plate.—It is situated on the dorsal surface of the tracheal extremity, and its apex extends cranially between the dorsal ends of the last two tracheal rings, but does not quite reach the ante-penultimate ring. The dorsal ends of the first bronchial semi-rings articulate with the lateral angles of the plate, and with its sides the ends of the last two tracheal rings are in close relation, but do not fuse.

(d) Last six tracheal rings.—(i.) Last tracheal ring. Of the six rings, this is the most developed. It is not flattened, but rounded. Ventrally, it widens considerably, and fuses with the triangular plate, but dorsally, it presses closely against the plate, without fusing.

(ii.) Penultimate ring. This second-last ring is band-like, and rather wider than the others. Its ventral extremities press closely against the sides of the ventral triangular plate, while dorsally the ends lie on each side of the dorsal plate.

(iii.) Ante-penultimate ring. The third-last ring is more reduced. It is made up of two straight, lateral, band-like rudiments. Its ventral ends do not fuse, but lie on each side, against the apex of the ventral triangular plate. Its dorsal ends taper considerably, and come to lie close to each other, without fusing, and just beyond the apex of the dorsal triangular plate.

(iv.) Fourth-last ring. This ring is so reduced and incomplete as to be represented by a mere thread-like band, situated a little beyond the apex of the ventral triangular plate. The left side is thinner, and does not go much further than half-way towards the dorsal surface, but generally fuses with the third-last ring. The right side is wider, and nearly reaches to the dorsal surface. Ventrally, the ends come very close together.

(v.) Fifth-last ring. This ring differs from a normal ring in being slightly incomplete dorsally, where its ends are turned downwards, towards the apex of the triangular plate. It is flattened, and purely cartilaginous in structure.

(vi.) Sixth-last ring. This is the only complete ring of the syrinx, and differs from those above the rings of the syrinx in not being osseous in structure.

(e) Bronchial semi-rings.—The first two semi-rings only are especially modified in connection with the syrinx. The first is characterised by its large size, thickness and marked curvature, the concavity being directed cranially. It is not flattened, but round, and it articulates very intimately with the basal angles of both ventral and dorsal triangular plates.

The second semi-ring has its ventral ends fused with those of the first, but dorsally they are widely separated.

2. Syringeal membranes.—As already stated, the syrinx has a general membraneous appearance, and on closer examination several distinct membranes may be recognised. As a whole, they are characterised by being set or stretched between an air space on either side. As will be seen, the wall of each membrane has histologically three layers. The following membranes may be distinguished :—

(a) Membranae externae.
(b) Membranae internae.
(c) Membranae tracheales.
(d) Membrana semilunaris.
(e) Bronchidesmus.

(a) Membranae externae.—These membranes are situated one on each side of the tracheal lower extremity. They are very thin and translucent, and occupy the region between the last tracheal ring and the first bronchial semi-ring. External to it is a respiratory air sac, internal to it is the air space of the trachea, and so the membrane is stretched between two air chambers. The wall of the membrane is three-layered. The middle layer is of mesoblastic origin, the other two being of hypoblastic origin.

(b) Membranae internae.—These membranes are the thin inner walls of the bronchi, and thus occupy the region between the free ends of the bronchial semi-rings. Above they are limited by the pessulus, and below, to some extent, by the bronchidesmus. The space between the two membranes is occupied by the subpessular air space. As before, the membrane has three layers, the innermost being bronchial epithelium, much folded in one part, the middle layer of mesoblastic origin, and the outer the epithelium of the air sac.

(c) Bronchidesmus.—This is a fibrous band, passing between the two membranae internae. It is set somewhat obliquely, and is formed by the apposition of the unsymmetrical right and left interbronchial respiratory air sacs.

(d) Membranae tracheales.—These are the membraneous lateral walls of the tracheal extremity. Embedded in them lie the last five tracheal rings, which are so flattened and reduced that, notwithstanding this cartilaginous framework, the walls are thin, translucent and membraneous. They are separated caudally from the membranae externae by the last tracheal ring. Like these latter membranes, they are composed of three layers, and set between the air in the trachea and that in the respiratory air sacs.

(e) Membrana semilunaris.—This is a thin fold of mucous membrane, overlying and projecting from the cranial border of the pessulus. It consists histologically of an inner core of mesoblastic origin, overlaid on each side by the tracheal epithelium. It is only slightly marked in the adult, but is of considerable size at one stage in the embryo.

3. Muscles.—In addition to the sterno-tracheales and tracheo-clavicular muscles, which have relation both to the lower and upper parts of the trachea, there are also present a dorsal and a ventral pair of muscles. These latter two pairs correspond to the true syringeal muscles of other birds, in which, however, they may be of considerable size, and more intimately associated with the syrinx. These true syringeal muscles are said to be derived from the sterno-hyoid group of muscles, and pass down the trachea to the syrinx (see Syrinx Dictionary of Birds, by Newton), but in the common

fowl they reach only as far as the eleventh or twelfth last tracheal ring, while the syrinx does not begin until the sixth-last ring. Thus these muscles of the common fowl have no very close relation to the membranes of the syrinx.

4. Respiratory Air Sacs.—The air sacs completely surround the syrinx. This envelope is not a simple one, but a composite one, in which the several air sacs are in intimate contact with each other, and with the syringeal membranes. In development, they are seen to be derived from the third entobronchus of the lung. The third entobronchus terminates in a stem, which subdivides into two main stems, of which one, opening into the interclavicular sac, goes to form the syringeal air sacs, while the other opens out into the anterior thoracic air sac. As the stem of the interclavicular or syringeal air sacs ascends from the third entobronchus of the lung to the interbronchial region, it expands into several air sacs, which take up different positions in relation to the parts of the syrinx.

A large ventral sac passes over the ventro-cranial region of the bronchus and triangular plate, and comes to occupy the ventro-lateral region of the syrinx.

A large sac from the right side extends up so far as to lie close beneath the pessulus, the sub-pessular air sac. On each side it is in relation to the membranae internae.

Another large sac passes dorsally from between the bronchi, and then opens out into dorso-lateral sacs. The most cranial one is large, and comes to occupy the dorso-lateral region of the syrinx.

Other branches pass off, and become related to structures apart from the syrinx, one main branch and several smaller ones returning to the lung tissue, and so constituting the recurrent branches of the interclavicular sac. The recent research of Juillet, 1912 (Chap. IV.), showing that the direct stem of the interclavicular sac arises in common with the stem of the anterior thoracic sac, is here confirmed. What was formerly thought to be the direct bronchial stem, he has shown to be the indirect recurrent interclavicular branch. Thus the stem of the interclavicular sac, besides giving off its recurrent branches, expands into the interclavicular region, where it gives rise to the syringeal air sacs.

Embryonic Development.

Passing now to the embryonic condition of the organ, a general survey of its development will first be given, followed by a detailed description of the gradual appearance, in time, of the several parts of the syrinx.

III.—*General Survey.*

Concurrent with the development of the trachea and bronchi as hypoblastic outgrowths, the surrounding primitive mesoblast begins to gradually condense, or concentrate, around them, and as early as the end of the third day of incubation this concentration is clearly indicated. As development proceeds, there are formed at regular intervals in this denser mesoblast, concentrations of tissue, each gradually assuming a ring-like form.

Ultimately, by differentiation, they give rise to the more or less cartilaginous framework of the trachea and bronchi. However, in the region of the tracheo-bronchial junction, these ring-like concentrations are considerably specialised, to form the supporting structure of the syrinx. The most distinctive modification, and one whose bolt-like form is so characteristic of the common fowl is the appearance of a rod-like concentration just between the conjoining bronchi, which expands into a dorsal and a ventral plate, and hence, from its shape, has been well called the pessulus. As the ring-like concentrations of the syrinx assume definition, there is a gradual change in regard to their relative size, some becoming strongly, others poorly, developed, even to the extent of becoming mere vestiges. There is also a change in shape, some losing their circular form, and becoming flatter and flatter, until merely band-like rudiments. Still further, there is modification not only in degree of development, but also in their mutual relations and relation to the dorsal and ventral pessular plates.

As the supporting framework thus develops, the membranes gradually appear, and become more and more differentiated from the surrounding tissue. The first to be indicated are the membranae externae, and, from the time when the tracheo-bronchial framework begins to appear, the position of these membranes is recognised by the greater interval between the last tracheal ring and the first bronchial semi-ring. In this interval the wall of the trachea gradually becomes deflected towards and into the lumen, while the tissue subsequently changes in structure, and finally gives rise to the very thin oval-shaped membrane of the adult. The next membrane to appear is the membrana semilunaris, which becomes thrown up as a wedge-shaped fold, capping the cranial border of the pessulus. It increases considerably in size, but in the adult it has become relatively small. Along with the development of this fold, the inner walls of the bronchi begin to be clearly separated from each other by a space, so as to give rise to the membranae internae. This is accomplished by the upgrowth of the interclavicular sacs from the lung into the interbronchial region. The stem of the interclavicular sac and that of the anterior thoracic air sacs, are the bifurcations of the main stem of the third entobronchus of the lung. The interbronchial sacs are not symmetrical, the large subpessular sac being derived from the right side, and in contact with both membranae internae. As a result, there is a three-layered band of tissue gradually developed, separating the air-spaces of the right and left sides, and tending to connect obliquely the two membranes. This band of tissue becomes the bronchidesmus, which, in the adult, is tough and fibrous. The membranae tracheales, or the two lateral walls of the upper part of the syrinx, have the last five or six tracheal rings embedded in their tissue, and even up to the time of hatching, these walls remain thick. After hatching, however, when the embedded rings rapidly begin to flatten, the walls become distinctly membraneous and tough, and finally constitute in the adult the membranae tracheales.

It has already been mentioned what an intimate relationship comes to exist between the membranae internae and interbronchial air sacs. A similar relationship comes about in regard to the membranae externae and tracheales. The stem of the interclavicular sac not only gives off the interbronchial and subpessular sacs, but also gives off large ventro-lateral and dorso-lateral sacs. The ventral sac expands over the bronchi and the triangular plate into a large sac, which gradually becomes closely applied to the ventro-lateral half of the membranae externae and tracheales. The dorsal sac expands around the dorsal surface of the bronchus and triangular plate, giving off several dilatations, one large one coming to occupy the dorso-lateral half of the membranae externae and tracheales.

Thus the whole syrinx becomes enveloped in air sacs, and this fact, together with the poor development of the syringeal muscles, is suggestive of the cause of vibration of the syringeal membranes. (Pls. XVIII. and XIX., figs. 1, 2, 3.)

The syringeal muscles make their appearance at about the end of the second week of incubation, where they are seen developing beneath the tracheo-clavicular muscles. A dorsal and a ventral pair develop, but they do not extend down as far as the syrinx, stopping short at about the eleventh or twelfth tracheal ring from the caudal end.

Such is the general survey of the developing organ. A more detailed description of various stages will now be given, showing the development of the several parts, in order of time.

IV.—*Developing Elements at Different Stages.*

1. Nine days' incubation.—After nine days of incubation, a concentration begins to take place in the enveloping dense mesoblast, and this is the first indication of what will be the first bronchial semi-ring.

2. Ten days.—Early in the stage there has also appeared the first indication of the last tracheal ring, but it is not so definitely marked as the first bronchial has now become. Just between the uniting bronchi, the mesoblast tissue is becoming very concentrated, and from this the pessulus will develop later. Towards the close of the tenth day, the penultimate ring and the second bronchial semi-ring are just forming, while the first bronchial semi-ring and the last tracheal ring are now more clearly differentiated from the surrounding tissue. Between these latter two there is a considerable interval, and in each case they cause the hypoblastic epithelium to project somewhat into the lumen, the interval marking the site of the future membrana externa.

3. Eleven and twelve days.—In an early stage of an eleven days' embryo, the pessulus begins to be indicated, as a change gradually takes place in the centre of the dense interbronchial mesoblast. Also, the developing tracheo-bronchial rings are becoming more differentiated, and a little later in the eleventh day, and by the twelfth day, the ante-penultimate fourth and fifth-last rings have just appeared, but are more marked in the dorsal region. Also, cranial to these, a large number of tracheal rings are developing, while caudally the third bronchial semi-ring has appeared, and the fourth is just beginning. The pessular mesoblast, in which the pessulus is developing, now extends to both dorsal and ventral surfaces of the tracheal extremity, where it is expanded to form dorsal and ventral plates of dense mesoblast, from which the triangular cartilaginous plates will arise. (Pl. XIX., fig. 4.) At this stage, thus, the main elements of the supporting framework are all indicated, but while the first bronchial semi-ring and the last tracheal ring are now large and clearly marked, the remainder are small, less definite, and imperfect. The degree of development is seen by comparing the extent to which each element has passed beyond the mid-lateral region, towards the dorsal and ventral surfaces. The last tracheal and first bronchial reach the dorsal and ventral surfaces, where there is fusion with the pessular plates of dense mesoblast, except in the case of the ventral ends of the first bronchial, which lie free just caudal to the plate of mesoblast. This ventral plate

also receives the ventral ends of the second and third-last rings, while just beyond them are the ventral ends of the fourth, fifth and sixth-last rings. Those of the fourth and fifth fuse on each side, and then with those of the other side, while those of the sixth fuse in the mid-line, and lie quite separate from the others. As to the extent of dorsal development, the fourth and fifth-last scarcely pass the mid-lateral line before fading away, and then, likewise, a little further, the third and the sixth-last. Still further dorsally, the second-last fades away, as well as the remnants of the bronchial semi-rings, except the first, which, together with the last tracheal ring, passes right to the dorsal surface, there merging into the pessular mesoblast plate. Even at this early stage, it is noticeable that the ventral development is much less restricted than that of the dorsal.

4. Thirteen days.—By this stage a considerable number of bronchial semi-rings and tracheal rings, not directly concerned with the syrinx, have begun to form. Those concerned with the syrinx have all become more distinctive, especially the last two tracheal rings, and the first two bronchial semi-rings. This is seen in regard to their structure, size and outline. The interval between the last tracheal and first bronchial is greater, and hence the rudiments of the membranae externae are more marked. The difference in size is even now very noticeable, the third, fourth and fifth last being relatively very small. The more distinctive structure and outline is seen, not only in the rings, but also in the pessulus and its plates, concentric circles of cells are now seen surrounding the pessulus As to the greater extent of development, compared with the last stage, this is seen in a few particulars. In the dorsal region, the extremities of the last tracheal ring and the first bronchial semi-ring are now being clearly differentiated from the dense dorsal mesoblast, so that their ends lie somewhat free. (Pl. XX., fig. 9.)

As early as this stage a variation is at times apparent. The fourth-last ring, which is most poorly developed, and passes little towards the dorsal surface, usually fuses on the left side with the third last, but sometimes, though less often, the fusion takes place with the fifth ring. This fusion on the left side is indicated at this stage, while on the right the ends are quite free. As in the last stage, there is little dorso-lateral development of this ring. As for the second, fifth and sixth-last rings, they now reach the dorsal surface where they merge into the dorsal plate of mesoblast, from which the dorsal triangular plate is not yet clearly defined. The chief changes in the ventral region are the separation of the fifth ring from the fourth ring, so that it becomes like the sixth ring. The fourth ring is still associated with the apex of the dense ventral plate, which is becoming definitely triangular in shape. (Pl. XIX., fig. 5.)

At a little later stage, on the thirteenth day, more changes are apparent. The whole framework is of greater size, and more definite outline, and rapidly approaching the cartilaginous stage. The boundaries of the pessulus are now well defined. Ventrally, the framework now presents its characteristic configuration—namely, the last four tracheal rings are clearly involved in fusion with the sides and apex of the ventral triangular plate, while its basal angles articulate with the ends of the first bronchial semi-rings, and with the latter the ends of the second bronchial have begun to fuse. (Pl. XIX., fig. 5.)

Dorsally, the ends of the ante-penultimate have now extended to the dorsal dense mesoblast.

5. Fourteen days.—As before, there is increased size and differentiation in the supporting framework, while other developments have appeared. On each side of the dorsal triangular plate lie the free ends of the last tracheal, penultimate and first bronchial. Just beyond the apex of the plate, there are the ends of the ante-penultimate, which are now clearly defined and pressed against each other and the apex of the plate, yet without fusing. The dorsal ends of the fifth-last similarly come close together in the middle line, without fusing, but those of the sixth last do fuse, so that this ring becomes the only complete one associated with the syrinx. The fourth-last is still small, and now passes further dorsal than before. Ventrally, no marked change has resulted. In addition to these changes in the supporting framework, two other changes are apparent. Firstly, the medial hypoblastic walls of the bronchi are thrown into folds; and, secondly, the syringeal air sacs can now be seen pushing their way up from the third entobronchus of the lung towards the interbronchial tissue. (Pl. XVII., fig. 1; and Pl. XXIV., figs. 19 and 24.)

As yet the membranae internae are not formed. The stem of the interclavicular or syringeal air sacs has, however, divided into its three main diverticula—namely, the large ventral sac, the dorsal sac, and the smaller craniallv-directed one, which, from the right side, will become the sub-pessular sac. (Pl. XXIV., fig. 19.)

This latter change subsequently becomes of great importance in its bearing on the whole syrinx, and this fact becomes more and more evident in following stages.

6. Fifteen days.—This stage of development is of considerable importance, since, by this time, the foundation of all the main structures of the syrinx has been laid. (Pl. XVIII., fig. 27.)

The supporting framework, with all its elements, is definitely formed, all the syringeal membranes are to some extent indicated, the syringeal muscles are developing, and lastly, the syringeal air sacs begin to show intimate relationship with the syrinx as a whole. As to the general enveloping mesoblastic tissue, it is now losing its dense character, and gradually changing into a reticular meshwork, but the tissue closely around the lower tracheal rings is still dense, and is made up of several layers of flattened cells.

Supporting framework.—A few changes have taken place. Previous to this stage, the last four tracheal rings have been fused with the sides and apex of the ventral triangular plate; but now, at this stage, there is the beginning of a change, which later results in the separation of all but the last ring from the plate. (Pls. XIX., XX., figs. 4 and 8.)

This goes on gradually, and reaches completion some time after the hatched condition. There is variation in the actual time of separation, but at the end of the fifteenth day the apex of the ventral plate is no longer intimately fused with the fourth-last ring. Again, the ends of the third-last now articulate with each side of the apex, so that only the last two rings remain fused with the sides of the plate. (Pl. XIX., fig. 6.)

It may also be noticed that the ventral ends of the first two bronchial semi-rings are now more definitely fused. The smaller size of the dorsal triangular plate, as compared with the ventral one, is now seen. Also, it is not directly fused with any of the tracheo-bronchial rings. As before, its lateral angles articulate with the first bronchial semi-ring, its sides with the ends of the last two tracheal rings, and its apex articulates with the ante-penultimate ring, whose ends are now fusing.

On the left side, the fourth-last ring fuses at its extremity with the fifth-last ring, just before the extremities come close together in the mid-line.

Syringeal membranes. (Pl. XVIII., fig. 2.)—At the close of the fifteenth day, the membrana semilunaris first begins to appear, capping the more ventral region of the pessular rod. It is wedge-shaped, and simply consists of a mesoblastic interior, covered by the hypoblastic epithelium. The unattached edge projects slightly into the lumen of the tracheal extremity. The membranae externae between the tracheal rings and the bronchial semi-rings are now larger in size, and somewhat deflected into the lumen of the syrinx. Their walls are still thick and dense in structure.

The membranae internae are now developing from the inner walls of the bronchi, between the free end of the bronchial semi-rings. At first, the mesoblastic tissue between the bronchi is one continuous sheet, but at the close of the fifteenth day the inter-bronchial air sacs have so extended upwards as to reach almost to the pessulus; hence the mesoblastic tissue is divided into two layers. In this way the membranae internae first begin to form. Their walls have three layers, and the mesoblastic layer is as yet of considerable thickness. As yet the right air sac has not completed the splitting of the mesoblast in the dorsal region, where the two membranes have not become differentiated. The hypoblastic epithelium of the membranes is thickened, and contains spaces, so that it tends to become folded. With the pushing up of the two interbronchial air sacs, the bronchidesmus becomes formed at this stage. It consists of the two thin walls of the right and left air sacs, with a strand of mesoblastic tissue between them, and continuous with the mesoblastic walls of the membranae internae. The intimate association of these three layers constitutes the bronchidesmus, and, owing to the greater and asymmetrical development of the right sac, the membrane is directed obliquely between the bronchi.

The membranae tracheales do not become membraneous in structure until after hatching, and hence at this stage their walls are thick, and the tracheal rings embedded in them have only just begun to flatten. There is also to be seen a denser tissue, connecting the rings.

Muscles of the syrinx (Pl. XVIII., fig. 2.)—By this stage, the sterno-tracheales and tracheo-clavicular muscles are well marked, lying close to the ventral and lateral sides of the trachea. The tracheo-clavicular leave the latter walls of the trachea just above the region of the eleventh and twelfth-last tracheal rings. Between these muscles and the trachea the syringeal muscles are developing and extending down a short distance towards the syrinx. They do not reach the syrinx, and, as yet, they are not clearly differentiated into a dorsal and a ventral pair.

Syringeal air sacs.—The syringeal air sacs have now become much expanded, both between the bronchi, and also to the lateral side of the syrinx. On the right side the sub-pessular air sac has been given off, and thus the membranae internae are now defined, except in the more dorsal region. On the left side the dorsal dilatation passes around the bronchus, and is approaching the membrana externa; other air spaces are also present, coming towards the lateral walls of the syrinx. (Pl. XVIII., fig. 2.)

7. Sixteen days.—The chief progressive changes that have taken place at the close of the sixteenth day have to do with the expansion of the syringeal air sacs. (Pls. XXI., XXII., and XXIII., figs. 11-16.) Very little change has occurred in the supporting framework. The ventral triangular plate has, fused to its sides, only the extremities of the last tracheal ring, and one end of the penultimate, the other end, usually the right one, having separated off from the plate. (Pl. XX., fig. 7.) The apex of the dorsal plate has become more acute, and is surrounded, as before, by the free ends of the third, fourth and fifth-last rings, the ends of the fifth ring now tending to turn downwards, towards the apex of the plate. Much variation and irregularity is at times seen at this stage, and in later stages, in regard to the fused or unfused condition of the dorsal end of the above rings. The ends of the fifth-last may, or may not, be fused. The different rings may be free from each other, or partially fused, the tendency being, however, towards fusion of these three rings in this dorsal region. In one case the fifth ring was fused on one side with that of the sixth.

As to the membranes, owing to the growth of the air sacs, they all now take on their characteristic structure of three layers, and are set between an air cavity on either side of them; so that eventually, in the adult, this probably becomes a condition of their vibration during the alternate expansion and contraction of these air spaces, as the air goes in and out. The membrana semilunaris is now very well marked, and extends along the whole cranial border of the pessulus. The tissue of the membranae externae is more reticular, and their walls become thinner as the air sacs push into them. (Pl. XXIII., fig. 15.) The membranae internae are now completely formed. Their walls are thinner, owing to the reduction of the mesoblastic tissue. To about the middle of the left membrane the bronchidesmus is attached. Little change has taken place in the membranae tracheales, except that its tissue has become more reticular, the middle rings smaller, and the membrane as a whole thinner.

Syringeal air sacs.—As this is the stage at which the air sacs take up their characteristic relation to the membranes, their origin, extent and position will now be somewhat fully described. (Pls. XXI., XXII. and XXIII., figs. 11-16.)

The mesobronchus of the lung, while passing from the medial to the lateral region of the lung, gives off its third entobronchus. (Pls. XXIII. and XXIV., figs. 17, 18, 22.) The third entobronchus is directed medially and ventrally, and subdivides into three main branches. Almost immediately it gives off its first branch, which is directed caudally, medially, and slightly dorsally, and is confined to the lung itself. (Pl. XXIV., figs. 18, 22.) The stem then passes ventrally, and in the ventro-medial region of the lung, bifurcates, the slightly smaller branch is the stem of the interclavicular sac, or syringeal air sacs, and is directed cranially and ventrally towards the interbronchial region. (Pl. XXI., fig. 11.) The other subdivision passes ventrally, and expands into the large anterior thoracic air sac. (Pls. XXIII. and XXIV., figs. 17-24.) The stem of the syringeal air sacs, after emerging from the lung, passes up close to the ventro-medial region of the bronchus, and begins to expand into several large air sacs, which take up different positions, in relation to different parts of the syrinx. (Pls. XXI., XXIII. and XXIV., figs. 11, 17, 19.) There are three main sacs arising—a ventro-lateral interbronchial, and dorsal, which latter is the continuation of the stem.

The ventro-lateral one passes over the bronchus and ventral triangular plate, and takes up a position in relation to the whole ventro-lateral region of the syrinx and bronchus. (Pls. XXI. and XXII., figs. 11-14.)

On the right side the interbronchial sac passes up between the bronchi as far as the pessulus, and extends to the left bronchus, so as to form the inner boundary of both membranae internae.

On the left side the sac is much smaller, not reaching to the pessulus, and confined to its own side. (Pls. XXI. and XXII., figs. 11-13.)

The third main sac, or dorsal one, is large, and gives off three main divisions before terminating. (Pls. XXI., XXII., XXIII., figs. 11-16.) The most cranial one passes laterally behind the bronchus into a large expanded sac occupying the whole of the dorso-lateral region of the syrinx. Just caudally, the second smaller division also passes dorso-laterally, beneath the bronchus, to the lateral side. The third division is large, and passes laterally, giving off diverticula to the upper region of the lung. It passes dorsal to the bronchus, and in close relation to the innominate artery. This is the recurrent bronchial branch of the interclavicular sac. (Pl. XXIII., fig. 15.) After giving off its three main divisions, the main dorsal sac terminates in several small diverticula in the lung region. In this way are formed the recurrent branches, large and small, of the interclavicular sac.

The ventro-lateral and dorso-lateral syringeal sacs press close against the membranae externae. tracheales and bronchus. They are also in close contact with each other, and overlie the dorsal and ventral triangular plates. Thus all surfaces of the syrinx—dorsal, ventral, lateral and interbronchial—are embraced by air sacs.

8. Seventeen to twenty-one days.—The development of the syrinx after the close of the sixteenth day is one of degree rather than the laying down of any new structures, hence the remaining days of incubation are taken together. There are a few changes in the supporting framework. There is first a histological change. The hyaline or cartilaginous matrix is gradually laid down, and the cartilaginous cells come to lie in their characteristic lacunae. On hatching, the left ventral end of the penultimate ring ceases to be fused with the ventral triangular plate, so that only the last ring is now fused to the plate. (Pl. XX., fig. 8.) Dorsally, the downturned ends of the fifth-last ring are bound to the apex of the plate by tissue, which becomes fibrous in the adult. A slight flattening has occurred in the rings embedded in the membranae tracheales, the intermediate ones being small, and bound together by a connective tissue. Hence the membranae tracheales, although thinner, are still far from being membraneous. (Pl. XIX., fig. 2.) The membranae internae and externae have also become much thinner. The syringeal muscles are more strongly developed. There is now the dorsal and the ventral pair, but they do not extend further down the trachea than the twelfth or eleventh-last tracheal rings. The air sacs have now so completely surrounded the syrinx as to separate it off from adjacent structures, such as the oesophagus and large vessels of the heart, which are in close relation to the tracheo-bronchial junction.

Other than the increased size of the elements of the syrinx, this comprises the development up to the time of hatching.

V.—*Post-embryonic development.*

The syrinx, being peculiar to birds as a vocal organ, shows considerable development in the post-embryonic period. This accounts for some marked differences between the adult and the hatched condition.

Since all the morphological structures of the syrinx have been laid down during the embryonic period, the development in the post-embryonic period is chiefly histological, but to such a degree that this tracheo-bronchial junction is converted into a truly membraneous chamber, whose lateral walls are made up of the membranae tracheales and externae. The membranae tracheales, between the time of hatching and the adult condition, undergo much change. The last five tracheal rings embedded in it flatten into extremely thin band-like vestiges, while the tissue between them becomes thin and tough, so that the whole constitutes the stout membranae tracheales of the adult. The membranae externae become the most distinctive membranes, thin, yet strong, oval in outline, and stretched between the last tracheal ring and the well-marked first bronchial semi-ring.

A similar change occurs in the membranae internae. The bronchidesmus gradually assumes the fibrous condition of the adult. As regards the supporting framework, the changes in the last five tracheal rings have been noted. The first two bronchial semi-rings become the most developed of all the syringeal rings, and they are curved so that their concavity looks cranially, and opposes that of the last tracheal ring. The dorsal and ventral plates considerably thicken and become very prominent, and only the ventral ends of the last tracheal ring fuse with it. Their basal angles, however, articulate with the other tracheal rings and first bronchial semi-rings.

In the older fowls, especially in the male bird, the pessulus becomes calcified, and may become partially ossified, not only along the whole extent of the rod, but also in the central portions of the dorsal and ventral triangular plates. In addition to this, there is a small centre of ossification in the ventral ends of the first bronchial semi-ring, just before it articulates with the basal angles of the ventral triangular plate. Ossification also takes place in many of the tracheal rings above the syrinx. The syringeal muscles change very little. There are the dorsal and ventral pairs, and they do not reach the syrinx. Finally, with the change in the external walls of the syrinx, the characteristic shape of the adult syrinx is assumed—namely, the lateral walls have approached one another, o that the lateral width of the syrinx is less than that of the trachea, but the dorso-ventral depth is somewhat greater.

As before, the whole syrinx is enveloped by the syringeal air sacs or diverticula of the interclavicular air sacs.

Summary.

In conclusion, the following points may be given as distinctive features of the syrinx of the common fowl :—

1. The formation of a syringeal chamber or "tympanum," with extensive membraneous walls.

2. The presence of membraneous internal bronchial walls, with the connecting bronchidesmus.

3. The presence of the bolt-like pessulus, with its ventral and dorsal triangular plates.

4. The very vestigial condition of the last five tracheal rings, the greater development of the first two bronchial semi-rings, and the close relationship of all these elements with the ventral and dorsal plates.

5. The very noticeable absence of muscles in direct or intimate association with the syringeal membranes.

6. The complex and intimate relationship of respiratory air sacs to the syrinx as a whole.

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DESCRIPTION OF PLATES XVIII-XXIV.

Figs. 1-3.—Median frontal or longitudinal horizontal sections through the tracheo-bronchial junction of the chick embryo at three stages, showing chiefly the elements of the cartilaginous framework, the developing membranes and the air sacs in relation to the syrinx.

Fig. 1.—Stage of 13-14 days' incubation.

Fig. 2.—Stage of 15 days' incubation; interbronchial air sacs in position, lateral sacs appearing.

Fig. 3.—Stage of hatched condition; all the syringeal air sacs in position, and the whole structure rapidly approaching the adult condition.

Figs. 4 to 10.—Frontal sections through the ventral and dorsal triangular plates of the pessulus at different stages, showing their relation to the tracheal rings, and the first bronchial semi-ring.

Fig. 4.—Stage of 11-12 days' incubation, ventral triangular plate appearing, along with the four last tracheal rings, and first bronchial semi-ring.

Fig. 5.—Stage of 13-14 days' incubation, ventral plate now well formed, with the four last rings fused to it. First bronchial semi-ring articulates, but is not fusing with the plate.

Fig. 6.—Stage of 15 days' incubation. The ventral ends of the third-last tracheal ring are separated from the ventral plate. The second bronchial semi-ring is fused ventrally with the first bronchial semi-ring.

Fig. 7.—Stage of 16 days' incubation. The right ventral ends of the second-last tracheal ring are now separated from the plate, as well as the ventral ends of the third.

Fig. 8.—Stage of the hatched condition. The left ventral end of the third-last ring is separated from the plate, so that only the last tracheal ring has its ventral ends fused to the ventral plate.

Fig. 9.—Stage of 13-14 days. Dorsal triangular plate appearing.

Fig. 10.—Stage of 15 days. Dorsal plate well formed, with the various tracheal rings and first bronchial semi-ring articulating, but not fusing, with it.

Figs. 11-16.—Stage of 16 days' incubation. Frontal, or longitudinal horizontal sections, through the region of the tracheo-bronchial junction, to show the arrangement and origin of the syringeal air sacs, derived from the interclavicular sac.

Fig. 11.—The interclavicular sac is seen passing up from its common stem of origin with the anterior thoracic air sac into the interbronchial region, and opening ventrally at the cranial end of the bronchus, into the large ventro-lateral sac, situated behind the triangular plate, and lateral to the lower tracheal rings.

Fig. 1.

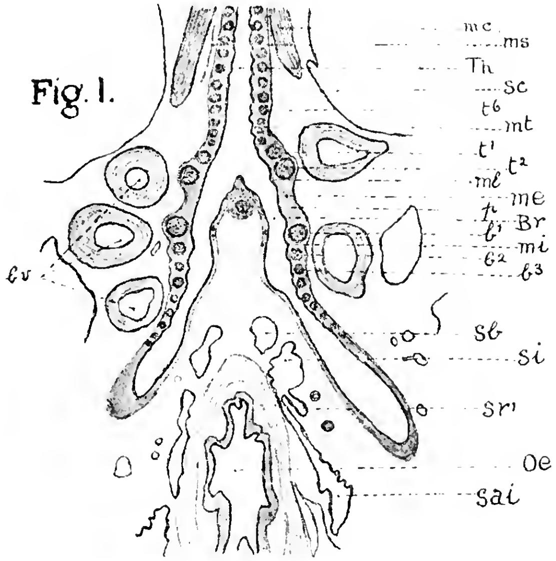
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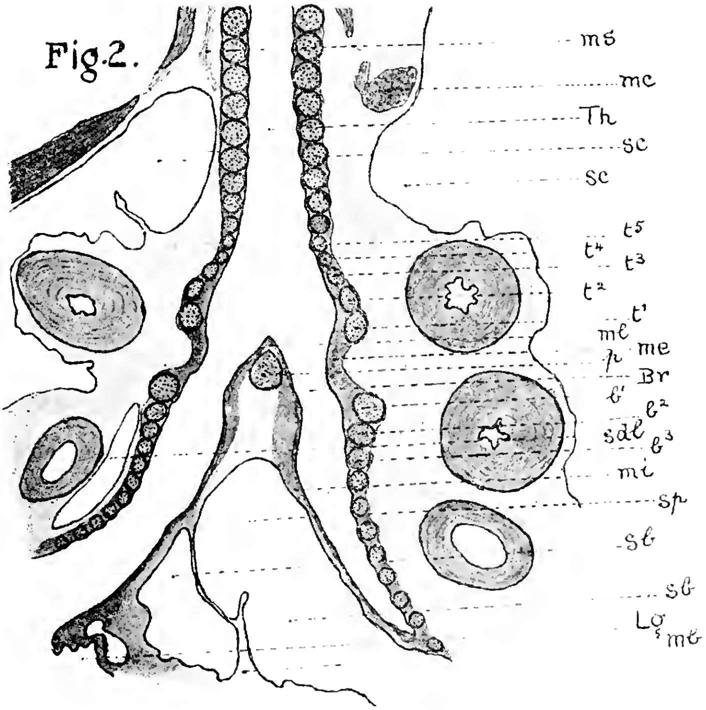
Fig. 2.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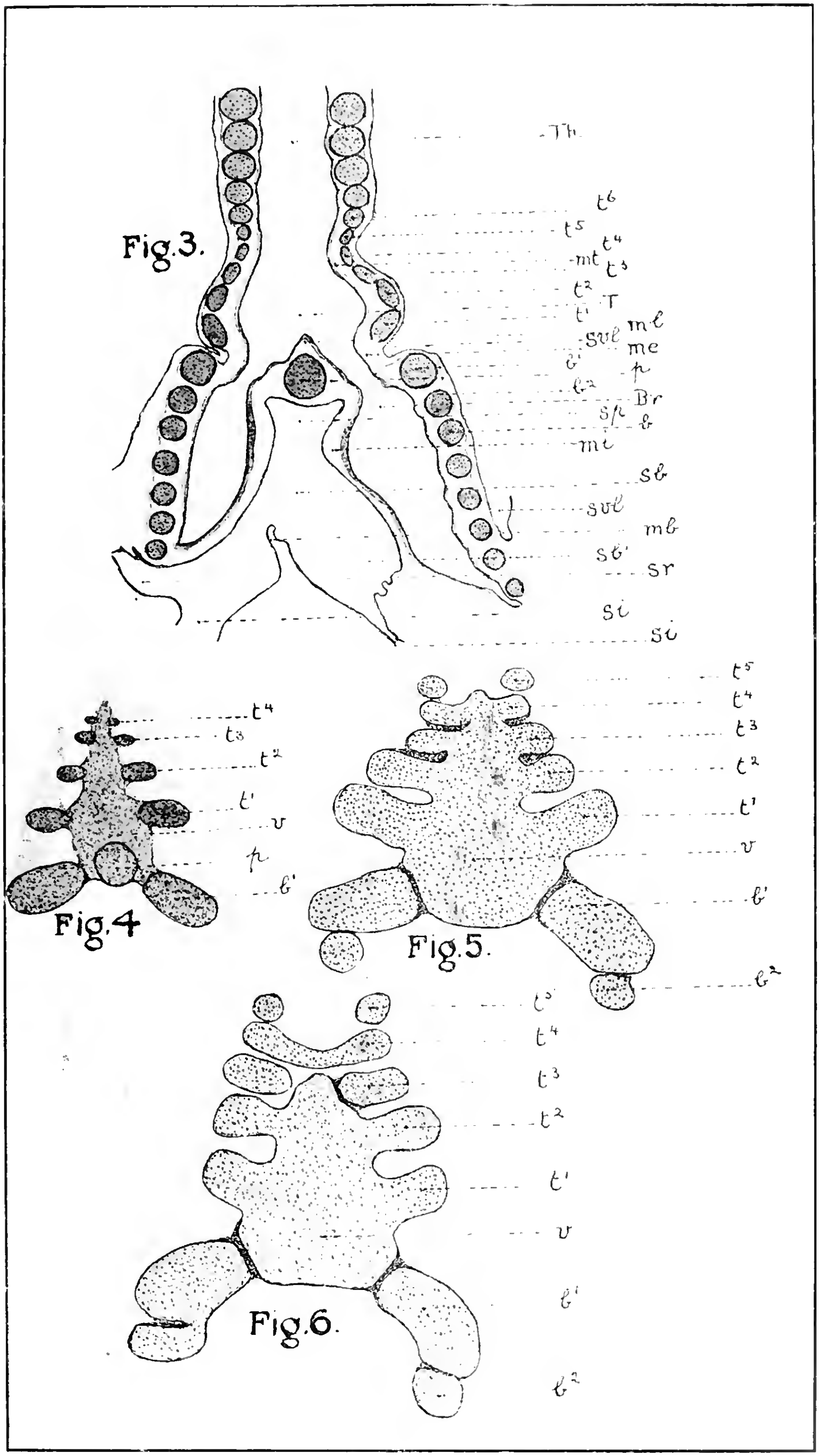
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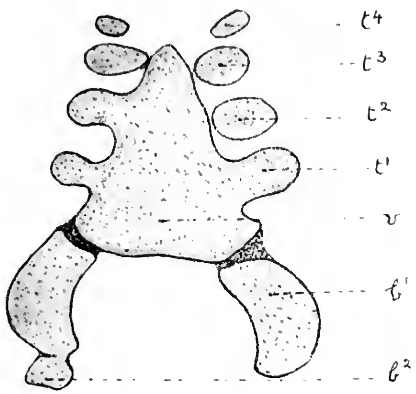
Fig. 7.



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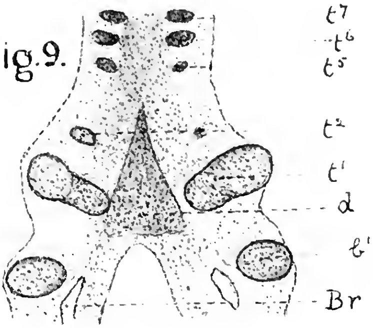

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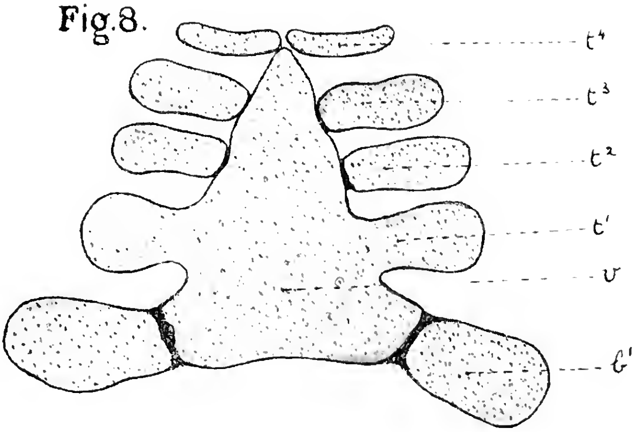

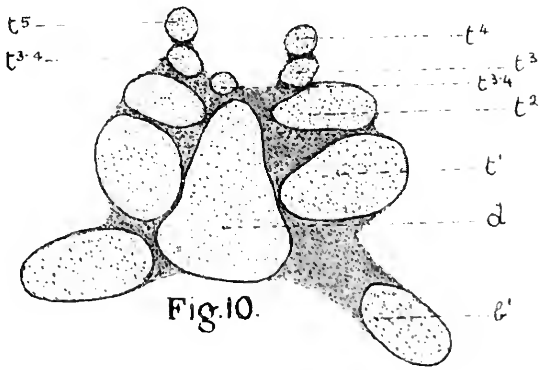

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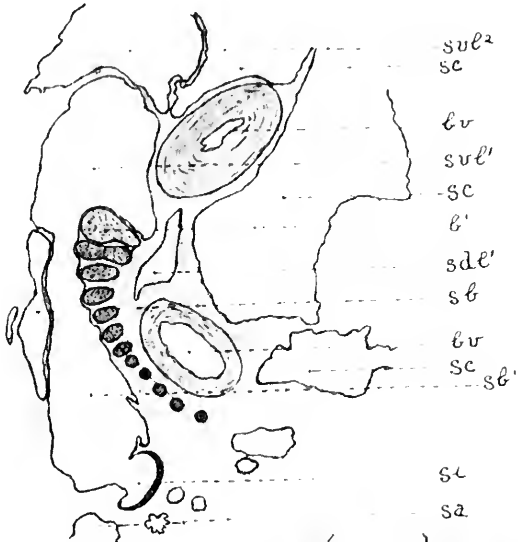
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Fig.11.

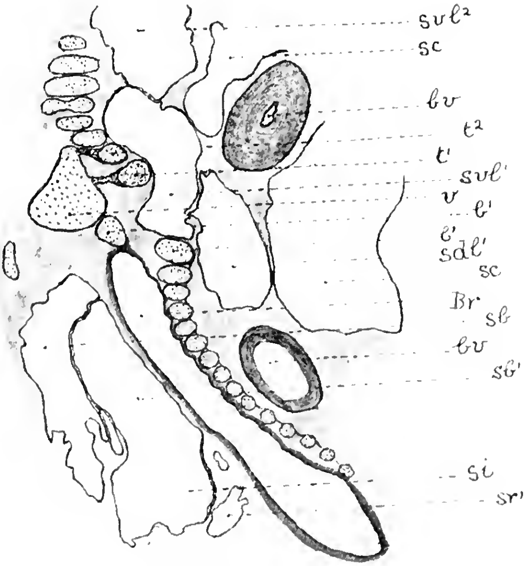
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Fig.12.

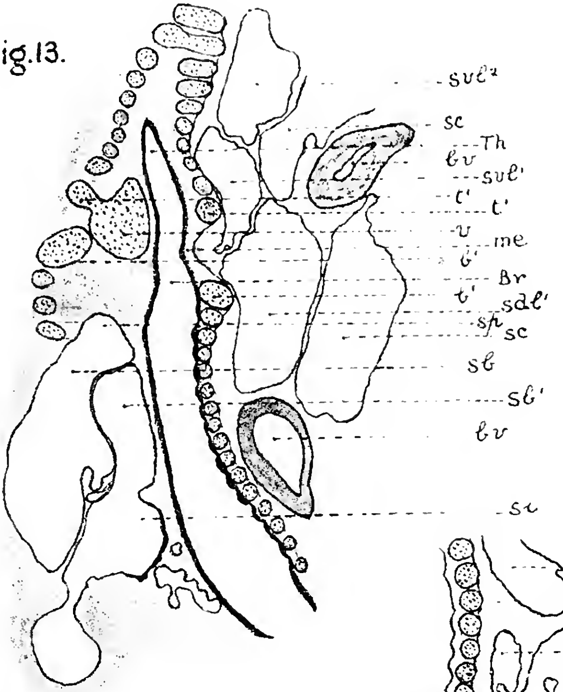
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Fig. 13.

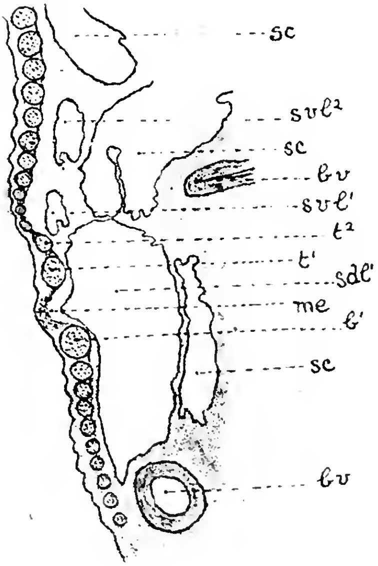
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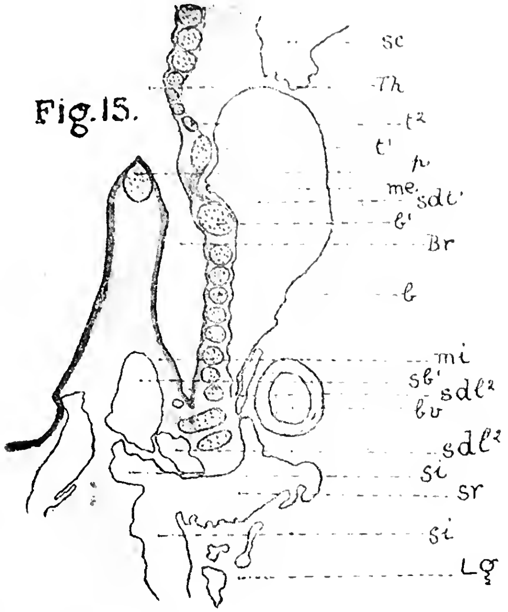
Fig. 14.

Fig. 15.



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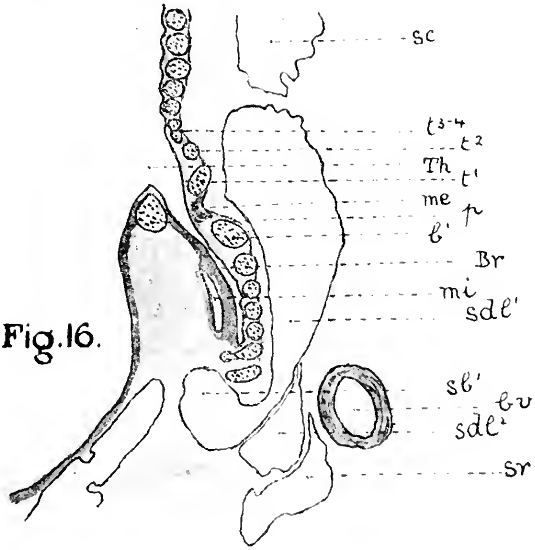

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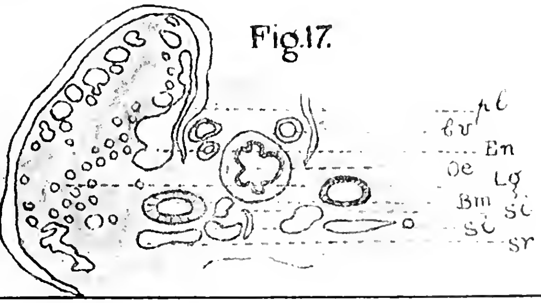

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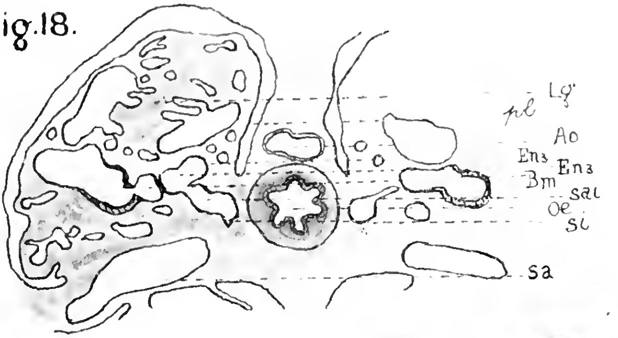

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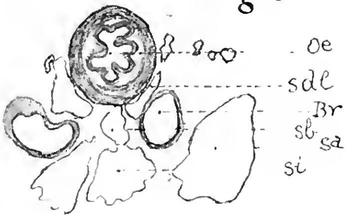

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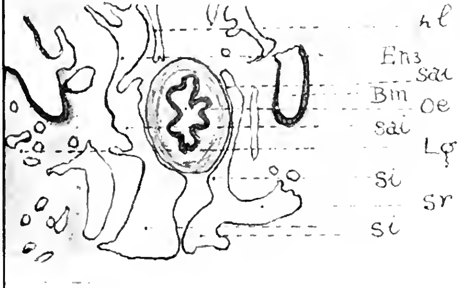

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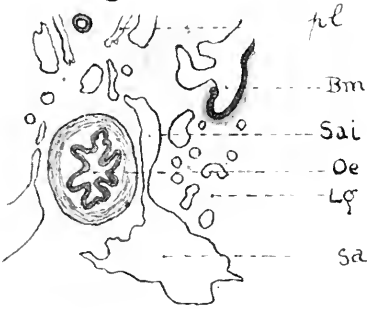

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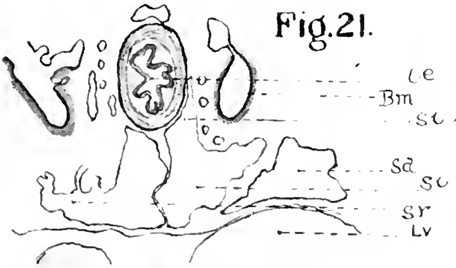

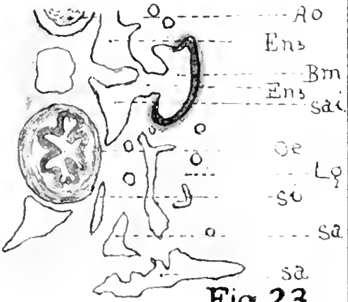

Fig. 23.

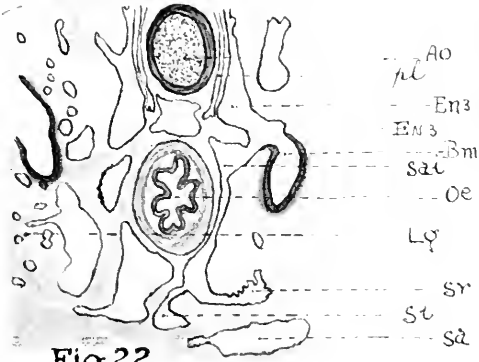

Fig. 22.

Fig. 12. Interbronchial, ventro-lateral, and dorso-lateral sacs shown.

Fig. 13.—Interbronchial and lateral sacs shown in relation to the membranae internae and externae.

Fig. 14.—Dorso-lateral sac, in relation to the membrana externa.

Fig. 15.—Main recurrent interclavicular branch shown, together with the interbronchial and dorso-lateral sacs.

Fig. 16.—Showing how the dorso-lateral sac passes up from the interbronchial region, dorsal to the bronchus, and at its caudal end.

Figs. 17-24.—Transverse sections through the bronchi and mesobronchi of the lung, showing the origin of the interclavicular and anterior thoracic air sacs from the third entobronchus of the lung.

Figs. 17, 18.—Stage of 10 days' incubation, showing the third entobronchus, the anterior thoracic air sac, and the interclavicular sac, with its recurrent branch.

Figs. 19-24.—Stage of 13-14 days' incubation, showing the third entobronchus, and the origin of the common stem of the interclavicular and anterior thoracic sacs. Recurrent interclavicular branch, shown in Figs. 20, 21, 22; interbronchial sacs shown in Fig. 19.

Reference Letters.

ao	Dorsal aorta.
b^1-b^3	Bronchial cartilaginous semi-rings.
Bm	Mesobronchus of the lung.
Br	Bronchus.
bv	Large blood vessels of the heart.
d	Dorsal triangular plate.
En	Entobronchus of the lung.
En_3	Third entobronchus of the lung.
Lg	Lung tissue.
Lv	Liver tissue.
mb	Membrana bronchidesmus.
mc	Tracheo-clavicular muscle.
me	Membrana externa.
mi	Membrana interna.
ml	Membrana semilunaris.
mt	Membrana trachea.
ms	Syringeal muscles.

Oe	Oesophagus.
p	Pessulus.
pl	Pleural cavity.
sa	Anterior thoracic air sac.
sai	Common stem of the anterior thoracic and interclavicular sacs.
sb, sb[1]	Right and left interbronchial sacs.
sc	Cervical air sac.
sdl[1], sdl[2]	Dorso-lateral sacs.
si	Interclavicular air sac.
sp.	Subpessular sac.
sr, sr[1]	Large and small recurrent interclavicular branches.
svl[1], svl[2]	Ventro-lateral sacs.
T	"Tympanum," or syringeal chamber.
t[1]-t[6]	Lower six tracheal cartilaginous rings; t[3]-t[4], fused.
Th	Trachea.
v	Ventral triangular plate.

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Art. XXIV.—*The Viscosity of Cream.*

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(Physiological Laboratory, University of Melbourne).

Read 12th December, 1912.

It seems to be commonly supposed that the thickness or viscosity of cream affords a fair test of its richness in fat; investigation, however, discloses a number of factors which affect the viscosity to a greater or less extent. Amongst these there are three to which a more prominent influence upon viscosity must be attributed—viz., acidity, fat content and temperature; but besides these there are several minor factors, which exercise an undeniable influence upon the viscosity, and whose relative importance is difficult to estimate. For instance, such factors as mechanical agitation, growth of organisms, exposure to higher or lower temperatures for a considerable period (all of which may be included under the term "previous history of the cream"), certainly have their effect upon the viscosity, but these can hardly be independently investigated, and hence their individual contribution to the general effect cannot readily be calculated. Again, the size of the fat globule may be of importance, or, since each globule may be encased in a layer of protein, the number of fat globules in a given volume of cream of known fat content may have an appreciable effect in determining the viscosity.

The nature of the protein may vary, as regard its physical condition, in creams from different sources, but it would be difficult to obtain an experimental evaluation of the viscosity effect of this factor, owing to the impossibility of ascertaining whether the various samples of cream under observation were directly comparable in other respects.

Hence in the following paper the variations in viscosity due to acidity, fat content and temperature changes are alone taken into consideration.

Acidity of Cream as Affecting Viscosity (Critical Acidity).—This is assuredly the most potent of the factors generally recognised as influencing viscosity. A fresh cream, of fat content as great as 40 per cent., will be comparatively liquid, and on this account ordinary commercial pasteurised cream seldom appears sufficiently rich to the average purchaser.

On the other hand, a cream of less fat content may, if acid, be apparently rich, and flow with difficulty.

In order to study the effect on viscosity of rise in acidity uncomplicated by other disturbing factors, a quantity of cream, obtained by separation from fresh milk, was gradually soured artificially, and its consequent increase in viscosity at a constant temperature experimentally determined.

In the majority of instances, the cream employed was obtained by immediately machine-separating milk fresh from one particular cow (new milk). Several experiments, however, were made with cream separated from milk as ordinarily supplied to the consumer in the city. These latter experiments are duly noted in the tables as having been made on commercial milk. The means employed to acidify the cream were as follow:—

(1) The addition to the sample of cream of minute quantities of pure lactic acid.

(2) The introduction of a small amount of a pure lactic culture to the cream, which was subsequently maintained for a prolonged period at a temperature of 32 deg. C., readings of its viscosity being taken at short intervals. The first method presents considerable difficulty, as local clotting is apt to occur upon the addition of the pure acid. Addition of dilute acid was attempted, but was abandoned owing to the diluting effect, with the consequent hydrolysis of the calcium caseinogenate of the cream.

Ultimately the following procedure was adopted:—A given quantity of cream, of previously determined fat content, was rapidly stirred with a glass rod just moistened with pure lactic acid. The additions thus effected were necessarily somewhat haphazard, and hence were subsequently estimated by titration of a sample of the acidified cream with N/10 alkali, using phenolphthalein as indicator.

The viscosity determinations were made with an Ostwald viscosimeter, surrounded by a water-jacket kept at a temperature of 25 deg. C. throughout the experiment, this temperature being the lowest that could be maintained approximately constant in the laboratory during the summer.

Preliminary experiments soon showed that, whilst up to a certain point gradual small additions of acid produce very slight increases in the viscosity, there is an acidity-value, at which the viscosity of the cream, as measured by the time interval required for the bulb of the viscosimeter to empty, rapidly rises. This acidity is approximately equivalent to that at which cream may be considered ripe for churning.

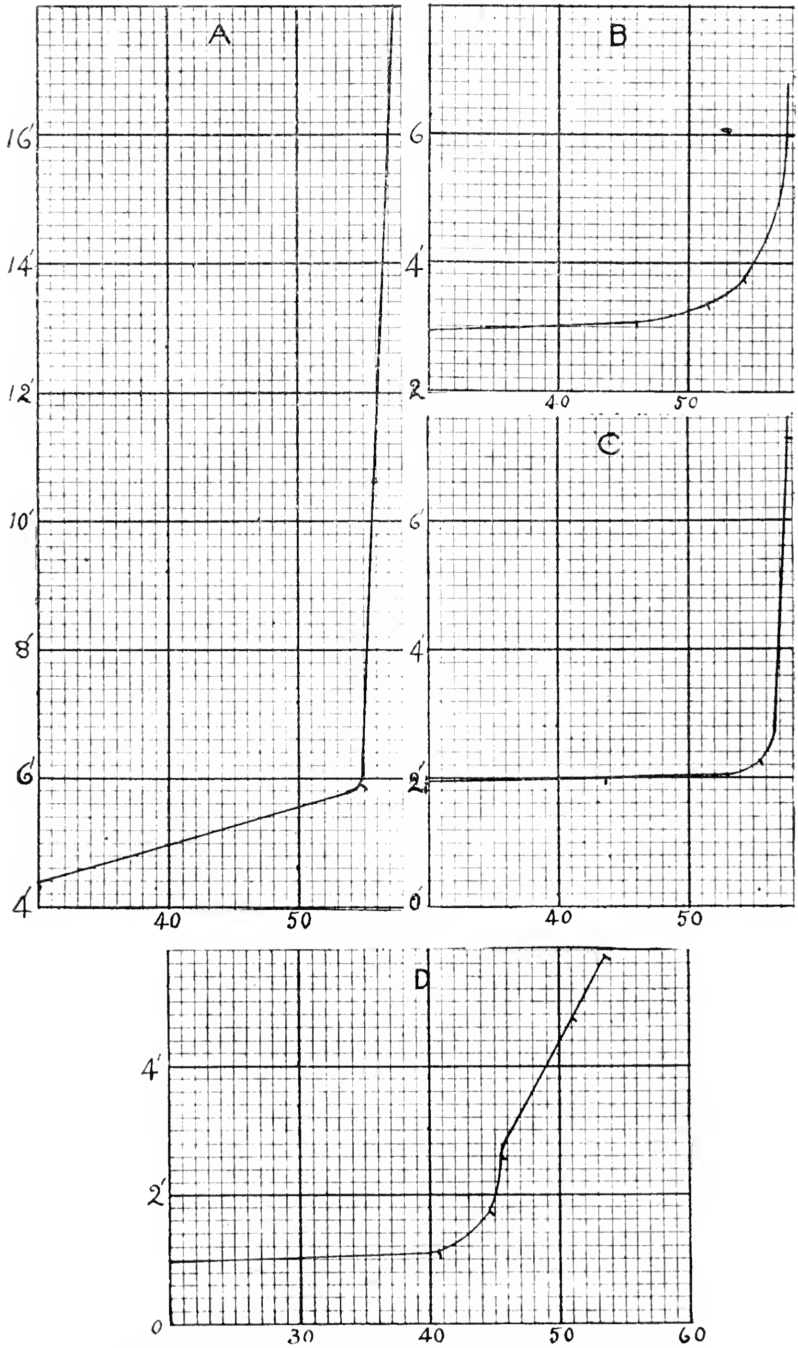
Following a suggestion made by Mr. P. Denston, dairy chemist to the Bacchus Marsh Dairy Co., it is proposed to speak of this acidity as the "critical acidity," and it can be shown that, for freshly-separated cream, the critical acidity of the cream serum is apparently a constant, independent of fat content. For example, if several samples of cream, differing in fat content be gradually acidified, there will be in each case a definite degree of acidity, at which the viscosity (which at first rises by barely perceptible amounts with small increases of acidity) suddenly increases very considerably upon the least further addition of acid. This is the critical point. The critical acidities in terms of the full cream have different values for the different samples, varying with the fat content. The fat is, however, an inert, suspended material, and if the critical acidities be recalculated for the cream minus fat—i.e., for the cream serum, they will be found to have approximately the same values.

The following experiments confirm this statement:—

TABLE I.

Cream separated from new milk, and soured by addition of pure lactic acid.

Experiment.	Time of flow. (seconds)	Acidity in cc. of $\frac{N}{10}$ NaOH per 100 cc. of cream serum.	Fat content. (per cent.)
A	240	19.6	49
	345	54.9	—
	1085	56.86	—
B	170	19.67	39
	187	45.9	—
	200	51.6	—
	225	54.1	—
	360	57.2	—
C	103	15.6	36
	108	43.75	—
	136	56.25	—
	560	57.8	—
	720	68.75	—
D	57.5	17.53	23
	67	50.65	—
	105	54.54	—
	155	55.84	—
	285	61	—
	345	63.6	—



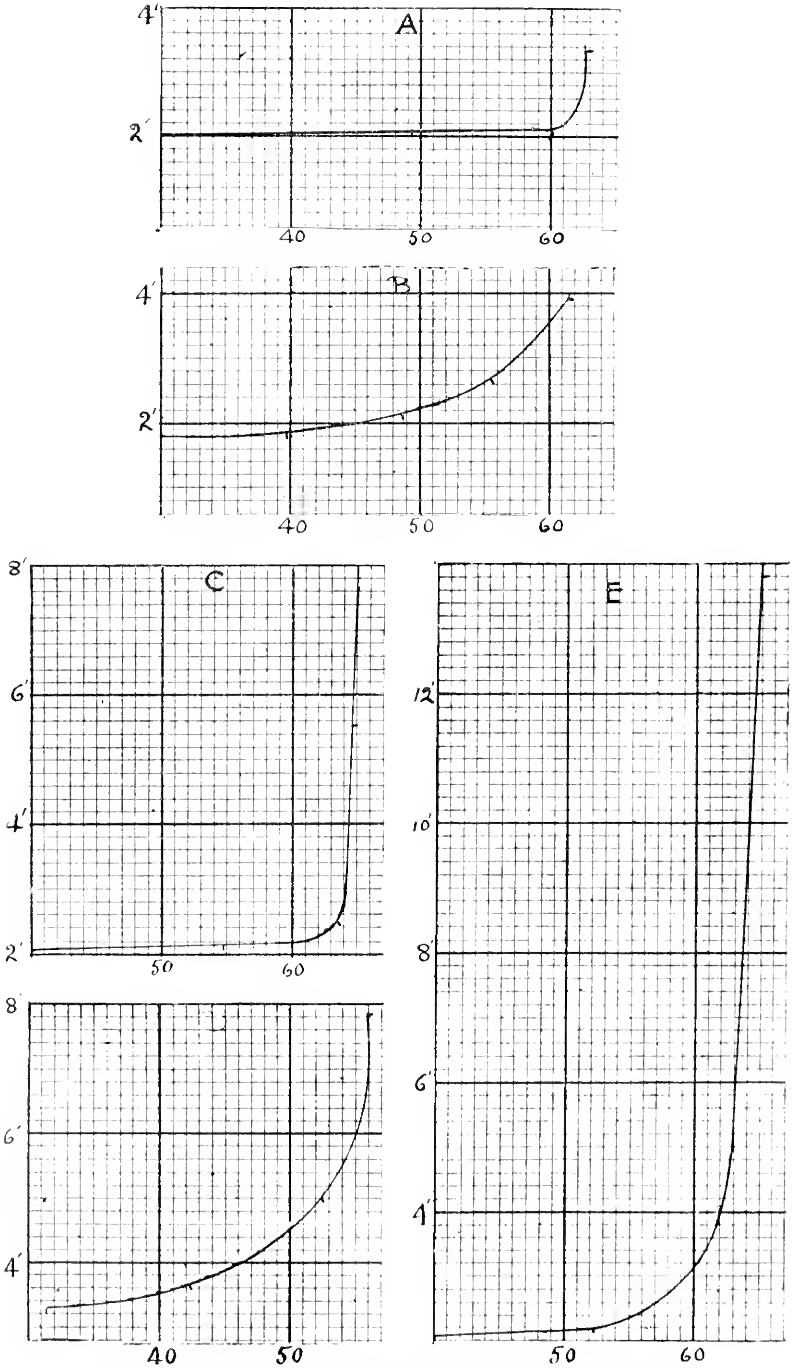
Acididity in cc. N/10 NaOH per 100 cc. cream serum.

Fig. 1.

TABLE II.

Cream separated from commercial milk, and acidified by pure lactic culture.

Experiment.	Time of flow (seconds)	Acidity in cc. NaOH $\frac{N}{10}$ per 100 cc. cream serum.	Fat content. (per cent.)
A	120	22.2	37
	122	28.5	—
	126	49.2	—
	127	60	—
	201	62.5	
B	100	15.9	32
	96	25	—
	110	39.7	—
	130	48.5	—
	160	65.9	
	236	61.7	—
C	120	29.6	29
	130	54.9	—
	150	63.4	—
	330	64.7	—
	540	67.6	—
D	197	31.6	43
	219	42.1	—
	300	52.6	—
	450	56.1	—
E	120	21.7	—
	123	40	—
	130	52.1	—
	1080	66.6	—
F	138	33	39
	145	42	—
	150	52	—
	170	67.2	—
	3600	77	—



Acidity in cc. N/10 NaOH per 100 cc. cream serum.

Fig. II.

From these figures it appears that, for fresh cream, soured by additions of pure lactic acid, the value of the critical acidity (expressed in the number of c.c. of NaOH N/10 required to neutralise the acid contained in the cream) is between 56 and 57 cc. N/10 per 100 cc. of cream serum; but if the souring be effected by means of a pure lactic culture, the critical acidity is considerably greater, approaching 65 cc. N/10 per 100 cc. of serum, or possibly even higher.

It is, however, difficult to obtain the exact value for the critical acidity in the latter case, owing, firstly, to lack of evidence as to the probable effect of such factors as the age of the culture employed, and the rate at which it produces lactic acid in the cream, and secondly, to inability to calculate the interval of time required for the culture to bring the acidity up to the critical point, as it is found that souring produced by this means is at first slow, but at a certain stage the rate of acidification is greatly accelerated.

Effect of Previous Heating on Critical Acidity of Cream.—It is worthy of note also that previous heating of the cream may modify the results of the experiments, and give a different value for the critical acidity. Cream, which has been pasteurised after separation from fresh milk, if acidified with pure lactic acid, has a critical acidity slightly higher than fresh cream so treated.

But if the pasteurised cream is soured by introduction of a pure lactic culture, the viscosity rises gradually with increase of acidity, so that instead of a sudden rapid rise at the critical point, there is a steady increase of viscosity with increased acidity over a certain range, a pronounced rise of viscosity being attained at the degree of acidity which corresponds to the critical acidity in the cases previously described.

A few experiments made with cream from milk kept at a high temperature for some little time are interesting in that they show a difference in the behaviour of the cream so obtained, on the addition of acid.

The fresh milk was gradually heated under pressure in an autoclave until the indicator registered 105 deg. C. The milk was kept at this temperature for about 20 minutes, then removed from the autoclave and allowed to cool. The skin which had formed on the top of the milk was skimmed off, and the milk separated. The critical acidity of the cream thus obtained was found to be considerably lower than that of fresh cream or pasteurised cream.

When the milk, after heating, was cooled rapidly by being made to pass through a condenser, around which circulated a stream of cold water, the critical acidity of the cream separated from this milk was somewhat higher than that of the cream from the milk cooled slowly in the air.

This is possibly explained by the fact that in the former case very little skin formed on the milk during the cooling process; in the latter case the skin which was removed before separating the cream contained the larger fat globules, together with an appreciable quantity of protein.

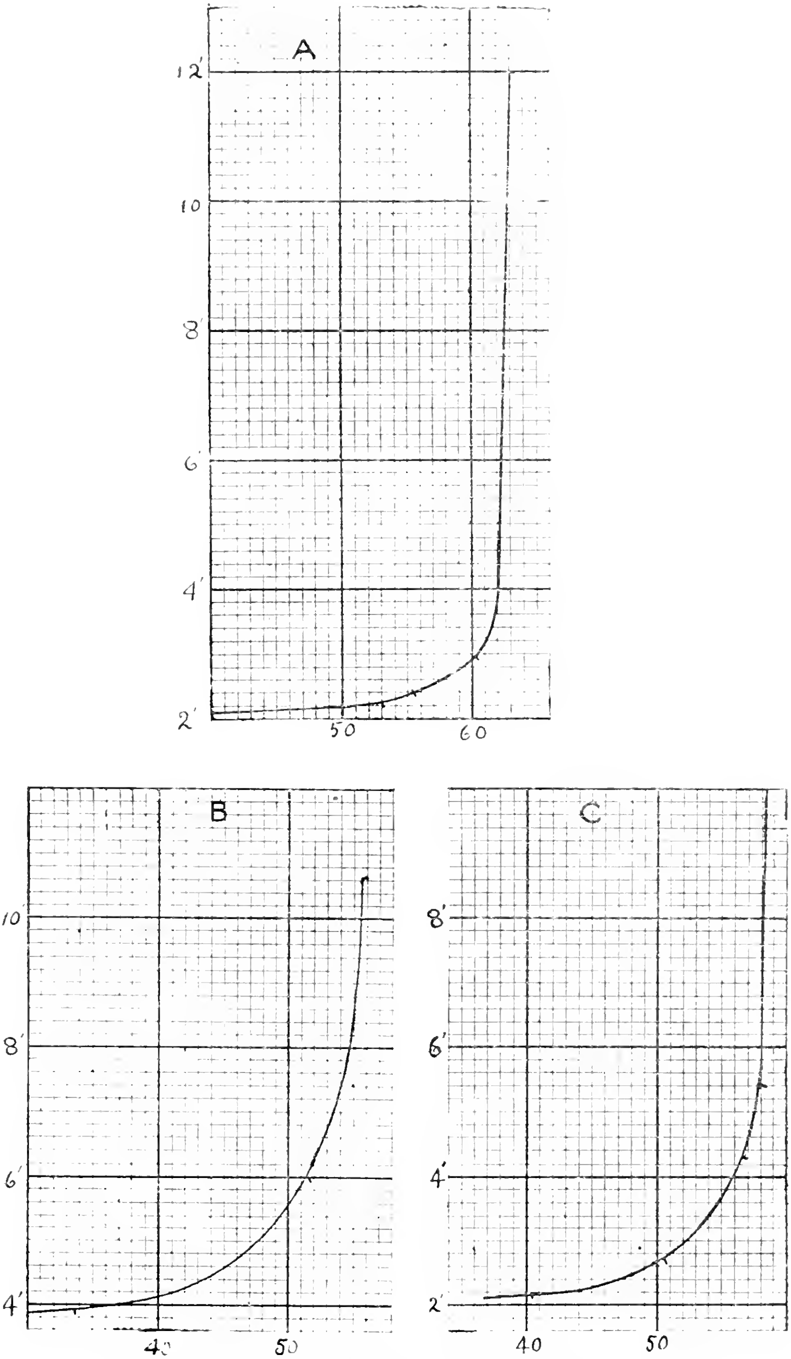
TABLE III.

Pasteurized cream from new milk soured by pure lactic acid.

Experiment.	Time of flow. (seconds)	Acidity in cc. NaOH $\frac{N}{10}$ per 100 cc. cream serum.	Fat. (per cent.)
A	118	22.2	32
	134	52.9	—
	145	55.1	—
	165	60.2	—
	1800	64.7	—

Commercial pasteurized cream acidified by pure lactic culture.

Experiment.	Time of flow. (seconds)	Acidity in cc. NaOH $\frac{N}{10}$ per 100 cc. cream serum.	Fat. (per cent.)
B	234	33.9	41
	360	51.7	—
	650	55.9	—
	1800	67.8	—
C	110	21.9	36
	130	40.6	—
	165	50.8	—
	255	53.1	—
	260	57	—
	325	57.8	—
	2700	59.4	—
	3600	68.7	—



Acidity in cc. N/10 NaOH per 100 cc. cream serum.

Fig. III.

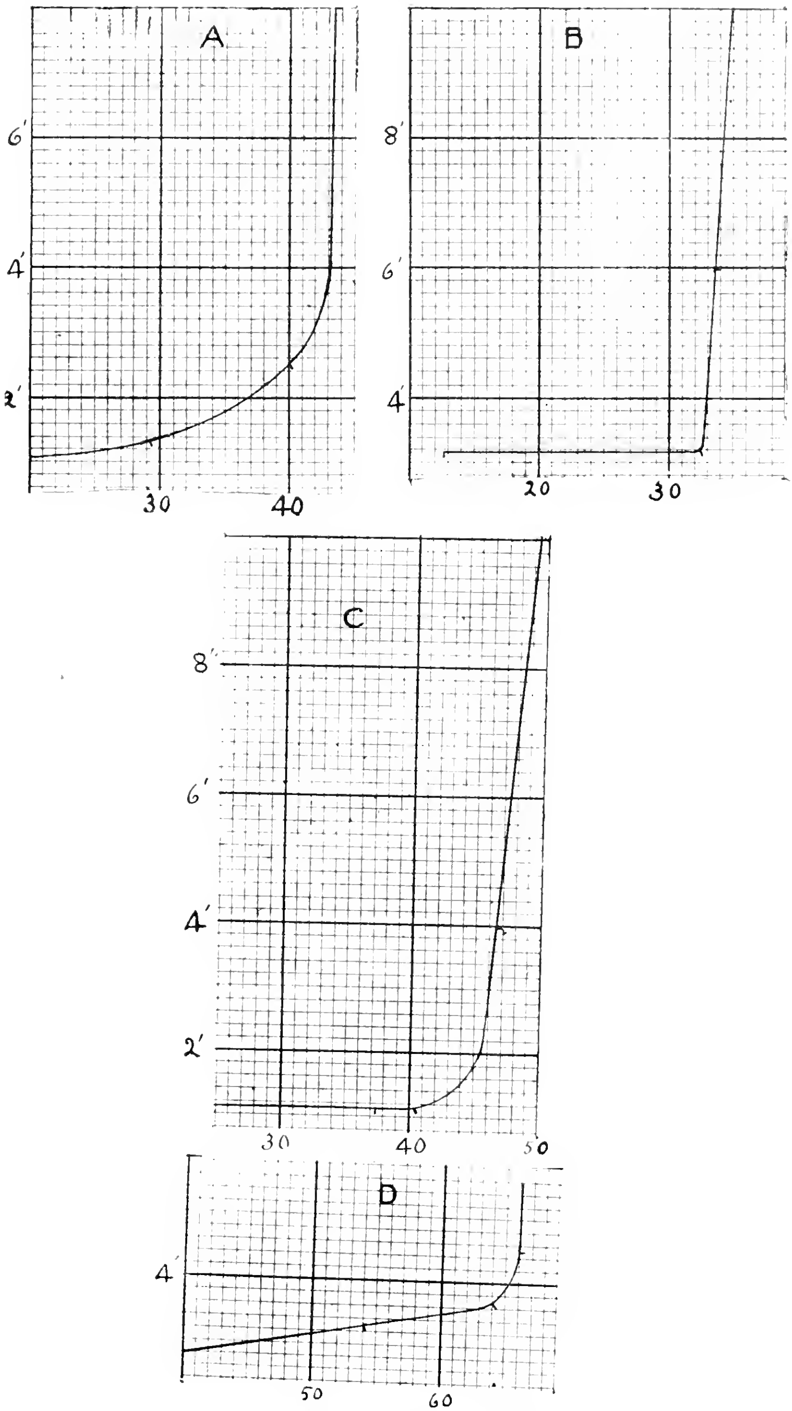
TABLE IV.

Cream from commercial milk previously heated for 20 minutes to 105° C. allowed to cool slowly.

Experiment.	Time of flow. (seconds)	Acidity in cc. NaOH $\frac{N}{10}$ per 100 cc. cream serum.	Method of acidifying	Fat. (per cent.)
A	78	29.1	Addition of	28
	158	40	pure lactic	—
	180	44.4	culture	—
B	220	31.3		52
	510	33.3		—
	1080	37.5		—

Cream from new milk previously heated to 105° C. for 20 minutes, and cooled rapidly.

Experiment.	Time of flow. (seconds)	Acidity in cc. NaOH $\frac{N}{10}$ per 100 cc. cream serum.	Method of acidifying	Fat. (per cent.)
C	70	21.7	Addition	31
	70	37.7	of lactic	—
	70	40.6	culture	—
	240	46.1		—
	1080	60.9		—
D	146	22	Addition	43
	200	51	of lactic	—
	220	64	acid	
	270	66		—
	860	72.		—
E	127	23	lactic acid	10
	129	45.8		
	141	56.6		—
	3600	73.		—



Acidity in cc. N/10 NaOH per 100 cc. cream serum.

Fig. IV.

As a matter of interest it may be mentioned that the increase of viscosity due to increased acidity imparts to the cream certain definite properties, viz. :—

(1) The property of whipping, and

(2) The property of buttering.

A cream of sufficient acidity (approaching the critical acidity) will readily whip, and having reached this condition, will, with very little further mechanical agitation, form butter. It is probable, therefore, that the butter-maker, in allowing the cream to ripen, not only aims at improving the flavour of the butter, but also takes advantage of this property of the cream acquired by acidification in order that the fat globules may coalesce with the minimum of loss. In making butter from fresh cream, a considerable loss of fat is inevitable, since the globules in this case have not the strong tendency to coalesce.

The probable explanation of the critical acidity is that at this point a definite change occurs in the proteins of the cream serum, and the nature of this change is such that the protein, which forms a kind of envelope around the fat globules, impedes their free motion in rolling past one another.

This theory is supported by the fact that in separated milk there is no such sharp rise in viscosity on acidifying as is the case with cream, although at the degree of acidity of the milk which corresponds to the critical acidity of the cream serum there is a definite change in the proteins present, evidenced by a visible precipitation.

The capillary of the viscosimeter employed for the experiments with separated milk had only 1/3 of the cross-section of the capillary used for the cream, so that there is no reason to suppose that a relatively larger space was occupied by the milk in any part of the tube, than by the cream serum, which might otherwise be thought a possible explanation of the difference in behaviour of the two liquids.

In Nature of June 1st, 1911, there appeared a short summary of a paper on "Viscosity of Emulsions," by Bancelin, in which the following statement occurred :—"In accordance with the Einstein theory, increase of viscosity is found to be independent of the size of particles in suspension, and depends only on the total volume of particles per unit volume."

On this assumption, since the total volume of the fat globules in any cross-section of the capillary of the viscosimeter could not be supposed to occupy nearly 2/3 of the total space for any of the samples of cream employed, it is reasonable to assume that any increase in the viscosity of separated milk corresponding to that at the critical acidity of cream serum could have been detected by the use of the smaller capillary, and as no such rise is discernible, the critical acidity must be due to the change in the nature of the envelopes of the fat globules, and not to the addition to the liquid of solid matter in the form of precipitate.

Influence of Temperature on Cream Viscosity.

The effect of rise of temperature of the cream is, as one would naturally expect from the case of other fluids, to diminish the viscosity, at first rapidly, but after reaching a temperature of about 35 deg. C., the decrease in viscosity due to a further increase in temperature is less marked. At about this temperature the fat commences to melt, and the globules tend to coalesce, so that the nature of the liquid is changed, and the results of further rise of temperature are no longer comparable with those obtained by experiment with liquids containing suspended particles which are not thus affected by change of temperature.

Fat Content as Affecting Viscosity.

For the investigation of the effect of the fat content of cream in determining its viscosity, a number of samples of cream, separated from the same milk, and differing only in fat content, were employed, the experiments being performed, as before, at a constant temperature of 25 deg. C., with an Ostwald viscosimeter.

The results of these experiments show that the viscosity of cream increases with increase in the fat conent, at first slowly, then more and more rapidly, till a viscosity is attained such that the cream will no longer flow.

In an interesting paper by Walter Hess, in Pflüger's Archiv. für Physiologie, May, 1911, on "Blutviskosität und Blutkörperchen," a new theory of the relation between viscosity and content of solid particles in blood was put forward. It is as follows:—Supposing a number of samples of blood, the plasma of which has the same viscosity for all, but which contain different quantities of solid particles, amounting to 10 per cent., 20 per cent., and 30 per cent., and so on for the different samples, the viscosity of any sample will be inversely proportional to the amount of plasma contained.

Hence the viscosities of the various samples will be 100/90, 100/80, 100/70, etc., of the viscosity of the plasma, and hence the viscosity of a sample containing 10 per cent. of solid particles will be 8/9 of that containing 20 per cent., so that a sample containing 50 per cent. solid particles would have a viscosity twice as great as that of the plasma.

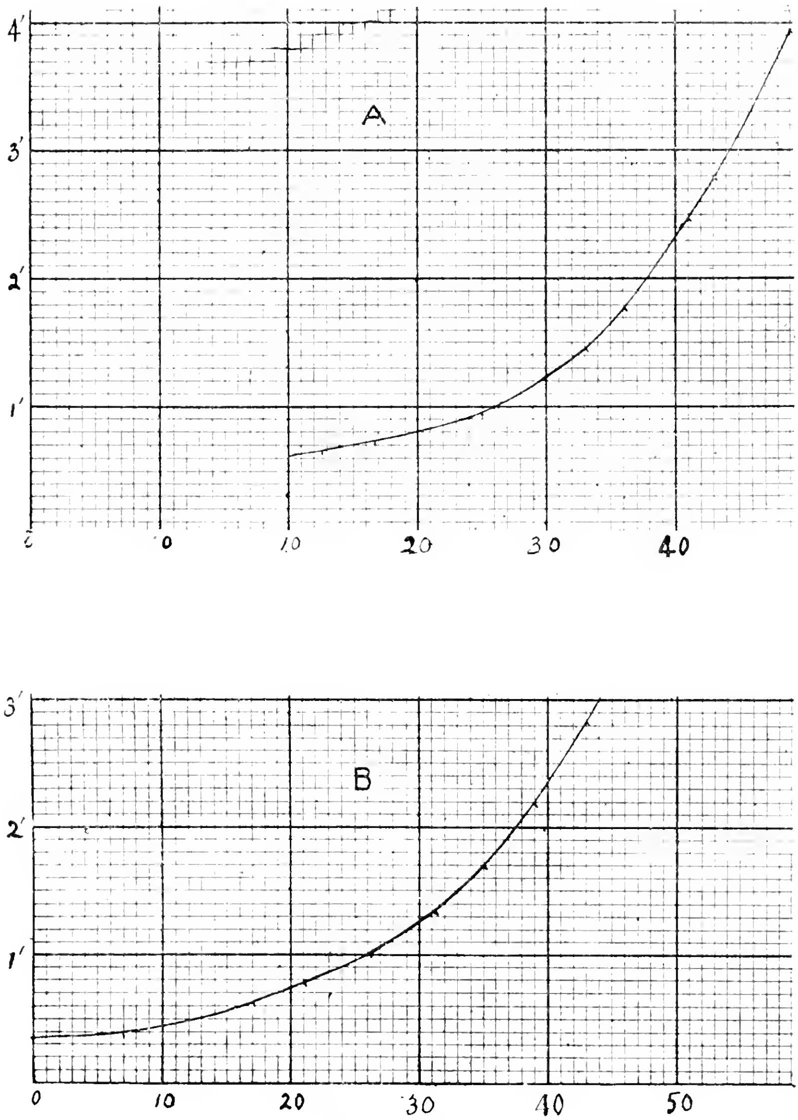
An attempt was made to apply this theory to the viscosity of cream, but it did not even approximately agree with the results of the experiments for the viscosity of samples of cream of varying fat content, since the viscosity of a sample of 50 per cent. fat is found to be nearly twelve times as great as that of separated milk.

From the actual experimental results it would appear that at constant temperature the viscosity is a quadratic function of the fat content, and the relation between these two quantities may be graphically represented by a hyperbola.

TABLE V.

Cream from new milk.

	Time of flow (seconds)	Fat content (per cent.)
Experiment A	57	25
	89	33
	103	36
	146	41
	168	43
	240	49
Experiment B	20.8	—
	38	17.2
	47.4	21.06
	61	26.1
	80	31.2
	102	31.1
	132	39
	169	44



Fat Content.

Fig. V.

SUMMARY.

1. The main factors instrumental in varying the viscosity of cream are acidity, temperature and fat content, and of these three the first holds the most important place.

2. Increase in acidity produces very little effect on viscosity of cream, up to the "critical point," at which a sudden sharp rise in viscosity occurs.

3. The change in viscosity of separated milk at the degree of acidity corresponding to the "critical acidity" of cream is very slight—i.e., for separated milk there is no "critical acidity," proving that this is a property of the fat globule, or rather of its envelope.

4. Increase in temperature of cream diminishes its viscosity, at first rapidly, afterwards at a slower rate.

5. The viscosity of cream is a quadratic function of the fat content, if the other factors remain constant.

In conclusion, I take this opportunity of expressing my sincere thanks to Dr. Rothera, at whose suggestion this work was undertaken, for his continued interest and help.

Proc. Roy. Soc. Victoria, 25 (N.S.) Pt. II., 1913.

Art. XXV.—*General and Mining Geology of the Diamond Creek Area.*

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(With Plates XXV. and XXVI.).

[Read 12th December, 1912].

1.—Introduction.

The area discussed in this paper comprises the central and western portions of the Parish of Nillumbik. The author originally intended to map the eastern portion also, but owing to a rather late beginning and to concentration on the mining geology, this was not possible. Nevertheless a fair amount of field work was done in the neighbourhood of Kangaroo Grounds. The only previous mapping done in the area was a rapid survey of portion of the Parish of Nillumbik by O. A. L. Whitelaw in 1895, and the mapping of the main axial lines east of Diamond Creek by J. T. Jutson.

2.—Previous Literature.

1. A. R. Selwyn began the literature on this area in a report on the Geological Structure of the Colony of Victoria, the Basin of the Yarra, etc.; Votes and Proceedings of the Legislative Council of Victoria, 1855-1856, Vol. 2, Pt. 1., with plans and sections.

In 1876, R. Brough Smyth[1] briefly described the general mining features of the Diamond Creek gold field. He mentions the occurrence of eurite at Diamond Creek, and draws a parallelism between it and the acid dykes at Mount Bischoff, Tasmania. He also traced a line of older basalt and gravels from Kangaroo Grounds past the Dandenongs to the River Latrobe, and thence to near the coast in South-West Gippsland. In 1894, R. A. F. Murray[2] visited the auriferous "cement" deposits near Greensborough, Eltham and Kangaroo Grounds, and reported very briefly thereon.

In 1895, O. A. L. Whitelaw, of the Victorian Geological Survey, made a rapid survey of portion of the goldfields between Warrandyte, Greensborough and Queenstown. He mentions a distinctive band of sandstone traced from the River Yarra to Diamond Creek, and intersected by spurs and veins of a dioritic dyke. He was of the opinion that the quartz reefs were formed along a line of anticlinal fracture.

H. S. Whitelaw[3] in 1899 noted the occurrence of stibnite in quartz reefs, and in certain bands of the silurian at Diamond Creek.

In 1900, V. R. Stirling[4] reported on the New Pioneer reef, Nillumbik. A ferruginous quartz-reef, two to four inches wide, and dipping at about 70 deg. to the west, had been worked with fair success.

1 R. B. Smyth. Report on Eltham and Allendale gold field. Prog. Report Vict. Geol. Surv., No. 3, 1876, pp. 34-38.

2 R. A. F. Murray. Report on the auriferous country near Queenstown. Prog. Report Vict. Geol. Surv., No. 8, 1894.

3 H. S. Whitelaw. Antimony ores in Victoria. Prog. Report Vict. Geol. Surv., No. 10, 1899.

4 V. R. Stirling. Notes on the New Pioneer reefs, Nillumbik. Monthly Prog. Report Vict. Geol. Surv., No. 10, pp. 7, 8, 1900.

Mr. Dunn,[1] in 1905, visited the Union Mine, Diamond Creek. In his report he mentioned the northerly pitch of the country and of the shoots of gold. He stated also that the quartz veins were filling contraction fissures in the dyke, and that payable gold would probably be localised near the intersection of the footwall reef with certain bands of the country rock. Two sections illustrating the relations of the dyke, breccia and quartz reefs with the silurian, accompany the report.

J. T. Jutson,[2] in a paper read before this Society in 1909, described very fully the physiographic characters of the Plenty River. The present valley of the Plenty, south from Morang, is described as a young stream which has eaten its way back towards the old Plenty River near Morang. A tongue of newer basalt filled up this valley to near Greensborough, and the present valley was carved out near the junction of the newer basalt with the older rocks.

J. T. Jutson,[3] in an excellent physiographic paper on the history of the Yarra River and Dandenong Creek basins, has described the Nillumbik peneplain, and he has shown that the Yarra River in its course through the Warrandyte gorge is a revived antecedent stream.

The age of the Nillumbik peneplain is discussed, and he shows that the age is probably kalimnan, and that uplift probably dates from late kalimnan, and has continued to very recent times.

In 1910 Jutson[4] described the interesting Warrandyte goldfield. The silurian sediments are described, and the main folds mapped. The probable age of the series is discussed, and he states that the oldest beds are probably at Warrandyte, and the youngest in the Bulleen syncline, and that the beds near the Diamond Creek are intermediate in age.

3.—Physiography.

The area is part of what has been called the Nillumbik peneplain.[5] The average elevation is between 300 and 400 feet, and the highest point is at Garden Hill, Kangaroo Grounds, which is

1 E. J. Dunn. The Union Mine, Diamond Creek. Rec. Vict. Geol. Surv., vol. ii., 1907-1908, pp. 33-35.

2 J. T. Jutson. A contribution to the physical history of the Plenty River, etc. Proc. Roy. Soc. Vict., vol. xxii., Pt. II., (n.s.). 1909.

3 J. T. Jutson. Physiog. of the Yarra river, etc. Proc. Roy. Soc. Vict., vol. xxiii., (n.s.), Pt. II., 1911.

4 J. T. Jutson. The structural and general geology of the Warrandyte gold field and adjacent country. Proc. Roy. Soc. Vict., vol. xxiii., Pt. II., 1911.

For purposes of reference we shall call these papers by Jutson, a, b, c, respectively.

5 Jutson. b, p. 477.

very nearly 1000 feet above sea level. The greater part of the peneplain consists of folded silurian sediments. Patches of basalt and gravel occur near Kangaroo Grounds and Greensborough. Residuals or monadnocks are few in number, and therefore presumably peneplanation was almost complete, and the then existing streams were probably all nearly base levelled. This being so, the present elevations of the river gravels should afford a clue in determining the variation in direction and intensity of the later movements connected with the uplift of the peneplain. The uplift was slow and differential in character, as is well shown by the antecedent character of the Yarra near Warrandyte.[1, 2] Tilting of the peneplain has occurred in an east and west direction, and also to a slight extent in a north and south direction. On going north towards Queenstown and Kinglake, the country is seen to rise gradually. The east and west slope, however, is very marked, a difference of over 400 feet in the elevation of the gravels occurring in a distance of about five miles. Thus, near Greensborough, the elevation of the gravels is about 350 feet.[3] About one mile east of the Diamond Creek mine, the elevation is 520 feet. At the west edge of the Kangaroo Grounds basalt, the elevation of the gravels is 650 feet, and near the cemetery about 750 feet. It is thus seen that as we go east across the area there is a progressive and moderately uniform increase in elevation. Following on the uplift a new cycle of stream activity was initiated, with the result that the peneplain has been rather deeply dissected, although at the same time dissection is far from being matured. The area is moderately hilly, numerous gullies and small streams abound, and the differences in elevation between these water courses and the hills are generally from 150 to 300 feet. The Plenty and Yarra Rivers have been described by Jutson, as has been above noted. The Diamond Creek, within the limits of the area, is in a fairly matured state. Fairly wide alluvial flats occur, and the creek meanders through these from side to side. The material constituting the flood plain is generally fine sand, and no coarse gravels occur, indicating that former stream velocities could only have been moderate. Residuals in the peneplain are few, and the main ones have been mentioned by Jutson. No physiographic evidence of faulting occurs in the area, although not far to the east, near Yarra Glen, such faulting has been described by Jutson.[5]

1 J. W. Gregory, Geography of Victoria, p. 106, 107.
2 Jutson. Ib, p. 485.
3 Note all elevations are aneroid readings.
4 Ib, p. 502.
5 Ib, p. 478.

4.—Stratigraphy.

The following formations are represented in the area:—

Palaeozoic	Silurian sediments.
	? Devonian acid dykes.
Tertiary	River or lacustrine gravels, sands, etc.
	Basalts.
Recent alluvium.	

The oldest member of the series consists of interbedded sandstones, mudstones and shales, containing considerable amounts of muscovite, and varying greatly in colour and coarseness. Occasional bands of quartzite and slate occur at intervals, and a series ot grits and conglomerates has been described from Warrandyte.[1] From the various lithological and microscopical characters of these rocks they appear to be entirely marine, and to have been laid down mostly under shallow water conditions. Cf Jutson, c, p. 530. Some of the sandstones in the west of the area show good current bedding on a small scale, one section in particular from Dry Creek showed this very well. No extensive palaeontological work was attempted, mainly owing to lack of time. An interesting find, however, was the discovery of graptolites in black pyritic slates from the Diamond Creek mine. Dr. Hall has kindly examined these, and he has informed me that both climacograptus and diplograptus are represented, but he says there was not sufficient evidence to enable their precise age to be determined. It may be of interest to note that climacograptus and diplograptus both range into the lowest member of the silurian, namely, the llandovery series in England; but as fas as the writer is aware, neither have been definitely proved to exist in the silurian in Victoria. It seems clear, therefore, that the beds near Diamond Creek are at least melbournian or older in age, and probably older than Jutson was inclined to regard them. It might be noted in this connection that Selwyn regarded the beds of the Templestowe anticline, i.e., the anticline near Diamond Creek, as the oldest of the series. Two or three other fossils were found, and for the examination of them the writer is indebted to Mr. Chapman. The first fossil is from section 7, allotment 3, in the east of the area, and is a trachyderma, which Mr. Chapman informs me occurs both in melbournian and in the yeringian, and so is of no diagnostic value. The other fossil examined was from the Plenty River just below the aqueduct.

1 Jutson. c, p. 530.

Mr. Chapman describes it as the remains of a phyllocarid resembling *Dithyocaris praecox*, Chapman, but much smaller. A similar form has been found in the melbournian at Merri Creek.

Acid dykes.

Three of these, namely, the Dry Creek dyke, the Diamond Creek dyke, and the Warrandyte dyke occur in the area investigated, although only the former pair have been studied in detail. The Diamond Creek dyke is most important economically, as it is with this dyke that mining operations in late years have been mainly concerned. Their exact age is not stratigraphically determinate. They are later than the folding of the silurian, and are overlaid in some cases by alluvium. In one case, in section 16, allotment D, a basaltic dyke cuts across one of these dykes. The age of the basic dyke is probably about middle tertiary, and so it affords little value in the determination of the age of the acid ones. Probably the intrusion of the acid dykes was connected with the earth movements that caused the folding of the silurian, and these are probably devonian in age.

Sub-basaltic river gravels, sands, etc.

Lithologically all stages are present in these between coarse gravels with pebbles up to six inches in diameter, and fine unconsolidated sands. Frequently the sands and gravels have been cemented together forming the following:—

Silicified grits grading into quartzite. Ferruginous grits where the cementing material is either limonite or hematite. Calcareous grits, consisting of quartz grains, set in a paste of calcium carbonate.

Where the grains of quartz are more angular, various types of breccia are formed. Thin bands of limestone occur interbedded with the sands in several places. Silicification of the fine sands frequently occurs with the formation of quartzite. Professor Skeats and Mr. Summers[1] have noted the intimate association of the quartzites with the lava flows in the Macedon area. While this is frequently the case near the basalts at Greensborough and Kangaroo Grounds, quartzite does nevertheless occur associated with the sands and gravels, where no basalt is present. In such cases an origin such as that suggested by Prof. Gregory[2] might be

1 Professor Skeats and H. S. Summers, M.Sc. Bulletin Vict. Geol. Surv., No. 24, 1912.

2 J. W. Gregory. The geography of Victoria, p. 94.

likely. Near the margin of the basalt in several places, but especially near the northern limit at Greensborough, good examples of fossil wood have been found. The structure has been remarkably well preserved in some examples. A section of the wood was examined by Prof. Ewart. He informed me that he felt sure that the wood belonged to the eucalypts, but that one section was not sufficient to correlate it with existing species. The sands are frequently horizontally bedded, and some sections show good current bedding. The gravels which were formerly the position of the valleys now frequently occur as ridges elevated above the surroundings. The reason for this is twofold, (1) the basalt has protected the gravels, and even in places where the basalt is not now present, it may formerly have covered them, (2) the resistant character of the gravels in themselves. Small amounts of gold occur in the sands and gravels throughout the area, and they have been worked at several places with indifferent results. Just to the east of the main road from Greensborough to Diamond Creek, near the southern limit of the basalt, over £1000 worth of gold was won in about seventeen years. The sands were also extensively used in the construction of the Maroondah aqueduct.

Basalts.

The basalts occur in the extreme east and west of the area; one small patch occurs about one mile to the east of Diamond Creek. The writer has separated them on petrological grounds into 3 types.

1. Fine grained aphanitic basalt.
2. Medium to coarse grained basalt and dolerite.
3. Garden Hill basalt, medium to fine grained in character.

No field separation of these types was possible. The first type is well exemplified in a quarry off the main road near the northern limit of the basalt at Greensborough, and also in a quarry just to the south-east of Garden Hill. In both quarries the basalt is clearly the basal member, and has filled up the prebasaltic stream valleys. In both cases also columnar structure indicative of fairly rapid cooling has been developed. The columns are vertical and cleanly cut. The second type is a rather coarse grained basalt or dolerite.[1] It is the average type throughout the area, and it overlies the finer grained type near Greensborough and Kangaroo Grounds.

The third type, as the name suggests, is typically developed at Garden Hill, Kangaroo Grounds. It is medium to fine grained

1 Chamberlin and Salisbury. Processes and Results, p. 398.

in character, and is frequently vesicular. Further down the slopes of Garden Hill, the basalt is a dark compact fine grained type. No stratigraphic determination of the age of the basalts is possible, since they overlie leads whose age also is in doubt. The basalt at Greensborough is older than the newer basalt to the east of Melbourne, since a tongue of this basalt has filled up the old valley, which has been cut near the junction of the older basalt and gravels with the silurian. On petrological and physiographical grounds the writer has no hesitation in correlating it with the older rather than the newer basalt. The 1902 geological map of Victoria issued by the Geological Survey shows the Greensborough basalt as older basalt and the Kangaroo Grounds type as newer basalt. A later map published by the same department shows both as older basalt. More certain evidence of their age is obtainable physiographically. Jutson[1] mentions that the Kangaroo Grounds basalt is a monadnock in the peneplain. He[2] also has shown that the age of the peneplain is probably kalimnan, that is, lower pliocene[3] or upper miocene. This being so, the age of the basalt is prepliocene and probably miocene. The brief investigation of this point by the writer supports the view that the Kangaroo Grounds basalt is a monadnock, and that very little vertical erosion occurred between the filling up of the river valleys by the basalt, and the final peneplanation. At Greensborough the evidence is less certain, but petrologically these basalts appear to be identical, and the writer believes therefore that they were both extruded towards the end of the peneplanation, and therefore their age is probably miocene. The Garden Hill basalt occurring at the highest point of Kangaroo Grounds is much more scoriaceous, and has a smaller specific gravity than the main Kangaroo Grounds basalt, and is possibly of more recent age.

5.—Structural Features.

(a) *Folding, crumpled anticlines; zones of crushing.*

The silurian sediments have been normally and fairly openly folded throughout most of the area. The major axial lines in the east of the area have been mapped by Jutson. The positions of these have been verified by the author, and, in addition, a few minor folds have been located. A major fold is well seen in a railway cutting near Greensborough station, and the same fold has

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1 b, p. 502.
2 b, p. 493.
3 F. Chapman. A study of th Batesford limestone. Proc. Roy Soc. Vict., vol. xxii. (n.s.), Pt. II.

been picked up where it crosses the Maroondah aqueduct in the north of the area. The railway section shows that near the axis the fold is extremely crumpled and crushed. Small thrust faults having displacements of three or four feet are common. No quartz reefs occur near by, and this is what we might expect. In general it is only in places where the rocks have fractured by tension as near the anticlinal axes that fissures have formed through which solutions have reached the surface. Following Gregory and Jutson it is proposed to call the above fold the Greensborough syncline. The western limb of this syncline consists of fairly steep, dipping beds, and near the Plenty River it passes into a sharp anticlinal flexure. The anticlinal axis is not symmetrical having a dip to the east of about 70 deg. In a section in Dry Creek an acid dyke occurs right on the axis. Going further east from here along the east and west bend of the Plenty River, two or three minor folds occur fairly close to one another. The Templestowe anticline is, however, the axis with which we are most directly concerned. Jutson[1] has traced this fold for nine miles south of the northern boundary of the parish of Nillumbik. The writer has traced it still further north to near Hurst's bridge, that is, for about three miles further north. The western limb of the fold, as Jutson has pointed out, is very greatly contorted and fractured. This is very well exemplified at and near the Diamond Creek mine. The silurian sediments throughout the area are well jointed, but near the above-mentioned anticline, rectangular jointing is sometimes so well developed that it is almost impossible to distinguish bedding from joint planes. This is well illustrated in cuttings in the recently-opened railway to Hurst's bridge. Another interesting feature are the numerous bedded and nearly vertical joint plane reefs in close proximity to the axial lines, especially the anticlines. It appears clear, therefore, that the pressure near the anticlinal axes during folding was tensional, and led to the formation of fractures and fissures through which mineral-bearing solutions have reached the surface, while the pressure in the synclines was compressional rather than tensional, as is shown by the case of the Greensborough syncline above mentioned, and hence no passages or outlets for solutions from below occurred. Hence the reason for the localisation of the mining belts to the anticlines,[2] such as Warrandyte and Diamond Creek, is apparent.

Associated with the Diamond Creek dyke there occurs a zone of brecciation which will be dealt with in detail later.

1 Jutson. b, p. 522.

2 The proximity of acid dykes to the anticlines near Warrandyte, Diamond Creek, Dry Creek and Templestowe further illustrates this point.

(b) *Dip and strike of the silurian and evidence of pitch.*

The strike of the folded sediments is fairly constant throughout. The maximum value of the strike is about north 45 deg. east, and the minimum value is a few degrees west of north. The average value is about north 20 deg. east. It is only in the west and northern parts of the area that any considerable variation from the average value occurs. To the north-west of Greensborough, near the bend to the west of the Plenty River, the strike is nearly north and south. The dip varies considerably, and when away from the axial lines the average value is between 50 deg. and 60 deg. In the east and north-east of the area, Jutson[1] has shown that the beds have a decided northerly pitch. Certain sections along the aqueduct illustrate this very well. Near Diamond Creek and further west near Greensborough, however, no defined regional pitch occurs. Mr. Dunn[2] has stated that the pitch of the beds near Diamond Creek is to the north. The writer has not been able to verify this, and he believes that no regional pitch is here present, but that minor local pitches do not infrequently occur.

(c) *Relation of mining belts to structural features.*

Since the fine and instructive paper by Emmons[3] in 1886, it has become more and more recognised that the study of the structural features in any mining field is essential to the complete mastering of the various problems connected with the ore deposits. We have in Victoria, at Bendigo, perhaps as fine an example of this connection as we might wish for. It is essential, therefore, that we should study the structural features in some detail. This has been done to some extent above, and it has been seen that the payable quartz reefs in the silurian in this area, in practically all cases, are localised to near the axial lines, and generally to near the anticlines, and a reason for this has been suggested. Synclinal reefs do sometimes occur, however, as at Warrandyte,[4] and in a section along the railway line between Greensborough and Eltham, a minor anticline and syncline occur with a thin bedded synclinal reef. Jointing has been shown

1 Jutson, c, p. 525.
2 Op. cit.
3 S. F. Emmons. The structural features of ore deposits. Trans. Amer. Inst. Min. Eng., vol. xvi., p. 801-839.
4 Jutson, c, p. 535.

to be extensively developed near the Templestowe anticline, and the joints are seen to be mainly strike joints, and are probably connected with the folding of the sediments.

(d) *Faulting.*

Two main periods of faulting have been noted :—

1. Pre-mineralisation.
2. Post-mineralisation.

As examples of faulting previous to the formation of the quartz reefs, we have the brecciated zone, now occupied by the Diamond Creek dyke, and probably the slips parallel to the bedding planes belong to this period. Movement later than the formation of the reefs is well illustrated by the numerous strike faults occurring in the Union and Diamond Creek mines. This type of faulting has not been recognised elsewhere in the area, although it is possible, but not probable, that such faulting has been missed, due to the fault planes coinciding with the dip of the beds.

As regards igneous intrusions, the basalts and acid dykes have already been described under stratigraphy. Only two basic dykes[1] from the area are known to the writer. One was found by Howitt[2] at the Caledonia mine, Warrandyte, and was determined by Professor Skeats as a monchiquite, and the other was found by the writer in section 16, and is described later.

6.—Petrology.

(a) *Sandstones and their origin.*

Several sections of the sandstones from various parts of the area have been examined by the writer. Section A18 from the Watts River aqueduct near the Warrandyte anticline is a typical example.

In hand specimen it is seen to be a dark-coloured, dense, micaceous rock.

Microscopically the following minerals are recognisable :—Quartz, muscovite, chlorite, flint, tourmaline, zircon, rutile, apatite, magnetite, leucoxene, biotite, plagioclase, iron oxides and patches of carbonaceous material. Quartz occurs in all sections examined in well over 90 per cent. of the rock. The grains are either angular or subangular, and are very rarely rounded. Numerous micro-

1 The writer has since seen in the National Museum, Melbourne, a specimen of *mica lanprophyre* from the Union Mine, Diamond Creek.

2 A. M. Howitt. Notes on a Sketch Survey of the Caledonia Reefs at Warrandyte. Rept. Geol. Surv. Vict., vol. 3, Pt. 1, 1909, p. 40.

scopic prisms of rutile or zircon, and linearly arranged gas and liquid inclusions are present in the quartz grains. Strain polarisation is a common feature in the quartz grains. Muscovite is fairly common, and occurs as twisted flakes which are frequently bordered by green chlorite. Chlorite also intrudes itself along cleavage planes. A brownish green variety of chlorite is more common, and it appears to be an alteration product of some iron magnesium mineral, as biotite. Biotite and an acid plagioclase also occur in small amounts in nearly all sections. Of the usual concentrates found in such rocks as these, zircon and tourmaline are most common. The detrital origin of these is evident by the rounding of the salient angles in the prismatic crystals. Rutile is not uncommon, and generally occurs in brown prismatic crystals. The individual quartz grains are generally not very closely packed, and the cementing material usually is micro- or cryptocrystalline silica, which is often stained with brown hydrated iron oxide. Occasionally fine sericitic mica and chloritic material form the bond. In the fossiliferous grit from Warrandyte, the cement is largely calcite. The nature of the rocks from which the silurian sediments were derived has been discussed by Jutson.[1] He showed that the pebbles in the Warrandyte conglomerate were practically entirely of a sedimentary nature, i.e., quartz, quartzite and sandstone, and no pebbles of an igneous rock were present, and this led him to conclude that the rocks from which the conglomerates were derived consisted largely, if not entirely, of altered and unaltered sediments. In such an old conglomerate as this, however, we might well expect to find only the more resistant rock types, like the ones above-mentioned, remaining, although igneous rocks may have originally been present. On petrological grounds, the writer draws the conclusion that the sandstones were derived to a fair extent at least from a pre-silurian igneous rock, probably granitic. This view is supported by the following evidence:—

(1) The abundance of muscovite;

(2) The presence of biotite and plagioclase, and chlorite, which is usually derived from unstable iron magnesium minerals;

(3) The occurrence of zircon and rutile crystals in the quartz grains in the sandstone may indicate an igneous origin for such quartz.

(4) The constant presence of tourmaline supports such an origin;

(5) The absence of metamorphic minerals, garnet, etc., show that they were not derived from metamorphic rocks.

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1 l. c., p. 532.

(b) *Basalts.*

1. Fine grained basalt, quarry near the northern limit of the basalt at Greensborough. Macroscopically this rock is dark grey in colour, and is compact, and aphanitic with the exception of occasional felspar phenocrysts. A sample was collected from the quarry above mentioned and analysed by the writer in the University geological laboratory. The weathering of the basalt in this quarry has led to the solution of lime and magnesia, and these have been redeposited as a magnesian limestone. For the purpose of comparison an analysis by F. L. Stillwell of the older basalt from near Broadmeadows is appended.

	A.	B.
SiO_2	46.43	44.95
Al_2O_3	17.60	15.50
Fe_2O_3	8.51	2.04
FeO	2.44	10.47
MgO	8.03	7.43
CaO	8.12	8.24
K_2O	0.92	1.98
Na_2O	3.56	3.04
H_2O+	1.20	2.60
H_2O-	0.81	0.52
CO_2	p.n.d.	0.18
TiO_2	2.25	2.77
P_2O_5	0.37	0.52
MnO	0.22	0.21
(Ni,Co)O	0.07	—
Total	100.53	100.45

A. Fine grained basalt quarry off main road, near northern limit of the basalt, Greensborough—S.G. 2.94.

B. Older basalt (A) quarry, Section 15, Tullmarine, county of Bourke.

Microscopically the texture is aphanitic with occasional porphyritic felspars. The mineral composition of the rock is thus:—Plagioclase, olivine, augite, magnetite, ilmenite, zeolites and apatite. Plagioclase occurs in two generations, firstly as long idiomorphic clear and glassy laths showing lamellar twinning generally, but occasionally only simply twinned. Pressure effects, probably of a local origin, are noticed in the twisting and fracturing of the laths, by wedging of the twin lamellae, and also by cross fractures almost at right angles to one another, and generally oblique to the planes of twinning. Olivine is almost indeterminate in ordinary light, due to its invasion by the ground mass. Concentration of black iron oxide occurs frequently in the centre of the crystals, and radiating linearly arranged rods of the same material pass out to the edges. In bright, reflected sunlight, the olivine is seen to be mostly altered to red iron oxide, probably hematite. An occasional porphyritic crystal of augite occurs, and has suffered like the olivine. The bulk of the augite, however, occurs scattered through the ground mass of the rock as yellow and colourless anhedral grains and prisms. The ground mass of the rock consists of microscopic laths of felspar, often in fluidal arrangement, and abundant dust and fine grains of black iron oxide. Zeolites occur in all sections examined, and they are frequently associated with apatite needles, and contain prisms of augite and grains of magnetite as inclusions. The phenocrysts of olivine and plagioclase had probably crystallised out from the magma before extrusion, and rapid chilling caused the separation of microlites of felspar and dust of iron oxide. Section A32, Kangaroo Grounds, quarry, south-east of Garden Hill, shows pilotaxitic structure. Zeolites of very low birefringence occur filling vesicles. Radiating natrolite with birefringence, considerably above the felspar also occurs, filling steam cavities. Section A28 shows olivine frequently clear and colourless. Occasionally the outlines of felspar now replaced by zeolites are seen.

2. Medium to coarse grained basalt.—In hand specimen, with the aid of a lens, crystals of weathered olivine and felspar laths can be sometimes identified.

Microscopically this type differs from the first in the presence of numerous phenocrysts of titaniferous augite, and in the nature of the ground mass. Section A15, Kangaroo Grounds, is a holocrystalline fairly even grained hypidiomorphic rock with ophitic texture. The minerals present are plagioclase, augite, olivine, magnetite, ilmenite and apatite. Zeolites and chlorite occur as secondary constituents. Plagioclase is present in long prismatic laths, frequently zoned, and having a maximum extinction of about 42 deg. The augite is a titaniferous variety, and it is pleochroic from purple to brown or yellow, and occurs in anhedral forms. Extinction angle of the augite is 50 deg. from 100. The augite is ophitically penetrated by the felspar laths. Numerous inclusions of olivine occur in the augite. Olivine is present chiefly as allotriomorphic grains. Alteration has taken place along cracks to greenish chloritic material, and occasionally to red iron oxide. Magnetite commonly occurs idiomorphic as octahedra. Numerous irregular grains, purple in reflected light, are probably ilmenite. Low polarising zeolites frequently fill interstices in the rock. The rock may be described as an ophitic olivine dolerite.

Section A23, Kangaroo Grounds, near the cemetery. In this section the ophitic texture is absent, and the felspar laths are larger than in section A15.

3. Garden Hill basalt.—This type differs from the second type in the rarity of the phenocrysts of augite, and in its finer grained character. The specific gravity of this type is also markedly different from that of the former types. The specific gravity of the third type is about 2.86, while that of the first two types is about 2.93.

Section A24, south of Garden Hill, is a typical example. In hand specimen it is a black, dense, almost aphanitic rock.

Microscopically it is a holocrystalline fine grained rock, showing pilotaxitic structure, and having a tendency towards a porphyritic habit. Phenocrysts of olivine occur in a moderately fine grained base of augite, plagioclase, magnetite, ilmenite and apatite. Secondary minerals, as serpentine, zeolites and iddingsite are present. Olivine, colourless, is occasonally altered to green serpentine, and red brown iddingsite. Augite occurs very rarely as purple phenocrysts, and is generally present as microscopic anhedral grains and prisms, having an extinction angle about 45 deg. Long prisms of felspar, with maximum extinction angle about 33 deg., indicate labradorite of composition near Ab_2 An_3. Microspherulitic zeolites occur distributed throughout the ground mass.

Section A21, Garden Hill.—Olivine is largely replaced by iddingsite. Small amount of glass or isotropic zeolite present.

(c) *Dykes.*

1. Basic dyke. This dyke occurs in a small shaft in section 16, allotment D. It was not possible to determine its strike or to trace it on the surface. Macroscopically it is a greenish grey coloured amygdaloidal rock, resembling a basalt. It weathers to a brown iron-stained material containing numerous unaltered crystals of augite. Microscopically it is a holocrystalline, panidiomorphic, porphyritic textured rock. It consists mineralogically of phenocrysts of olivine and augite in a ground mass of microlites of felspar, granular augite, olivine, magnetite and apatite. Secondary minerals comprise zeolites, talc, calcite and leucoxene. Augite occurs in large idiomorphic phenocrysts, brown or purple in colour, and decidedly pleochroic, indicating a titaniferous variety. Simple twinning on 100 is seen by re-entrant angles and differences in polarisation colours. Multiple twinning, twin and

composition plane 001 well developed. Iddings[1] mentions that this type of twinning is often developed by pressure. Extinction angle of the augite varies from 30 deg. to 37 deg. Cleavage parallel to 110 perfect. This augite is of interest since in some cases it appears to be almost uniaxial, and the writer was able to determine its sign as positive by the mica plate. A. N. Winchell[2] has noted that in a titaniferous pyroxene from Pigeon Point, Minnesota, the optical axial angle is so small that in some cases the mineral appears uniaxial. This seems to be the case in the above-mentioned augite. Inclusions of plagioclase in augite show that, in part, the augite crystallised out later than the felspar. Augite in the ground mass occurs as eight-sided granules and prisms. The prisms occasionally cross one another, forming stellate aggregates suggestive of the rare mode of twinning on ($\bar{1}22$).[3] Olivine occurs as anhedral crystals of moderate size, now almost entirely replaced by a colourless micaceous mineral with high birefringence, probably talc. Along cracks alteration to green serpentine or chlorite has occurred. Plagioclase is present in long laths, having a maximum extinction of about 37 deg. The rock may be described as a basaltic dyke.

2. Dry Creek dyke. Section A25, Dry Creek dyke, near the Plenty River. In hand specimen this is a light-coloured rock, frequently iron stained due to oxidation of crystals of pyrite. The minerals present are not determinable in hand specimen. Microscopically the texture is holocrystalline and porphyritic. Mineralogically the rock consists of phenocrysts of orthoclase and quartz in a ground mass of quartz, sericite, bleached biotite, plagioclase, orthoclase, magnetite and kaolin. Brown hydrated iron oxide is fairly abundant. Orthoclase is the chief porphyritic constituent. It is present as large, simply twinned crystals, having a maximum extinction angle of about 17 deg. Considerable replacement by quartz and sericite has occurred in many cases. Kaolin is probably a surface alteration of the orthoclase. Plagioclase having a maximum extinction angle of 14 deg. from the traces of the twin planes, to probably albite, occurs in considerable amount in the ground mass of the rock. The biotite has been bleached, and hydrated iron oxide has been redeposited along cleavage traces, and it is frequently associated with brown prisms of rutile. The considerable amount of iron oxide throughout the section represents the

1 Iddings. Rock Numerals, p. 305.
2 A. N. Winchell. Notes on a titaniferous pyroxene. Amer. Geologist, vol. xxxi., 1903.
3 Iddings. Op. cit., p. 305.

replacement of pyrites by limonite. An occasional six-sided crystal of quartz, partially replaced by sericite, is present. The original rock is thus seen to have been a quartz felspar porphyry. A similar conclusion was reached as to the original character of the Diamond Creek dyke.

Section A21, from near the edge of the Dry Creek dyke, contains numerous xenoliths of sandstone and slate. The plagioclase is zoned, and the quartz is frequently eaten into and replaced by sericite.

3. Diamond Creek dyke.—This dyke was sectioned and examined before the writer had seen the Dry Creek dyke, and the main conclusions regarding the nature of the alteration it has suffered were thus deduced previous to the examination of the latter dyke. In hand specimen the Diamond Creek dyke is yellow green in colour, and contains abundant minute cubes of pyrite. Microscopically it is a hypocrystalline, very even grained aphanitic rock, with skeleton outlines of original porphyritic constituents. Microcrystalline quartz grains and flakes of sericite constitute considerably over 90 per cent. of the rock, the other minerals present being pyrite, stibnite, bleached biotite, rutile, carbonate occasionally, and possibly arsenopyrite and zircon. Idiomorphic outlines of the original felspar crystals are distinguished by the more compact nature of the sericite in such areas. The metasomatic replacement of the felspar is generally complete, and so the stages in the alteration are not determinable. In only one section of the Diamond Creek dyke did the writer see original orthoclase remaining. Rarely a residual phenocryst of quartz occurs. Sericite usually occurs in clear, colourless microscopic flakes, showing the usual delicate polarisation colours. Where replacing felspar, a linear arrangement of the sericite is sometimes seen. The original femic constituent of the rock was apparently biotite. As a result of the alteration, the biotite was leached, and simultaneously rutile separated out in the biotite areas. This separation was usually in the form of "segenite"[1] webs, but occasionally rutile occurs in prisms roughly parallel to the length of the biotite. Carbonate often occurs associated with quartz in veins through the dyke, but otherwise it is rare. Some of this vein carbonate was examined and found to be dolomite. Pyrite is common in cubic crystals, and stibnite is always present, but generally in very small amount when not near the quartz veins.

1 Rosenbusch, Iddings, p. 146.

(d) *Discussion of the alteration of the dykes.*

It will be seen that the Diamond Creek dyke consists of a very much altered porphyry. The alteration has been complete, and all of the original minerals have been replaced, and the ground mass has been recrystallised. Petrologically, it is seen that the biotite was the first mineral to be attacked, as in all sections of the Dry Creek dyke examined biotite was always entirely replaced, although plagioclase and orthoclase were sometimes only partially altered. The alteration appears to start first in the areas of orthoclase, although orthoclase occasionally remains when all the plagioclase has been replaced. Kirk,[1] in discussing somewhat similar mineral changes to those here described, has shown that the iron magnesium minerals are the first attacked, and that plagioclase commences to be replaced by sericite and quartz before the orthoclase is attacked. Replacement of the felspar frequently starts along planes of weakness, such as cracks and cleavage planes. An analysis of the Diamond Creek dyke was made for the purpose of studying the chemical migrations during the alteration. The analysis gave the following results :—

	A.
SiO_2	76.25
Al_2O_3	15.12
Fe_2O_3	1.86
FeO	tr.
MgO	0.18
CaO	tr.
K_2O	3.10
Na_2O	1.37
H_2O -	0.10
H_2O +	1.61
TiO_2*	—
S	0.92
MnO	tr.
Sb_2S_3	p.n.d.
	100.51
less O = S	.34
	100.17

A. Diamond Creek Dyke, 800 feet level, about 200 feet from the underlay shaft along the north drive, Diamond Creek Mine. S.G = 2.72.

—N. R. Junner, Analyst.

1 C. T Kirk. Conditions of mineralisation in the copper veins at Butte Montana. Economic Geology, vol. ii., No. 1., 1912.

* TiO_2 included with the Al_2O_3

From the fair amount of biotite and lime soda felspars probably originally present, it may be inferred that the percentages of lime and magnesia were very much higher than in the altered rock. The iron has probably not changed very much in amount, but sulphur has been introduced either as sulphuretted hydrogen or as alkaline sulphides, and this has united with the iron forming pyrites. It is not possible to say from the evidence of a single analysis what migration has taken place in the alkalies, although it seems probable that a reduction in amount of both potash and soda has occurred. Silica and water have both apparently increased in amount. Sericite is essentially a potash mica, and in the analysis over one per cent. of soda is represented. This may possibly be due to the presence of the soda mica paragonite, although microscopically no distinction could be made out. Regarding the temperature of the altering solutions, Kirk[1] states "that where sericite can be certainly identified, it becomes a useful corroborative criterion in the interpretation of previous hydrothermal high pressure conditions." Rutile is also mentioned as forming under considerable pressure and moderate temperatures. We may, therefore, conclude that the alteration which the Diamond Creek dyke has suffered was probably of the nature of a solfataric after-effect under moderately high pressure and temperature operating on the quartz felspar porphyry. This type of alteration agrees with "propylitisation" as defined by Vogt.[2] Kirk[3] has summed up in tabular form the various alterations during propylitisation of the Butte granite, and the table below is a partial extraction.

Chemical Alterations.

Iron gained, sulphur added to form pyrite. Losses in lime, magnesia and soda; transformation of iron oxides to sulphides; decrease in all bases except potash. Gains in iron sulphide, silica and water, alumina, potash, etc.

Mineral Alterations.

Development of sericite, quartz, pyrite, chlorite, epidote, rutile, etc. Femic minerals are first altered and felspars are more resistant.

1 Kirk. Op. cit., p. 57.
2 Vogt. Genesis of ore deposits. Trans. Amer. Inst. Min. Eng., 1901, p. 668.
3 Op. cit., p. 67.

Physical Alterations.

Increase in density.

With a view to determining the change in density due to the alteration, the specific gravities of the Dry Creek and Diamond Creek dykes were compared, with the following result:—Density of little altered dyke at Dry Creek, equals 2.59. Density of the Diamond Creek dyke from the 800 feet level of the mine, equals 2.72. We see thus that a marked increase in specific gravity has occurred, and this is largely explained by the presence of pyrite in the one and its absence in the other. The chemical and mineral changes agree very well with those tabulated above, and the writer feels quite justified in calling the alteration a "propylitic" one. In the typical propylitic alteration, chlorite is generally developed, and the potash percentage is generally increased. The alteration of the above dykes appears to differ from the typical propylitisation in these respects. The only previous cases of propylitisation that have been described in Victoria are the Woods' Point dykes,[1] and a propylitised dacite[2] from Macedon. The Diamond Creek example differs from both of these in the absence of chlorite, and also in the fact that the ground mass recrystallised in eutectic proportions in both of the above cases, while it has not done so in the Diamond Creek dyke.

(c) *Dyke veins and slate reefs.*

Section A23.—Gold-bearing quartz vein in the dyke, Diamond Creek mine.

The vein is small, but very rich. The gold is seen without the aid of a lens sticking out at points through the vein. A considerable amount of stibnite is present, giving the quartz a dark colour. Under the microscope the gangue is seen to be practically entirely quartz, and the metallic minerals are chiefly stibnite and gold. Grains of a translucent, highly refracting and apparently isotropic mineral associated with the stibnite appear to be the oxide senarmontite. The section shows that the gold occurs in anhedral grains and masses, frequently disseminated through the stibnite, and occasionally intergrown with it. The intimate association of the gold and the stibnite is well recognised by the miners, for they say that wherever you find stibnite, gold is certain to be present. Lincoln[3] has examined twenty-eight specimens of gold stibnite veins

1 Prof. Gregory. Mem. Geol. Surv. Vict., No. 3, 1905, p. 34.

2 Prof. Skeats and H. S. Summers, M.Sc. Bull. No. 24, Geol. Surv. Vict., 1912.

3 F. C. Lincoln. Certain natural associations of gold. Economic Geology, vol. vi., 1911, p. 287.

from various localities, and he has shown that in 16 cases the gold occurs with the stibnite, in 7 cases disseminated through it, and in 4 cases intergrown with it. The above-mentioned section shows well the contemporaneous origin of the gold, quartz and stibnite. Pyrite occasionally occurs in the quartz veins associated with the gold, and in the 800 feet level small crystals of sphalerite were present.

Section A4, slate vein, 600 feet level south, Diamond Creek mine.

Quartz, sericite, carbonate, pyrite and stibnite are the minerals present. A series of roughly parallel wave-like fractures pass through the grains of quartz, and sericite and carbonate have intruded along these planes and replaced some of the quartz. Marked granulitisation of the quartz grains occurs. Pyrite and a little stibnite are present along cracks and through the vein.

7.—Geology of the Diamond Creek Mine.

The Diamond Creek mine is situated on a hill just to the east of the Diamond Creek, and just south of the railway station of the same name. At present it is the only mine working in the field, although the "Allendale" Company is about to recommence operations. Of late the working of the mine has been carried on with very fair results. For the half-year ending July 19th, 1912, 2009 tons of ore were crushed, yielding 2835 ounces of gold, giving an average yield per ton of 28.2 pennyweights. Five sixpenny dividends have been paid since the beginning of the year, and during the same time the shaft has been sunk a further one hundred and fifty feet. The main shaft is sunk vertically for 700 feet, and then on the underlay of the dyke for a further 280 feet. Most of the development work, especially in the lower levels, has been done north of the shaft. The reefs in the bottom levels were of very fair value, and there seems no reason why permanence in depth of the gold bearing veins should not be realised.

(a) *Features of the silurian, structural and lithological.*

The chief structural features of the silurian have been dealt with before. Near the mine the silurian consists of shales and sandstones and rarely small bands of black slate. These, when they occur in proximity to the dyke, are frequently changed to graphitic slate. Bands and small lenticular segregations of carbonaceous matter occur in nearly all the shales. The dip near the mine is to the W.N.W. at about 45 deg.—60 deg., and the strike is approximately N. 24 deg. E.

The dyke outcrops on the surface just to the west of the mine, and some good sections showing the various relations of the dyke breccia and silurian are seen in shallow workings in the dyke.

(b) *The breccia and crush conglomerate.*

This interesting feature was first examined in numerous workings along the line of the dyke below the mine, and north of the Diamond Creek. Numerous pebbles, set in a very fine matrix, frequently occur in the silurian alongside the dyke. At first sight this might be mistaken for a sedimentary conglomerate, but a little consideration shows that it is a fault conglomerate, and not a sedimentary one. In the first place all the pebbles consist of similar sandstone, shale and quartzite to the adjacent wall rock. Secondly, on the surface this conglomerate has been seen alongside the dyke at places over half a mile apart. Now the strike of the dyke is approximately north and south, while that of the silurian is about north 20 deg. east. Hence it will be seen that the conglomerate is not bedded, and cannot therefore be a clastic conglomerate. Thirdly, when examined in the mine, sections frequently show the junction of the normally dipping silurian with the breccia and dyke, and it is seen that brecciation occurs in a zone roughly parallel to the walls of the dyke. Also in some cases a passage from a breccia into a breccia conglomerate and crush conglomerate is noticeable. Fourthly, the cobbles show certain peculiarities, such as dimpling, plane surfaces where the cobbles have rubbed against one another flattening and twisting. The fault origin appears therefore to be clearly established. Considerable variation in the size of the cobbles has been noted. The average size is two or three inches in diameter, while one extreme example was over two feet long, and more than fourteen inches in diameter. When the fragments are angular and sub-angular the rock is called a crush breccia. Further rolling and crushing of the pebbles rounds off the angles and forms a crush conglomerate. Mr. Dunn[1] mentions the occurrence of the breccia on only one wall of the dyke. The writer, however, has seen that at the mine and elsewhere the breccia frequently occurs on both walls. This fault zone has acted as a plane of weakness, through which the dyke has been intruded. Horses of brecciated-material and fault cobbles are frequently found well within the dyke; in one case in the 300 feet level fault cobbles were seen as much as six feet within it. The dyke occasionally wanders from the zone

1 E. J. Dunn. Op. cit.

of brecciation, as is well seen in a section between the mine and the Diamond Creek station. The dyke in this section is seen to be bounded by crumpled slates, and the brecciated zone occurs seven or eight feet to the west. The width of the original fracture zone is probably not represented by the width of the dyke. Lateral pressure exerted during intrusion and a certain amount of stoping has probably enlarged the width of the fracture. It is not clear what the final displacement is, but it is probable that the movement was oscillatory, and the final displacement may have been small. If the quartz reefs on either side of the dyke at the surface are identical no great displacement can have occurred.

(c) *The Diamond Creek dyke.*

The dyke near the mine strikes practically north and south, and dips to the east at about 45 deg., i.e., the dip is approximately at right angles to the dip of the shales. In some places the dip is nearly vertical and in others it is much flatter than the average. Considerable variation occurs in the width of the dyke, both along its length, and in vertical sections. The maximum width is about 35 feet, and the average about 20 feet. Rectangular jointing, with one set of joints roughly parallel to the dip of the dyke, and the other set almost at right angles to these, frequently occurs. Slickensides, striae, brecciation and other evidence of movement under pressure are not uncommon, especially near the faults. Large horizontal slickensides occur in the dyke below the 300 feet level north, and large curved ones are not infrequently present in other parts of the mine. Impregnation with pyrites of the breccia and slates surrounding the dyke for a few feet has taken place.

(d) *Faulting later than the intrusion of the dyke.*

The best opportunity for studying this faulting was afforded at the mine. Nearly all these faults appear to be normal strike faults having a strike approximately north 20 deg. east, and hading to the west. Their strike varies from north 10 deg. east to about north 30 deg. east, and their hade is generally between the limits 40 deg. and 80 deg. The effect of the difference in strike of the faults and the dyke gives the faults the appearance of pitching to the north. Being normal faults, the dyke is always brought back in a westerly direction, and this has materially aided the company in the lower levels, where the dyke was going away from the shaft. In the Union mine, immediately to the south of the Diamond

Creek Company's workings, two fair-sized faults of this nature were encountered. The first one was passed through near the surface, and it intersects the dyke near the Diamond Creek shaft at the 500 feet level. The other one came in near the Union shaft at the No. 6 level. The vertical displacement, or blank ground, in this case was about sixty feet, and as yet it has not cut the Diamond Creek workings. Another fairly large fault of a similar nature has intersected the dyke near the latter shaft at about 200 feet from the surface. Numerous others, with displacements of 20 feet and under, occur throughout the mine. Considerable brecciation of the dyke has occurred near the faults, and later solutions passing through these fissures have deposited pyrites, and this frequently binds the fragments of dyke together. Besides these strike faults, one or two cross or "transverse" faults have been noted. A good example of this faulting occurs in the 700 feet level, south drive. The strike of the fault is about 15 deg. north of east, and it hades to the N.N.W.

8.—Relations of the various Quartz Reefs to one another.

(a) *Occurrence and relative size.*

At least 4 distinct types of veins have been observed. They are, in order of age as far as has been determined :—

1. Vertical reefs—oldest.
2. Bedded reefs.
3. Dyke reefs.
4. Joint plane reefs—youngest.

As an illustration of the first type, we have the reef which runs into the dyke from the south-west side of the main drive north, at the 300 feet level. The actual junction of the dyke with the slate reef was not seen, but sections along the drive show that the reef is not continuous across the dyke. The management have driven along the hanging wall of the dyke for some short distance with the view of locating the northern continuation of the reef. They were not successful, however, and it is probable that pre-dyke faulting connected with the brecciation has displaced the reef. On the surface two reefs, one of which is possibly the upward extension of the above mentioned reef outcrop on the north-east side of the dyke. From surface shafts which are only down to relatively shallow depths, and are nearly all vertical, it was not possible to be certain that these reefs were not bedded, as the dip of the silurian near by is very steep, being 70 deg. or 80 deg. The possibility of these reefs being bedded is not very likely, however, as the bedded reefs are generally very thin and barren, while these are much wider, and they are fairly rich. The reef at the 300 feet level dips slightly to the east, and cuts across west dipping country. This reef has been located about 500 feet south from where it junctions with the dyke, and its departure is about seventy feet from the dyke at this point. A reef worked for a short distance on the surface to the south-west of the dyke appears to be the upward continuation of this reef. Similar reefs occur in the Union No. 7 level, and in the Diamond Creek 400 feet level. In the Union level above-mentioned, the relation of these reefs to the bedded ones is well seen. The bedded reefs are seen to displace these nearly vertical ones, although the displacement is small, generally a foot or two. Jutson[1] has shown that the bedded reefs displace the main reefs in the Warrandyte goldfield. The reefs worked on the western limb of the Templestowe anticline, about three-quarters of a mile south of the Diamond Creek mine, are also probably of the same nature as those near the mine. The strike of the reefs in both cases conforms with the strike of the silurian, being north 15 deg. east to north 25 deg. east. Another reef of this kind was seen in a section in the Maroondah aqueduct just to the west of the Bulleen syncline. The reef is about 16 inches in width, and it has been displaced by a small dip fault. As far as the writer could learn, considerable amounts of gold have been won from these reefs. Near the surface they averaged about one ounce to the ton, and occasionally patches giving returns of as much as twelve ounces to the ton were found.

Bedded veins.—These are common at and near the Diamond Creek mine. They have been shown before to occur only in close proximity to the axial lines, especially the Templestowe anticline. The veins are generally thin, varying from ½ inch to 2 inches in casts of friction striae are well preserved in the quartz. In some places the quartz reefs give place to a small fissure filled with gouge or flucan. The relation of these veins to the dyke is rather obscure. Nowhere do they cut across the dyke, although occasionally the reefs have been traced on either side of it. These reefs, as far as the writer is aware, contain little or no gold, and their effect, if any, on the localisation of the gold in the dyke veins, is not apparent. The striae on the quartz show that the movement that has occurred was mainly a slip in the direction of the dip of the dyke.

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1 c, p. 536.

Dyke Veins.—These are the most persistent and by far the most important economically of the reefs near Diamond Creek. Generally two well-defined reefs occur:—

1. Hanging wall reef.
2. Footwall reef.

Besides these, others are occasionally present, and sometimes one reef will split into two, and the parts may junction again to form the main reef. In general these reefs are approximately parallel to the walls of the dyke, and it is only on rare occasions that a quartz-reef cuts the dyke transversely. The reefs are generally within the dyke, sometimes as much as six feet, but generally only about twelve inches. An inch or so of pug sometimes accompanies these reefs and striae and slickensides are often present. The thickness of the reefs varies considerably, from a mere thread to two or three feet. The reefs, when they occur at the junction of the dyke and the shales, are usually smaller than the average, and sometimes they split up into a number of leaders, running out into the country.

Joint Plane Reefs.—These are not of any economic importance. They occur typically in the 600 feet level south. Here one section shows one of these reefs displacing a tongue of the dyke, and therefore they are later in age than the dyke.

(b) *Fissures and their origins.*

1. The dyke fissures. The frequent association of the dyke veins with a little flucan, and the striae on the dyke walls between the dyke and the quartz are suggestive of movement. The direction of the striae is generally, but not always, in that of the dip of the dyke, and having no north or south component. One very good example of these striae occurred on the footwall of the dyke in the stopes above the 800 feet level, where the quartz had been broken out. Two sets of striae were present, the first consisting of coarse corrugations, having no meridional component, and the second set were later, and very fine, and pitched to the south. The question is whether these movements occurred before the formation of the reefs or after. Rarely the striae are also on the quartz, indicating that the movement in part at least was later than the formation of the reefs. The writer believes that the reefs are filling contraction joints which are roughly parallel to the walls of the dyke, and that movement has occurred both before the formation of the reefs and for a while, after the ore had formed. According to this view the fissures are essentially neither contraction fissures nor fissures of

discission, but they are a combination of both. It is also fairly certain that the fissures in some places have been enlarged by metasomatic replacement. Absence of crustification, the dense character of the quartz, and irregular inclusions of dyke material, probably undigested portions, suggest this.

(2) Fissures in which the bedded reefs occur. The origin of these has previously been suggested as due to movements connected with the folding of the sediments. The correspondence of these reefs in dip and strike with the silurian also supports such an origin. Movement on a minor scale has taken place along the bedding before the formation of these reefs as noted above. Occasionally slipping has occurred along the bedding, although no reefs are present.

9.—Origin of the Gold Bearing Solutions.

One or two points bearing on this discussion might be first noted :—

(1) The close association of the quartz veins with the dyke suggests strongly some genetic relationship between them.

(2) The nature of the minerals formed in the dyke due to the alteration. These minerals have been shown above to be those that are formed by juvenile solutions rather than by vadose ones. Pyrite, for instance, is generally decomposed by the vadose waters, but is frequently formed by either upward or downward moving thermal waters.

(3) Assays of the pyrites and of the dyke have been made at various times to see whether it would pay to treat the proposition as a low grade one. Very little gold was found to occur in the pyrites, and still less in the dyke. It might be suggested that the gold originally occurred disseminated through the dyke, and that it was transferred to the veins by a process of lateral secretion. The assays show, however, very little gold in the dyke away from the mineral veins, and such a transference as suggested above does not seem likely to have occurred. The presence of stibnite in both the dyke and in the quartz veins suggests that the solutions which caused the alteration of the dyke, and those which introduced the gold were of similar origin. The fact that the Dry Creek dyke, which has been very little altered, contains very little gold,[1] is strong evidence in support of the view that the solutions which brought the gold into its present position were a final phase of the same solutions that caused the alteration of the dyke. The writer pic-

1 Cf. Gregory. Memoir Geol. Surv. Vict., No. 3, 1905, p. 34.

tures the following sequence:—The quartz porphyry was intruded from some magma, probably at considerable distance below the then surface, along a plane of weakness, namely, the zone of brecciation. After solidification, and probably while the dyke was still hot, alkaline sulphide solutions were introduced along fissures in the dyke, and these caused the extensive propylitisation. Finally, the gold stibnite and quartz were introduced through the same or enlarged fissures. Contrasted with the above alteration, is the effect of the present day vadose circulation. Pyrites is dissolved from the dyke, and from the brecciated fault zones, and becomes oxidised, and is redeposited in the lower levels of the mine as hydrated iron oxide. In abandoned and little-used workings, as in the Union mine, long needles and hair-like crystals of epsomite are abundant. Green vitriol ($Fe\ SO_4 . 7\ H_2O$), also frequently occurs, due to the oxidation of the pyrites. Where water has percolated down the hanging wall of the dyke, considerable alteration of the dyke to a clayey material, largely kaolin, has occurred.

10.—Additional Features.

Localisation of values, evidence of secondary enrichment, etc.

Owing to the rather limited study of the occurrence of the gold, the writer being largely concerned with the then working levels, namely, the two bottom ones and the uppermost one, sufficient data were not gained for the fixing of pay shoots of gold, although there is little doubt that they do exist. According to evidence that the writer has gained from the officials at the mine, there appear to be two main shoots.

1. North hanging wall or whim shoot.
2. South footwall shoot.

Of these two shoots, the northern one is the richer, and is more well defined than the southern one. They both pitch to the north, the north one at a very steep angle, and the south one at about 45 deg., so that they incline towards one another, and in the 700 feet level the two shoots are only 70 feet apart. The length of the shoots appears to be fairly uniform, and about 250 feet. With respect to the cause of the shoots, the evidence is largely of a negative character. Mr. Dunn,[1] in his examination of the Union mine, was inclined to think that the shoots were due to the selective influence of certain bands of the country rock. Appearances at the mine point against this, however. The best values occur when

1 Dunn. Op. cit.

the reefs are within the dyke. When the reefs wander out into the slate or breccia, no noticeable increase in values occurs, and, in fact, in such cases there seems to be rather a decrease in values.

The effect of the "diagonal"[1] veins. Bedded reefs are common at the mine, but their effect, if any, on the gold values is not clear. A very interesting case of local enrichment occurs in the 300 feet level north near the intersection of the dyke, with the nearly vertical shale reef before mentioned. Here a very rich pocket of gold occurred in the very fractured dyke. This fracturing in parts appears to antedate the formation of the quartz veins, as no definite reefs exist here, the dyke being simply veined by numerous very rich stringers of quartz. Three possibilities exist for the localisation of the gold at this point:—

1. Action of the shale reef.
2. Effect of pre-existing fractures.
3. Secondary enrichment.

The first effect may probably be omitted, for the same reason that the effect of certain bands of the country is out of question.

A section was made of the ore from here, and it was seen that the gold and stibnite were intimately associated, although both were secondary in relation to the quartz. The stibnite was seen to consist of aggregates of needles, and not to be like the usual secondary sulphides that occur in some mineral fields, such as Broken Hill, near the water level. Very little information could be gained regarding the character and value of the ore above the 300 feet level at the mine, as this was worked in the early days of the field. No great variation in values, as far as could be learned, occurred in going down from the surface. The evidence appears insufficient to justify us drawing any extensive conclusions with regard to secondary enrichment. The presence of senarmontite in the lower levels does not necessarily mean that the zone of oxidation reached that depth, but probably that such ore was near fractures down which surface waters percolated. The evidence, such as it is, tends to support the view that secondary enrichment has occurred to a limited extent. The great amount of strata removed since folding[2] would tend to concentrate the gold, while the dense character and small size of the quartz reefs would exclude any large circulation of solutions. In the neighbourhood of faults, enrichment has occasionally been noted. In the Union mine, the gold-bearing stone was mainly the footwall stone,[3] and the hanging wall stone was hardly

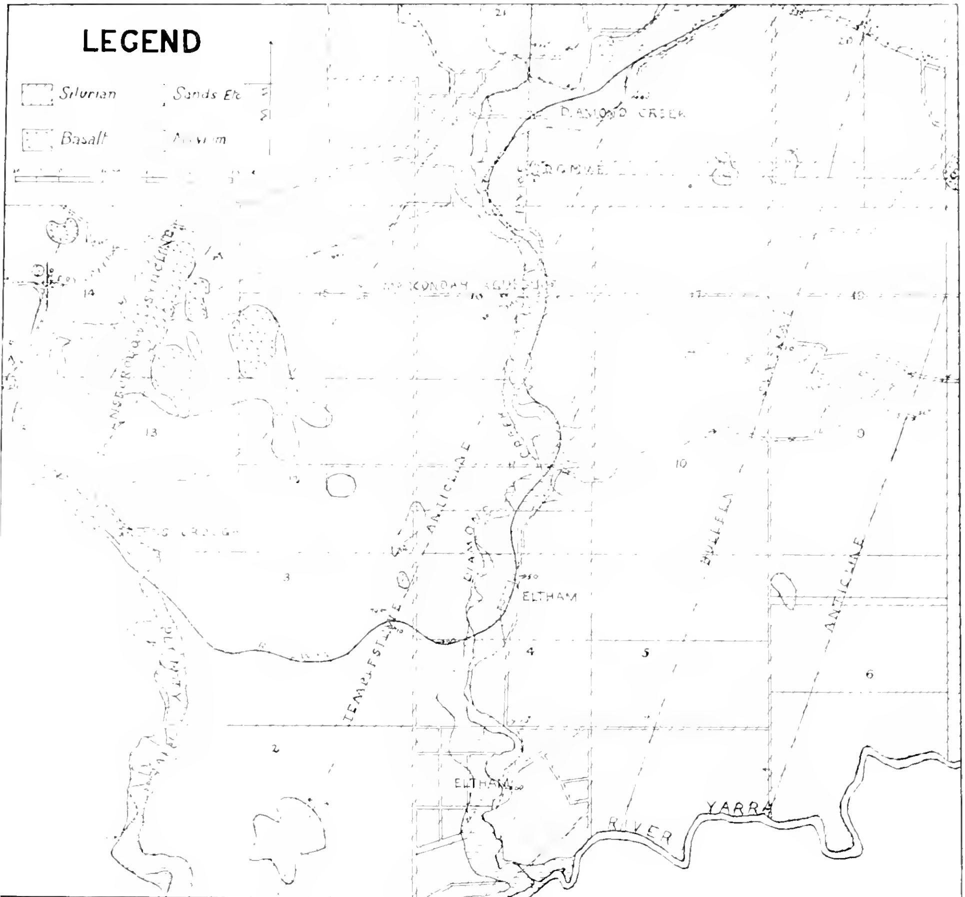
1 "Diagonal" is the miner's term for the slate veins.
2 Jutson. c, p. 559.
3 Dunn. Op. cit.

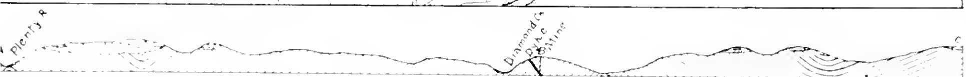
thought profitable to break out. In the south workings of the Diamond Creek mine, the footwall stone was worked almost exclusively. North of the shaft, however, both walls have been worked considerably. It is taken as a general rule at the mine that if the gold occurs on one wall it will not occur on the other. An exception to this was noted in the 700 feet level north, where the gold occurred on both walls.

Summary and Conclusions.

The study of the Diamond Creek area has brought to light some very interesting relations. The bearing of the present elevation of the river gravels formed before uplift in the direction of the slope of the peneplain has been noted. The stratigraphical relations have been described, and a few fossils found. The discovery of climacographtus and diplograptus in the so-called silurian near Diamond Creek is of interest, and should act as an incentive to further palaeontological work. The other fossils support a melbournian age for these beds. An intimate relation between the mining belts and the structural features, especially the anticlines, has been shown to exist. The petrological examination of two dykes from the area brought out some interesting relations; the Diamond Creek dyke appears to be an almost completely altered facies of a rock allied to the Dry Creek dyke. The former dyke has been described as a propylitised quartz felspar porphyry. The contemporaneous character of the gold and stibnite, and sometimes of the quartz, has been noted. Another interesting feature is the friction breccia and conglomerate, through which the Diamond Creek dyke has been intruded. The relations of the various quartz reefs the problem of the genesis of the ores, the localisation and cause of the ore shoots, etc., have also been dealt with. Chemical analyses were made of the basalt and of the Diamond Creek dyke.

In conclusion, the writer wishes to record his indebtedness to Professor Skeats for his advice and suggestions on many occasions, and for his kind criticism of the paper; also to Mr. Summers, M.Sc., for help in the laboratory, and references to the literature. He also desires to thank Dr. Hall, Prof. Ewart and Mr. F. Chapman, A.L.S., for their kind examination of fossils, and Mr. Grayson for rock sections, and micro-photographs. To Mr. Christian, the manager of the Diamond Creek mine, the writer is greatly indebted for securing him access to the mine, and for information relating to it, and to Mr. Brooks, Mr. Ditchburn, and the various officials of the mine for their kind co-operation in the work.





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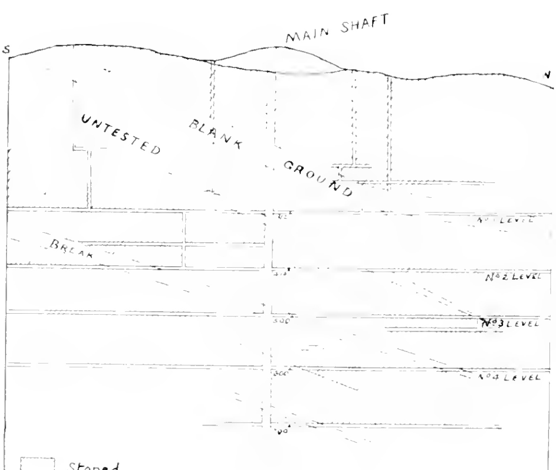
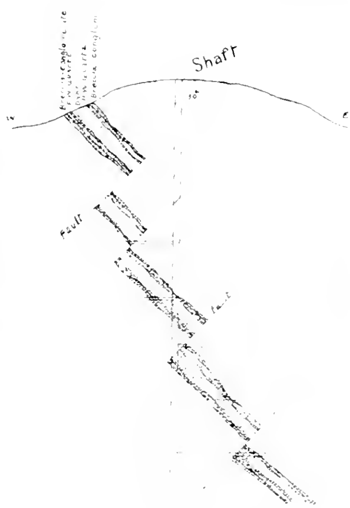


LONGITUDINAL SECTION OF MINE



TRANSVERSE SECTION

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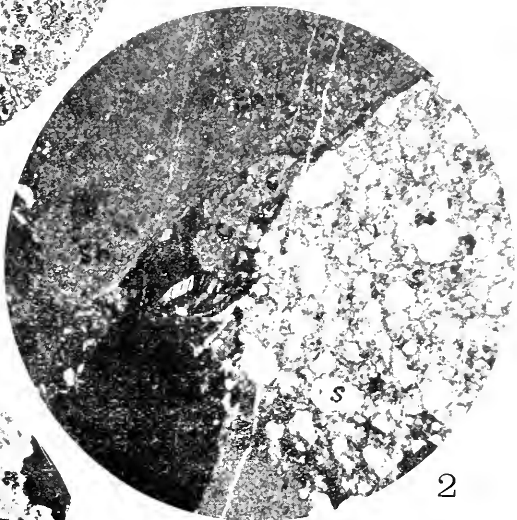

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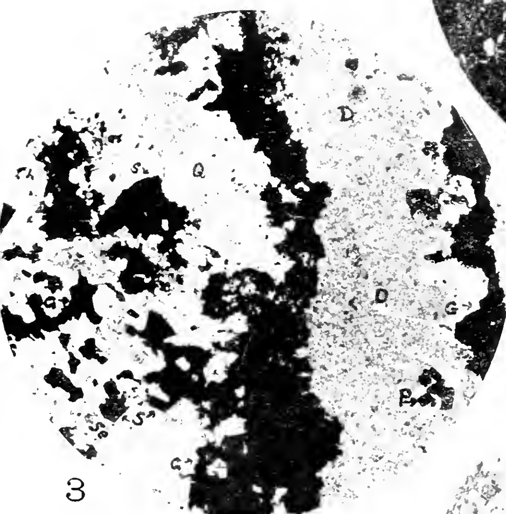

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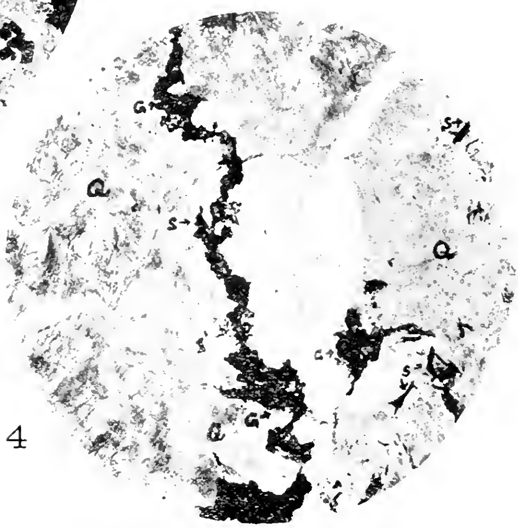

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EXPLANATION OF PLATES.

Plate XXV.

Geological sketch map of the Diamond Creek area; the alluvium of the Yarra not shown; also longitudinal and transverse sections at the Diamond Creek mine. The longitudinal section is published by permission of Mr. Christian.

Plate XXVI.

Fig. 1. Photomicrograph of the fine-grained basalt analysed, × 25, ordinary light, with a felspar phenocryst in the field of view.

Fig. 2. Photomicrograph of the breccia, Diamond Creek mine, × 8, ordinary light, S = sandstone, Sl = slate, C = calcite, Sh = shale. Secondary quartz and calcite veins intersect the rock.

Fig. 3. Microphotograph of a gold-bearing dyke vein, × 25, ordinary light, showing the contemporaneous origin of the gold, quartz and stibnite. Q = quartz, G = gold, S = stibnite, P = pyrite, Se = senarmontite, D = dyke.

Fig 4. Microphotograph of gold-bearing quartz from the 300 feet level of the Diamond Creek mine, × 25, ordinary light. The secondary character of the gold is well shown.

[PROC. ROY. SOC. VICTORIA, 25 (N.S.), PT. II., 1913.]

ART. XXVI.—*A New Variety of Volute from Western Australia.*

BY AGNES F. KENYON.

[Read 12th December, 1912].

Voluta nivosa, var. coxi.

Shell, dull red colour. This dullness may be owing to being a dead specimen; ovately oblong, spire short, lower whorls noduled, upper whorls slanting from apex and noduled. These are almost obscure when touching body whorl at an angle. Columella four plaited, snowflake marking large on body whorl, and in most respects resembling original description of *V. nivosa*. The differences consist in the largeness of the size, difference of colour, and the tuberculation of the whorls, also colouring of interior, which is lemon colour merging into orange.

Greatest length, 5 inches. Greatest breadth, 2 inches.

Greatest circumference, 6½ inches.

Locality.—Garden Island, W.A.

There are now several varieties of *V. nivosa*, but in colouration and form the most remarkable of these varieties is the recently described var. *irviniana* of E. A. Smith, owing to its coronal spikes, whereas *V. coxi*, although of the same ruddy hue, has reverted to the original shape of *V. nivosa* as described by Lamarck, but is of much larger size.

The specimen now described is from the collection of Mrs. J. F. Irvine, Evandale, Tasmania, and is named as a tribute to the late Dr. J. C. Cox, of Sydney, whose lamented death is a great loss to the scientific world.

[Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. II., 1913.]

Art. XXVII.—*Further Descriptions of the Tertiary Polyzoa of Victoria, Part XII.*

By C. M. MAPLESTONE.

(With Plate XXVII.).

[Read 12th December, 1912].

Strongylopora concinna, n.s. (Plate XXVII., Fig. 1).

Zooecium oviform, with six marginal fenestrae. Avicularia in distal angles. Thyrostome arched above; margins raised, with a sinus in the proximal one. Ooecium large, ventricose, adnate on distal zooecium; with a raised median longitudinal ridge; aperture large, arched above.

Locality.—Geelong (J. F. Mulder).

A single specimen, consisting of three zooecia and an ooecium; the proximal zooecium is imperfect, the front wall is broken away; in the lateral one the lower margin of the thyrostome is imperfect; the distal one has the thyrostome perfect, and the ooecium extends over the front wall nearly up to the thyrostome.

Strophipora episcopalis, n.s. (Plate XXVII., Fig. 2).

Ooecium oblong, ventricose. Front surface with a subtriangular or mitriform depressed area surrounded by raised margins and a round perforation with a raised margin at the apex. Aperture large, with raised margins, arched above; lower margin somewhat irregular, with a ridge extending from the centre to the base, and dividing into two parts a depressed area in which are several minute perforations: an elevated transverse ridge separates this area from two lateral depressed areas. On one side of the ooecium, near the distal end, outside the mitriform area, are a few small perforations.

Locality.—Geelong (J. F. Mulder).

A single specimen. I place this in *Strophipora* on account of its resemblance to *S. triangularis.*

Strophipora dubia, n.s. (Plate XXVII., Fig. 4).

Ooecium subtriangular, elongated, broad at the base, with projecting angles, above which is a sub-globose area, with pores (or fenestrae), having slits distally converging towards the centre. An avicularium at each distal angle. Aperture broad, distal and proximal margins arcuate, proximal one with a small sinus in the centre, proximal to which is a broadly cordate depressed area with a quadrate projection from the lower margin; on each side of which is a small oval depressed area.

Locality.—Geelong (J. F. Mulder).

A single specimen, which, although it is difficult to assign it definitely to *Strophipora*, is sufficiently distinctive to warrant its description, and to place it tentatively in that genus.

Catenicella rugosa, n.s. (Plate XXVII., Fig. 3).

Ooecium pyriform, broad end proximal, surface rugose: a round elevation on the distal end. Aperture broad, arched above, lower margin slightly curved and projecting over the aperture.

Locality.—Geelong (J. F. Mulder).

A single specimen, not very well preserved, but distinct from any other species.

Caberea pedunculata, nom. nov.

From Mr. R. Henry Walcott, of the National Museum, I have received a note made by Mr. Chapman, Palaeontologist to the Museum, that a species of fossil polyzoa, which I described in 1911 (Proc. Roy. Soc., Victoria, vol. xxiii. (New Series), p. 271), under the name of *Caberea morningtoniensis*, was apparently different from one which I described under the same name in 1900 (ibid., vol. xii., p. 164). The species are quite distinct, and the use of the same name in the later case was the result of my having forgotten that I had used it before; consequently a new name is required for the species described in 1911. I have therefore re-named that species *Caberea pedunculata*.

Caberea pedunculata, nom. nov.

=*C. morningtoniensis*, Proc. Roy. Soc., Vict., vol. xxiii. (New Series), p. 271, *non C. morningtoniensis*, ibid., vol. xii. (New Series), p. 164.


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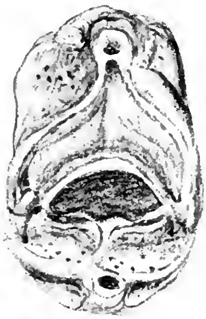
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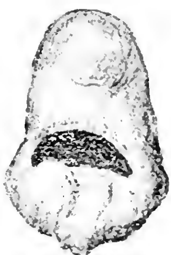
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[Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. II., 1913.]

Art. XXVIII.—*New or little-known Polyzoa.*

By C. M. MAPLESTONE.

(With Plate XXVIII.).

[Read 12th December, 1912.]

Digenopora latissima, n. sp. (Pl. XXVIII., Fig. 1).

Some few years ago, in the course of my examination of my slides of recent polyzoa, to compare with the fossil forms upon which I was working, I discovered a new species of *Digenopora* (a genus of the family of *Catenicellidae*, described by me in Part II. of "Further Descriptions of the Tertiary Polyzoa of Victoria"), which I found at Williamstown in 1869, and labelled it *Catenicella hastata*, overlooking the two sets of fenestrae. Ten years afterwards I found it living at Portland, and figured it in my paper to the Society on "Observations on Living Polyzoa," in 1881, and in that figure the two sets of fenestrae are indicated in one zooecium; but as the drawing was made specially to show only the pigment cells in the ectocyst, other details being omitted, their significance was again overlooked. Unfortunately, I have only the specimen mounted at Williamstown.

Zooecia oval; lateral processes very wide and flat, with numerous minute perforations or semi-globose elevations. Inner set of fenestrae, seven; pyriform, imperforate, in a scutiform area; outer set seven round elevations, submarginal; avicularia recessed, very small, on a level with the proximal lip of the thyrostome; thyrostome arched above, straight below with a very small irregular sinus in the lower margin. Ooecium globose, surmounted by a truncate conical process, a shallow oval depression surrounded by a raised border on each side on the upper part; an irregular reniform, slightly raised area on each side of the aperture; a small vertical oval opening in the centre; aperture very large and broad, lower margin, with a sharp sinus in the centre; five large oval perforations in a curve below and three small fenestrae underneath the sinus.

Locality.—Williamstown and Portland.

The colour of the zoarium when living is orange, but the zooecia are more or less spotted with purple or dark green pigment cells the greater or less abundance of which cause it to appear of various shades, from orange to purple and dark greenish grey.

The inner fenestrae are very slightly raised pyriform areas, not always well defined, and might be easily overlooked, but the scutiform area is always present, though the boundaries of individual fenestrae are often indiscernible. In the fossil *D. compta* they are conspicuous, as the ectocyst is not preserved, and they show as perforations. This species is the only living representative of the genus.

Schizoporella baccata, n. sp. (Pl. XXVIII., Figs. 2, 2a).

Zooecia undefined; surface granulose; with numerous subconical umbonate processes upon them; most of those near the margin of the zoarium and in the vicinity of the ooecia are furnished with avicularia which have straight ligulate mandibles, incurved at the distal end. Thyrostome large, arched above with a very broad curved sinus in the proximal margin. Ooecia globose, surface granulose, with a prominent conical umbo on the summit.

Locality.—Portland.

This is a very distinct species. The zoarium is orange coloured. The umbonate processes on the zooecia in the central portion of the zoarium bears no avicularia. The portion figured shows two perfect ooecia; on another portion of the margin of the zoarium are numerous ooecia in an incompleted state. Fig. 2a is an outline sketch of one.

Schizoporella complanata, n. sp. (Pl. XXVIII., Fig. 3).

Zoarium encrusting, zooecia oval, slightly ventricose. Thyrostome arched above with large rounded sinus in the proximal margin. Avicularian cells very large, Ooecia (?).

Locality.—Portland.

This species is characterised by the very large, almost flat, avicularian cells which cover the whole surface of the zooecia; at the distal end of them there is a ventricose process, with a variously denticulated margin, and within which is an acute mandible opening upwards. These large avicularian cells completely conceal the thyrostome in almost every case, and in the specimen figured it is seen in only one zooecium, in which the avicularium is absent.

Mucronella ovifera, n. sp. (Pl. XXVIII., Fig. 4).

Zoarium encrusting, zooecia undefined. Thyrostome suborbicular, with a broad ligula in the proximal margin. Avicularian cells ovoid, enormous, concealing almost the whole surface of the zooecia and bearing broad semi-elliptical avivularia.

Locality.—Portland.

The great distinguishing feature of this species is the enormous ovoid avicularian cells, which are sometimes "twinned." They cover nearly the whole surface, only a small portion of which can be seen, not sufficient to allow of the determination of the form. The distal basal margins of the avicularian cells overhang, and partially hide the proximal margins of some of the thyrostomes.

Dimorphocella portmarina, n. sp. (Pl. XXVIII., Fig. 5).

Zoarium erect, flabellate, bilaminate, zooecia of two forms, subtle and angular, elongated; margins raised; surface granular; a row of pores round the margins. Thyrostome of smaller zooecia transversely sub-elliptical, with distal margins more curved than the proximal. Thyrostome of larger zooecia transversely elongated, proximal margin sometimes slightly incurved; an ovoid avicularium, with an acute triangular mandible, in the centre of the frontal wall in both kinds. The larger zooecia are more or less covered with mammillated nodules. Smaller zooecia 0.4 to 0.5 mm. long; 0.2 to 0.3 mm. wide. Larger zooecia 0.6 to 0.8 mm. long; 0.4 to 0.5 mm. wide.

Locality.—Portsea.

A single specimen, about 12 mm. in diameter. This species belongs to the genus *Dimorphocella*, which I, in Proc. Roy. Soc., Vict., Vol. XVI. n.s. Pt. I. p. 340, established to include *D. pyriformis* and *D. triton*, McG. sp., found in our tertiary deposits.

The larger zooecia are present, either singly or in groups, upon both surfaces of the zoarium. All the zooecia are somewhat irregular in shape; in the smaller form the marginal row of pores is very regular, but in the larger form they are sometimes obscured by the mammillated nodules. The oval avicularium is constantly present in both forms, and in the portion illustrated one of them is reversed; the mandible pointing proximally instead of distally

The following is a description of a very interesting form, from Disaster Bay, N.S.W., given to me by Mr. C. J. Gabriel.

Selenariopsis, n. gen.

Zoarium dome-shaped. Zooecia quadrate in a single layer, and in radial series. Ooecia and avicularia present. No vibracula.

Selenariopsis gabrieli, n. sp. (Pl. XXVIII., Figs, 6, 7, 8, 9, 10).

Zoarium a hemispherical dome, 5 mm. in diameter, 2.5 mm. high. Zooecia radially arranged in straight rows, quadrate or sub-quadrate in form, smooth with slightly raised and faintly sinuous margins. Thyrostomes oval, ooecia somewhat larger than the zooecia, with a broad aperture below two smaller ones on the front wall. Avicularian cells quadrate, with a large, somewhat hourglass shaped cavity. In the basal walls of the zooecia there is a large aperture, and there is also an aperture on the side walls of the zooecia.

Locality.—Disaster Bay, N.S.W. (C. J. Gabriel). A single specimen.

This is a very peculiar form; it is allied to *Selenaria*, and, in the radial and linear disposition of the zooecia, to *Lunulites*. It is a hemispherical dome (a small portion of which is broken away), composed of a single layer of zooecia arranged in radial lines, intercalating towards the margin. The thyrostomes are oval, but somewhat iregular in form. The ooecia have a large, broadly oval aperture, with two smaller ones above. The basal walls have a large aperture, and there is also a smaller one in the side walls of the zooecia, through which probably living tissue, connecting the occupants of the adjoining zooecia, extended. It differs from *Selenaria* in having large avicularia, but not vibracula, and the ooecia are on the same level as, and in series with, the zooecia, not exterior as in *Selenaria*, and by the zooecia being clearly defined on the basal surface.

Owing to the irregularity in the shape of the thyrostomes, and in the presence of the large aperture in the basal wall, and also the absence of the opercula of the thyrostomes and the mandibles of the avicularia, I am of opinion that the specimen exhibits the internal calcareous structure only, and that in life it had an ectocyst covering it entirely on both basal and upper surface in or upon which were the true thyrostomes with their opercula, also the mandibles of the avicularia, and that it covered the basal surface, and the large aperture in the basal wall of the zooecia, which is such a conspicuous feature, and which must have had a covering of some kind. Consequently, if living, or perfect, specimens be found, it will be necessary to modify the description, but there is no doubt that its structure abundantly justifies the establishment of a new genus for its reception.

Parmularia obliqua. (Pl. XXVIII., Fig. 11).

A new form from West Australia.

The specimens of *Parmularia obliqua*, from the South Australian coast, to which I alluded in my "Observations on *Parmularia* *obliqua* and a fossil species" (Proc. Roy. Soc., Vict., Vol. XXIII. (new series), p. 42), are almost always symmetrical in form; in the adult stage kidney shaped; in the younger forms they are either fan-shaped, with obtusely crenate edges, or are palmate.

I have lately received from Dr. Verco, of Adelaide, some specimens which he dredged in King George's Sound, West Australia, which are extremely asymmetrical and sometimes very much lobed, almost digitate in some cases. I have drawn several of the zoaria, half natural size, and it will be seen that there is great dissimilarity in the forms. I can detect no difference whatever in the zooecia from those in South Australian form, but as the zoarial character is so different, the specimens from West Australia must be considered a distinct variety, for which I propose the name "*Parmularia obilqua* var. *lobata*.

In the South Australian form the zoaria do not bear ooecia until they arrive at the adult stage, and they they are always on, or near the outer margin of the zoarium, but in West Australian form one specimen (marked "A") bears a few ooecia in a curved transverse row in the central portion of the zoarium.

Variable forms of **Cellepora fossa** (Harwell sp.).

I think the variations in the form of the zoaria of this species worthy of notice, as from a casual examination of the specimens no one would think they belonged to the same species.

The form from which Prof. Haswell originally described the species, under the generic name of *Sphaeropora*, is "subspherical, slightly depressed."

Among the polyzoa, dredged by Dr. Verco in South Australian waters, sent to the late J. Dennant, and which I examined some years ago, there were two different forms. One was circular, thick, slightly raised in the centre, with rounded edges (bun-shaped), and on the under surface (chiefly in an annular area near the edge of the zoarium), there were numerous small conical pits, which descend to a considerable distance into the zoarium. These pits are formed by a small parasitic "actinid." The upper surface of the larger specimens was mammillated, but in the smaller ones was not. The zooecia on the edges of the zoarium have the umbonate process, which bears a semi-circular avicularium, produced into a blunt conical process. This form grows to a very large size, some being over an inch in diameter.

The other form was oval, or rather ellipsoidal, smooth, with a deep conical pit at one end.

Another very different form occurred in some material dredged off the coasts of New South Wales. It was spindle, or cigar-shaped, with a very irregular, nodular surface. It was 3 cm. long, 7 mm. wide at the truncated end; tapering to a rounded point at the other end. It had a single conical pit in the truncated end of a larger size than those in the other specimens, but evidently caused in a similar way.

EXPLANATION OF PLATE.

Fig. 1.—Digenopora latissima, × 30.
Fig. 1a.—Do. do. do., ooecium, × 30.
Fig. 2.—Schizoporella bacata, × 24.
Fig. 2a.—Do. do. incomplete ooecium, × 24.
Fig. 3.—Do. complanata, × 24.
Fig. 4.—Mucronella ovifera, × 24.
Fig. 5.—Dimorphocella portmarina, × 24.
Fig. 6.—Selenariopsis gabrieli, portion of zoarium, × 5.
Fig. 7.—Do. do. section of zoarium, × 20.
Fig. 8.—Do. do. basal surface of zooecia, × 20.
"o" do. do. of ooecium, × 30.
Fig. 9.—Do. do. upper surface of zooecia, × 20.
"o" do. do. of ooecium, × 20.
Fig. 10.—Do. do. upper surface of zooecia, × 20.
"a" avicularian cell
"o" ooecium
Fig. 11.—Parmularia obliqua var. lobata
various forms of zoaria, nat. size.
"a" zoarium, with ooecia.

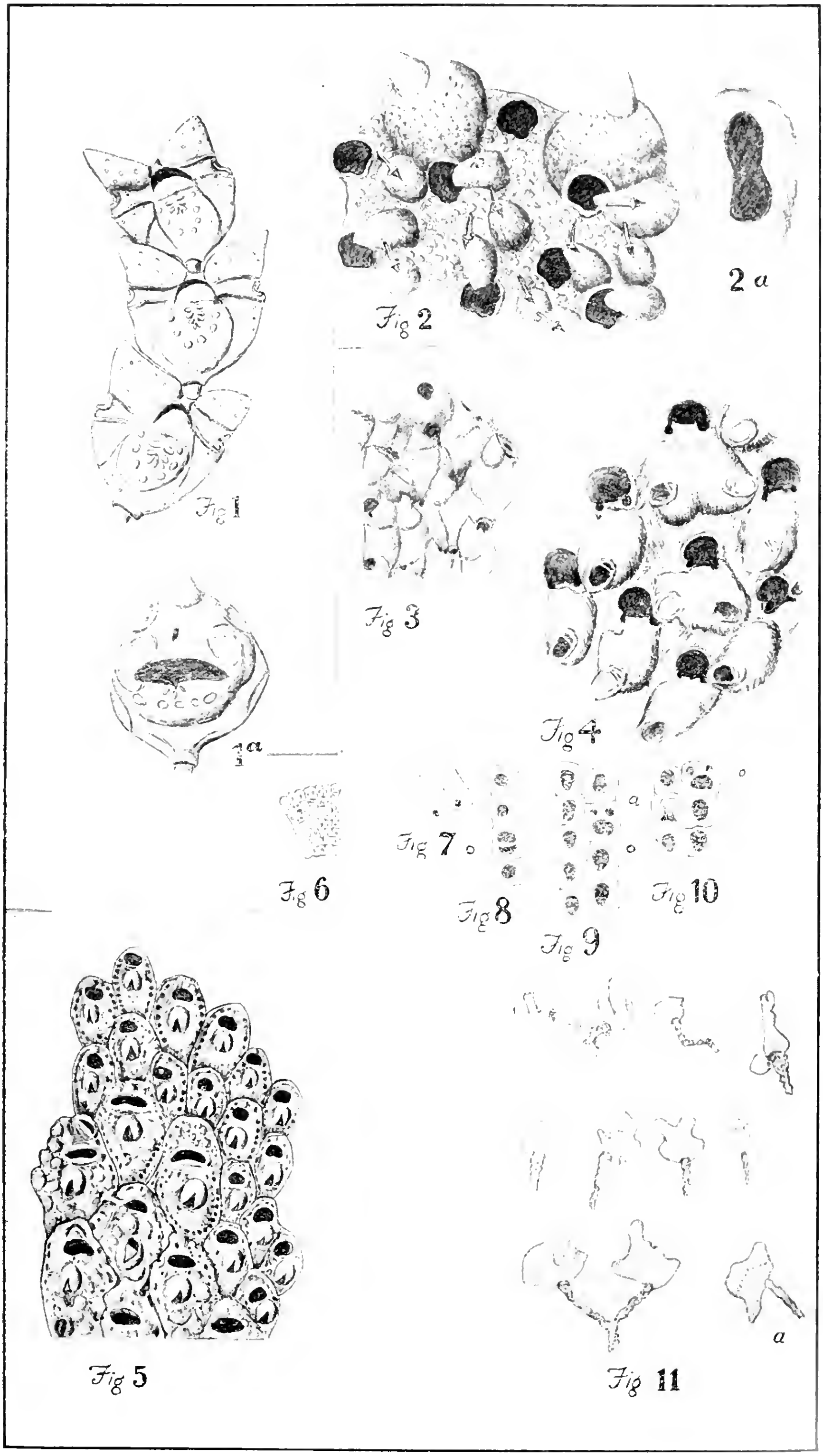


Fig 1
1a
Fig 2
2 a
Fig 3
Fig 4
Fig 5
Fig 6
Fig 7
Fig 8
Fig 9
a
Fig 10
Fig 11
a

Proc. Roy. Soc. Victoria, 25 (N.S.), Pt. II., 1913.

Art. XXIX.—*On a New Silurian Bivalve from the Lilydale Quarries, Lucina (Prolucina) mitchelli.*

By G. B. PRITCHARD, D.Sc., F.G.S.

(Lecturer in Geology, &c., School of Mines Department, Working Men's College, Melbourne).

(With Plate XXIX.).

[Read 12th December, 1912.]

Lilydale is a well known locality for well-preserved fossils of very high antiquity, namely, silurian, and the Cave Hill Quarries have been yielding up their treasures to diligent searchers for quite a number of years. A glance at the list of fossils from this locality will, however, show that we have at present rather a scanty knowledge of its bivalved molluscan fauna, as the record includes only six species.

Any additional information should therefore be of some interest and value, and it is with pleasure that I now make the record of a new species.

During a recent visit to the Cave Hill Quarries, my assistant, Mr. Stanley R. Mitchell, had the good fortune to discover a very fine and perfect specimen of a large bivalve, which evidently belongs to the family *Lucinidae*. This specimen he has very kindly placed in my hands for description, and I take this opportunity of tendering him my thanks and of naming the species after him.

Lucina (Prolucina) mitchelli, sp. nov.

Description.—Shell orbicular, tumid, beak small, depressed, convexly rounded and situated at about one-third of the diameter from the anterior margin; lunule narrowly cordate, very small but distinct. Anterior margin regularly convexly rounded, from the lunule to the ventral margin, the latter becoming distinctly straighter as it reaches up to the posterior margin; posterior truncation makes an obtusely angular junction with the ventral margin of about 110 degrees, and runs obliquely upwards to join the convex posterior dorsal margin. The shell shows its greatest tumidity slightly to the front of its centre line umbo-ventrally, but becomes notably flattened towards the anterior margin as well as towards the posterior keel. Posterior keel only faintly defined umbonally, but rapidly increasing in strength posteriorly, till it forms an exceptionally strong ridge margining the depressed posterior area. Shell surface finely concentrically sculptured, running about three ridges in two millimetres in the middle region, apparently raised into slight frills on the posterior keel; the frills are strongest post-ventrally, but the preservation of the specimen is not so perfect as to fully show the original extent of this feature. No radial marking is apparent. Interior of valve deeply concave umbonally and running out shallower towards the ventral margin, which is bevelled off to a general acute edge, with a suspicion of faint denticulation. The hinge has been cleared of matrix, but the cardinal teeth are evidently obsolete; there is a faint suspicion of an anterior lateral tooth, whilst to the posterior a broad shallow area for the reception of the internal ligament is margined by an elongated narrow ridge. Anterior adductor muscular scar very large, ovate, and showing a distinct and elevated callous rim towards the ventral margin, callous facing out dorsally. Posterior adductor muscular scar much smaller, narrowly elongate and margined anteriorly with a strong callous ridge. Pallial line entire and narrow. Internally there is some evidence of a radial structure which probably gave rise to a slight denticulation of the ventral margin, but this is not very distinctly preserved in the present specimen.

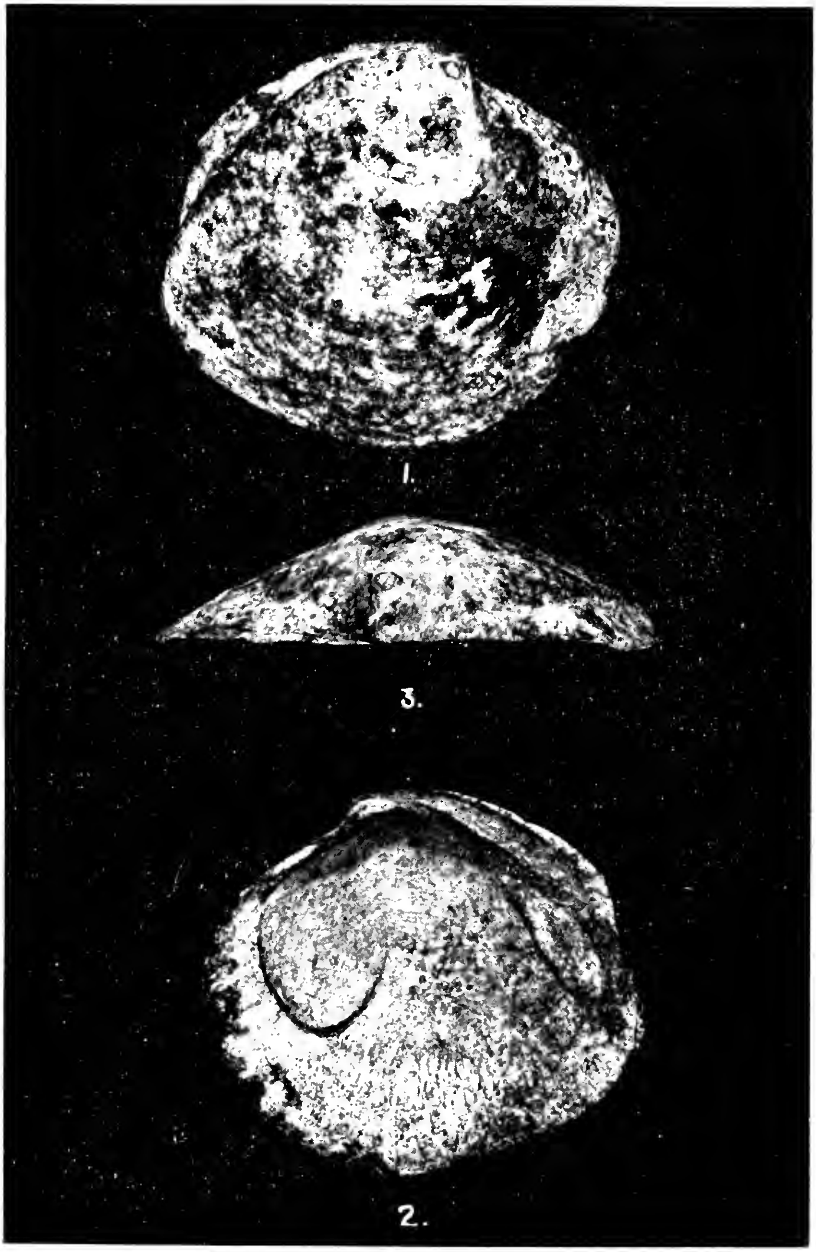
Dimensions.—Antero-posterior diameter, 68 mm.; umbo-ventral diameter, 62 mm.; greatest thickness through one valve, 15 mm.; thickness of shell about 2 mm.

Locality.—Cave Hill Quarries, Lilydale. Silurian limestone fauna. Collected by S. R. Mitchell.

I desire to express my best thanks to Mr. L. Knibbs for the photographs which illustrate this shell.

EXPLANATION OF PLATE XXIX.

Fig. 1. External view of valve, about two-thirds natural size.
Fig. 2. Internal view of valve, about two-thirds natural size.
Fig. 3. Umbonal aspect, a little less than natural size.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ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR 1912.

The Council herewith presents to Members and Associates of the Society the Annual Report and Details of Receipts and Expenditure for the year 1912.

March 14th.—Papers read: (1) "Esperanto and Science," by Dr. W. T. Kendall; (2) "On the Introduction of the Cattle-tick Fever into Australia," by Professor J. A. Gilruth, D.V.Sc., etc.; (3) "Further Observations on Onchocercus gibsoni, the Cause of Worm Nodules in Cattle," by Professor J. A. Gilruth and Dr. Georgina Sweet.

April 11th.—Papers read: (1) "Australian and Tasmanian Coleoptera Inhabiting or Resorting to the Nests of Ants, Bees and Termites": Supplement, by A. M. Lea; (2) "On a New Chiridotinid of the Genus Taeniogyrus Found in Port Phillip Bay," by E. C. Joshua; (3) "The Occurrence and Development of Cervical Ribs in Man and Some of the Mammals that have Abandoned Quadrupedal Progression," by Walter Stapley, M.D., D.V.Sc., etc.

May 9th.—Papers read: (1) "Contributions to the Flora of Australia," Part XVIII., by Professor A. J. Ewart, D.Sc., etc., and Bertha Rees; (2) "Note on the Ascent and Descent of Water in Trees," by Professor A. J. Ewart, D.Sc., etc.

June 13th.—Lecture: "The Diamond in South Africa," by Prof. E. W. Skeats, D.Sc. The lecture was illustrated by lantern slides and numerous specimens.

July 11th.—Papers read: (1) "An Investigation of Fifty-two Tasmanian Crania, by Klaatsch's Craniotrigonometrical Methods," by L. W. G. Buchner; (2) "Description of Two New Ischnochitons from Western Port," by A. F. Basset Hull (communicated from C. J. Gabriel); (3) "Some New Victorian Mollusca," by J. H. Gatliff and C. J. Gabriel; (4) "Additions to the Census of Victorian Marine Mollusca," by J. H. Gatliff and C. J. Gabriel; (5) "Additional Remarks on the Psychrometric Formula," by Glennie Smeal, B.Sc.; (6) "New or Little-known Fossils from the National Museum, Part XV.—Some Tertiary Species," by F. Chapman, A.L.S.; (7) "Notes on Some 'Stringy Bark' Eucalyptus Oil, and the Occurrence of Eucalyptus consideniana near Melbourne," by

Royston Drew (Victorian Research Scholar), Heber Green, and P. R. H. St. John. Mr. Gabriel showed the two species of Ischnochiton described by Mr. Hull; Messrs. Gatliff and Gabriel, Chapman and Drew, Green and St. John showed specimens illustrating their papers. Mr. T. Griffith Taylor exhibited and spoke on rock specimens from Antarctica.

August 8th.—Papers read: "On the Cross-Inoculation of the Root-tubercle Bacteria upon Native and the Cultivated Leguminosae," by Professor A. J. Ewart, D.Sc., and Norman Thomson B.Ag.Sc. Mr. A. J. Higgin showed a Leitz metallographic microscope; Dr. Hall, by permission of the Director of the Geological Survey, showed a Parkes-Lapworth microscope, and also teeth of Nototherium tasmanicum from Tasmania, lent by Mr. T. Stephens. Prof. Skeats showed an alkaline rock from Macedon, which indicated the way in which "buckshot gravel" could originate. Dr. Payne Philpots showed aboriginal jaws which gave evidence of great wear and of the absence of dental caries.

September 12th.—Paper read: "Paralysis in Horses and Cows due to the Ingestion of Fodder," by Dr. J. A. Gilruth, M.R.C.V.S. Mr. J. J. Fenton exhibited a dioptremeter. Mr. F. Chapman showed marble from Buchan, such as is being used in the new reading-room at the Public Library.

October 10th.—Papers read: (1) "The Anatomy of Two Australian Land Snails, Paryphanta atramentaria, Shuttleworth, and P. compacta, Cox and Hedley, by Olive B. Davies, B.Sc.; (2) "The Correlation or Size of Head and Intelligence, as Estimated from the Cubic Capacity of Brain of 355 Melbourne Criminals," by Professor R. J. A. Berry and L. W. G. Büchner. Prof. Ewart showed the seed of Caesalpinia sp., a native of Queensland, said to have come from the Otway Forest.

November 14th.—Lecture: "Rock Paintings and Carvings in South Africa," by J. L. Elmore, M.D. Papers read: (1) "On the Country between Melbourne and the Dandenong Creek," by T. S. Hart, M.A., F.G.S.: (2) "The Correlation of Size of Head and Intelligence, as Estimated from the Cubic Capacity of Brain of Thirty-three Melbourne Criminals Hanged for Murder," by Professor R. J. A. Berry and L. W. G. Büchner.

December 12th.—Papers read: (1) "Parasitic Hymenoptera of Victoria," by P. Cameron (communicated by J. A. Kershaw); (2) "The Syrinx of the Common Fowl; Its Structure and Development," by A. O. V. Tymms (Government Research Scholar); (3) "The Viscosity of Cream," by Frances K. M. Dunaresq, M.A., B.Sc. (communicated by Prof. W. A. Osborne); (4) "The General and Mining Geology of the Diamond Creek Area," by Norman R. Junner (Kernot Research Scholar); (5) "A New Variety of Volute from Western Australia (*Voluta nivosa*, var. *coxi*), by Agnes F. Kenyon; (6) "Further Descriptions of the Tertiary Polyzoa of Victoria," Part XII., by C. M. Maplestone; (7) "New or Little-known Polyzoa," by C. M. Maplestone. Mrs. Kenyon showed specimens of Voluta in illustration of her paper, also siliceous sinter from the Pink and White Terraces of Rotomahana. Mr. Junner showed rocks from the Diamond Creek District.

During the year 4 members, 1 country member, and 6 associates were elected. Two life members who served the Society well in its early days, namely, Mr. H. F. Eaton and Mr. J. S. Butters, have died. Mr. Butters was one of the founders of the Society and an occasional attendant at meetings till a few months before his death. One member, 1 country member, and 1 associate resigned, and the names of two associates who were non-financial were removed from the lists.

The Proceedings, Vol. XXIV., Pt. 2, and Vol. XXV., Pt. 1, were published during the year.

The Committee of the National Park, Wilson's Promontory, has erected a cottage at Barry's Hill, for a second ranger, who was appointed in December. A cottage for the accommodation of the Committee and a rest-house for tourists were erected at the Derby River. A rest-house was put up at the Beehives, and the pier, at the same place, was moved to a better position. A track to Sealers' Cove was marked by an officer of the Public Works Department, and work on it will be begun. Several new animals were introduced, and most appear to be doing well.

The Librarian reports the addition of 1925 volumes and parts during the year. A large number of copies of Brough Smythe's "Australian Aborigines," Baron von Mueller's "Iconography of the Acacias," and Neumayer's "Meteorological Observation," were received from the Government Printer. The storage of this material and of the Library is a more acute problem than ever, and the question of additions to the building should be faced as soon as possible.

Royal Society of Victoria in Account with Hon. Treas.—March 1st, 1912, to February 28th, 1913.

RECEIPTS.

To Bank of Australasia—Balance ...		£61 19 9
Subscriptions—		
Members	£111 17 0	
Associates ...	69 1 0	
		210 18 0
Government Grant ...		200 0 0
Rents—		
Comwlth. Government	£50 0 0	
Field Naturalists' Club	12 0 0	
		62 0 0
Sale of Publications		5 2 1
Memorial Donation from Mrs. Officer ...		10 10 0
		£550 9 10

EXPENDITURE.

By Publishing—		
Printing, &c.	£256 12 7	
Assistant Editor	20 0 0	
Distribution	24 0 0	
		£300 12 7
Maintainance—		
Rates	£7 12 4	
Insurance	5 1 3	
Repairs	14 11 8	
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Caretaker's A/cs.	21 12 2	
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Cash Charges—Commission	£17 3 6	
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Cheque Book, etc.	1 4 9	
		18 18 3
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Periodicals		4 5 10
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Society's Balance	£127 8 3	
Memorial Donation as other side	10 10 0	
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W. A. HARTNELL. *March 1st, 1913.* J. E. GILBERT, A. E. V. RICHARDSON, } *Auditors.*

Royal Society of Victoria.

1912.

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W. A. M. BLACKETT.

Trustees:

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WITH THEIR YEAR OF JOINING.

Patrons.

His Excellency Sir John Fuller, Bart., K.C.M.G. 1911

Honorary Members.

Forrest, The Hon. Sir J., K.C.M.G., West Australia ... 1888

Liversidge, Professor A., LL.D., F.R.S., Hornton-street, Kensington, Lond. 1892

Scott, Rev. W., M.A., Kurrajong Heights, N.S.W. 1855

Verbeek, Dr. R. D. M., Speelmanstraat 19, s'Graven hage, Holland. 1886

Life Members.

Butters, J. S., F.R.G.S. 1860

Fowler, Thos. W., M.C.E., Colonial Mutual Ch., 421 Collins-street, Melb. 1879

Gibbons, Sydney, F.C.S., 31 Gipps-street, East Melb. 1854

Gilbert, J. E., "Melrose," Glenferrie-road, Kew, Vic. ... 1872

Gregory, Prof. J. W., D.Sc., F.R.S., University, Glasgow. 1900

Love, E. F. J., M.A., D.Sc., F.R.A.S., Moreland Grove, Moreland 1888

Nicholas, William, F.G.S 1864

Selby, G. W., 99 Queen-street, Melb. 1881

Smith, W. Howard, "Moreton," Esplanade, St. Kilda 1911

White, E. J., F.R.A.S., Observatory, Melb. 1868

Ordinary Members.

Anderson, J. H., M.B., B.S., Woodend, Vic. .. 1909

Balfour, Lewis, B.A., M.B., B.S., Burwood-road, Hawthorn, Vic. 1892

Baracchi, Pietro, F.R.A.S., Observatory, Melb. 1887
Barnes, Benjamin, Queen's Terrace, South Melb. 1866
Barrett, A. O., "Melisse," Bruce-street, Toorak, Vic. 1908
Barrett, Dr. J. W., M.D., M.S. Collins-street 1910
Berry, Prof. R. J. A., M.D., F.R.C.S., F.R.S.E., University, Melb. 1906
Boys, R. D., B.A., Public Library, Melbourne 1903
Brittlebank, C. C., "Queensgate," St. George's-road, Elsternwick 1898
Broome, G. H., State Coal Mine, Wonthaggi 1911

Cameron, S. S., D.V.Sc., Agricultural Dept., Melb. 1910
Cherry, T., M.D., M.S., University, Melbourne. 1893

Dunn, E. J., F.G.S., "Roseneath," Pakington-street, Kew, Vic. 1893

Ewart, Prof. A. J., D.Sc., Ph.D., F.L.S., University, Melb. 1906

Fryett, A. G., care Dr. F. Bird, Spring-street, Melb. ... 1900

Gault, Dr. E. L., M.A., M.B., B.S., Collins-street, Melb. 1899
Gillott, The Hon. Sir S., K.C.M.G., "Edensor," Brunswick-street, Fitzroy, Vic. 1905
Gilruth, His Excellency Dr. J. A., D.V.Sc., M.R.C.V.S., F.R.S.E., Darwin, Northern Territory. 1909
Grimwade, W. R., B.Sc., 335 Spencer-street, Melb. ... 1912
Grut, P. de Jersey, F.R.Met.S., 29 Kensington-road, South Yarra. 1901

Hake, C. N., F.C.S. 1890
Hall, T. S., M.A., D.Sc. University, Melb. 1890
Hartnell, W. A., "Irrewarra," Burke-road, Camberwell, Vic. 1900
Harvey, J. H., A.R.V.I.A., 128 Powlett-street, East Melb. 1895
Higgin, A. J., University, Melb. 1912

Jamieson, James, M.D., 12 Malvern Road, Toorak. ... 1877

Kelly, Bowes, 70 Queen-street, Melb. 1910
Kendall, E. A., G.M.V.C., "Coniston," Esplanade, Middle Brighton 1910
Kendall, W. T., D.V.Sc., M.R.C.V.S., 36 Park-street, Brunswick. 1911

Kernot, W. N., B.C.E., University, Melb. ... 1906
Kershaw, J. A., F.E.S., National Museum, Melb. ... 1900
Kitson, A. E., F.G.S., Imperial Institute, S. Kensington, Lond. 1894

Laidlaw, W., B.Sc., Department of Agriculture, Melbourne. 1911
Leach, A. J., D.Sc., Education Department, Melb. ... 1904
Lyle, Prof. T. R., M.A., D.Sc., University, Melb. 1889
Loughrey, B., M.A., M.D., Ch.B., M.C.E., 1 Elgin-street, Hawthorn, Vic. 1880
Lowe, W., M.B., B.S., 279 Victoria-street, W. Melb. 1911

MacDonald, N., Veterinary School, Parkville 1911
MacKenzie, Colin W. M.D., B.S., F.R.C.S., Collins-street, Melb. 1910
Masson, Prof. Orme, M.A., D.Sc., F.R.S.E., F.R.S., University, Melb. 1887
Merrill, A. P., D.D.S., Collins-street, Melbourne 1911
Michell, J. H., M.A., F.R.S., University, Melb. 1900

Nanson, Prof. E. J., M.A., University, Melb. 1875

Oliver, C. E., M.C.E., Metropolitan Board of Works, Melb. 1878
Osborne, Prof. W. A., M.B., Ch.B., D.Sc., University, Melb. 1910

Payne, A. T., "Scotsburn," Toorak 1911
Payne, Prof. H., M.I.C.E., M.I.M.E., University, Melb. ... 1910
Petherick, E.A., F.R.G.S., F.L.S., 251 Albert-street, East Melbourne. 1910

Richardson, A. E. V., Agricultural Dept., Melb. 1912
Robertson, A. W. D., M.D., B.S., University, Melb. 1909
Robertson, W. A., G.M.V.C, Agricultural Dept., Melb. ... 1910
Rowe, W. C., "Invicta," Chaucer-street, Canterbury, Vic. 1908

Schlapp, H. H., 31 Queen-street, Melb. 1906
Shephard, John, Clarke-street, South Melb. 1894
Skeats, Prof. E. W., D.Sc., University, Melb. 1905
Spencer, Prof. W. Baldwin, C.M.G., M.A., F.R.S., University, Melb. 1887
Stapley, W., M.D., D.V.Sc., M.R.C.V.S., Cambridge, New Zealand. 1910
Sweet, George, F.G.S., Wilson-street, Brunswick, Vic. ... 1887

Swinburne, The Hon. G., M.L.A., "Shenton," Kinkora-road, Hawthorn, Vic. 1905

Taylor, R., 31 Queen-street, Melb. 1907
Taylor, T. G., B.A., B.E., B.Sc., Commonwealth Weather Bureau, Melb. 1912
Thom, L. N., B.Sc., Essex-road, Surrey Hills, Melb. ... 1910

Walcott, R. H., F.G.S., Technological Museum, Melb. ... 1897
Ware, S., M.A., Education Department, Melb. 1901
Wisewould, F., 408 Collins-street, Melb. 1902

Country Members.

Desmond, J., R.V.S., G.M.V.C., "Ellerslie," Hurtle-square, Adelaide, S.A., 1901

Hart, T. S., M.A., B.C.E., F.G.S., School of Mines, Ballarat, Vic. 1894
Hogg, H. R., M.A., 38 Harrington Gardens, S. Kensington, Lond., S.W. 1890

Ingram, Alex., Hamilton, Vic. 1903

Lea, A. M., F.E.S., Museum, Adelaide, S.A. 1909

Maplestone, C. M., Eltham, Victoria 1898
Mennell, F. P., Rhodesian Museum, Buluwayo, South Africa 1902
Murray, Stuart, C.E., "Morningside," Kyneton, Vic. ... 1874

Shaw, Dr. A. E., Healesville, Vic. 1912

Corresponding Members.

Bailey, F. M., F.L.S., Government Botanist, Brisbane, Queensland 1880

Dendy, Professor Arthur, D.Sc., F.R.S., Sec.L.S., King's College, London 1888

Etheridge, Robert, Junr., Australian Museum, Sydney, N.S.W. 1877
Lucas, A. H. S., M.A., B.Sc., Sydney Grammar School, Sydney, N.S.W. 1895

Stirton, James, M.D., F.L.S., 15 Newton-street, Glasgow 1880

Associates.

Abbott, S. B., 67 Pakington-street, Kew 1910
Armitage, R. W., B.Sc., Inspector of Schools, Education Dept., Melb. 1907
Ashton, H., "Argus" Office 1911
Audas, J. W., "Engowra," Punt-road, St. Kilda 1911

Bage, Mrs. Edward, "Cranford," Fulton-street, St. Kilda, Vic. 1906
Bage, Miss F., M.Sc., Fulton-street, St. Kilda, Vic. 1906
Baker, F. H., 167 Hoddle-street, Richmond 1911
Baker, Thomas, Bond-street, Abbotsford, Vic. 1889
Bale, W. M., F.R.M.S., Walpole-street, Hyde Park, Kew, Vic. 1887
Bennetts, W. R. Pakington-street, Kew, Vic. 1894
Barkley, H., 9 Denham-street, Hawthorn 1910
Booth, John, M.C.E., B.Sc., "The Gables," Berkeley-street, Hawthorn. 1872
Breidahl, H., 36 Rouse-street, Port Melbourne 1911
Brodribb, N. K. S., Cordite Factory, Maribyrnong 1911
Brook, R. H. T. 1906
Buchanan, Miss G., M.Sc., University, Melb. 1910
Büchner, L. W. G., 258 Riversdale-road, Hawthorn ... 1912

Canwell, C., 139 Hoddle-street, Richmond 1911
Chapman, F., A.L.S., National Museum, Melb. 1902
Corbett, J., "Clifton," 39 Rushall-crescent, N. Fitzroy, Vic. 1907

Danks, A. T., 391 Bourke-street West, Melb. 1883
Davies, Miss O. B., B.Sc., Mentone Parade, Mentone ... 1911

Fenton, J. J., 89 Royal Parade, Parkville 1910
Ferguson, W. H., 59 Brinsley-road, E. Camberwell 1894
Finney, W. H., 40 Merton-street, Albert Park, Vic. 1881
Foubister, J. J., 45 Queen's Parade, Clifton Hill 1911
Foxcroft, A. B., Public Library, Melbourne 1911

Gabriel, C. J., Victoria-street, Abbotsford, Vic. 1908
Gabriel, J., "Cwmdar," Walmer-street, Kew 1887
Gatliff, J. H., Clowes-street, S. Yarra 1898
Green, W. Heber, D.Sc., University, Melb. 1896
Grayson, H. J., University, Melb. 1902
Hamilton, J. T., F.L.S., "Brooklyn," Heidelberg-road, Ivanhoe. 1910

Hardy, A. D., F.L.S., Forest Department, Melb. 1903
Herman, Hyman, B.C.E., F.G.S., Department of Mines, Melb. 1897
Hoadley, C. A., B.Sc., "Bella Vista," Cotham-road, Kew 1910
Howitt, A. M., Department of Mines, Melb. 1910
Hunter, S. B., Department of Mines, Melb. 1908

Jobbins, G. G., Electric Lighting and Traction Co., Geelong, Vic. 1902
Joshua, E. C., 906 Malvern-road, Armadale 1911
Junner, N., Geol. Department, University, Melb. ... 1912
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Kenyon, Mrs. A. F., 291 Highett-street, Richmond, Vic. ... 1908
Kenyon, A. S., Heidelberg, Vic. 1901

Lambert, Thomas, Bank of New South Wales, Benalla, Vic. 1890
Lewis, J. C., L.V.Sc., Darwin, N.T., ... 1910
Luly, W. H., Department of Lands, Treasury, Melb. ... 1896

Mann, J., Chester-street, Surrey Hills, Melb. 1912
Maclean, C. W., "Bronte," Strand, Williamstown, Vic. 1879
Mahony, D. J., M.Sc., Dept. Mines, Melb. 1904
McKenzie, G. Lands Department, Melb. 1907
McNab, V. R., "Almaden," Kooyong-road, Caulfield 1910
Mickle, K. A., "Illira," Marine Parade, St. Kilda 1911
Miller, E. E., Boundary-road, Toorak, Vic. 1908
Morris, M., B.Sc., Cotham-road, Kew 1912

Nicholls, E. B., 164a Victoria-street, North Melb. 1904

O'Neill, W. J., Lands Department, Melb. 1903
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Philpots, G., E.P., D.D.S., M.A.C.D., 110 Collins-street, Melbourne. 1911
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Raff, Miss J., M.Sc., University, Melb. 1910
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Ritchie, E. G., Assoc. M.I.C.E., Met. Board of Works, Melb. 1909

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Schäfer, R., "Invercloy," Napier-street, Essendon, Vic. 1882

Smeal, G., B.Sc. 1911

Smith, J. A., 15 Collins-place, Melb. 1905

Stillwell, F. L., B.Sc. 1910

Summers, H., M.Sc., University, Melbourne 1902

Sutton, C. S., M.B., B.S., Rathdown-street, N. Carlton, Vic. 1908

Sutherland, Ian M., M.C.E., "Novar," Dandenong, Vic. 1905

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Thorn, Wm., Mines Department, Melb. 1907

Thiele, E. O., M.Sc., c/o O. A. Thiele, "Evandale," Chatham-road, Canterbury, Vic. 1898

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NOTE.—*Most of the volumes published before 1890 are out of print.*